# Geodetic Computation for Earth Tide, Load Effects and Deformation Monitoring ETideLoad4.0 User Reference

Easy for Classroom Teaching and Independent Self-study



Chinese Academy of Surveying & Mapping January 2022, Beijing, China Geodetic Computation for Earth Tide, Load Effects and Deformation Monitoring (ETideLoad4.0) is a large Windows package for scientific computing of geophysical geodetic monitoring. Which has five subsystems including the solid Earth tidal effects on various geodetic quantities, processing and analysis on geodetic non-tidal time series, approaching of surface load-deformation field and temporal gravity field, CORS/InSAR collaborative monitoring and ground stability variation estimation as well as editing, calcutating and visualization for geodetic data files.

ETideLoad4.0 is suitable for senior undergraduates, graduate students, scientific researchers, and engineering technicians in geodesy, geophysical, geological disasters, hydrodynamics, satellite dynamics, seismic, and geodynamics. Which considers various potential needs such as classroom teaching, independent self-study, applied computing and scientific research.

**Key words:** Geodesy, Geophysics, Earth Tide effect, Loading deformation, Collaborative Monitoring, Groundwater, Ground Stability, Geological Disasters.

## https://www.zcyphygeodesy.com/en/

Chinese Academy of Surveying & Mapping January 2022, Beijing, 100036, China ZHANG Chuanyin, zhangchy@casm.ac.cn WANG Wei (wangwei@casm.ac.cn) JIANG Tao (jiangtao@casm.ac.cn)

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## 1 ETideLoad4.0's features, strengths, concepts, and usage

Geodetic Computation for Earth Tide, Load Effects and Deformation Monitoring (ETideLoad4.0) is a large Windows package for scientific computing of geophysical geodetic monitoring. Which adopts the scientific uniform numerical standards and analytic compatible geophysical algorithms accurately to compute various tidal and non-tidal effects on various geodetic quantities outside the solid Earth, approach global-reginal load deformation field and temporal Earth's gravity field, and then quantitatively monitor surface hydrology environment, ground stability variations and geological disasters, in order to promote the collaborative monitoring of multi-geodetic technologies and deep fusion of multi-source heterogeneous geodetic data.



#### 1.1 ETideLoad4.0 structure of computation functions

ETideLoad4.0 has five subsystems, which includes the solid Earth tidal effects on various geodetic quantities, processing and analysis on geodetic non-tidal time series, approaching of surface load-deformation field and temporal gravity field, CORS/InSAR collaborative monitoring and ground stability variation estimation as well as editing,

calculation and visualization for geodetic data files.

ETideLoad4.0 was developed by QT C++ (Visual C++) for the user interface, Intel Fortran (Fortran90, 132 Columns fixed format) for the core function modules, and mathGL C++ for the geodetic data file visualization in the Visual Studio 2017 x64 integrated environment. Which is composed of more than 50 win64 executable programs with nearly 600 function modules.

ETideLoad4.0 considers various potential needs such as the classroom teaching, selfstudy exercises, applied computing and scientific research. There are the example files saved in the folder C:\ETideLoad4.0\_win64en\examples for each Win64 program. Each example includes the operation process file processinf.txt, some input-output data files and screenshots.



## 1.1.1 Computation of various tidal effects on various geodetic quantities

Using the consistent geophysical models, the uniform numerical standards, and the compatible geodetic and geodynamic algorithms, compute various geodetic effects of the solid Earth tide, ocean tide loading and surface air pressure tide loading. Which is an important foundation for the collaborative monitoring of multi-geodetic technologies, is also a necessary condition for the deep fusion of multi-source heterogeneous Earth monitoring quantities.



### 1.1.2 Processing and analysis on non-tidal geodetic variations time series

Based on the characteristics of non-tidal geodetic time series, the group of programs adopt stable and reliable algorithms to uniformly process and analyze massive various geodetic variations time series data.



# 1.1.3 Approaching of load-deformation field or temporal gravity field

The non-tidal load variations of atmosphere, sea level, soil water, groundwater, lakes, glaciers, and snowy mountains in the Earth's surface layer, excite solid Earth deformation, which can cause variations of various geodetic quantities with time. These variations can also be quantitatively captured by a variety of ground, space, or ocean geodetic technologies.



# 1.1.4 CORS/InSAR collaborative monitoring and ground stability estimation



# 1.1.5 Geodetic data files editing, calculation, and visualization tools



# 1.2 Geodetic variations in ETideLoad4.0

# 1.2.1 Conventions of the geodetic variations

Geodetic variation in ETideLoad is defined as the difference between the geodetic quantity at the current epoch time and the mean of the quantities over a period or the difference between the geodetic quantity at the current epoch time and the geodetic quantity at a certain reference epoch time. The geodetic quantity may be a geodetic observation or a geodetic parameter, and the geodetic variation refers to the difference in the geodetic quantity with time.

# 1.2.2 Type and unit of the geodetic variations

(1) Height anomaly or geoidal height variation in the unit of mm, ground gravity or gravity disturbance variation in the unit of  $\mu$ Gal, and ground tilt or vertical deflection variation (vector) in the unit of mas namely 0.001".

(2) Ground horizontal displacement in the unit of mm, ground radial displacement namely ground ellipsoidal height variation in the unit of mm, and ground normal or orthometric height variation in the unit of mm.

(3) Gravity gradient variation in the unit of  $10\mu E$ , and tangential gravity gradient vector variation in the unit of  $10\mu E$ .

(4) External (outside the Earth) geopotential perturbation in the unit of  $0.1m^2/s^2$ , gravity perturbation in the unit of  $\mu$ Gal, and gravity gradient perturbation in the unit of  $10\mu$ E.

(5) Land equivalent water height variation in the unit of cm, sea level variation in unit of cm, ocean tidal height in unit of cm, and air pressure variation in unit of hPa.

### 1.2.3 The geodetic variation vectors

(1) Ground tilt or vertical deflection variation vector (SW). The first component points to the south direction, and the second component points to the west direction, which forms a right-handed rectangular coordinate system with the ground gravity direction. This coordinate system is a natural coordinate system.

(2) Ground horizontal displacement vector (EN). The first component points to the east direction, and the second component points to the north direction, which forms a right-handed rectangular coordinate system with the ground radial displacement direction.

(3) Tangential gravity gradient variation vector (NE). The first component points to the north direction, and the second component points to the east direction, which forms a right-handed rectangular coordinate system with the gravity gradient variation direction.

(4) The harmonic parameters of the tidal constituent. The first component is the prograde amplitude for cos(argument), and the second component is the retrograde amplitude for sin(argument).

#### 1.2.4 Expressions of the date and epoch

Time (date and epoch) are agreed to adopt Greenwich Time (zero time zone), which is expressed in modified Julian Date (MJD, in GPS time, and Julian Date 2000.0 = MJD 51544.5) or a long integer agreed by ETideLoad.

In most cases, the long integer agreed by ETideLoad is used. E.g., 20181224122642 represents 12:26:42 on December 24, 2018, 2018122412 represents 12: 0: 0 on December 24, 2018, and 20181224 represents 0: 0: 0 on December 24, 2018. But 201812, 2018 are not valid date and epoch. Here, the epoch is an instantaneous time.

## 1.3 Science goals and strengths of ETideLoad4.0

#### 1.3.1 Scientific goals of ETideLoad4.0

(1) Using the consistent geophysical models and uniform numerical standards, accurately compute the various tidal and non-tidal effects on various geometric and physical geodetic quantities on the ground and outside the solid Earth by constructing compatible geodetic and geodynamic algorithms.

(2) Unifying various geodetic spatiotemporal monitoring datum frames and reference epoch time, by constructing geometric and physical geodetic constraints between various monitoring quantities, highlight the spatiotemporal geodynamic relationships between these monitoring quantities to promote the collaborative monitoring of multi-technologies.

(3) Provide a set of scientific and practical geodetic geodynamic computation tools for construction and maintenance of geodetic spatiotemporal monitoring frames, and deep fusion of multi-source heterogeneous Earth monitoring quantities, computation of solid Earth

deformation, monitoring of surface hydrology environment, and surveying of geological disasters.

### 1.3.2 Geodetic features and strengths

(1) Adopt the scientific uniform numerical standards and analytic compatible geophysical algorithms accurately to compute the Earth tidal, ocean tidal, and surface air pressure tidal, permanent tidal, polar motions, and geocentric motions effects on various geodetic quantities on the ground and outside the solid Earth. Realize global forecasts of various tidal effects on surface various geodetic quantities.

(2) Compute global or regional load-deformation field and temporal gravity field caused by surface non-tidal load variations such as air pressure, sea level, soil water, lakes, rivers, glaciers, and snow. From various geodetic observations time series, assimilate the surface load observations by some constraints of the solid Earth deformation, to monitor the spatiotemporal variations of regional land water, and then to improve the load-deformation field and temporal gravity field.

(3) Construct regional uniform geometric and physical spatiotemporal monitoring datum frames with high robustness to make scientific computations and deep fusion of the CORS, InSAR, and other geodetic variations to promote multi-geodetic collaborative monitoring. Propose the quantitative deterministic criteria of the ground stability reduction based on temporal geodetic field, to realize quantitative monitoring of the ground stability spatiotemporal variations.

#### 1.4 Dominant concepts and ideas integrated into ETideLoad4.0

## 1.4.1 Deep fusion principles of multi-source heterogeneous geodetic data

(1) Using scientific consistent geophysical models, rigorous uniform numerical standards, and analytic compatible geodetic and geodynamic algorithms, construct the theoretical basis and necessary conditions for geodetic collaborative monitoring by unifying the spatiotemporal monitoring frames and reference epoch.

(2) For the same type of multi-source heterogeneous geodetic monitoring quantities, the basic geodetic constraints or joint adjustment methods with additional monitoring datum parameters as needed are used to deep fusion.

(3) For different types of monitoring quantities, physical geodetic, solid geophysical, or environmental geodynamic constraints with additional dynamic parameters as needed are used to deep fusion.

(4) The purpose of reconstructing the geodetic or geodynamic relationship between various monitoring data is not only to improve the spatiotemporal monitoring capability, but also to further reveal the geodynamic structure and characteristics of the monitored objects.

## 1.4.2 Tidal deformations of solid Earth and tidal effects on geodetic quantities

(1) The external celestial bodies, ocean tides, and atmospheric tides excite the periodic

deformation of the solid Earth and the periodic change of the gravity field, which are called the tidal deformation of the solid Earth.

(2) The geodetic variations caused by the external celestial bodies, ocean tides, and atmospheric tides are usually called the tidal effects on the geodetic quantities.

(3) The geodetic tidal effects include the solid Earth tidal effects and the load tidal effects. The geodetic solid Earth tidal effects are excited by the external celestial bodies, and the tidal load effects are excited by the ocean tides and atmospheric tides.

(4) The geodetic tidal effects can be modeled and can be accurately removed or restored anytime and anywhere. The geodetic tidal effect is equal to the negative value of the geodetic tidal correction.

The geodetic reference frame with only some tidal effects removed but non-tidal effects neglected is still stationary (unchanged with time). For example, a precision leveling network or a gravity control network, if its observations have been corrected only using some tidal effects, is still stationary.

## 1.4.3 Non-tidal deformation of solid Earth and their effects on geodetic quantities

(1) In the Earth surface system, surface non-tidal load variations such as soil and vegetation water, lake water, glacier and snow, groundwater, atmosphere, and sea level variations can induce the external geopotential variations, and then excite solid Earth deformation, which is manifested as ground displacement, gravity, and tilt variations. This is called the load-deformation of the solid Earth, which also takes the form of the variation of the Earth's gravity field with time.

(2) Groundwater use, underground mining, underground construction, glacier or ice sheet melting, and other natural or artificial surface mass adjustments can break the mechanical balance state of the surface rock and soil layer, and then the surface rock and soil layer will slowly tend to another equilibrium state under the action of its own gravity or internal stress. The process causes plastic or viscous vertical deformation which is also called isostatic vertical deformation.

(3) The load-deformation is excited by the surface environment load variations, and act on the entire solid Earth. Which is an elastic deformation and can be quantitatively represented by the load Love numbers. The isostatic vertical deformation is induced by environmental geology change. Whose dynamic action is in the underground rock and soil and is transmitted by the rock and soil own as the mechanical medium. The isostatic deformation is a slow plastic or viscous vertical deformation.

(4) The pole shift is the instantaneous loaction shift of the Earth pole relative to a certain reference epoch (such as epoch J2000.0) after removing all solid earth tides and loading tidal effects. Neither the pole shift nor geocentric movement include various tidal effects. Non-tidal effects are difficult to be modeled and are generally measured using geodetic techniques. In most fast or real-time geodetic applications, short-time forecast estimations

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of the pole shift are adopted.

The geodetic reference frame that needs to account for non-tidal effects can only be dynamic, and the reference value of the dynamic reference frame corresponds to a specific and unique reference epoch time. The reference value at the current epoch time is equal to the sum of the reference value at the reference epoch time and a correction. The correction is equal to the difference of the non-tidal effects between at the current epoch time and at the reference epoch time. The correction process is also called the (non-tidal effects) epoch reduction.

# 1.4.4 Representation and approaching of load deformation and temporal gravity field

(1) The non-tidal load effects can be uniquely represented by the variations of the Earth's gravity field with time. The relationship between the non-tidal load effects is completely consistent with the relationship between the parameters of the Earth's gravity field.

(2) Global Earth gravity field can be represented by a geopotential coefficients model (GCM). Similarly, the global load-deformation field (namely temporal global gravity field) can be represented by a global surface load spherical harmonic coefficients model (LCM).

(3) Using a geopotential coefficients model, you can calculate various gravity field quantities on the surface or outside Earth. Similarly using a global load spherical harmonic coefficients model, you can calculate load effects on various geodetic quantities outside the solid Earth.

(4) Regional gravity field (geoid) can be approached by the remove-restore process based on a GCM. Similarly, the regional load-deformation field or temporal gravity field can also be approached by the remove-restore process based on an LCM.

(5) The approach theory of the Earth's gravity field is linear. Similarly, the approach theory of the load-deformation field is also linear. For example, when surface air pressure, land water, and sea level variation are expressed as equivalent water height (EWH) variation, calculating the load effects from the surface air pressure, land water, and sea level variation firstly and then summing them, is equivalent to summing the three EWH variations firstly and then calculating the load effects.

#### 1.4.5 Types of ground vertical deformation and space-time quantitative natures

There are three forms of ground vertical deformation (or ground subsidence), namely, the elastic loading vertical deformation, viscous or plastic isostatic vertical deformation, and plastic tectonic vertical deformation near the compressive geological fracture zone. The latter two are also called the non-loading vertical deformations, both of which are plastic vertical deformations.

(1) The loading vertical deformation is excited by the surface mass redistribution which firstly causes the Earth geopotential variation called as the direct effect, and then by Earth elastic dynamic action, causes the solid Earth deformation simultaneously to generate an

additional geopotential variation called as the indirect effect. The loading vertical deformation synchronizes with the time of the loading redistribution, whose time-varying characteristics are similar to the surface load variations, showing complex nonlinearity and quasi-periodicity.

(2) The isostatic vertical deformation usually manifests as a dynamic process. In the process, the original equilibrium state of the underground rock and soil layer is firstly destroyed by the geology dynamic action, and then under the action of the gravity or internal stress, the rock and soil layer slowly approach another equilibrium state. For example, the compaction effect of the rock and soil layers with voids in the ground after the loss of water and the expansion effect after water infiltration, the deformation of the upper rock layer (wall rock deformation) caused by underground engineering, and plastic isostatic rebound of the rock and soil layer after surface mass migration.

Spatial quantitative characteristics of the isostatic vertical deformation

The dynamic action is located inside the underground rock and soil layer, and the equilibrium adjustment object is the rock and soil layer above the dynamic action point. The space influence angle of the equilibrium adjustment is about 45°, that is, the spatial range of ground vertical deformation is approximately equal to the buried depth of the action point.

· Temporal quantitative characteristics of the isostatic vertical deformation

The duration of the equilibrium adjustment is approximately proportional to the burial depth of the dynamic action location. The isostatic vertical deformation is the opposite of its acceleration rate sign in a relatively long period of time (several years), and linear time variation in a short period of time (several months).

(3) The tectonic vertical deformation, driven by the horizontal movement of the lithospheric plate, only appears near the compressive fault zone. Whose spatial influence radius is equivalent to the depth of the fault, and the deformation decays rapidly to zero with the distance of the calculated point away from the fault zone. On a centennial timescale, the tectonic vertical deformation rate remained basically unchanged.

### 1.4.6 CORS and InSAR collaborative monitoring principle for vertical deformation

(1) Through the gross error detection, spatial filtering, and time series analysis, the InSAR vertical variation is separated into two parts, one part is the vertical deformation of the rock and soil layer several meters deep, and the other part is the expansion and contraction of the soil own. Only the former is compatible with most geodetic variations, while the latter is mainly affected by the temperature and rainfall and should not be regarded as a solid Earth deformation.

(2) Using the CORS network ellipsoidal height variations time series as the constraints on the multi-source InSAR vertical variations time series, separate the ground vertical deformation signal, and then realize the collaborative monitoring of the CORS network and multi-source InSAR.

(3) Only the vertical deformation of the rock and soil layer several meters deep is the

useful information needed for monitoring of the ground subsidence, earthquakes, geological disasters, ground stability variations, solid Earth deformation, groundwater variations, and geodynamics.

### 1.4.7 Continuous quantitative monitoring scheme of ground stability variations

(1) Construct the quantitative criteria for the ground stability reduction from the regional grids time series of the geodetic vertical deformation, ground gravity and tilt variations, and then continuous quantitatively monitor the ground stability variations.

(2) Quantitative criteria of the ground stability reduction mainly include that the ellipsoidal height increases, the gravity decreases, the horizontal gradient of the height or gravity variation is large, and the inner product of the tilt variations and terrain slope vector is greater than zero.

(3) According to the geological disasters that occurred, optimize and synthesize a variety of geodetic ground stability variation grids time series to adapt to the local environmental geology, and then consolidate regional stability variations monitoring capabilities.

### 1.4.8 Analytical compatibility between various geodetic algorithms

The consistency and analytical compatibility between various geodetic algorithms are the concrete manifestation for the requirement of geodetic theory and the uniqueness of monitoring objects. Which is the smallest requirement for the collaborative monitoring of multi-geodetic technologies and deep fusion of multi-source heterogeneous geodetic data.

Analytical compatibility between geodetic algorithms involves two issues: (1) Compatibility between various geodynamic influences for different types of geodetic quantities. (2) Compatibility between different types of geodynamic influences of one kind of geodetic quantitity.

The first type of compatibility is the basic requirement of geodetic theory. For example, the load effect on the normal height on a site is equal to the Hotine integral of the load effect on gravity disturbances. For another example, the solid tidal effect on the normal height on a site is equal to the sum of the effects on the ellipsoidal height and geoid.

The second type of compatibility is constrained by the solid deformation geodynamic equations (including constitutive equations).

#### 1.5 Conventions, examples and usage in ETideLoad4.0

#### 1.5.1 Geophysical models and numerical standards in ETideLoad4.0

ETideLoade4.0 is mainly based on the geophysical models and numerical standards recommended by IERS Conventions (2010). You can update them from the program [geophysical models and numerical standards settings]. These geophysical models and numerical standards are stored in file form in the folder of C:\ETideLoad4.0\_win64cn.

Geophysical models and numerical standards in ETideLoad4.0 mainly include the surface air pressure tidal load spherical harmonic coefficients model, ocean tidal load

spherical harmonic coefficients model, Earth's Load Love numbers, IERS Earth orientation parameters time series, geocentric motion parameters time series, ocean tidal constituent harmonic parameters grid model, JPL Moon and Planetary Ephemeris DE405, corrections coefficients of frequency dependence on Love numbers, Desai ocean pole tide coefficients, and center of mass correction coefficients for the ocean tide.

Geophysical models and numerical standards setting	js			- 🗆
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Ocean tidal load spherical harmonic coef	ficients model (cm)	C:/ETideLoad4.	0_win64en/iers/EOT11a	alERS.dat
Air pressure tidal load spherical harmonic	coefficients model	(hPa) C:/ETide	Load4.0_win64en/iers/	ECMWF2006.dat
The IERS Earth orientation parameter EC	OP file (EOPC04)	C:/ETideLoad4.0_	win64en/iers/IERSeop	c04.dat
The geocentric motion parameters time s	eries file C:/ETide	eLoad4.0_win64er	n/iers/GCN_L1_L2_30d	_CF-CM.txt
The folder of ocean tidal constituent harn	ionic parameters gr	rid files C:/ETide	Load4.0_win64en/Ocea	anTide/
The Love number frequency dependent of	coefficients file C:/	/ETideLoad4.0_wi	n64en/iers/IERS2010T6	65.dat
The load Love numbers (load-deformatio	n coefficients) file	C:/ETideLoad4.0	_win64en/iers/Love_loa	d_cm.dat
Select the Desai ocean pole tidal coefficient	ents file C:/ETidel	_oad4.0_win64en/	iers/desaiscopolecoef.t	xt
The center of ocean tidal mass correction	coefficients file	C:/ETideLoad4.0_v	win64en/CmcOtide/EO	T11a.cmc
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<ul> <li>&gt; [Function] Set the geophysical models, I ETideLoad4.0.</li> <li>** The fourth basic constant can be select botential at ellipsoid U<sub>0</sub>(m<sup>2</sup>/s<sup>2</sup>).The dynamic</li> <li>&gt; Replace the ocean tidal load spherical h EOT11alERS.dat</li> <li>&gt;&gt; ETideLoad4.0 settings have been updat</li> </ul>	ed from the dynami al form factor J₂ is c armonic coefficient	cal form factor J <sub>2</sub> , currently selected s model file asC:/I	reciprocal flattening 1/f as the fourth basic cons	, and normal stant.

# 1.5.2 Five kinds of variations time series agreed in ETideLoad4.0

The geodetic variation time series files adopt the ETideLoad own format, which include the ground geodetic variations time series file, geodetic site variation records time series file, geodetic network observation records time series file, variation (vector) grids time series files, and spherical harmonic coefficient (Stokes coefficient) models time series files.

(1) The ground geodetic variations time series

A ground geodetic variations time series file can store the time series data of several kinds of variations on a certain site, a certain baseline or route, and the sampling epochs

(here, the epoch is an instantaneous time) of these variations are the same. Such as the CORS station coordinate solution time series, solid tide station observation or analysis result time series, GNSS baseline solution time series, etc.

(2) The geodetic site variation records time series

A geodetic site variation records time series file can store the time series data of one kind of variation for a group of geodetic sites. Such as the station coordinates time series for the CORS network, benchmark heights time series for the leveling network, observations time series for the tide station network, and InSAR monitoring time series, etc.

(3) The geodetic network observation records time series

A geodetic network observation records time series file can store the variation records time series of the baseline component for the CORS network, the variation records time series of the height difference for the leveling network, or the variation records time series of the gravity difference for the gravity control network.

(4) The variation grids time series for geodetic field

A group of variation grids time series files is composed of a series of numerical grid model files of one kind of variation (vector), and the seventh attribute of the header in each grid file is agreed to be the sampling epoch time. Such as the grids time series of the land equivalent water height, sea level variation, and the grids time series of various regional load-deformation fields or temporal gravity fields, etc.

(5) The spherical harmonic coefficient models time series

A group of spherical harmonic coefficient models time series files can store the time series of the spherical harmonic coefficients (Stokes' coefficients) models of the global surface load variations, global load-deformation field, or temporal global gravity field.

The header file occupies one row and consists of three attributes, namely the geocentric gravitational constant  $GM(\times 10^{14} \text{m}^3/\text{s}^2)$ , equatorial radius of the Earth a(m), and sampling epoch time (in ETideLoad format). GM, a are the scale parameters of the model.

The degree n and order m spherical harmonic coefficients are expressed by a record with the format: degree n, order m,  $C_{nm}$ ,  $S_{nm}$  (,  $C_{nm}$  error,  $S_{nm}$  error). At different sampling epochs, the maximum of the degree need not be the same.

The program [Conversion of general ASCII records data into ETideLoad format], and the function [Normalized extraction of batch time series of geodetic monitoring network] are the important interfaces for ETideLoad to accept external text data. Using the function [Global prediction of solid earth tidal effects on various geodetic quantities], or [lobal prediction of surface air pressure tidal load effects on various geodetic quantities], you can construct a geodetic variations time series with the given location and sampling specifications. Using the program [Generating and constructing of regional geodetic grid], you can construct a numerical grid with the given grid specifications. The other programs or functions only accept the format data generated by ETideLoad own.

#### 1.5.3 Full examples for the classroom teaching and self-study exercises

To ease the classroom teaching and self-study exercises, there are the example files saved in the folder C:\ETideLoad4.0\_win64en\examples for each Win64 program. Each example includes the operation process file processinf.txt, some input-output data files and screenshots. The folder name of the example files is the same as the name of the window executable program.

Before using the ETideLoad4.0 programs, it is recommended to perform completely the program example using the input-output example data files by comparing the screenshots according to the process information in processinf.txt. It will take about 5 working days to complete all the example exercises. Thereafter, you can use ETideLoad4.0 alone.

### 1.5.4 ETideLoad4.0's applicable professional fields and usage instructions

ETideLoad4.0 is suitable for senior undergraduates, graduate students, scientific researchers, and engineering technicians in geodesy, geophysical, geological disasters, hydrodynamics, satellite dynamics, seismic, and geodynamics. ETideLoad4.0 considers various potential needs such as classroom teaching, independent self-study, applied computing and scientific research.

You can design your own schemes and processes, then organize flexibly the related programs and functions from ETideLoad4.0, perform some scientific computations for various tidal or non-tidal effects, ground deformation field or temporal gravity field, land water, ground stability, or surface dynamic environment monitoring, and multi-source heterogeneous geodetic data deep fusion.

# 2 Computation of various tidal effects on various geodetic quantities

The set of programs adopt the consistent geophysical models, uniform numerical standards, and the compatible geodetic and geodynamic algorithms, to compute various geodetic effects of the solid Earth tide, ocean tide loading and surface air pressure tide loading. Which is not only an important foundation for the collaborative monitoring of geodetic multi-technologies and but also a necessary condition for the deep fusion of multi-source heterogeneous Earth monitoring quantities.



These programs are suitable for various geodetic quantities outside the solid Earth. A point outside the solid Earth generally refers to a space point that is not fixed to the Earth in ocean space, near-Earth space, or satellite altitude. The geodetic quantities marked with  $\odot$  in the following program interface are valid only when the site is fixed to the solid Earth.

# 2.1 Computation of solid tidal effects on various geodetic quantities outside solid Earth

[Purpose] According to the location and time in the input time series file, compute the solid Earth tidal effects time series on various geodetic quantities on the ground or outside the solid Earth. Here a point outside the solid Earth generally refers to a space point that is

not fixed to the Earth in ocean space, near-Earth space, or satellite altitude.

The solid tidal effects on the physical geodetic quantities are computed according to the IERS conventions (2010) considering the latitude correlation and the frequency-dependent of the Love numbers, which include the direct effects of the Sun, Moon, N-body and indirect effects of 71 tidal constituents (degree 2). The solid tidal effects on the geodetic site displacement adopt compatible algorithms and same geophysical models and numerical standards with the physical geodetic quantities.

# 2.1.1 Computation of solid Earth tidal effects time series at a ground site

[Function] From a geodetic site variations time series file, compute the time series of the solid Earth tidal effects on the geoid or height anomaly (mm), ground gravity ( $\mu$ Gal), gravity disturbance ( $\mu$ Gal), ground tilt (SW, to the south and to the west, mas), vertical deflection (SW, to the south and to the west, mas), horizontal displacement (EN, to the east and to the north, mm), ground radial displacement (mm), ground normal or orthometric height (mm), disturbing gravity gradient (10 $\mu$ E) or horizontal gravity gradient (NE, to the north and to the east, 10 $\mu$ E).

	at ground sites wit	lid Earth tidal eff h given time			of solid Earth tid te or outside so		<u>.</u>	Algorithms for t of solid Earth t	he effects ide	J
Open a geodetic site variations time series file	>> Program Process	** Operation Pr	ompts					🚑 Save j	program proc	ess
Set the file parameters olumn ordinal number of ellipsoidal eight in the header olumn ordinal number of time 1 the record olumn ordinal number of starting 5 Select the type of effects ground gravity (µGal) ⊙ gravity disturbance (µGal)	>> [Purpose] Accord quantilies on the gro Earth in ocean space >> Select the compu- select the comput- net of the second proma- anomaly (mm), group the south and to the nontrate optiometric >> Set and the second second proma- second proma- proma- second proma- second proma- proma- second proma- second proma-	und or outside th , near-Earth spa tation function fr geodetic site va d gravity (µGal) west, mas), horiz c height (mm), di site variations tin t parameters acc name, click the d results as Cr./ file record, add c s have been imp	the solid Earth. ace, or satellite to m the 3 contu- initiations time s , gravity distur- zontal displace isturbing gravit isturbing gravit isturbin	Here a point o altitude. ol buttons on t eries file, com bance(µGal), c mment (EN, to t y gradient (10) y gradient (10) x/2FTideLoad4. rext box below, import setting win64 ph/exam coglumr 5 of the rogram	utside the solid the top of the in pute the time si- ground tilt (SW, the east and to $\mu$ E) or horizont 0_win64en/exs, and then selec parameters] mples/Tideffects as	Earth generally terface eries of the solid to the south an the north, mm), al gravity gradie amples/Tideffect ct the type of the solidearth/tmsqu a the output file	Earth tidal effe d to the west, m ground radial d nt (NE, to the n solidearth/Tms/ geodetic varia rst.txt. record.	ce point that is acts on the geo has), vertical de isplacement (n orth and to the aries.txt. tion to be comp	not fixed to the id or height affection (SW, nm), ground east, 10µE). bouted. After	he
ground tilt (SW, mas) ()	** Click the control >> Computation star			ne tool button	[Start computat		When the sam in ETideLoad			
vertical deflect on (SW, mas)	>> Complete the con			lette			MJD0 is not n		arung	
horizontal dispacement (EN, mm) 💿				5013:						
nonzontal diop docinent (Ert, min) ()	> Computation end	time: 2022-03-0.	2 14:57:52							
	> Computation end	time: 2022-03-0	2 14:57:52							
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ground radial cisplacement (mm) 💿		uted results as	2 14:57:52		Import setting	g paran eters		-	Start computa	
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The solid tidal effect on normal height (approximately 300mm) is out of phase with the effect on the ellipsoidal height or geoid (approximately 600mm, namely the sign is opposite). The east-west component of the site displacement, tilt or horizontal gradient effect is generally much greater than the north-south component.

[Input file] The geodetic site variations time series file.

The file header contains site name, longitude (degree decimal), latitude (degree decimal), height (m) relative to the ellipsoidal surface, the starting MJD0 (optional).....

Starting from the second row of the file, each row record stores the sampling values of all the variations at one sampling epoch time. At least one column of the attributes in the record is the sampling epoch time.

[Parameter settings] Set the input file format parameters, select the type of solid Earth tidal effects.

The geodetic quantities marked with  $\odot$  are valid only when the site is fixed to the solid Earth.

[Output file] The geodetic site solid Earth tidal effects time series file.

The file header is the same as the input time series file. Behind the input file record, add one or several columns of the tidal effects selected as the output file record. In this example, all types are selected, and there are 14 attributes added to the record.

When the ellipsoidal height of the computed point is equal to the ellipsoidal height of the geoid, the solid tidal effect on the height anomaly is the effect on the geoid.





#### 2.1.2 Computation of solid Earth tidal effects at ground sites with given time

[Function] According to the location and time in the computed points file, compute the solid Earth tidal effects on the geoid or height anomaly (mm), ground gravity ( $\mu$ Gal), gravity disturbance ( $\mu$ Gal), ground tilt (SW, to the south and to the west, mas), vertical deflection (SW, to the south and to the west, mas), horizontal displacement (EN, to the east and to the north, mm), ground radial displacement (mm), ground normal or orthometric height (mm), disturbing gravity gradient (10 $\mu$ E) or horizontal gravity gradient (NE, to the north and to the east, 10 $\mu$ E).

[Input file] The location and time file of the computed points.

The first row is the file header. From the second row onwards, the second and third attributes in the file record are conventionally longitude and latitude (degree decimals), and there are the sampling epoch time and ellipsoidal height attributes in the records.

[Parameter settings] Set the input file format parameters, select the type of solid Earth

tidal effects.

[Output file] The solid Earth tidal effects file.

The file header is the same as the input file. Behind the input file record, add one or several columns of the tidal effects selected as the output file record. In this example, the height anomaly, gravity disturbance, and disturbing gravity gradient are selected, and there are 3 attributes added to the record.

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The start MJD0 attribute in the input file header is required when the date is in MJD format. In this case, the sampling epoch MJD is equal to the sum of the starting MJD0 and the number of days in the record.

If the time (date) is in the long integer format agreed by ETideLoad, it is not necessary for the starting MJD0 attribute in the input file header, and the program automatically recognizes and ignores the selection.

## 2.1.3 Computation of solid Earth tidal effects of Earth satellite or outside solid Earth

[Function] According to the location and time in the external points file, compute the solid Earth tidal effects on the geopotential  $(0.1m^2/s^2)$ , gravity (µGal) or gravity gradient  $(10\mu E)$ 

outside the solid Earth.

[Input file] The location and time file of the external points.

The first row is the file header. From the second row onwards, the second and third attributes in the file record are conventionally longitude and latitude (degree decimals), and there are the sampling epoch time and ellipsoidal height attributes in the records.

[Parameter settings] Set the input file format parameters, select the type of solid Earth tidal effects.

[Output file] The solid Earth tidal effects file.

The file header is the same as the input file. Behind the input file record, add one or several columns of the tidal effects selected as the output file record. In this example, the geopotential, gravity vector, and gravity gradient are selected, and there are 7 attributes added to the record.



 $1+(2h_{nm} - (n+1)k_{nm})/n$  is the solid tidal effect factor of the ground gravity at degree n and order m.  $1-(n+1)k_{nm}/n$  is the solid tidal effect factor of the gravity disturbance.  $1+k_{nm}-h_{nm}$  is the solid tidal effect factor of the ground tilt. And  $1+k_{nm}$  is the solid tidal effect factor of the vertical deflection or height anomaly.

In general,  $\Delta C_{n^0}$  mainly consists of the long-term or long period constituents of the solid tidal effects (the cycle is greater than half a lunar month, n=1, 2, ...).  $\Delta C_{n^1}$ ,  $\Delta S_{n^1}$  mainly consists of the diurnal tidal effects. And  $\Delta C_{n^2}$ ,  $\Delta S_{n^2}$  mainly consists of the semi-diurnal tidal

effects. More generally,  $\Delta C_{nm}$ ,  $\Delta S_{nm}$  is mainly composed of the 1/m diurnal tidal effects.

The solid tidal effect on normal height (approximately 300mm) is out of phase with the effect on the ellipsoidal height or geoid (approximately 600mm, namely the sign is opposite). The east-west component of the site displacement, tilt or horizontal gradient effect is generally much greater than the north-south component.

# 2.2 Spherical harmonic synthesis on ocean tidal load effects outside solid Earth

[Purpose] Using the global ocean tidal load spherical harmonic coefficients model (cm), according to the location and time in the input file, compute the ocean tidal load effects on various geodetic quantities on the ground or outside the solid Earth by the spherical harmonic synthesis algorithm. Here a point outside the solid Earth generally refers to a space point that is not fixed to the Earth in ocean space, near-Earth space, or satellite altitude.

## 2.2.1 Computation of ocean tidal load effects time series at a ground site

[Function] From a geodetic site variations time series file, compute the time series of the ocean tidal load effects on the geoid or height anomaly (mm), ground gravity ( $\mu$ Gal), gravity disturbance ( $\mu$ Gal), ground tilt (SW, to the south and to the west, mas), vertical deflection (SW, to the south and to the west, mas), horizontal displacement (EN, to the east and to the north, mm), ground radial displacement (mm), ground normal or orthometric height (mm), disturbing gravity gradient (10 $\mu$ E) or horizontal gravity gradient (NE, to the north and to the east, 10 $\mu$ E).

[Input file] The geodetic site variations time series file.

The file header contains site name, longitude (degree decimal), latitude (degree decimal), height (m) relative to the sea surface, the starting MJD0 (optional).....

Starting from the second row of the file, each row record stores the sampling values of all the variations at one sampling epoch time. At least one column of the attributes in the record is the sampling epoch time.

The height of the calculated point is normal or orthometric height relative to the sea surface since the ocean tidal loads are generally considered to be on the sea surface.

[Parameter settings] Set the input file format parameters, select the type of ocean tidal load effects.

[Output file] The geodetic site ocean tidal effects time series file.

The file header is the same as the input time series file. Behind the input file record, add one or several columns of the tidal effects selected as the output file record. In this example, all types are selected, and there are 14 attributes added to the record.

The program automatically selects the minimum value between the maximum degree of the spherical harmonic coefficients model and the entered maximum degree as the calculated degree.

The computation process needs to wait. During the computation period, you can open

#### the output file to look at the computation progress!



Different from the effect of the solid Earth tide, the load effect on the normal height is in the same phase as the effect on the ellipsoidal height, and the magnitude of effect on the normal height is about 1.75 times that of the ellipsoidal height. The east-west component of the site displacement, tilt or horizontal gradient effect is generally smaller than the north-south component.

 $1+(2h'_n-(n+1)k'_n)/n$  are the load-deformation coefficients of the ground gravity at degree n.  $1-(n+1)k'_n/n$  are the load-deformation coefficients of the gravity disturbance.  $1+k'_n-h'_n$  are

the load-deformation coefficients of the ground tilt. And  $1+k'_n$  are the load-deformation coefficients of the vertical deflection or height anomaly.

## 2.2.2 Computation of ocean tidal load effects at ground sites with given time

[Function] According to the location and time in the computed points file, compute the ocean tidal load effects on the geoid or height anomaly (mm), ground gravity ( $\mu$ Gal), gravity disturbance ( $\mu$ Gal), ground tilt (SW, to the south and to the west, mas), vertical deflection (SW, to the south and to the west, mas), horizontal displacement (EN, to the east and to the north, mm), ground radial displacement (mm), ground normal or orthometric height (mm), gravity gradient (10 $\mu$ E) or horizontal gravity gradient (NE, to the north and to the east, 10 $\mu$ E).

[Input file] The location and time file of the computed points.

The first row is the file header. From the second row onwards, the second and third attributes in the file record are conventionally longitude and latitude (degree decimals), and there are the sampling epoch time and height attributes in the records.

[Parameter settings] Set the input file format parameters, select the type of ocean tidal load effects.

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disturbing gravity	/ gradient (10µE)	Displ 20 20 20 20 20 20 20 20 20 20 20 20 20	ne coefficient av of the ing 19010100 19010101 19010102 19010103 19010105 19010105 19010105 19010107 19010108 19010108 190101010	tts model 001 47.2: 151.0901 151.0901 151.0901 151.0901 151.0901 151.0901 151.0901 151.0901 151.0901 151.0901 151.0901	18 58484. 12.5001 12.5001 12.5001 12.5001 12.5001 12.5001 12.5001 12.5001 12.5001 12.5001 12.5001	00000 250000.0 250000.0 250000.0 250000.0 250000.0 250000.0 250000.0 250000.0 250000.0 250000.0	0.000000 0.041667 0.08333 0.125000 0.166667 0.208333 0.250000 0.291667 0.333333 0.375000 0.416667 0.458333	-3.9789 -4.3345 -4.4641 -4.5489 -4.6356 -4.6129 -4.2967 -3.5479 -2.3292 -0.6780 1.3463 3.6649	-2.8201 -3.2395 -3.2679 -3.0530 -2.7031 -2.2439 -1.6642 -0.9902 -0.3031 0.3205 0.8853 1.4859	2.1038 3.0911 3.5642 3.5725 3.1816 2.4231 1.3515 0.1307 -0.9652 -1.6720 -1.8919 -1.7542	-0.9902 -1.2300 -1.1746 -0.8996 -0.4837 -0.0055 0.4316 0.6945 0.6688 0.3326 -0.2042 -0.7375	data in the text i 0.8820 1.5219 1.9281 2.0606 1.9266 1.9266 0.7267 -1.3990 -1.7552 -1.7568	
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disturbing gravity	/ gradient (10µE)	Disp 51 20 20 20 20 20 20 20 20 20 20 20 20 20	e coefficient av of the inp 1901010 1901010 1901010 19010103 19010105 19010106 19010106 19010109 19010109 19010110 19010111 19010111	tts model 001 47.2: 151.0901 151.0901 151.0901 151.0901 151.0901 151.0901 151.0901 151.0901 151.0901 151.0901 151.0901	18 58484, 12.5001 12.5001 12.5001 12.5001 12.5001 12.5001 12.5001 12.5001 12.5001 12.5001 12.5001 12.5001 12.5001 12.5001	250000.0 250000.0 250000.0 250000.0 250000.0 250000.0 250000.0 250000.0 250000.0 250000.0 250000.0 250000.0 250000.0	0.000000 0.041667 0.08333 0.125000 0.166667 0.220000 0.291667 0.33333 0.375000 0.416667 0.458333 0.550000	-3.9789 -4.3345 -4.4641 -4.5489 -4.6129 -4.2267 -3.5479 -2.3292 -0.6780 1.3463 3.6649 6.1155 8.3910	-2.8201 -3.2395 -3.2679 -3.0530 -2.7031 -2.2439 -1.6642 -0.9902 -0.3031 0.3205 0.8853 0.8853 1.4859 2.2232 3.0916	2.1038 3.0911 3.5642 3.5725 3.1816 2.4231 1.3515 0.1307 -0.9652 -1.6720 -1.8919 -1.7542	-0.9902 -1.2300 -1.1746 -0.8996 -0.4837 -0.0055 0.4316 0.65945 -0.6688 0.3326 -0.2042 -0.7375 -1.0658 -1.0603	data in the text i 0.8820 1.5219 1.9281 2.0606 1.9266 1.9266 0.7267 -1.3990 -1.7552 -1.7568	
disturbing gravity	/ gradient (10µE)	Disp 51. 20 20 20 20 20 20 20 20 20 20 20 20 20	e coefficient av of the inp 0011 12. 19010100 19010100 19010102 19010103 19010105 19010105 19010105 19010105 19010101 19010111 19010111 19010113 19010113 19010114	ts model 001 47.2: 151.0901 10	12.5001 12.5001 12.5001 12.5001 12.5001 12.5001 12.5001 12.5001 12.5001 12.5001 12.5001 12.5001 12.5001 12.5001 12.5001 12.5001	00000 250000.0 250000.0 250000.0 250000.0 250000.0 250000.0 250000.0 250000.0 250000.0 250000.0 250000.0 250000.0 250000.0 250000.0	0.000000 0.041667 0.083333 0.125000 0.166667 0.20933 0.375000 0.416667 0.458333 0.550000 0.541667 0.58333 0.625000	$\begin{array}{c} -3.9789\\ -4.3345\\ -4.4641\\ -4.5489\\ -4.6129\\ -4.2567\\ -3.5479\\ -2.3292\\ -0.6780\\ 1.3463\\ 3.6649\\ 6.1155\\ 6.3910\\ 10.0656\\ 10.7291 \end{array}$	-2.8201 -3.2395 -3.2679 -3.0530 -2.7031 -2.2439 -1.6642 -0.9902 -1.6642 -0.9902 -1.8853 1.4859 2.2232 3.0916 3.9354 4.5166	2.1038 3.0911 3.5642 3.5725 3.1816 2.4231 1.5515 0.1307 -0.9652 -1.6720 -1.9919 -1.7542 -1.5211 -1.4099 -1.4739 -1.6245	-0.9902 -1.2300 -1.2300 -1.2706 -0.8996 -0.4837 -0.0055 -0.4316 0.6945 0.6688 0.3326 -0.2042 -0.7375 -1.0658 -1.0603 -0.7897 -0.2770	0.8820 1.5219 1.9281 2.0606 1.9266 1.9266 1.9266 0.7267 -1.3990 -1.3990 -1.4916 -1.1074 -0.7238 -0.3895	
disturbing gravity	/ gradient (10µE)	Disp 51 20 20 20 20 20 20 20 20 20 20	e coefficient av of the inp 0011 12.1 19010100 19010101 19010102 19010105 19010105 19010105 19010105 19010101 19010101 19010101 190101101 19010111 190101114 19010115 19010115	ts model out-output file 001 47.2: 151.0901 151.	La 58484, 12.5001 12.5001 12.5001 12.5001 12.5001 12.5001 12.5001 12.5001 12.5001 12.5001 12.5001 12.5001 12.5001 12.5001 12.5001	00000 250000.0 250000.0 250000.0 250000.0 250000.0 250000.0 250000.0 250000.0 250000.0 250000.0 250000.0 250000.0 250000.0 250000.0	0.000000 0.041667 0.09333 0.125000 0.166667 0.208333 0.291667 0.416667 0.416667 0.458333 0.500000 0.541667 0.583333 0.656667	$\begin{array}{c} -3,9789\\ -4,3345\\ -4,4641\\ -4,5489\\ -4,6356\\ -4,6129\\ -4,6356\\ -4,6129\\ -2,3292\\ -0,6780\\ 1,3463\\ 3,6649\\ 6,1155\\ 8,3910\\ 10,0656\\ 10,7291\\ 0.1548\end{array}$	-2.8201 -3.2395 -3.2679 -3.0530 -2.7031 -2.2439 -1.6642 -0.9902 -0.3031 0.3205 0.8853 1.4855 2.2232 3.0916 3.9354 4.5168 4.6442	2.1038 3.0911 3.5642 3.5725 3.1816 2.4231 1.3515 0.1307 -0.9652 -1.6720 -1.8919 -1.7542 -1.5211 -1.4099 -1.4739 -1.6245 -1.7520	-0.9902 -1.2300 -1.1746 -0.9996 -0.4837 -0.0055 0.6888 0.3326 -0.2042 -0.7375 -1.0658 -1.0658 -1.0658 -0.2042 -0.7397 -0.2770 0.3595	0.8820 1.5219 1.9281 2.0606 1.9266 1.9266 0.1066 -0.7267 -1.3990 -1.7552 -1.7558 -1.4916 -1.1074 -0.7238 -0.3895 -0.1071	
disturbing gravity	/ gradient (10µE)	Disp 51, 20 20 20 20 20 20 20 20 20 20 20 20 20	e coefficient av of the inp 0011 12. 19010100 19010100 19010102 19010103 19010105 19010105 19010105 19010105 19010101 19010111 19010111 19010113 19010113 19010114	ts model 001 47.2: 151.0901 10	12.5001 12.5001 12.5001 12.5001 12.5001 12.5001 12.5001 12.5001 12.5001 12.5001 12.5001 12.5001 12.5001 12.5001 12.5001 12.5001	00000 250000.0 250000.0 250000.0 250000.0 250000.0 250000.0 250000.0 250000.0 250000.0 250000.0 250000.0 250000.0 250000.0 250000.0	0.000000 0.041667 0.083333 0.125000 0.166667 0.20933 0.375000 0.416667 0.458333 0.550000 0.541667 0.58333 0.625000	$\begin{array}{c} -3.9789\\ -4.3345\\ -4.4641\\ -4.5489\\ -4.6129\\ -4.2567\\ -3.5479\\ -2.3292\\ -0.6780\\ 1.3463\\ 3.6649\\ 6.1155\\ 6.3910\\ 10.0656\\ 10.7291 \end{array}$	-2.8201 -3.2395 -3.2679 -3.0530 -2.7031 -2.2439 -1.6642 -0.9902 -1.6642 -0.9902 -1.8853 1.4859 2.2232 3.0916 3.9354 4.5166	2.1038 3.0911 3.5642 3.5725 3.1816 2.4231 1.5515 0.1307 -0.9652 -1.6720 -1.9919 -1.7542 -1.5211 -1.4099 -1.4739 -1.6245	-0.9902 -1.2300 -1.2300 -1.2706 -0.8996 -0.4837 -0.0055 -0.4316 0.6945 0.6688 0.3326 -0.2042 -0.7375 -1.0658 -1.0003 -0.7897 -0.2770	0.8820 1.5219 1.9281 2.0606 1.9266 1.9266 1.9266 0.7267 -1.3990 -1.3990 -1.4916 -1.1074 -0.7238 -0.3895	
disturbing gravity	/ gradient (10µE)	Disp 51, 20 20 20 20 20 20 20 20 20 20 20 20 20	e coefficient of the ing 1 12.1 19010100 19010101 19010101 19010103 19010103 19010105 19010105 19010105 19010107 19010101 19010113 19010113 19010113 19010114 19010114 19010114 19010114 19010114 190101118 19010118	ts model out-output file out-output file out 47,22 151,0901 151,09	18 58484 12.5001 12.5001 12.5001 12.5001 12.5001 12.5001 12.5001 12.5001 12.5001 12.5001 12.5001 12.5001 12.5001 12.5001 12.5001 12.5001 12.5001 12.5001	000 250000.0 250000.0 250000.0 250000.0 250000.0 250000.0 250000.0 250000.0 250000.0 250000.0 250000.0 250000.0 250000.0 250000.0 250000.0 250000.0	0.00000 0.041667 0.0333 0.125000 0.16667 0.20333 0.20000 0.2016667 0.33333 0.50000 0.452000 0.451667 0.541667 0.541667 0.541667 0.541667 0.541667 0.541667 0.541667 0.541667 0.550000 0.666667 0.708133 0.70000	$\begin{array}{c} -1, 2789\\ -4, 3345\\ -4, 4641\\ -4, 5489\\ -4, 5356\\ -4, 54297\\ -3, 5479\\ -2, 2292\\ -0, 6780\\ 1, 3463\\ 3, 3463\\ 0, 1555\\ 8, 3910\\ 10, 0556\\ 10, 7281\\ 10, 1558\\ 8, 3902\\ 5, 1178\\ 2, 5276\\ 1, 728\\$	-2.8201 -3.2395 -3.2679 -3.2679 -2.7031 -2.7031 -2.7031 -2.2439 -1.6642 -0.902 -0.3031 0.0315 0.8853 1.4855 2.2232 3.4855 2.2232 3.4354 4.5166 4.6442 4.5262 2.2590 4.2256	2.1038 3.9911 3.5642 3.5725 0.1307 -0.6642 3.5725 0.1307 -0.6642 -1.7542 -1.5742 -1.5742 -1.7542 -1.8503 -1.85	-0.9902 -1.2300 -1.1746 0.6996 -0.4035 -0.0055 -0.0055 -0.0055 -0.0045 -0.2042 -0.2042 -0.2042 -0.2042 -0.2042 -0.2042 -0.2042 -0.2042 -0.2042 -0.2042 -0.2045	data in the text!           0.8820           1.5219           1.9281           2.0606           1.5374           0.0092           0.1066           -0.7267           -1.7552           -1.1074           -0.2885           -0.3885           -0.1071           0.1074	
disturbing gravity	/ gradient (10µE)	Disp 51. 20 20 20 20 20 20 20 20 20 20	e coefficient av of the inj 1901100 19010101 19010101 19010102 19010105 19010105 19010105 19010106 19010106 19010101 19010101 19010110 19010111 19010112 19010113 19010114 19010115 19010115 19010115	ts model out-output file 001 47,2: 151,0901 151	18 58484 12.5001 12.5001 12.5001 12.5001 12.5001 12.5001 12.5001 12.5001 12.5001 12.5001 12.5001 12.5001 12.5001 12.5001 12.5001 12.5001 12.5001 12.5001	000 250000.0 250000.0 250000.0 250000.0 250000.0 250000.0 250000.0 250000.0 250000.0 250000.0 250000.0 250000.0 250000.0 250000.0 250000.0 250000.0	0.000000 0.041667 0.08333 0.125000 0.166667 0.20033 0.375000 0.416667 0.468333 0.500000 0.541667 0.58333 0.500000 0.658333 0.650000	-3,9789 -4,441 -4,441 -4,4549 -4,6129 -4,6129 -4,267 -3,5479 -2,2392 -0,6780 1,3463 3,6649 6,1155 8,3910 10,0656 10,7291 10,1548 8,3902 5,7178	-2.8201 -3.2395 -3.2679 -3.2679 -2.2439 -1.6642 -0.3031 0.8253 0.8853 0.8853 1.4652 2.2232 3.0916 3.9354 4.51642 4.6462 4.6462 4.6462 4.6462	2.1038 3.0911 3.5642 3.5725 2.4231 1.3515 0.1307 -0.9652 -1.6720 -1.6720 -1.4739 -1.5421 -1.4739 -1.4739 -1.6745 -1.4739 -1.6745 -1.4739 -1.6745 -1.4739 -1.6745 -1.4739 -1.6745 -1.8487	-0.9902 -1.2300 -1.1746 -0.8996 -0.4837 -0.4837 -0.4837 -0.4837 -0.4837 -0.4837 -0.4837 -0.4837 -0.4837 -0.4837 -0.688 -0.2042 -0.7375 -1.0658 -1.0658 -1.0658 -0.2770 -0.37997 -0.2770 -0.3595 1.0301 1.6334	data in the text 0.8820 1.5219 1.2281 2.2660 1.2266 1.2266 0.1066 0.7267 1.7552 1.7552 1.4916 1.1074 0.2385 0.1071 0.1140 0.2385	
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listurbing gravity norizontal gravity	r gradient (10µE) gradient (NE, 10µE)	Disp 51 20 20 20 20 20 20 20 20 20 20	e coefficient av of the injunct 1901010 1901010 1901010 1901010 1901010 1901010 1901010 1901010 1901010 1901010 1901010 19010110 19010110 19010110 19010110 19010110 19010111 19010115 19010115 19010115 19010115	ts model out-output file 001 47.2: 151.0901 151.	La 59484, 12,5001 12,5	0.00 250000.0	0.00000 0.04167 0.08333 0.128000 0.29167 0.29167 0.29167 0.375000 0.45833 0.50000 0.458333 0.50000 0.458333 0.50000 0.458333 0.50000 0.458333 0.50000 0.458333 0.50000 0.458333 0.50000 0.458333 0.50000 0.458333 0.50000 0.458333 0.50000 0.458333 0.50000 0.458333 0.50000 0.458333 0.50000 0.458333 0.50000 0.458333 0.50000 0.53333 0.575000 0.750000 0.759000 0.759000 0.759000 0.759000 0.759000 0.759000 0.759000 0.759000 0.759000 0.759000 0.759000 0.759000 0.759000 0.759000 0.759000 0.5915 0.59	-3. 7789 -4. 345 -4. 4641 -4. 4499 -4. 42967 -3. 5479 -2. 2292 -0. 6700 1. 3463 3. 3900 6. 1155 8. 3910 10. 5656 9. 1157 8. 3910 10. 5656 9. 1175 8. 3910 10. 5656 9. 1175 10. 5656 9. 1175 10.	-2. 3201 -3. 2395 -3. 2679 -3. 0530 -2. 7031 -2. 2439 -1. 6642 -0. 9902 -0. 3031 1. 4659 2. 2232 3. 0916 3. 3255 4. 6142 4. 54602 3. 4296 2. 25590 2. 255900 2. 255900 2. 255900 2. 255900 2. 25590000000000000000000000000	2.1038 3.0911 3.5642 3.1816 2.4231 1.3515 0.1307 -0.9652 -1.6720 -1.6720 -1.7542 -1.7542 -1.7542 -1.4739 -1.6245 -1.4739 -1.6245 -1.8203 -1.8203 -1.81500 -1.81500 -1.81500 -1.81500 -1.81500 -1.81500 -1.81500 -1.81500 -1.81	-0.9902 -1.2300 -0.9902 -1.2307 -0.0905 -0.0005 -0.000	Jata in the text I           0.8820           1.5219           2.6666           1.8281           1.8281           1.8281           1.8281           1.8281           1.8281           1.8281           1.8281           1.8281           1.8281           1.8281           1.8281           1.9261           -1.7582           -1.4305           -1.4305           0.1285           0.1305           0.2495           0.1706	bo
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listurbing gravity norizontal gravity The height of the The global ocea cion (Global tida	r gradient (10µE) gradient (NE, 10µE) = palculated point is norm an tidai Tosat spherica in	Disp Disp 20 20 20 20 20 20 20 20 20 20 20 20 20	e coefficient a of the inp 1901100 1901100 1901100 1901102 1901101 1901102 1901104 19010104 19010104 19010104 19010104 19010114 19010113 19010113 19010115 1901015 190105 19005 1905 19005 1905 1905 190	ts model out-output file out-output file out-output file out-output file file out-output file file out-output file out-output file output	12         598484.           12         5001           12	250000.0 25000000.0 250000.0 250000.0 250000.0 250000.0 250000.0 250000.0 250000.0 250000.0 250000.0 250000.0 250000.0 250000.0 2500000.0 250000.0 250000000000	0.00000 0.04167 0.08333 0.125000 0.16667 0.33333 0.50000 0.45833 0.50000 0.45833 0.50000 0.45833 0.50000 0.45833 0.554167 0.554167 0.775300 0.254067 0.775300 0.254067 0.79333 0.554167 0.79333 0.554167 0.79333 0.554167 0.79333 0.554167 0.79333 0.554167 0.79333 0.554167 0.79333 0.554167 0.79333 0.554167 0.79333 0.554167 0.79353 0.554167 0.79353 0.7754 0.775500 0.775500 0.775500 0.77550000000000	-3.5789 -4.345 -4.4641 -4.5499 -4.129 -4.129 -3.5479 -2.3292 -0.47800 -0.47800 -0.47800 -0.47800 -0.47800 -0.47800 -0.47800 -0.47800 -	-2.8201 -3.2395 -3.2679 -3.0530 -2.7031 -2.4649 -0.102 -0.1031 -2.4649 -0.1031 -2.4649 -0.1031 -2.4649 -0.1031 -2.4649 -0.1031 -2.2232 -0.1031 -0.2232 -0.1031 -0.2232 -0.1031 -0.2232 -0.1031 -0.2232 -0.1031 -0.2032 -0.2332	2.1038 3.90911 3.5642 3.57725 3.1816 4.42311 1.5551 4.5551 4.5551 4.5551 4.5551 4.5551 4.5551 4.5551 4.5551 4.5551 4.5203 1.5203 1.5203 1.5455 4.5203 1.5455 1.5203 1.54555 1.5455 1.5455 1.5455 1.5455 1.5455 1.5455 1.5455 1.5455 1.5455 1.5455 1.5455 1.5455 1.5455 1.5455 1.5455 1.54555 1.54555 1.54555 1.54555 1.54555 1.54555 1.54555 1.54555 1.545555 1.5455555 1.545555555555	-0.9902 -1.2300 -1.2300 -0.4307 -0.4837 -0.2942 -0.2737 -0.2957 -0.2737 -0.2737 -0.2737 -0.2737 -0.2737 -0.2737 -0.2737 -0.27777 -0.27777 -0.27777 -0.27777 -0.277777 -0.2777777777777777777777777777777777777	Jata in the text I           0.8820           1.5219           2.0606           1.92261           1.9266           1.9266           1.9267           -1.7562           -1.7562           -1.7582           -1.7582           -1.1074           -0.3835           -0.1071           0.1102           0.1106           0.1706           model, by calli	i bo:

[Output file] The ocean tidal load effects file.

The file header is the same as the input file. Behind the input file record, add one or several columns of the tidal effects selected as the output file record. In this example, the height anomaly, gravity disturbance, disturbing gravity gradient, and horizontal gravity gradient are selected, and there are 5 attributes added to the record.



(N, 10µE, along the GOCE satellite orbit) horizontal gravity gradient (E, 10µE)

### 2.2.3 Computation of ocean tidal load effects of Earth satellite or outside solid Earth

[Function] According to the location and time in the external points file, compute the ocean tidal load effects on the geopotential  $(0.1m^2/s^2)$ , gravity (µGal), or gravity gradient (10µE) outside the solid Earth.

Computation of ocean tidal load effect	S		utation of ocean tidal load ound sites with given time	effects	¢		of ocean tidal lo or outside solid		) 
Open a location and time file of the external points	>> Program Proces	s ** Operation P	rompts				4.2	Save program	process
Set the file parameters folumn ordinal number of normal or functional registing the record olumn ordinal number of time in the record Select the type of effects geopotential (0.1m/s <sup>2</sup> ) gravity vector (XYZ, µGai)	>> Computation sta >> Complete the cc >> Complete the cc >> Computation en >> [Function] Accoor (µGal), or gravity gi >> Open a location ** Enter the file for output file name, cl >> Sate the comput ** Behimt the input >> Setting Paramet	art time: 2022-03 mputation of the d time: 2022-03- ding to the locati radient (10µE) ou and time file of ti mat parameters ick the control bu ted results as C- t file record, add ers have been in	ocean tidal load effects! 02 16:03:40 on and time in the external tside the solid Earth. he external points C:/ETid according to the text box tton [Import setting param (ETidal cad/d	I points file, compute eLoad4.0_win64en/e below, and then sele- teters] vamples/OTideloadi / the load tidal effects on [Start computatio	examples/OTide ct the type of the permsynth/sator as the output f n]	loadharmsynth e geodetic vari brst.txt. file record.	/outerptm.txt. ation to be com	nputed. After givi	ing the
gravity vector (ENU, µGal)					an oner the out	tout file C:/FTir	tel nad4 0 wini	64en/examples/	1
i gravity vector (ENU, μGal) j gravity gradient (Δ(rZ, 10μE) j gravity gradient (ENU, 10μE)	** The computation OTIdeloadharmsyn >> Computation sta >> Complete the co >> Computation en Maximum truncate of the coefficients	ad degree model 120	ocean tidal load effects!	progress!!		GRACE	satellite	altitude	nputatio
gravity gradient (XYZ, 10µE)	** The computation OTideloadharmsyn >> Computation sta >> Complete the co >> Complete the co >> Computation en Maximum truncate	ad degree model 120	b look at the computation 3-02 16:14:49 ocean tidal load effects! 02 16:16:06	rogress!!	The	GRACE	satellite	altitude	nputatic

Different from the effect of the solid Earth tide, the load effect on the normal height is in the same phase as the effect on the ellipsoidal height, and the magnitude of effect on the normal height is about 1.75 times that of the ellipsoidal height. The east-west component of the site displacement, tilt or horizontal gradient effect is generally smaller than the north-south component.

[Input file] The location and time file of the external points.

The first row is the file header. From the second row onwards, the second and third attributes in the file record are conventionally longitude and latitude (degree decimals), and there are the sampling epoch time and ellipsoidal height attributes in the records.

[Parameter settings] Set the input file format parameters, select the type of ocean tidal load effects.

[Output file] The ocean tidal load effects file.

The file header is the same as the input file. Behind the input file record, add one or several columns of the tidal effects selected as the output file record. In this example, the geopotential, gravity vector and gravity gradient are selected, and there are 7 attributes added to the record.



The ocean tidal load effects at 450km altitude: gravity vector (E, N: along the GRACE SST-II, U, µGal)

The global ocean tidal load spherical harmonic coefficients model (cm) adopts the FES2004 format, which can be constructed from the global tidal height harmonic parameters grid model, by calling the function [Global tidal parameters spherical harmonic analysis].

The computation speed of the program depends on the degree of the spherical harmonic coefficients model and the number of the tidal constituents.

The program adopts the default global ocean tidal load spherical harmonic coefficients model. You can select other global ocean tidal load spherical harmonic coefficients models by the program [geophysical model and numerical standard settings].

# 2.3 Spherical harmonic synthesis on air pressure tidal load effects outside solid Earth

[Purpose] Using the global surface air pressure tidal load spherical harmonic coefficients model (hPa), compute the surface air pressure tidal load effects on various geodetic quantities on the ground or outside the solid Earth according to the location and time in the input file by the spherical harmonic synthesis algorithm. Here a point outside the solid Earth generally refers to a space point that is not fixed to the Earth in ocean space, near-Earth space, or satellite altitude.

The program adopts the 360-degree surface air pressure tide spherical harmonic coefficients model ECMWF2006.dat, which contains semi-diurnal, diurnal, semi-annual, and

annual period constituents. Using this model to compute the surface air pressure tidal load effects, even if the non-tidal air pressure load effects are not considered, the surface air pressure load effects on the geodetic observations or parameters can be controlled to the accuracy level of 1cm.

# 2.3.1 Computation of surface air pressure tidal load effects time series at a ground site

[Function] From a geodetic site variations time series file, compute the time series of the surface air pressure tidal load effects on the geoid or height anomaly (mm), ground gravity ( $\mu$ Gal), gravity disturbance ( $\mu$ Gal), ground tilt (SW, to the south and to the west, mas), vertical deflection (SW, to the south and to the west, mas), horizontal displacement (EN, to the east and to the north, mm), ground radial displacement (mm), ground normal or orthometric height (mm), disturbing gravity gradient (10 $\mu$ E) or horizontal gravity gradient (NE, to the north and to the east, 10 $\mu$ E).

[Input file] The geodetic site variations time series file.

et the file parameters Jumn ordinal number of height relative 4 the surface in the header Jumn ordinal number of time in the record 1 Jumn ordinal number of starting 5 20 in the header elect the type of effects	>> Select the comput >> [Function] From a height anomaly (mm) the south and to the orthometric height (m	** Operation Prompts tation function from the 3 cc geodetic site variations tim , ground gravity (µGal), gra- west mas), borizontal disp	e series file, compl		arface		42	Save program	process a
Numn ordinal number of height relative the surface in the header slumn ordinal number of time in the record 1 JUD in the header elect the type of effects	>> [Function] From a height anomaly (mm) the south and to the orthometric height (m	geodetic site variations tim , ground gravity (µGal), gra	e series file, compl		erface				New Addition of
geoid or height anomaly (mm) ground gravity (µGal) ⊙ gravity disturbance (µGal) ground tilt (SW, mas) ⊙ uerical deflection (SW, mas)	output file name, cited >> Save the compute ** Behind the input f 	im), disturbing gravity gradi site variations time series fil at parameters according to the control button [Import de results as C/2 Finde.coad lile record, add offer any share been imported in the utton [Stat computation], process needs to wait. DD Transport butte looi at the times. 2022-03-02 16:44:1	acement (EN, to th ant (10µE) or horiz or C/ETideLoad4.0 the text box below setting parameters .0_win64en/examp al columns of the I program! r the too Botton (S pring the computation computation program	Gal), ground til e east and to ti ontal gravity gi win64en/exait, and then sele j oles/ATideload oad tidal effect (ant computatii on period, you oe!!	ries of the surface t (SW, to the source of the source of the source of the source of the source of the source of the type of the type of the type of the source of the so	Ith and to the w round radial dis e north and to th harmsynth/Tms e geodetic varia jurst.txt. file record. tput file C:/ETid	lest, mas), veri placement (m the east, 10µE eries.txt. ation to be com el_oad4.0_win e sampling of	tical deflection m), ground nor ). nputed. After gi	(SW, to rmal or iving the s/
vertical deflection (SW, mas) horizontal displacement (EN, mm)		nputation of the surface air time: 2022-03-02 16:47:43	pressure tidal load	effects!			not necessar		9
ground radial d splacement (mm) 💿	Maxmum truncated	dagrag						-	
ground normal or orthometric height (mm) 💿	of the coefficients m		ave the computed	results as	Import settir	ig parameters		- Start con	mputation
disturbing grav ty gradient (10µE)									
horizontal grav ty gradient (NE, 10µE)	Display of the input-	output file					No.	ave data in the	text box
	Forceast 100720 2018/010100 2018/010106 2018/010106 2018/010106 2018/01012 2018/01012 2018/010121 2018/010218 2018/010200 2018/010200 2018/010200 2018/010205 2018/010205 2018/010218 2018/010218 2018/010218 2018/010218 2018/010303 2018/010303 2018/010303	000 29.428100 0. 0.00000 - 8.6453 0.125000 -8.233 0.255000 -9.1342 0.355000 -9.1342 0.355000 -9.1342 0.455000 -8.233 0.625000 -8.233 0.625000 -8.233 0.625000 -8.233 0.625000 -8.233 0.625000 -8.233 0.625000 -8.531 1.125000 -9.055 1.355000 -10.1047 1.455000 -9.555 1.355000 -10.1047 1.455000 -8.555 1.355000 -10.1047 2.2050000 -8.593 2.225000 -8.593	-3.8335 -3.9699 -2.8979 -2.5971 -3.4769 -3.6801 -2.8301 -2.7716 -3.7840 -3.9204 -2.8482 -2.5423 -3.4270 -3.6300 -2.7799	4.0051 4.0096 4.9916 4.9916 3.6304 4.5958 4.7878 3.9491 3.9538 4.9356 4.9284 3.7916 3.5738 4.5390 4.7308 3.8920 3.8964 4.8781	3.4219 3.4347 4.2660 4.2460 3.2711 3.0948 3.9240 4.0857 3.3745 3.3874 4.2206 4.1904 4.1904 4.1904 3.2234 3.0469 3.8760 3.8760 3.3261 3.3389 4.1719	0.7092 0.6447 0.6654 0.8055 0.6538 0.6003 0.6003 0.6003 0.6522 0.7880 0.7922 0.6405 0.5827 0.5869 0.6827 0.7047 0.6180	$\begin{array}{c} -0.2600\\ -0.2735\\ -0.4677\\ -0.6563\\ -0.5207\\ -0.2113\\ -0.1162\\ -0.2202\\ -0.2637\\ -0.4578\\ -0.6464\\ -0.5108\\ -0.2014\\ -0.1063\\ -0.2086\\ -0.2403\\ -0.2403\\ -0.2403\\ -0.2437\\ -0.4478\end{array}$	0.2813 0.3000 0.2685 0.2693 0.3156 0.2545 0.2545 0.2759 0.2946 0.2638 0.3103 0.2638 0.3101 0.2489 0.2268 0.2703 0.2889 0.2573	-0.12 -0.12 -0.12 -0.27 -0.22 -0.10 -0.06 -0.11 -0.12 -0.11 -0.12 -0.27 -0.22 -0.10 -0.06 -0.11 -0.11 -0.11 -0.11 -0.11 -0.13
When calculating the indirect effects of the surface air	is pressure tidel lead t	he program assumes that		de ere concor	trated on the Fe	rth's surface of	nd the beight i	h of the coloub	otod noin

The file header contains site name, longitude (degree decimal), latitude (degree

decimal), height (m), starting MJD0 (optional), ...

Starting from the second row of the file, each row record stores the sampling values of all the variations at one sampling epoch time. At least one column of the attributes in the record is the sampling epoch time.

[Parameter settings] Set the input file format parameters, select the type of the surface air pressure tidal load effects.

[Output file] The geodetic site surface air pressure tidal load effects time series file.

The file header is the same as the input file. Behind the input file record, add one or several columns of the tidal effects selected as the output file record. In this example, all types are selected, and there are 14 attributes added to the record.



radial displacement (mm), ground orthometric height (mm)

When calculating the indirect effects of the surface air pressure tidal load, the program assumes that the air pressure loads are concentrated on the Earth's surface, and the height h of the calculated point is the height of the point relative to the surface. When calculating the direct effects on the gravity or gravity gradient, it is assumed that there is a proportional relationship between air pressure  $P_h$  at height h and surface air pressure  $P_0$ , namely  $P_h=P_0$  (1-h/44330)<sup>5225</sup>.

The global surface air pressure tidal load spherical harmonic coefficients model (hPa) adopts the FES2004 format, which can be constructed from the global surface air pressure harmonic parameters grid model by calling the function [Global tidal parameters spherical harmonic analysis]. In the program [geophysical model and numerical standard settings], you can select other global spherical harmonic coefficient model of the surface air pressure tidal load.

# 2.3.2 Computation of surface air pressure tidal load effects at ground sites with given time

[Function] According to the location and time in the computed points file, compute the surface air pressure tidal load effects on the geoid or height anomaly (mm), ground gravity ( $\mu$ Gal), gravity disturbance ( $\mu$ Gal), ground tilt (SW, to the south and to the west, mas), vertical deflection (SW, to the south and to the west, mas), horizontal displacement (EN, to the east

and to the north, mm), ground radial displacement (mm), ground normal or orthometric height (mm), disturbing gravity gradient ( $10\mu E$ ) or horizontal gravity gradient (NE, to the north and to the east,  $10\mu E$ ).



# 2.3.3 Computation of surface air pressure tidal load effects of satellite or outside Earth

[Function] According to the location and time in the external points file, compute the surface air pressure tidal load effects on the geopotential  $(0.1m^2/s^2)$ , gravity(µGal), or gravity gradient (10µE) outside the solid Earth.

[Input file] The location and time file of the external points.

The first row is the file header. From the second row onwards, the second and third attributes in the file record are conventionally longitude and latitude (degree decimals), and there are the sampling epoch time and height attributes in the records.

[Parameter settings] Set the input file format parameters, select the type of ocean tidal load effects.

[Output file] The surface air pressure tidal load effects file.

The file header is the same as the input file. Behind the input file record, add one or several columns of the tidal effects selected as the output file record. In this example, the

geopotential and gravity vector are selected, and there are 4 attributes added to the record.



The annual periodic amplitude of the surface air pressure tide is more than 10 times the diurnal periodic amplitude. In the land area, the surface air pressure is high in winter and low in summer, so that the ground decline in winter and uplift in summer, resulting in annual and semi-annual periodic ground vertical deformations, which should be considered in centimeter-level geodesy.

The surface air pressure tidal load effects on the east-west component of the site displacement, tilt or horizontal gradient are generally smaller than that on the north-south component.

# 2.4 Computation of Earth pole shift and ocean pole tide effects outside solid Earth

[Purpose] Using IERS Earth orientation parameters (EOP) product file IERSeopc04.dat, compute the Earth pole shift and ocean pole tide effects on various geodetic quantities on the ground or outside the solid Earth according to the location and time in the input file.

# 2.4.1 Computation of pole shift or ocean pole tide effects time series at a ground site

[Function] From the geodetic site variations time series file, compute the time series of the Earth pole shift or ocean pole tide effects on the geoid or height anomaly (mm), ground gravity ( $\mu$ Gal), gravity disturbance ( $\mu$ Gal), ground tilt (SW, to the south and to the west, mas), vertical deflection (SW, to the south and to the west, mas), horizontal displacement (EN, to the east and to the north, mm), ground radial displacement (mm), ground normal or orthometric height (mm), disturbing gravity gradient (10 $\mu$ E) or horizontal gravity gradient (NE, to the north and to the east, 10 $\mu$ E).

[Input file] The geodetic site variations time series file.



The file header contains site name, longitude (degree decimal), latitude (degree decimal), ellipsoidal height (m), starting MJD0 (optional), ...

Starting from the second row of the file, each row record stores the sampling values of

all the variations at one sampling epoch time. At least one column of the attributes in the record is the sampling epoch time.

[Parameter settings] Set the input file format parameters, select the type of the pole shift or ocean pole tide effects.

[Output file] The geodetic site Earth or ocean pole-shift effects time series file.

The file header is the same as the input file. Behind the input file record, add one or several columns of the tidal effects selected as the output file record. In this example, all types are selected, and there are 14 attributes added to the record.



Love numbers in the program are  $k_2 = 0.3077 + 0.0036i$ ,  $h_2 = 0.6207$ , and  $l_2 = 0.0836$ . If the epoch time to be calculated exceeds the time range of the Earth orientation parameters time series file, please update the parameters time series file.

The pole shift is non-tidal, which does not contain the diurnal swing of the Earth pole caused by various tides. It is difficult to accurately model the non-tidal effects. The program adopts the IERS measured or forecast product IERSeopc04.dat (which can be downloaded directly from the IERS website), which can be updated in time by the program [Geophysical models and numerical standards settings].

# 2.4.2 Computation of pole shift or ocean pole tide effects at ground sites with given time

[Function] According to the location and time in the computed points file, compute the Earth pole shift or ocean pole tide effects on the geoid or height anomaly (mm), ground gravity ( $\mu$ Gal), gravity disturbance ( $\mu$ Gal), ground tilt (SW, to the south and to the west, mas), vertical deflection (SW, to the south and to the west, mas), horizontal displacement (EN, to the east and to the north, mm), ground radial displacement (mm), ground normal or orthometric height (mm), disturbing gravity gradient (10 $\mu$ E) or horizontal gravity gradient (NE, to the north and to the east, 10 $\mu$ E).

[Input file] The location and time file of the computed points.

The first row is the file header. From the second row onwards, the second and third attributes in the file record are conventionally longitude and latitude (degree decimals), and

there are the sampling epoch time and ellipsoidal height attributes in the records.

[Parameter settings] Set the input file format parameters, and select the type of the effects.

[Output file] The Earth pole shift or ocean pole tide effects file.

Open a location and time file of the computed points		at give	und sites with given time	pole-shift effects		of of	mputation of Ea Earth satellite o	r outside solid	Earth
	s >> Program Proces	s ** Operation F	Prompts					4	Save program proce
the file parameters unn ordinal number of ellipsoidal ghi in the record unn ordinal number of time in the record unn ordinal number of starting to in the header lead the type of effects geold or height anomaly (mm) ground gravity (juGa) O gravity (distubance (uGa)	anomaly (mm), gro the west, mas), hor disturbing gravity g >> Open a location * Set the file form name, click the con * Save the openput * Denind the inpu >> Setthe paramet >> Prepare to com * Click the contro >> Computation s3	und gravity (µGa izontal displacer radient (10µE) or and time file of t at parameters a troi button [Impoo ted results as C the file record, and there have been in pute the Earth po button [Start co at time: 2022-0.	mputation], or the tool b	Gal), ground tilt ( I to the north, mn ent (NE, to the no TideLoad4.0_wi below, and then s h/examples/Poles of the Earth pole	SW, to the so n), ground rac orth and to the n64en/examp select the type hifteffectscald shift or ocean	uth and to the v fial displacement east, 10µE). les/Poleshifteffe e of the geodetic c/Postmrst.txt. n pole shift effe	west, mas), vert nt (mm), ground actscalc/Postior c variation to be cts as the outpu	ical deflection i normal or ort itm.txt. computed. Af it file record.	(SŴ, to the south an hometric height (mm) ter giving the output f me is in ETideLoad
gravity disturbance (µGai)	>> Computation en								
vertical deflection (SW, mas)	select the type to b	e computed 11	e Earth pole shift effects	🗸 📙 Save th	e computed r	esults as  🍹 I	mport setting p	arameters	J Start comput
horizontal displacement (EN, mm) 💿	Display of the input	t-output file L						ar 1	Save data in the text t
ground radial displacement (mm) 💿									
ground normal or orthometric height (mm) 💿	107.230000	107.230000	2.4 56658.00000 29.910000 72.4	0.000000	6.713	19.0647	-5.8471	9.0536	-10.0111
disturbing gravity gradient (10µE)	201401011200 201401020000	107.230000	29.910000 72.4 29.910000 72.4	0.500000	6.375	19.0827 19.1007	-5.8527	9.0622	-10.0205
horizontal gravity gradient (NE, 10µE)	201401021200	107.230000	29.910000 72.4	1.500000	6.412	19.1193	-5.8639	9.0796	-10.0397
nonzonial gravity gradient (NE, TOPE)	201401030000 201401031200	107.230000 107.230000	29.910000 72.4 29.910000 72.4	2.000000	6.786 6.445	19.1379 19.1414	-5.8696	9.0884 9.0901	-10.0495 -10.0512
	201401031200	107.230000	29.910000 72.4	3.000000	6.818	19.1414	-5.8717	9.0918	-10.0512
	201401041200	107.230000	29,910000 72.4	3.500000	6.476	19,1534	-5.8744	9.0959	-10.0575
	201401050000	107.230000	29.910000 72.4	4.000000	6.847	19.1620	-5.8770	9.1000	-10.0620
	201401051200	107.230000	29.910000 72.4	4.500000	6.504	19.1765	-5.8815	9.1069	-10.0696
	201401060000	107.230000	29.910000 72.4	5.000000	6.874	19.1911	-5.8859	9.1138	-10.0772
	201401061200 201401070000	107.230000	29.910000 72.4 29.910000 72.4	5.500000	6.529	19.2102	-5.8918 -5.8976	9.1230 9.1321	-10.0872
	201401070000	107.230000	29.910000 72.4	6.500000	6.551	19.2293	-5.9048	9.1321	-10.1094
	201401080000	107.230000	29.910000 72.4	7.000000	6.917	19.2760	-5.9120	9.1544	-10.1217
	201401081200	107.230000	29.910000 72.4	7.500000	6.570	19.3021	-5.9200	9.1668	-10.1354
	201401090000	107.230000	29.910000 72.4	8.000000	6.935	19.3282	-5.9280	9.1792	-10.1490



The file header is the same as the input file. Behind the input file record, add one or several columns of the Earth pole shift or ocean pole tide effects selected as the output file record. In this example, select to compute the Earth pole shift effects, and the height anomaly, gravity disturbance, ground radial displacement and ground normal or orthometric height are selected, and there are 4 attributes added to the record.

# 2.4.3 Computation of pole shift or ocean pole tide effects of satellite or outside solid Earth

[Function] According to the location and time in the external points file, compute the

Earth pole shift or ocean pole tide effects on the geopotential  $(0.1m^2/s^2)$ , gravity(µGal), or gravity gradient(10µE) outside the solid Earth.

For geodetic applications with a one-centimeter accuracy level, the Earth pole shift effects should be considered. The magnitude of the ocean pole shift effects is small (less than 1cm), and it can be ignored for regional geodetic purposes.



#### 2.5 Computation of permanent tidal effects and correction of Earth's mass center

[Purpose] Compute the permanent tidal effects on various geodetic quantities and the geocentric correction for the coordinates of the ground site.

When calculating the permanent tidal effects, input the geodetic discrete point records file, and when calculating the center of mass correction, input the ground site coordinates file with the epoch time.

## 2.5.1 Computation of permanent tidal effects on various geodetic quantities

[Function] According to the location in the calculated point records file, compute the permanent tidal effects on the geoid or height anomaly (mm), ground gravity ( $\mu$ Gal), gravity disturbance ( $\mu$ Gal), ground tilt (SW, to the south and to the west, mas), vertical deflection (SW, to the south and to the west, mas), horizontal displacement (EN, to the east and to the north, mm), ground radial displacement (mm), ground normal or orthometric height (mm), disturbing gravity gradient (10 $\mu$ E) or horizontal gravity gradient (NE, to the north and to the east, 10 $\mu$ E).

[Input file] The computed geodetic point records file.

Multi-row file headers are allowed with unlimited content and format.

A row of record represents geodetic data for a site. Attributes for each record include site number (name), longitude (degree decimal), latitude (degree decimal), .... There is an ellipsoid height attribute in the record.

[Parameter settings] Set the input file format parameters, select the type of permanent tidal effects.

[Output file] The permanent tidal effects file.

The file header is the same as the input file. Behind the input file record, add one or several columns of the permanent tidal effects selected as the output file record. In this
example, all types are selected, and there are 14 attributes added to the record.

The permanent tide does not change with time. It is the zero-frequency tide  $\Delta C_{20}$  in the long-period solid tide. The permanent tide produces a permanent additional oblateness that varies with latitude to the Earth, and its effects on the geodetic quantities have nothing to do with the longitude of its location.

Open a computed geodetic point records file				me	to c	cean tidal mas	s for ground site	es	Computation to pressure	e tidal mass for g	pround sites
	>> Program	m Process ** C	Operation Pro	m <mark>pt</mark> s						斜 Save pro	gram process
Set the file parameters The number of rows of the file heade Column ordinal number of ellipsoidal 4 Select the type of effects	>> Select t >> [Function gravity (µG horizontal of gradient (1	the computation on] According to al), gravity distri displacement ( 10µE) or horizon	n function from the location is urbance (µGa (EN, to the each ntal gravity gravity gravity	n the 4 control in the calculate I), ground tilt (S st and to the ne adient (NE, to the	buttons on th ed point record SW, to the sou orth, mm), gro he north and t	e top of the inter ds file, compute th and to the we und radial disp o the east, 10µl	rface e the permanent est, mas), vertic placement (mm)	tidal effects on al deflection (SV , ground normal	the geoid or he V, to the south or orthometric	es of the ground ight anomaly (m and to the west, i height (mm), dis	m), ground mas),
geoid or height anomaly (mm)										rt setting parame	eters]
ground gravity (µGal) 💿							ntdgeocenter/pe				
✓ gravity disturbance (µGal)		the input file re parameters ha				ted results as th	he output file red	cord.			
ground tilt (SW, mas) 💿						art computation	nl			-	
vertical deflection (SW, mas)		station start tim								1	
horizontal displacement (EN, mm) 💿		ete the comput station end time			effects!						
ground radial displacement (mm) 💿			2022-03-02	19.03.41							
ground normal or orthometric height (mm) ()	Type of per		effects	Save the save the	e computed	esults as	Import setting p	arameters		JE St	art computatio
disturbing gravity gradient (10µE)	tida	al effects									
	Display of	the input-output	utfile⊥							Save the data	a in the text box
horizontal gravity gradient (NE, 10µE)								*		-	
		102.546777		1659.0410 2111.3872	-0.1046	63.4456 63.4281	26.1954 26.1863	12.5279	4.9901 4.9897	0.0000	9.4020
		102.528697			-0.0491	62.9131	25.9745	12.4223	5.0056	0.0000	9,4313
		102.832641		1977.4949	-0.1223	62.8483	25.9476	12.4094	5.0075	0.0000	9.4349
	10	102.345532	24.668953	1919.7825	-0.0782	62.3749	25.7525	12.3161	5.0218	0.0000	9.4618
		102.423972		1959.3369	-0.0548	62.4559	25.7857	12.3320	5.0193	0.0000	9.4571
			24.657055	1906.3415	-0.1185	62.4355	25.7775	12.3281	5.0200	0.0000	9.4585
		102.742718		1935.7882	-0.0767	62.4564	25.7860	12.3322	5.0194	0.0000	9.4572
Longitude, latitude of the sites		102.843573		1880.7707	-0.1319	62.5081	25.8076	12.3425	5.0179	0.0000	9.4544
		103.137778		1838.4387	-0.0730	62.4302	25.7756	12.3272	5.0203	0.0000	9.4590
		102.426305		1929.0475	-0.0771	62.0402	25.5964 25.6146	12.2415	5.0331 5.0319	0.0000	9.4830
			24.752018	2117.8582	-0.1356	61.9505	25.5765	12.2320	5.0341	0.0000	9.4809
			24.728089	2050.9590	-0.0907	62.0730	25.6273	12.2320	5.0306	0.0000	9.4783
									5.0337		
	22	102.939253		2034.1986	-0.1217	61,9693	25.5846	12.2358		0.0000	9.4842
	22		24.748496	2034.1986 1575.0654	-0.1217	61.9693 61.9501	25.5846	12.2358	5.0337	0.0000	9.4842
	22 23 24	103.029713	24.748496 24.753135								

The Love numbers in the program are  $k_{20}$ =0.29525,  $h_{20}$ =0.6078, and  $I_{20}$ =0.0847.

According to the permanent tide correction way, there are three types of geodetic tide systems, namely free tide, mean tide, and zero tide. The mean tide does not remove the permanent tidal effects, the zero tide removes the direct effects of the permanent tide, and the free tide removes the sum of the direct and indirect effects of the permanent tide.

There is no direct effect of the tide potential on the ground geometric geodetic quantities. Therefore, the zero-tide geometric geodetic quantities are equal to the mean tide geometric geodetic quantities.

#### 2.5.2 Computation of geocentric correction of ground sites with given time

[Function] According to the location and time in the ground site records file, compute the correction (ENU, mm) of Earth center of mass for the coordinates of the ground site using the SLR geocentric motion measurement or prediction parameters time series.

[Input file] The location and time file of the computed points.

The first row is the file header. From the second row onwards, the second and third

attributes in the file record are conventionally longitude and latitude (degree decimals), and there are the sampling epoch time and ellipsoidal height attributes in the records.

[Parameter settings] Set the input file format parameters.

[Output file] The correction of Earth center of mass file.

The file header is the same as the input file. Behind the input file record, add 3 columns of the correction of Earth center of mass as the output file record.



Geocentric motion is non-tidal, which can be represented by the degree 1 geopotential coefficient variations ( $\Delta C_{10}$ ,  $\Delta C_{11}$ ,  $\Delta S_{11}$ ). Physical geodetic observations do not contain geocentric motion information, and the corrections of the center of mass are only for the coordinates of the ground site.

The coordinates Xcm of the ground site in the Earth's mass center frame are equal to the sum of its coordinates Xcf in the terrestrial reference frame and the center of mass corrections dX, that is, Xcm=Xcf+dX.

If the epoch time to be calculated exceeds the time range of the SLR geocentric motion parameters time series, please update the parameters time series file.

# 2.5.3 Computation of geocentric correction due to ocean tidal mass for ground sites

[Function] According to the location and time in the ground site records file, compute the correction (ENU, mm) of the center of mass for the coordinates of the ground site using the center of ocean tidal mass correction coefficients by the equation (7.17) in the IERS conventions (2010).

[Input file] The location and time file of the computed points. The Desai ocean pole tide coefficients file (automatically called by the program without manual input, can be updated from the program [geophysical models and numerical standards settings]).



[Parameter settings] Set the input file format parameters.

[Output file] The geocentric correction due to ocean tidal mass file.

The file header is the same as the input file. Behind the input file record, add 3 columns of the geocentric correction due to ocean tidal mass as the output file record.



The geocentric correction due to ocean tidal mass: East (mm), North (mm), radial displacement (mm)

# 2.5.4 Computation of geocentric correction due to pressure tidal mass for ground sites

[Function] According to the location and time in the ground site records file, compute the correction (mm) of the center of mass for the coordinates of the ground site using the geocenter coefficients of the semi-diurnal and diurnal air pressure tidal mass by the equation (7.20) in the IERS conventions (2010).



## 2.6 Computation of solid Earth tide and loading tide effects on geodetic networks

[Purpose] Compute the solid Earth, ocean load, or air pressure load tidal effects on the GNSS baseline or level height difference according to the location and observation time in the input geodetic control network records file.

[Input file] Geodetic network observation records file.

The GNSS baseline network file and the level route network file are the same in ETideLoad format.

The first row is the file header. The record format: the GNSS baseline or leveling route name, starting point longitude, latitude, height, ending point longitude, latitude, height, ..., observation time, ....

The column ordinal number of the time attribute should not be less than 8.

Computation of solid Earth tide and loading tide effects o	n geodetic networks			– 🗆 🗙
📵 🚼 🏂 🚚				
Open file Save as Import parameters Start computation	Save process Follow example			
Computation of solid Earth tidal effects	Computation of ocean t	dal load effects	Computation of are press	sure tidal load effects
Select the type of control network GNSS baseline network ~ >> Program Proc	ess ** Operation Prompts			🐳 Save program process as
Open a CNSS baseline network file     Compute the     Co	a of the control network firstly, and sele- solid Earth tidal effects (mm) idial effects on 3-D GNSS baseline vec baseline network file including time al verilingroutine tit. format parameters according to the text puted results as C./ETideLoad4.0_win putfile record, add the tidal effects as t veters have been imported in the progr rol button [Start computation], or the tox start time: 2022-03-02 20:57:38 computation of the tide effects!	tors tribute C/ETIdeLoad4.0_win64 box below. After giving the outp 64en/examples/Controlnetwork he output file record. am!	en/examples/Controlnetworktide	4/
Save the co	mputed results as	Fimport setting pa	rameters	J Start computation
Display of the input-output file		a import octaing po		Save data in the text box as
Display of the input-output met		<hr/>	2	a Save data in the text box as
9 4 57022 CANN DONT 120.424700 27.522580 21.8 121.15027	0 27.834630 28.6 79493.9	1.5 2016072412 1.2202	0.9169 0.1390	-2.6996
CANN FDIQ 120.424700 27.522580 21.8 120.20732		1.5 2016072412 1.2202	-0.2741 -0.0297	0.9609
CANN_JHYW 120.424700 27.522580 21.8 120.07838	0 29.272690 32.5 196899.1	1.5 2016072412 1.3927	-0.3779 -0.2858	-1.4864
CANN_JINH 120.424700 27.522580 21.8 119.64258		1.5 2016072412 1.6668	-0.9095 -0.4033	-0.0219
CANN_JINX 120.424700 27.522580 21.8 119.37922		1.5 2016072412 1.3931	-1.2331 -0.4626	1.0484
CANN_JNJZ 120.424700 27.522580 21.8 119.63754 CANN_JSAN 120.424700 27.522580 21.8 118.60856		1.5 2016072412 1.2143 2.5 2016072512 1.2766	-0.9599 -0.2578	1.8537
		2.5 2016072512 1.2766	The Solid tidal eff	ects on
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CANN_LONQ 120.424 heights of Starting tending		2.5 2016072512 1.3241	-0.73480.6809	3.2250
CANN_LUOY 120.424700 27.522580 21.8 119.70509	0 27.552460 32.5 71164.3	2.5 2016072512 1.1005	-0.7348 (EAU3100m)	
CANN_PANA 120.424700 27.522580 21.8 120.43666		2.5 2016072512 1.8985	0.3005 -0.2660	-4.3396
		2.5 2016072512 1.4645	-1.1268 -0.9136	5.9061
CANN_PCJM 120.424700 27.522580 21.8 118.44544 CANN QINT 120.424700 27.522580 21.8 120.28998		2.5 2016072512 1.7441 2.5 2016072512 1.1991	-1.1378 -1.0100 0.0243 -0.1768	5.5613
CANN QIYU 120.424700 27.522580 21.8 119.07925		2.5 2016072512 2.1814	-0.8551 -0.6080	4.7436
CANN QNYN 120.424700 27.522580 21.8 118.96382		2.5 2016072512 1.3150	-0.9277 -0.6579	5.1957
The GNSS baseline network file and the level route network fi height, ending point longitude, latitude, height,, observation time The tidal effect on geodetic observation should be at the actua of the semi-diumal tidal constituent. The height of the ground control site is the ellipsoidal height w	e, The column number of the time a I observation time. The duration of the hen calculating the solid tidal effects, t	tribute should not be less than leveling height difference obse	8. rvation should not exceed 2 hour	is to compute validly the effect
the surface (set as zero in the program) when calculating the air p	essure udal load effects.			

[Parameter settings] Set the input file format parameters, select the type of geodetic control network, and enter maximum truncated degree of the coefficients model when computing the tidal load effects.

The tidal effect on geodetic observation should be at the actual observation time. The duration of the leveling height difference observation should not exceed 2 hours to compute validly the effect of the semi-diurnal tidal constituent.

The height of the ground control site is the ellipsoidal height when calculating the solid tidal effects, the normal or orthometric height when calculating the ocean load effects, the height relative to the surface (set as zero in the program) when calculating the air pressure tidal load effects.

💱 Computation of solid Earth tid	al effects	Computation of oce	in tidal load effects	Computa Computa	ation of are pressure tidal load effects
elect the type of Levelling control network	>> Program Process	** Operation Prompts			Save program process
Open a levelling network routes file including time attribute Set the file parameters JUDD in the header JUDD in the header olumn ordinal number of time 10 the record the coefficients model	>> Compute the ocea >> Compute the tidal >> Come a levelling n GNSSbaseline_level ** Enter the file form parameters] >> Save the compute ** Behind the input f >> Setting parameter Click the control b	at parameters according to the dresults as C/ETideLoad4.0_ ile record, add the tidal effects is have been imported in the pro- putton [Start computation], or the time: 2022-03-02 21:02:37	e attribute C:/ETideLoad4.0 text box below. After giving t win64en/examples/Control is the output file record. ogram!	the output file name, clici	k the control button [Import setting
		Hane: 2022-03-02 21:02:42	🌮 Import se	etting parameters	J Start computation
isplay of the input-output file↓	>> Computation end	Hane: 2022-03-02 21:02:42	🌮 Import se	atting parameters	in the second second second second second second second second second second second second second second second
isplay of the input-output filej 9 4 57022 CANN DOXT 120.424700 27.522580	>> Computation end	Hane: 2022-03-02 21:02:42		etting parameters	Start computativ

## 2.7 The regional approaching of tidal load effects by load Green's Integral

[Purpose] From the regional residual ocean tide or surface air pressure tide harmonic parameters grid, compute the residual ocean or air pressure tidal load effects near-Earth space by Green's integral.

Here, the residual harmonic parameters are equal to the regional harmonic parameters minus the model value of the harmonic parameters calculated by the global load spherical harmonic coefficients model.

The program requires that residual harmonic parameter grids files of all tidal constituents are stored in a folder. The harmonic parameter grid file is saved in the form of a vector grid, and the seventh attribute of the file header is the Doodson constant.

ETideLoad4.0 takes the regional harmonic parameters grid as the observations, uses global tidal load spherical harmonic coefficients model as a tidal load reference field, and refines the regional residual tidal load effects by Green's integral. Which is also called the remove-restore process.

## 2.7.1 Computation of residual ocean tidal load effects by Green's Integral

[Function] From the regional residual ocean tide harmonic parameters grid, compute the residual ocean tidal load effects on the geoid or height anomaly (mm), ground gravity ( $\mu$ Gal), gravity disturbance ( $\mu$ Gal), ground tilt (SW, to the south and to the west, mas), vertical

deflection (SW, to the south and to the west, mas), horizontal displacement (EN, to the east and to the north, mm), ground radial displacement (mm), ground normal or orthometric height (mm) by Green's integral, and compute the direct or indirect residual tidal effects on disturbing gravity gradient (mE) or horizontal gravity gradient (NE, to the north and to the east, mE) by Green's Integral.

[Input file] The location and time file of near-Earth points, and the residual ocean tide harmonic parameters regional grid files.

The location and time file of near-Earth points. The first row is the file header. From the second row onwards, the second and third attributes in the file record are conventionally longitude and latitude (degree decimals), and there are the sampling epoch time and height attributes in the records.

In this example, 8 residual ocean tidal constituent harmonic parameters grid files are selected from the difference between the ocean tide height model GOT4.8 ( $0.5^{\circ} \times 0.5^{\circ}$  harmonic parameters grid) and FES2004.

[Parameter settings] Set the input file format parameters, select the type of ocean tidal load effects, and enter Green's integral radiu.

The height of the calculated point is normal or orthometric height relative to the sea surface since the ocean tidal loads are generally considered to be on the sea surface.



[Output file] The residual ocean tidal load effects file.

The file header is the same as the input file. Behind the input file record, add one or



several columns of the residual tidal effects selected as the output file record. In this example, all types are selected, and there are seventeen attributes added to the record.

The ocean tidal load is located on the surface, and its load effects are all-wavelength. Gravity gradient ultrashort waves are dominant, and its ocean tide load effects are bigger. In order to fully display the spatial inhomogeneity of direct and indirect effects on gravity gradient, the program divides the ocean tidal effects on gravity gradient into two parts namely the direct and indirect effects with their unit enlarged from  $10\mu$ E to mE.

Let the 8 residual tidal constituent harmonic parameters as the ocean tidal modelling error. The calculation results show that the ocean tide modelling error influence on the indirect load effect of the northward component of the horizontal gravity gradient can reach tens of mEs, and the direct effect can reach 600mE. The indirect load effect of the eastward component is more than 10mE, and the direct load effect is more than 200mE.



The tide modelling error influence (GOT4.8-FES2004): Direct effect of disturbing gravity gradient (mE)



The tide modelling error influence (GOT4.8-FES2004): Indirect effect of disturbing gravity gradient (mE)

In coastal areas, it is difficult for gravity gradient measurement with the mE level of accuracy without a high-precision, high-resolution regional accurate tide model or sea surface height synchronous observations. In sea and coastal areas, the vertical gravity gradient observation scheme should be preferred, and the direct measurement of the horizontal gravity gradient should be avoided as much as possible.



The tide modelling error influence (GOT4.8-FES2004): Indirect effect of horizontal gravity gradient (N, E; mE)

## 2.7.2 Computation of residual air pressure tidal load effects by Green's Integral

[Function] From the regional residual surface air pressure tide harmonic parameters grid, compute the residual tidal load effects on the geoid or height anomaly (mm), ground gravity ( $\mu$ Gal), gravity disturbance ( $\mu$ Gal), ground tilt (SW, to the south and to the west, mas), vertical deflection (SW, to the south and to the west, mas), horizontal displacement (EN, to the east and to the north, mm), ground radial displacement (mm), ground normal or orthometric height (mm), by Green's integral, and compute the direct or indirect residual tidal effects on disturbing gravity gradient (mE) or horizontal gravity gradient (NE, to the north and to the east, mE).

The height of the ground site is the normal or orthometric height when calculating the ocean tidal load effects, and the height relative to the surface (set as zero in the program) when calculating the surface air pressure tidal load effects.

## 2.8 Global forecast of various tidal effects on various surface geodetic quantities

[Purpose] Forecast the solid Earth tidal, ocean tidal load, or surface air pressure tidal load effects on various surface geodetic quantities anywhere and anytime.

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Solid tide effects Ocean tidal loa	d Air pressure	tidal load Import	parameters Sta	art computation	Follow example	
Global forecast of solid Earth tidal effects	$\supset$	Global forecast tidal load effects		Global fo pressure	recast of surface air tidal load effects	Forecast of the ocean tide height by tidal harmonic parameters
Forecast a time series by the	iven location			[	<b>\$</b>	Import setting parameters
and sampling specifications						Jan Start computation
Longitude of the forecast point	121.240000°	*				
Latitude of the forecast point	29.428100°	•				
Height of the forecast point	17.830m	•				
Enter a forecast time	20160701					
Forecast with the given location ar	ud time					
geoid or height anomaly (mm)		ground gravity (	JGal) 196,711		gravity dis	turbance (µGal) 218.887
horizontal displacement (E, mm)	r	ground tilt (S, m				flection (S, mas) 11.668
horizontal displacement (N, mm)		ground tilt (W, m				flection (W, mas) -18.765
ground radial displacement (mm)	214.859	ground normal	or orthometric hei	ght (mm) -259.0	080	
disturbing gravity gradient (10µE)	137.925	horizontal gravit	y gradient (N, 10µ	E) -36.545	horizontal	gravity gradient (E, 10µE) -35.639
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Solid tide effects Ocean tidal loa	ad Air pressure	tidal load Import	parameters Sta	art computation	Follow example	
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Forecast a time series by the grant and sampling specifications	given location					
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Latitude of the forecast point 29. Height of the forecast point 0.000 Enter a forecast time 2018 Forecast with the given location ar geoid or height anomaly (mm) 1 horizontal displacement (E, mm) horizontal displacement (N, mm)	428100* )m 0701 dtime 7.781 3.596 -1.289	ground gravity (j ground tilt (S, m ground tilt (W, m	as) 1.079 nas) -3.577	of the coeffici	ents model Filmport St. tidal height (cm) 63.24 gravity dis vertical de vertical de	setting parameters art computation I3 turbance (µGal) 29.152
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The height of the site is the ellipsoidal height when calculating the solid tidal effect, the normal or orthometric height when calculating the ocean load effects, height relative to the

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turbing gravity	gradient (10µE)	-25.354	hori	zontal gravity gra	dient (N, 10	µE) -25.238		horizontal gr	avity gradient (E	E, 10µE) -5.56	61
•• •				20000						<b>D</b>	
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surface (set as zero in the program) when calculating the air pressure load effects.

Date or time adopts the long integer format agreed by ETideLoad. E.g., 201812241226 represents 12:26:00 on December 24, 2018, and 2018122412 represents 12: 0: 0 on December 24, 2018.

The spherical harmonic coefficients model of the ocean tidal load and surface air

pressure tidal load can be updated with the program [geophysical model and numerical standard settings].



## 3 Processing and analysis on non-tidal geodetic variations time series

Based on the characteristics of non-tidal geodetic time series, the group of programs adopt stable and reliable algorithms to uniformly process and analyze massive various geodetic variations time series data.



ETideLoad only recognizes the five kinds of geodetic variation time series data in own format. The five kinds files include the ground geodetic variations time series file, geodetic site variation records time series file, geodetic network observation variations time series file, variation (vector) grids time series files, and spherical harmonic coefficient (Stokes coefficient) models time series files.

### 3.1 Separation and processing of gross errors in geodetic variations time series

[Purpose] On the irregular sampling time series in the given input file, perform preprocessing such as gross error detection and separation, time format transform, reference epoch unification of multi-columns time series or averaging according to the given time period.

In the record of the geodetic variations time series file, each attribute except the sampling epoch time represents a type of variations time series, and the sampling epoch time of all types of variations time series are the same.

### 3.1.1 Gross error detection and separation on variations time series

[Function] According to the given number of the low-pass filtering parameters, using the continuous Fourier and Chebyshev combined basis functions, construct the low-pass

filtering reference curve from the irregular variations time series of the specified attribute, calculate the difference between the sampling value and the reference value to get the residual time series, and then separate the variation at the corresponding epoch time when the residual is greater than the given multiple of the standard deviation of the residual time series as the gross error. The program performs 5 iterations of the gross error detection and separation.

[Input file] The geodetic variations time series file.

The first row is the file header. Starting from the second row of the file, each row record stores the sampling values of all the variations at one sampling epoch time. At least one column of the attributes in the record is the sampling epoch time.

[Parameter settings] Set the input file format parameters, enter column ordinal number of the epoch time and target attribute time series to be detected in the record, and enter the multiple of the standard deviation and the number of low-pass filtering parameters.

The entered number of the low-pass filtering parameters is not more than 1/2 of the number of time series samples, and not less than 1/30 of the number of samples. When the entered number exceed this range, the program automatically takes the minimum or maximum value.



[Output file] The variations time series analysis file after removing gross errors.

Behind the input time series file header, add two attributes including the constant term

and linear term (annual rate of variation, /a) as the output file hearder. Behind the input time series file record, add 5 attributes including the low-pass filtering value, low-pass filtering value after removing the constant, low-pass filtering value after removing the constant and linear term, linear variation, and residual value as the output file record.

## 3.1.2 Transform of time in between ETideLoad and MJD

[Function] Automatically detect the time (date) format in the variations time series file, and then transform time (date) in between the ETideLoad format and MJD day (GPS time). The zero point of MJD (GPS time) is JD2400000.5.



The transformed time is stored as the last column of the record. When the target is the MJD day, the program also adds the MJD day corresponding to the first sampling epoch time (namely the starting MJD0) into the last column of the input file header as the output file header.

## 3.1.3 Unification of reference epoch for the specified attribute time series

[Function] Using the cubic spline or Gaussian function interpolation method, interpolate the sampling value of the specified attribute time series at the given reference epoch time, and then remove the corresponding sampling values from the time series, thereby unifying the reference epoch time. At the reference epoch time, the sampling value of the specified attribute time series is always zero.

[Input file] The geodetic variations time series file.

[Parameter settings] Set the input file format parameters, enter column ordinal number of the first and last attribute time series, the reference epoch time (ETideLoad long integer format), and select interpolation method.

The program requires that the reference epoch time is no earlier than the first sampling time and no later than the last sampling time, otherwise automatically set to the first or last sampling time.

The program requires that the number of the time series attributes selected are not more than 20, that is, the difference between the column ordinal number of the last attribute time series and the first attribute time series is small than 20.

The reference epoch time need not be one of the sampling epochs of the input variations time series.

When there are more noise or missing samples in time series signals, Gaussian function interpolation is recommended.



[Output file] The variations time series analysis file.

Behind the input file header, add the reference epoch time as the output file header. Behind the input file record, add the unified attributes of the specified time series as the output file record.

The unification of reference epoch time for multi-source data is the most basic requirement for geodynamics monitoring.

#### 3.1.4 Averaging on time series according to the given time period

[Function] From the regular or irregular time series, according to the column ordinal number of the specified attribute, calculate the attribute mean value time series by the given averaging method.

[Input file] The geodetic variations time series file.

[Parameter settings] Set the input file format parameters, enter column ordinal number of the the specified attribute, and select average period.

[Output file] The variations average time series file.

Behind the input file header, add the average mode (0 is the monthly average, 1 is the GPS weekly average, and 2 is the given days average) as the header of the average time series file. The record format: the middle epoch, the average value, the number of the samples used to average.



## 3.2 Low-pass filtering and signal reconstructing for irregular time series

[Purpose] Using the continuous Chebyshev and triangular base function combination method, estimate the low-pass parameters of the irregular time series, separate the constant term and linear term, and then reconstruct the time series according to the user's requirements.

The program can separate the constant term, linear term, and noise, and realize the short-time interpolation and bidirectional prediction of various irregular variations time series.

#### 3.2.1 Estimation of low-pass parameters and linear term of irregular time series

[Function] Using the continuous Chebyshev and triangular base function combination method, estimate the constant term, linear term, and low-pass parameters of the irregular time series according to the entered number of estimated parameters.

[Input file] The geodetic variations time series file.

The first row is the file header. Starting from the second row of the file, each row record stores the sampling values of all the variations at one sampling epoch time. At least one column of the attributes in the record is the sampling epoch time.

Separation and processing of c	چ		<b>F</b>	ave process	Follow exam	ple			- 0 ×
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2015010712 25.9	6.0	20.7491	-8.8893	-8.8789	-0.0104	5.1509	6.0000		
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[Parameter settings] Set the input file format parameters, enter column ordinal number

of the epoch time and target attribute time series in the record, and enter the number of lowpass filtering parameters.

The total number of the estimated low-pass parameters should not be greater than 1 / 2 of the number of samples in the input time series and should not be less than 1 / 30 of the number of samples. If the total number exceeds the range, the program automatically takes the minimum or maximum values.

[Output file] The low-pass filtering parameters file. The low-pass filter variations time series analysis file.

The low-pass filtering parameters file. Behind the input time series file header, add the 5 attributes including the constant term, linear term (annual rate of variation, /a), number of the estimated parameters, starting MJD0, and ending MJD as the parameters file header. And then all low-pass filter parameter values be saved into the file in order.

The low-pass filter variations time series analysis file \*.rst. Here, \* is the input geodetic variations time series file name.

Behind the input time series file header, add two attributes including the constant term and linear term (annual rate of variation, /a) as the output file header. Behind the input time series file record, add 5 attributes including the low-pass filtering value, low-pass filtering value after removing the constant, low-pass filtering value after removing the constant and linear term, linear variation, and residual value as the output file record.

## 3.2.2 Reconstruction of the low-pass signal at all sampling epochs of given time series

[Function] According to the entered number of the low-pass parameters (here, the entered number should be no greater than the maximum number of the estimated low-pass parameters), reconstruct the low-pass time series with the sampling epochs corresponding to the given time series.

[Input files] The geodetic variations time series file to be reconstructed. The low-pass filtering parameters file, which be automatically called by the program without manual input.

[Parameter settings] Set the column ordinal number of the epoch time in the input file record, enter the number of the low-pass parameters to be reconstructed.

The number of the low-pass parameters used for reconstruction should not exceed the estimated number of the low-pass parameters. Otherwise, the program automatically takes the estimated number as the number of the low-pass parameters.

[Output file] The low-pass reconstruction variations time series file.

Behind the input time series file header, add two attributes including the constant term and linear term (annual rate of variation, /a) as the output file header.

Behind the input time series file record, add 4 attributes including the low-pass filtering value, low-pass filtering value after removing the constant, low-pass filtering value after removing the constant and linear term, and linear variation as the output file record.



# 3.2.3 Reconstruction of low-pass time series according to given sampling specification

[Function] Reconstruct low-pass time series according to the starting and ending epoch time, sampling interval (hours), and the entered number of the low-pass parameters.

[Input files] The low-pass filtering parameters file, which be automatically called by the program without manual input.

[Output file] The low-pass reconstruction variations time series file.

The output file header comes from the low-pass parameter file. The file record have 5 attributes including the sampling epoch time, low-pass filtering value, low-pass filtering value

after removing the constant, low-pass filtering value after removing the constant and linear term, and linear variation.

The starting-ending epoch time should be not earlier (or slightly earlier) than the starting time of the time series used to estimate the low-pass parameters, and not later (or slightly later) than the ending time of the time series.

	tion of low-pass erm of irregular	a parameters ar time series	d		nstruction of the low ling epochs of giver			Reconstruction to given sampling		series according
et the starting epoch	time 201501	05 🗘	>> Program P	rocess ** Opera	ition Prompts				al Sa	ve program process
et the ending epoch	time 2017121	6	output file rec	ord						
			>> Complete >> Computati >> [Function] number of the >> Save the n "* The output pass filtering v and linear var >> Setting pai ** Click the o >> Computati	the computation! on end time: 202 Reconstruct low I low-pass paran esult time series it file header com value, Iow-pass f iation. rameters have b control button [St on start time: 20 the computation!	22-03-03 12:08:53 -pass time series an teters. as C:/ETideLoad4. tes from the low-pa filtering value after r een imported in the fart computation], or 022-03-03 12:11:41	ccording to the st 0 win64en/exam ss parameter file emoving the con program! the tool button [	ples/Tmsrslowpfitr The file record ha stant, low-pass filte	constr/normrecon ve 5 attributes inc ring value after re	str.txt. luding the samp	rs), and the entered ling epoch time, low- stant and linear term,
			>> Computati		22-03-03 12:11:42				_	-
umber of parameter lisplay of the input-o	utput file↓	ng 90 🔹		le Save	22-03-03 12:11:42		mport setting para			Start computation

## 3.3 Weighted operation, difference, integral and interpolation on time series

[Purpose] Directly perform weighted operation, difference, integral and interpolation operations on the irregular time series in the given manner.

#### 3.3.1 Weighted operation between two attributes time series

[Function] Perform weighted plus, minus, or multiply operation between two attributes time series in the irregular time series file.

[Input file] The geodetic variations time series file.

The first row is the file header. Starting from the second row of the file, each row record stores the sampling values of all the variations at one sampling epoch time. The attributes in the record include the sampling epoch time and two attributes time series to be operated.

[Parameter settings] Set the input file format parameters, enter column ordinal number of the epoch time and two attributes time series to be operated in the record, and enter the two attribute weights. [Output file] The weighted operation result variations time series file.

Behind the input time series file record, add a column of the calculated values as the output file record.

😇 Weighted operation, difference, integral and interpolation on								
🛋 🖬 🏂		(a)	0					
	computation Save process	<b>***</b>	)					
Open file Save as Import parameters Start of	computation Save process	Follow example						
Weighted operation between	Difference operation o	n irregular	👞 Inte	gral operation o	n irregular		struction of time serie	s by interpolation
two attributes time series	variations time series		varia	ations time serie	es	from	another time series	
Open a geodetic variations time series	file >> Program Proc	ess ** Operation	Prompts				Save	program process as
Set the file parameters								
Column ordinal number of starting		ectly perform weig	hted operation,	difference, integ	gral and interpo	lation operation	ns on the irregular tir	ne series in the
MJD0 in the header	given manner.							
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in the record							eries in the irregular erinterp/ErrsepU.txt.	time series file.
Column ordinal number of the							rameters. After giving	the output file
first attribute time series		ontrol button [imp			and then set o	iner related par	rameters. Alter giving	g the output file
	>> Save the resi	Its time series as	C:/ETideLoad4	win64en/exar	mples/TmsrsAc	differinterp/olu	srst.txt.	
Select Weighted operation mode plus +	** Behind the in	put time series file	record, add a d	olumn of the ca	lculated values	as the output	file record.	
Column ordinal number of the	>> Setting param	eters have been i	mported in the p	rogram!				
second attribute time series	** Click the con	rol button [Start ci	omputation], or t	he tool button [	Start computati	on]		
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Weight of the second attribute time series 1.0000	>> Computation	end time: 2022-02	-24 10:53:50					
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	2015010212	2.2 1.0	-28.9982	-17.9572	-0.0035	-11.0409	-17.9607	
	2015010312 2015010412	6.51 2.0 9.96 3.0	-24.6847	-17.5105	-0.0070	-7.1742	-17.5175 -16.7922	
		9.96 3.0 2.85 4.0	-21.2312	-16.7818	-0.0104	-4.4494	-16.7922	
		2.55 5.0	-18.6342	-14.5776	-0.0139	-4.0566	-14,5950	
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			9.9862	-9.9554	-0.0278	19.9416	-9.9832	
		6.64 9.0	5.4697	-8.2409	-0.0313	13.7106	-8.2722	
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	2015011112 2015011212 2015011312 2015011412 2015011512 2015011612 2015011712	16.64         9.0           10.85         10.0           12.32         11.0           11.81         12.0           14.43         13.0           14.08         14.0           5.37         15.0           7.61         16.0	5.4697 9.6832 1.1567 0.6501 -6.7264 -7.0729 -15.7794 -13.5359	-8.2409 -6.5180 -4.8320 -3.2251 -1.7346 -0.3924 0.7761 1.7521	-0.0313 -0.0348 -0.0383 -0.0418 -0.0452 -0.0487 -0.0522 -0.0557	13.7106 16.2011 5.9887 3.8752 -4.9918 -6.6805 -16.5555 -15.2880	-8.2722 -6.5528 -4.8703 -3.2669 -1.7798 -0.4411 0.7239 1.6964	
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#### 3.3.2 Difference operation on irregular variations time series

[Function] Perform difference operation on a given irregular variations time series by calculating the weekly variation rate (namely per dt = 1/7). The result of the difference calculation is the weekly rate of the variations difference between before and after in variations time series, and the epoch time of the difference result is the middle time of the variations before and after.

The output file header comes from the input time series file. The output file record consists of four attributes including the sampling epoch time in ETideLoad format, number of days relative to the first sampling epoch, period of the difference (days), and the variation rate (per week, /wk).

#### 3.3.3 Integral operation on irregular variations time series

[Function] Perform integral operation on a given irregular variation time series by accumulating the weekly variation (namely dt = 7 days). The first sampling epoch value of the integration result time series is always zero, and the weekly rate at the middle epoch time is calculated by the Gaussian function interpolation method from the given time series. The accumulated value of each step is equal to the weekly rate at the middle epoch time multiplied by seven days.

The output file header comes from the input time series file. Behind the input time series file record, add a column of the calculated values as the output file record.



### 3.3.4 Construction of time series by interpolation from another time series

[Function] Using the irregular time series, interpolate the time series sampling value with the given sampling epochs according to the cubic spline interpolation or Gaussian function interpolation.

[Input file] The geodetic variations time series file to be interpolated. The geodetic variations time series file used for interpolation.

[Output] The interpolation result variations time series file.

The output file header comes from the input time series file. Behind the input time series file record, add a column of the interpolation sampling values as the output file record.



#### 3.4 Normalized extraction from batch time series of geodetic monitoring network

[Purpose] From the text files of batch geodetic sites or batch CORS network baselines that contain the specified time series data and are in the same format, extract data and generate the corresponding time series files according to the ETideLoad format.

The program requires all the source text files stored in a folder, and the source file name contains the site name or baseline name with the same number of. The extracted time series files are saved into another folder.

#### 3.4.1 Normalized extraction from batch time series of geodetic network sites

[Function] From the text files of batch geodetic network sites that contain the specified time series data with the same file format, according to the ETideLoad format, extract data

and generate the corresponding time series files, which are saved in the specified folder.

[Parameter settings]

The program requires that wildcards can uniquely identify files in the folder, and their instance characters will be also used as the extracted time series file name.

If there is no height attribute in the source file, or the entered height column ordinal number exceeds the maximum number of the attributes, the program automatically sets the height to zero.

If there is not the starting MJD0 in the header of the source file, please enter the starting time agreed in ETideLoad format. After entering the epoch time in ETideLoad format, the program would automatically calculate MJD day.

[Output files] Batch geodetic variations time series files in ETideLoad format.

The file header: The site name (instance of the file name wildcard), longitude, latitude, height, starting MJD0, and constant term (the first sampling value of the target time series).

The record format: The sampling epoch time, days relative to the starting MJD0, sampling value which has removed the first sampling value, other copy attributes.



The sum of the starting MJD0 in the header and the sampling epoch time (day) is equal to the sampling epoch time of MJD day in the record. When the sampling epoch time is in ETideLoad format, the starting MJD0 is not necessary for the file header.

#### 3.4.2 Normalized extraction from batch time series of CORS network baselines

[Function] From batch baseline solution files of the CORS network that contain the specified time series data with the same file format, according to the ETideLoad format, extract data and generate the corresponding baseline solution time series files, which are saved in the specified folder.

The program extracts the time series of one-dimension components of the ENU baseline solutions at a time.

101 represents the first row and first column, and 202 represents the second row and second column.

2 302 indicates that the attributes time series of 2 consecutive columns starting from the 3rd column will be saved into the target file. The program automatically ignores the column ordinal number that exceeds the attribute range of the source file record.

[Output files] Batch CORS baseline solutions time series files in ETideLoad format.

The file header: The baseline name (instance of the file name wildcard), starting station longitude, latitude, height, ending station longitude, latitude, height, starting MJD0, and constant term (the first sampling value of the target time series).

The record format: The sampling epoch time, days relative to the starting MJD0, sampling value which has removed the first sampling value, other copy attributes.



### 3.5 Processing and analysis on batch time series of geodetic monitoring network

[Purpose] On the specified attribute time series from batch variations time series files with the same format, perform gross error detection, linear term separation, low-pass filtering, and signal reconstructing, or calculate the mean time series according to the given period.

The program requires all source time series files saved in a folder. The output time series files are saved into the specified folder.

# 3.5.1 Gross error detection, low-pass filtering, and reconstructing for batch time series

[Function] On the specified attribute time series from batch time series files with the same format, estimate the low-pass filtering parameters, and use the low-pass filtering curve as a reference curve to detect gross errors, separate linear term, and then reconstruct the low-pass filtering value time series. The output time series files are saved in the specified folder.

[Input files] Batch geodetic variations time series files with the same formats.

The first row is the file header. Starting from the second row of the file, each row record stores the sampling values of all the variations at one sampling epoch time. At least one column of the attributes in the record is the sampling epoch time.



[Parameter settings] Set the wildcard patameters for batch variations time series files, enter column ordinal number of the epoch time and target attribute time series in the record, and enter the multiple of the standard deviation and number of low-pass filtering parameters.

The entered number of the low-pass filtering parameters is not more than 1/2 of the number of time series samples, and not less than 1/30 of the number of samples. When the entered number exceeds this range, the program automatically takes the minimum or maximum value.

[Output files] Batch low-pass filtering time series files. The linear variation file.

The low-pass filtering time series file. Behind the input file header, add two attributes including the constant term and linear term (annual variation rate) as the output file header. Behind the input file record, add 5 attributes including the low-pass filtering value, low-pass filtering value after removing the constant term, low-pass filtering value after removing the constant term, low-pass filtering value after removing the constant and linear term, linear variation, and residual value as the output file record.

The linear variation file TsqLinear#.txt (# is the column ordinal number of the specified attribute time series in the source time series file) without the file header. Each record of the file stores an input time series filtering information which includes the input time series file header, number of the filtering parameters, annual variation rate (per year, /a), constant term, and residual standard deviation after reconstruction.

#### 3.5.2 Batch time series averaging and record format time series construction

[Function] On the specified attribute time series from batch time series files with the same format, perform the average according to the given mode. The output time series is stored in two ways. The one is each time series saved as a file. The other is to arrange all the time series in rows, each record store a time series, and all the time series are stored into a records time series file.

[Input files] Batch variations time series files with the same format.

[Parameter settings] Set the wildcard patameters for batch variations time series files and input file format parameters, enter column ordinal number of the epoch time and target attribute time series in the record, and select the average period and type of the input time series files.

"The site variations time series" means that the sample of time series is the coordinate component, gravity, normal (orthometric) height, or tilt component of the ground site.

"Geodetic network time series" means that sample of the time series is the GNSS baseline component, leveling height difference, or gravity difference of the ground geodetic network.

[Output files] Batch mean variations time series files.

Behind the input file header, add the average mode (0 is the monthly average, 1 is the GPS weekly average, and 2 is the average of the given days) as the header of the average time series file. The record format: the middle epoch, average value, and number of the

#### samples used to average.



The program output the average values time series in the record format in the following two files.

(1) The average value records time series file. Each average time series is arranged as a row record into the records time series file, and the file name is TsqavrRow#.txt (# is averaging mode).

The file header: the number of chatacter of the time series name (equal to the number of wildcards), the number of the attributes (M) that represent location information, average mode (0~2), the number of samples (N), N sampling epochs.

The file record format: average time series name (wildcard instance), M location information, N average value (default 9999).

(2) The average number file TsqavrRkk#.txt (# is averaging mode). The file is in the same format as the records time series file, only replacing "average value" with the number of samples used to average.

After batch time series processing and analysis, plot and check the processing quality of each time series. When necessary, the functions [Separation and processing of the gross errors in irregular time series] and [Low-pass filtering and signal reconstructing for Irregular time series] can be called to process and analyze some a time series individually.

#### 3.6 Construction and analysis on records time series from geodetic network

[Purpose] Construct and analyze the variation records time series composed of multiperiods or continuous data of the geodetic monitoring network.

The records time series file is used to represent the time series of a certain monitoring quantity in the geodetic network composed of multi-sites. One record represents a variation time series for a geodetic site, a GNSS baseline component, a gravity difference, a leveling route height difference, or an InSAR monitoring point.

# 3.6.1 Construction of records time series from batch time series with same specifications

[Function] From batch time series files with the same specifications (same sampling time span and interval) stored in a folder, construct a records time series file according to the specified attribute.

The program calculates the maximum-minimum values of the sampling epochs and the minimum sampling interval in all the time series to build a new sampling specification. Each record stores one time series of the specified attribute, whose location information comes from the header of the corresponding input file. An attribute of 9999.000 indicates that there is no valid sampling value at the current epoch time.

[Input files] Batch time series files with the same sampling specifications.

Open folder Save as Import parameters Start comput	tation Save process Follow example		
	tion repair for missing in records time series Time-space statist separation for reco	tics and space-mean Removal or addition of sampli ributes for records time series	
Open any time series file in the folder	>> Program Process ** Operation Prompts		save program process
dinal Number of the first wildcard in the filmfame 1 mber of consecutive wildcards in file name 4 location parameters in header 203 lumn ordinal number of starting MUC in header 5 lumn ordinal number of sampling time in record 1 lumn ordinal record of the target 5 mbute time series in record	rew samping specificator. Each record st Coregoording input (it.e., antitubute of 996 Coregoording input (it.e., antitubute of 996 The file neader, this means and core of 996 The file neader, this means and core of 996 Coregoording input (it.e., antitubute of 996 Coregoording input (it.e., antit.e., antitubute of 996 Coregoording inteut (it.e., antitubut	minimum values of the sampling epochs and the minimum ores one time series of the specified attribute, whose local 9.000 incleates that there is no valid sampling value at the ETGLeLocAL O_windEnvicosmitter Timecordanalysproci- text box below, set the format parameters of the records in locad 0 windEnvicosmitter Timecordanalysproci- tands 0 windEnvicosmitter Timecordanalyspro- actives of the time series name, the number of the columns to location information (generally 3 to 4 attributes for a site event of the time series name, the number of the columns teocration information (generally 3 to 4 attributes for a site event information (generally 3	tion information comes from the header of the current epoch time. tationsrst/SCPZ_U.bt. ne series file draft bt occupied by the location information of the g epochs sorted by time.
	>> Complete the Computation! >> Computation end time: 2022-02-24 16:1	2:06	
	Note: Save the results as	Import setting parameters	Start computation
	Save the results as Display of the input-output file	Import setting parameters	Start computation
MELL STATE	Display of the input-output file	0 2018010300 2018010400 2018010500 2018010	600 2018010700 2018010800 2018010900
M2.5. tot D DATA 2016/010 2016/00	Signal of the input-output file;           5         4:3         1091         C018010100         201801021           5         7107         1017403         26.5002         1157.55           7         7107         1008505         24.6171         1244.60           7         1008505         24.6171         1244.60           7         1008505         24.6171         1244.60           7         1008505         24.6171         1244.60           7         1008505         24.6171         1244.60           7         100.07550         24.6171         1244.60           7         101.015805         24.6171         1244.61           7         101.015805         24.612         1470.12           7         101.9661         24.1024         197.79           7         101.9661         24.024         197.79           7         100.7539         26.6831         2143.89	00 2018010300 2018010400 2018010500 2018010	400 2018010700 2018010800 2018010800 50 -11.41000 -1.1200 5.0000 0 -11.4100 -0.4200 5.0000 0 -0.5200 -0.4400 4.0500 0 -0.5200 -13.1100 -6.9300 0 1.1200 -3.4200 0.3000 0 3.3600 6.4500 14.2400

[Parameter settings] Set the wildcard patameters for batch variations time series files and site location parameters in the input file header, enter column ordinal number of the epoch time and target attribute time series in the record.

[Output files] The variation records time series file.

The file header: the number of characters of the time series name, number of columns occupied by the location information of the monitoring object in the record, length of the time series (number of samples), and all the sampling epochs arranged with time.

The file record: the time series name, location information (generally 3 to 4 attributes for a site, 6 to 8 attributes for a baseline or route), sampling variations arranged with sampling time.

### 3.6.2 Interpolation repair for missing samples in records time series

[Function] Interpolate and repair the missing samples in the variation records time series by the cubic spline or Gaussian function interpolation method. The function is not suitable for short-time estimation and prediction. For more missing samples repaired, please use the function [Low-pass filtering and signal reconstructing for Irregular time series].

When there are more noise or missing samples in time series signals, Gaussian function interpolation is recommended.



## 3.6.3 Time-space statistics and space-mean separation for records time series

[Function] Firstly, calculate the time average, standard deviation, minimum and

maximum of each variation record time series during the entire sampling period. Then calculate the spatial average, standard deviation, minimum and maximum of all variations at each sampling epoch time. Finally, calculate the spatiotemporal average, standard deviation, minimum and maximum of all variations during the entire sampling period.

[Input file] The variation records time series file.

The sampling epochs in the header are no one-by-one correspondence with the sampling variations in the record.

[Parameter settings] Set the input file format parameters, enter column ordinal number of the epoch time in the header and target attribute time series in the record, and select the checkbox of time-space separation of records time series and converting records time series into site time series.

[Output files] The statistics results file on records time series, the variation records time series file after removing the space average, the variation records time series file after removing the time average, and the spatial statistics time series file.

The statistics results file on records time series file. No file header, and the record format: all the attributes between the first attribute and the first sampling value (excluding the first sampling value) from the input records time series, the time average, standard deviation, minimum and maximum of the time series.

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The spatial statistics time series file. The file header: Epoch\_statistics, spatial mean of

longitudes, latitudes, and heights for all the points, the spatiotemporal mean, standard deviation, minimum and maximum of all sampling variations over the entire sampling time span. The record: The sampling epoch time, valid sampling variations number at the epoch time, spatial mean, standard deviation, minimum, and maximum.

#### 3.6.4 Removal or addition of sampling attributes for records time series file

[Function] Remove several consecutive columns of the sampling attributes from the record in the records time series file, and then remove the corresponding sampling epoch time in the file header. Or extract several consecutive columns of the attributes in the discrete point records file and add them before the first sampling attribute in the record of the time series file.

When adding some sampling attributes from the discrete point records file to records time series, the program requires the point value records file to have one and only a row header and the location of discrete points and the location of monitoring quantities of the records time series correspond one to one.



#### 3.6.5 Removal or restoration of linear variations for records time series

[Function] From the variation records time series file record, select the column ordinal number of the linear term parameter (annual variation rate), then according to the given reference epoch time (at this time, the linear variation is equal to zero), calculate the linear variation records time series, and then remove or restore the linear variations from the input

variation records time series.

[Input file] The variation records time series file.

[Parameter settings] Set the input file format parameters, enter column ordinal number of the linear term parameter in the record and the reference epoch time, and select to remove or restore the linear term.

[Output files] The result variation records time series file. The result file format is the same as that in the input records time series file.



## 3.7 Processing and analysis on variation (vector) grids time series

[Purpose] Perform operations such as the reference epoch transformation, difference, and statistical analysis on the variation (vector) grids time series in the specified folder. The variation (vector) grids time series files are extracted according to the given wildcards.

The variation (vector) grids time series is composed of a series of numerical grid files of a certain kind of variation (vector), and the seventh attribute of the file header in each grid file is agreed to be the sampling epoch.

#### 3.7.1 Reference epoch transformation for grids time series

[Function] Unify the reference epoch time for all the variation (vector) grids time series by subtracting the variation (vector) grid at the given sampling time. After the epoch is unified, the variation grid values on the reference epoch time are always zero.

#### 3.7.2 Low-pass filtering operation on grids time series

[Function] Using the low-pass filters such as the moving average, Gaussian, exponential,

or Butterworth, perform low-pass filtering on the variation grids time series. Before and after filtering, the grid specifications (Latitude and longitude range and spatial resolution) remain unchanged.

For the moving average filtering, the greater the filtering parameter n, the greater the filtering strength. For "Gaussian", "Exponential" or "Butterworth" filters, the smaller the n, the greater the filtering strength.



#### 3.7.3 Statistical analysis on variation (vector) grids time series

[Function] Calculate the space average, standard deviation, minimum and maximum of the variation (vector) grids time series at each sampling epoch time, to generate the space average, standard deviation, minimum and maximum (four attributes) time series file. Then generate a new variation (vector) grids time series by removing the space average grid at each epoch time. Finally, calculate the time average, standard deviation, minimum and maximum of the time series of each (vector) grid element, to generate time average, standard deviation, minimum and maximum (vector) four grids files.

The program outputs the space average, standard deviation, minimum and maximum time series file gridstatmsqu.txt of the variation (vector) grids time series.

The file header: tmgridstatitics, the grid center longitude, latitude, zero value. The record:

the sampling epoch time of the variation (vector) grids time series, the space average, standard deviation, minimum and maximum of the grid at sampling epoch time.

The program also outputs the time average, standard deviation, minimum and maximum (vector) grid files gridtmavr.dat, gridtmstd.dat, gridtminv.dat, and gridtmaxv.dat.



## 3.7.4 Coordinate form transformation for variation vector grids time series

[Function] The variation vector representation in the variation vector grids time series is transformed between the polar coordinate form (r, a) and the plane rectangular coordinate form (E, N).

#### 3.7.5 Removal and restoration of linear variations for grids time series

[Function] Using the annual variation (vector) rates grid, calculate the linear variation (vector) grids time series according to the given reference epoch time (the linear variation at reference epoch time is always equal to zero), and then remove or restore the linear variations of the variation (vector) grids time series.

#### 3.8 Multi-form spatiotemporal interpolation from grids time series

[Purpose] From the variation (vector) grids time series files in the specified folder, construct the variations time series according to the location and sampling specifications by the specified space and time interpolation method. The variation (vector) grids time series files are extracted according to the given wildcards.

The latitude and longitude of the site to be interpolated should not exceed the latitude and longitude range of the grids time series, and the interpolated epoch should not exceed the sampling time range of the grids time series by too much.

When there is large noise or more default values in the variation (vector) grids or their
time series, Gaussian function interpolation is recommended for space interpolation, and the trigonometric function method is recommended for time interpolation.

## 3.8.1 Interpolation of irregular variation time series from grids time series

[Function] From the variation (vector) grids time series files, construct the irregular variations time series according to the location and sampling specification in the input irregular time series by the specified two-dimensional space interpolation and one-dimensional time interpolation method.

[Input file] The variation (vector) grids time series files. The site variations time series file to be interpolated.

[Parameter settings] Set the wildcard patameters for the variation (vector) grids time series files and the site variations time series file format parameters. Select the space interpolation and time interpolation method.



# 3.8.2 Interpolation of given records time series from grids time series

[Function] Using the specified two-dimensional space interpolation and one-dimensional time interpolation method, interpolate to obtain all the sampling values of the input records time series from the variation grids time series files. The output records time series file format is the same as the input records time series file.

The program also outputs the remnant variation records time series file (file extension rnt) into the current folder. The format is the same as the input records time series file. Here the remnant variation is equal to the difference between the input sample value and the interpolation.



## 3.8.3 Interpolation at the given location and time from grids time series

[Function] Using the specified two-dimensional space interpolation and one-dimensional time interpolation method, interpolate or estimate the sampling value at the given location and epoch time from the variation grids time series files.

## 3.8.4 Construction of records time series by space-time interpolation

[Function] Using the specifed two-dimensional space interpolation and one-dimensional time interpolation method, from the variation grids time series files, construct the records time series at the given location sites in the input discrete points file according to the given sampling time specifications.



# 3.8.5 Reconstruction of grids time series according to given spatiotemporal resolution

[Function] Using the specified two-dimensional spatial interpolation and onedimensional time interpolation or estimation method, increase or decrease the spatial and temporal resolution of the grids time series according to the given grid spatial resolution and time sampling specification, and then calculate time-derivative (per week, /wk) of the variation grids time series.

The program output the variation (vector) grids time series files grdtmsp\*.dat and their time-derivative (vector) grids time series files grdtmdf.dat (per week, /wk).



# 4 Approaching of load-deformation field or temporal gravity field

The non-tidal load variations of atmosphere, sea level, soil water, groundwater, rivers, lakes, glaciers, ice caps, and snowy mountains in the Earth's surface layer, excite solid Earth deformation, which can cause variations of various geodetic quantities with time. These variations can also be quantitatively captured by a variety of ground, space, or ocean geodetic technologies.

Using the consistent geophysical models, uniform numerical standards, and compatible algorithms to monitor and represent various geodetic non-tidal effects, are an important basis for 1cm (20µGal) accuracy level geodesy. And are also necessary conditions to realize the collaboration of the geodetic multi-technologies, the deep fusion of the multi-source heterogeneous geodetic data, and construction and maintenance of a high-accuracy geodetic datum frame.



# 4.1 Spherical harmonic analysis on global surface load time series

[Purpose] From the global grid model of the surface loads such as land/sea surface air pressure, land water, and sea level variation, generate a normalized surface load spherical harmonic coefficients model by spherical harmonic analysis. Using the model, the non-tidal load effects on various geodetic quantities outside the solid Earth can be computed by the spherical harmonic synthesis method.

The spherical harmonic coefficient degree n is equal to the number of grid-elements of

global surface load grid in the latitude direction. For example, the 0.25° × 0.25° global surface load grid corresponds to n=720.

# 4.1.1 Construction of global surface data grid in spherical coordinates

[Function] From the global land/sea surface discrete point value data, according to the simple average method and given spatial resolution, construct the spherical coordinate grid model. When there is no valid discrete point data in the grid element region, the value on the grid element is set to zero.

[Input files] A series of global land/sea surface discrete point value data files with the same format.

The file record format: Point number (name), longitude, latitude (decimal degrees), ..., attribute to be gridded, ....

[Parameter settings] Set the wildcard patameters of the input file names. enter the number of rows of the input file header, row ordinal number of target attribute in the file record, and grid resolution.

[Output files] A series of spherical coordinate grid files that correspond one-to-one with the input discrete point value files.



# 4.1.2 Spherical harmonic analysis on global surface air pressure variations

[Function] From the global land/sea surface air pressure variation (in unit hPa) spherical coordinate grids time series, compute the air pressure non-tidal load spherical harmonic coefficient models (in unit m) time series by normalized spherical harmonic analysis.

The spherical coordinate grids time series files are extracted according to the given wildcards.

[Input files] The global land/sea surface air pressure variation spherical coordinate grids time series files.

[Parameter settings] Set the wildcard patameters for the file names of grids time series and enter the iteration condition parameters.

[Output files] The surface air pressure load spherical harmonic coefficients model files airpress\*\*\*cs.dat, iteration process statistics file pro\*\*\*.ini and residual air pressure grid file rnt\*\*\*.dat. Here, \*\*\* are the instance of the given wildcards.



The file header of the airpress\*\*\*\*cs.dat: the geocentric gravitational constant GM (×10<sup>14</sup>m<sup>3</sup>/s<sup>2</sup>), equatorial radius of the Earth a (m), zero degree term  $a\Delta C_{\infty}$  (hPa), relative error  $\Theta$  (%). Where  $\Theta$  is the residual standard deviation of the last step iteration as a percentage of the standard deviation of the original grid values, and *GM*, *a* are also known as the scale parameter of the spherical harmonic coefficient model.

The zero degree term represents the variations of the total atmospheric mass caused by the variation of global atmospheric pressure, which is meaningless under the condition of Earth's atmospheric mass conservation. The three first degree spherical harmonic coefficients ( $\Delta C_{10}$ ,  $\Delta C_{11}$ ,  $\Delta S_{11}$ ) represent variations of the Earth's center of mass due to the variations of global atmospheric pressure.

#### 4.1.3 Spherical harmonic analysis on global land water variations

[Function] From the global land equivalent water height variation (in unit cm) spherical coordinate grids time series, compute the land water non-tidal load spherical harmonic coefficient models (in unit m) time series by normalized spherical harmonic analysis.

[Input files] The global land equivalent water height variation spherical coordinate grids time series files. The land-sea terrain spherical coordinates grid file.

The spatial resolution of the land-sea terrain grid should not be lower than the spatial resolution of the surface loads grid.

[Parameter settings] Set the wildcard patameters for the file names of grids time series and enter the iteration condition parameters.

[Output files] The global land water load spherical harmonic coefficients model files Indwater\*\*\*cs.dat, Iteration process statistics file pro\*\*\*.ini and Residual air pressure grid file rnt\*\*\*.dat. Here, \*\*\* are the instance of the given wildcards.

The file header of the Indwater\*\*\*cs.dat: the geocentric gravitational constant GM (×10<sup>14</sup>m<sup>3</sup>/s<sup>2</sup>), equatorial radius of the Earth a (m), zero degree term  $a\Delta C_{00}$  (cm), relative error  $\Theta$  (%).

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The three first degree spherical harmonic coefficients ( $\Delta C_{10}$ ,  $\Delta C_{11}$ ,  $\Delta S_{11}$ ) represent variations of the Earth's center of mass due to variations of global land water. For global geodetic purposes, the first degree spherical harmonic coefficients needs to be taken into account. The zero-order term can be controlled to a small value by adjusting the time datum.

## 4.1.4 Spherical harmonic analysis on global sea level variations

[Function] From the global sea level variation (in unit cm) spherical coordinate grids time series, compute the sea level variation non-tidal load spherical harmonic coefficient models (in unit m) time series by normalized spherical harmonic analysis.

[Input files] The global sea level variation spherical coordinate grids time series files. The land-sea terrain spherical coordinates grid file.

The spatial resolution of the land-sea terrain grid should not be lower than the spatial resolution of the surface loads grid.

[Parameter settings] Set the wildcard patameters for the file names of grids time series and enter the iteration condition parameters.

Iteration termination condition: The standard deviation of the residual grid value is less than a% of the standard deviation of the original grid value, or the difference of the residual standard deviation of the previous step iteration relative to the current step iteration is less than b‰ of the standard deviation of the original grid values.

[Output files] The global sea level variation load spherical harmonic coefficients model files seachg\*\*\*cs.dat, iteration process statistics files pro\*\*\*.ini and residual sea level variation grid files rnt\*\*\*.dat. Here, \*\*\* are the instance of the given wildcards.



The three first degree spherical harmonic coefficients ( $\Delta C_{10}$ ,  $\Delta C_{11}$ ,  $\Delta S_{11}$ ) represent variations of the Earth's center of mass due to global sea level variations. For global geodetic purposes, the first degree spherical harmonic coefficients needs to be taken into account. The zero-order term can be controlled to a small value by adjusting the time datum.

For global geodetic purposes, the zero constraint should be considered that the sum of the zero-order terms of sea, land and atmosphere at any epoch time is equal to zero, that is, the total loads of sea level, land water and atmospheric pressure variations is conserved.

# 4.2 Spherical analysis on tide parameters and construction of tidal load model

[Purpose] From the tidal constituent harmonic parameters grid of the global land/sea air pressure or ocean height, generate a normalized tidal load spherical harmonic coefficients model by spherical harmonic analysis. The model format is the same as FES2004 ocean tidal load model in the IERS conventions (2010). Using the model, the tidal load effects on various geodetic quantities outside the solid Earth can be computed by the spherical harmonic synthesis method.

## 4.2.1 Construction tidal harmonic parameters grid in spherical coordinates

[Function] From the tidal constituent harmonic parameters of the surface air pressure or ocean height on the discrete points, according to the simple average method and given spatial resolution, construct spherical coordinate harmonic parameters vector (prograde amplitude, retrograde amplitude) grid model. When there is no valid discrete harmonic parameter data in the grid element region, the vector on the grid element is set to zero.

[Input files] A series of global discrete tidal constituent harmonic parameters files with the same format.



The program requires at least one row of file header in the tidal constituent harmonic parameters file, and there are the name and Doodson constant of the tidal constituent in the

file header.

The Doodson constant (integer, such as M<sub>2</sub> tidal Doodson constant is 255555) is the basis for ETideLoad prgrams to identify the tidal type and calculate the tidal frequency, and it should be correct.

[Parameter settings] Set the wildcard patameters of the input file names. Enter the number of rows of the input file header, column ordinal number of the tidal constituent name and its Doodson constant the input file header, column ordinal number of the component 1 and 2 of harmonic parameters in the record, and select the form of harmonic parameters.

[Output files] The spherical coordinate grid files of the tidal constituent harmonic parameters sph\*\*\*.dat. Here, \*\*\* are the tidal constituent's name.

# 4.2.2 Spherical harmonic analysis on surface air pressure tidal harmonic parameters

[Function] From the surface air pressure tidal constituent harmonic parameter (in unit hPa) spherical coordinate grid, compute the surface air pressure tidal load spherical harmonic coefficients model (in unit hPa) in FES2004 format by normalized spherical harmonic analysis.

The tidal constituent harmonic parameter vector spherical coordinate grid files are extracted according to the given wildcards.



[Input files] All the surface air pressure tidal constituent harmonic parameter vector spherical coordinate grid files.

[Parameter settings] Set the wildcard patameters for the file names, enter the column ordinal number of the tidal constituent's name and its Doodson constant the input file header, and set the iteration condition parameters.

[Output files] The surface air pressure tidal load spherical harmonic coefficients model file Airtdloadcs.dat, all tidal constituent spherical harmonic coefficients model files airptide\*\*\*cs.dat, iteration process statistics files pro\*\*\*.ini and residual harmonic parameter grid files rnt\*\*\*.dat. Here, \*\*\* are the tidal constituent's name.

### 4.2.3 Spherical harmonic analysis on ocean tidal constituent harmonic parameters

[Function] From the ocean tidal constituent harmonic parameter (in unit cm) spherical coordinate grid, compute the ocean tidal load spherical harmonic coefficients model (in unit cm) in FES2004 format by spherical harmonic analysis.

[Input files] All the ocean tidal constituent harmonic parameter vector spherical coordinate grid files. The land-sea terrain spherical coordinates grid file.

The land-sea terrain spherical coordinates grid is used for the land-sea separation for the ocean tidal harmonic parameters, whose resolution should not be lower than the resolution of the ocean tidal constituent harmonic parameters grid.



[Output files] The ocean tidal load spherical harmonic coefficients model file Otideloadcs.dat, all tidal constituent spherical harmonic coefficients model files Otidetide\*\*\*cs.dat, iteration process statistics file pro\*\*\*.ini and residual harmonic parameter grid file rnt\*\*\*.dat. Here, \*\*\* are the tidal constituent's name.

The unit of the tidal constituent harmonic parameters is the same as the unit of the spherical harmonic coefficients. The unit of the surface air pressure tidal harmonic parameters and the load spherical harmonic coefficients is hPa, and the unit of the ocean tidal harmonic parameters and the load spherical harmonic coefficients is cm.

## 4.3 Computation of the model value by spherical harmonic synthesis

[Purpose] From the tidal load spherical harmonic coefficients model or the surface nontidal load spherical harmonic coefficients model, calculate the model values of the tidal harmonic parameters or the non-tidal surface loads by spherical harmonic synthesis.

Adopting the remove-restore process, the program can be used for regional tidal load effects refinement based on the tidal load spherical harmonic coefficients model, and for regional load-deformation field and temporal gravity field approaching based on the surface load spherical harmonic model.

## 4.3.1 Computation of model value of surface load equivalent water height

[Function] From the surface air pressure, land water, or sea level variation load normalized spherical harmonic coefficients model (m), compute the model value of the surface air pressure (hPa), land equivalent water height (cm), or sea level variation (cm) at the given location.

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[Input files] The discrete calculated points file. The surface load spherical harmonic coefficients model file.

The calculated points file record format: Point number (name), longitude, latitude (decimal degrees), ....

[Parameter settings] Enter maximum truncated degree of the coefficients model, and select the type of surface loads.

The program automatically selects the minimum value between the maximum degree of the spherical harmonic coefficients model and the entered maximum degree as the calculated degree.

[Output file] The surface load model values file.

The output file header comes from the input calculated points file. Behind the input file record, add a column of the model value of surface load as the output file record.

## 4.3.2 Computation of model values of tidal constituent harmonic parameters

[Function] From the surface air pressure or ocean tidal load normalized spherical harmonic coefficients model (hPa/cm), compute the harmonic parameter model values (hPa/cm) of all tidal constituents in the harmonic coefficients model at the given location.

[Input files] The discrete calculated points file. The tidal load spherical harmonic coefficients model file.

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t records <u>\$1164556</u> \$2 273555 1 104.041667 25.041667 0.000 2 104.125000 25.041667 0.000 3 104.20833 25.041667 0.000 4 104.291667 25.041667 0.000 5 104.375000 25.041667 0.000	$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	0,31/ 1,364 0,290 1,347 0,276 1,330 0,257 1,312 0,255 1,295
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t records <u>31 164596 82 273555</u> 1 104.041667 25.041667 0.000 3 104.200333 25.041667 0.000 3 104.200333 25.041667 0.000 6 104.405333 25.041667 0.000 6 104.458333 25.041667 0.000 8 104.42500 25.041667 0.000 9 104.425033 25.041667 0.000	-1.76         1.309         0.240         1.303         -0.214         -5.819           -1.755         1.300         0.240         1.304         -0.459         -5.935           -1.737         1.289         0.239         1.304         -0.459         -5.935           -1.720         2.74         0.238         1.305         -0.431         -6.176           -1.760         1.574         0.232         1.305         -0.212         -6.306           -1.761         1.574         0.232         1.305         -0.212         -6.306           -1.695         1.69         -1.69         -1.69         -1.69         -1.69         -1.69           -1.695         1.305         -0.212         -3.004         -6.514         -6.514           -1.695         1.40         -1.69         -6.20         -6.306         -6.20           -1.699         1.40         -1.69         -6.20         -6.20         -6.20         -6.20           -1.699         1.40         -1.69         -6.20         -6.20         -6.20         -6.20           -1.699         1.40         -6.20         -6.20         -6.20         -6.20         -6.20           -1.699         1	U.317 1.764 0.220 1.347 0.275 1.347 0.275 1.312 0.235 1.255 0.218 1.225 0.218 1.228
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $	-1.76         1.309         0.240         1.303         -0.514         -5.815           -1.755         1.300         0.240         1.304         -0.459         -5.935           -1.737         1.289         0.239         1.304         -0.459         -5.935           -1.737         1.289         0.239         1.304         -0.451         -6.074           -1.702         2.274         0.238         1.305         -0.338         -6.176           -1.704         1.257         0.235         1.306         -0.272         -6.300           -1.641         1.48         0.232         1.307         -0.204         -6.425           -1.658         1.42         1.764aad.7         2.024         -6.425           -1.675         1.2         1.764abd.7         2.024         -6.425           -1.674         1.764bbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbb	U-31.7         1340           0201         1347           0276         1347           0276         1327           0.235         1278           0.235         1278           Ciliant Cost         0278           1278         1278           Ciliant Cost         02184           -020101         020101           -020101         020101           -0201011         020101           -0201012         0201040001           -0201012         0201040001           -0201012         0201040001           -0201012         0201040001           -0201012         0201040001           -0201012         0201040001           -0201012         0201040001           -0201012         0201040001           -0201012         0201040001           -0201012         0201040001
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$ \begin{array}{c c c c c c c c c c c c c c c c c c c $	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	U-31.7         1340           0.201         1347           0.276         1.334           0.276         1.332           0.235         1.258           0.210         1.278           0.235         1.278           1.278         1.278           1.200         0.01356           0.210         0.010466           0.210         0.010466           0.210         0.010466           0.210         0.010466           0.000000         0.010466           0.000000         0.0104666           0.000000         0.0104666           0.000000         0.000000           0.000000         0.000000           0.000000         0.000000           0.000000         0.000000           0.000000         0.000000           0.000000         0.000000           0.0000000         0.000000           0.0000000         0.0000000           0.0000000         0.0000000           0.0000000         0.0000000           0.00000000         0.0000000           0.00000000         0.00000000           0.00000000         0.00000000           0.0
t records $\underline{11164556}$ 82 273555 1 104.041667 25.041667 0.000 2 104.12500 25.041667 0.000 3 104.208333 25.041667 0.000 5 104.428333 25.041667 0.000 5 104.437500 25.041667 0.000 7 104.541667 25.041667 0.000 9 104.420833 25.041667 0.000 1 04.708333 5.041667 0.000 1 04.70833 25.041667 0.000 1 04.87500 25.041667 0.000 1 000 200 200 200 200 200 200 2 000 200 200 200 200 200 2 000 200 200 200 200 200 200 200 200 2	-1.76         1.309         0.240         1.303         -0.514         -5.815           -1.755         1.300         0.240         1.304         -0.459         -5.935           -1.737         1.289         0.239         1.304         -0.459         -5.935           -1.737         1.289         0.239         1.305         -0.338         -6.176           -1.700         1.274         0.238         1.305         -0.338         -6.176           -1.700         1.257         0.235         1.306         -0.272         -6.300           -1.694         1.48         0.232         1.307         -0.204         -6.425           -1.695         1.4         0.232         1.307         -0.204         -6.425           -1.691         1.575         1.1         1.576         1.566         1.566         -0.272         -6.300           -1.675         1.1         1.578         1.5         1.566         -0.274         -6.425           -1.674         1.145         1.566         1.566         -566         -566         -566           -1.674         1.456.56         1.1         -5614.417         -564         -5626666         -52766666         -52766666 <td>U.3.17         1.764           0.226         1.347           0.775         1.347           0.725         1.322           0.235         1.225           0.211         1.275           0.235         1.225           0.210         0.235           0.235         1.225           0.210         0.215841           0.010437         0.004437           0.010437         0.005431           0.010437         0.005431           0.010437         0.005431           0.010437         0.005431           0.010437         0.005431           0.010437         0.005431           0.0105431         0.0110541           0.0105431         0.0110541           0.0105431         0.0110541           0.0105431         0.0110541           0.0105431         0.0110541           0.0105431         0.0110541           0.0105431         0.0110541           0.0105441         0.0110541           0.0105441         0.0110541           0.0105441         0.0110541           0.010541         0.0110541           0.010541         0.0110541           <t< td=""></t<></td>	U.3.17         1.764           0.226         1.347           0.775         1.347           0.725         1.322           0.235         1.225           0.211         1.275           0.235         1.225           0.210         0.235           0.235         1.225           0.210         0.215841           0.010437         0.004437           0.010437         0.005431           0.010437         0.005431           0.010437         0.005431           0.010437         0.005431           0.010437         0.005431           0.010437         0.005431           0.0105431         0.0110541           0.0105431         0.0110541           0.0105431         0.0110541           0.0105431         0.0110541           0.0105431         0.0110541           0.0105431         0.0110541           0.0105431         0.0110541           0.0105441         0.0110541           0.0105441         0.0110541           0.0105441         0.0110541           0.010541         0.0110541           0.010541         0.0110541 <t< td=""></t<>
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$ \begin{array}{c c c c c c c c c c c c c c c c c c c $	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	U.J.J.F.         1.364           0.296         1.347           0.296         1.347           0.295         1.347           0.275         1.332           0.295         1.347           0.275         1.322           0.295         1.322           0.295         1.232           0.295         0.2157           0.295         0.2157           0.295         0.2157           0.295         0.2157           0.295         0.2157           0.295         0.2157           0.295         0.2157           0.295         0.2157           0.295         0.2157           0.295         0.2157           0.295         0.2157           0.295         0.2157           0.295         0.2158           0.010461         0.2158           0.010461         0.2158           0.010461         0.2158           0.010461         0.2158           0.0010461         0.2158           0.0010461         0.2158           0.0010461         0.2158           0.0010461         0.2158           <
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	U-31.7         1345           0.200         1347           0.270         1347           0.271         1347           0.272         1347           0.235         1278           0.235         1278           0.236         1278           0.237         0236           0.238         1278           0.201         0.0000000           0.235         1278           0.0000000         0.0000000           0.00000000         0.0000000           0.00000000         0.00000000           0.00000000         0.0000000           0.00000000         0.00000000           0.000000000         0.00000000           0.00000000000000000000000000000000000
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	U.317         1.356           0.296         1.347           0.296         1.347           0.295         1.347           0.275         1.332           0.295         1.232           0.296         1.232           0.296         1.232           0.2970         1.232           0.2010         1.272           0.2010         1.272           0.2010         0.2010           0.2010         0.2010           0.2010         0.2010           0.2010         0.2010           0.2010         0.2010           0.2010         0.2010           0.2010         0.2010           0.2010         0.2010           0.2010         0.2010           0.2010         0.2010           0.2010         0.2010           0.2010         0.2010           0.2010         0.2010           0.2010         0.2010           0.2010         0.2010           0.2010         0.2010           0.2010         0.2010           0.2010         0.2010           0.2010         0.2010           0.2010 </td

[Output file] The tidal harmonic parameter model values file.

The output file header comes from the input calculated points file. Behind the input file record, add 2n columns of the tidal harmonic parameter model values as the output file record. Here, n is the number of tidal constituents in the harmonic coefficients model.

## 4.3.3 Computation of model values time series of load equivalent water height

[Function] From the surface air pressure, land water, or sea level variation load normalized spherical harmonic coefficients model (m) time series, compute the records time series of the model value of the air pressure (hPa), land equivalent water height (cm), or sea level variation (cm) on the given points in the input file.

[Input files] The discrete calculated points file. The surface load spherical harmonic coefficients model time series files.

[Parameter settings] Set the wildcard patameters for the surface load spherical harmonic coefficients model time series files. Enter the number of rows of the input file header, row ordinal number of target attribute, and grid resolution.

	Computation of mo oad equivalent wa		f surface			on of model val harmonic para				tation of model v equivalent water		ries
0 📓	Open the calculate	d points file	:	>> Program Pro	ocess ** Operati	on Prompts				42	Save program	n process
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	ated degree of the	coefficient	model 180	just been comp >> Computatio >> Complete th >> Computatio	leted. n start time: 202 e computation on n end time: 2022	22-03-04 14:33 f the load EWH	:48 I model values 2					t compu
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[Output file] The surface load model value records time series file.

Behind the input file header, add n sampling epoch times of the surface load spherical harmonic coefficients model time series as the output file header. Behind the input file record,

add n load model values as the output record. Here, n is the sampling number.

The computation process needs to wait... During the computation period, you can open the output files to look at the computation progress!

The instance wildcards in the file header represent that the computation of the model value at the corresponding epoch time has just been completed.

Combining with the function [The regional refinement of tidal load effects by Green's Integral], you can refine the regional air pressure or ocean tidal effects by the remove-restore process based on the tidal load spherical harmonic coefficients model.

Combining with the function [Regional approaching of the load-deformation field by Green's Integral], you can approach the regional load-deformation field or temporal gravity field by remove-restore process based on global load spherical harmonic coefficients model.

Due to the mixing effects of the high-degree spherical harmonic coefficients, the model values of the sea level variation and ocean tidal harmonic parameters are not zero in the coastal land area, and the model values of the land equivalent water heigh are not also zero in the coastal sea area.

## 4.4 Computation of load-deformation field by spherical harmonic synthesis

[Purpose] From the surface air pressure, land water, and sea level variation load spherical harmonic coefficients model (m), compute the load effects on various geodetic variations on the ground or outside the solid Earth by the spherical harmonic synthesis algorithm.

The time of the load effects is equal to the sampling epoch time of the load spherical harmonic coefficients model.

When computing the load effects of sea level variations, the height of the calculated point is the normal or orthometric height. When computing the load effects of surface air pressure or land water variations, the height of the calculated point is the height relative to the Earth's surface.

#### 4.4.1 Computation of various load effects by spherical harmonic synthesis

[Function] From the surface air pressure, land water, and sea level variation load spherical harmonic coefficients model (m), compute the load effects on the geoid or height anomaly (mm), ground gravity ( $\mu$ Gal), gravity disturbance ( $\mu$ Gal), ground tilt (SW, to the south and to the west, mas), vertical deflection (SW, to the south and to the west, mas), horizontal displacement (EN, to the east and to the north, mm), ground radial displacement (mm), ground normal or orthometric height (mm), disturbing gravity gradient ( $10\mu$ E) or horizontal gravity gradient (NE, to the north and to the east,  $10\mu$ E) by the spherical harmonic synthesis.

[Input files] The discrete calculated points file. The surface load spherical harmonic coefficients model file.

The calculated points file record format: Point number (name), longitude, latitude (decimal degrees), height....

[Parameter settings] Enter column ordinal number of the height in the input file record and maximum truncated degree of the spherical harmonic coefficients model, and select the type of surface loads.

The program automatically selects the minimum value between the maximum degree of the spherical harmonic coefficients model and the entered maximum degree as the calculated degree.

[Output file] The surface load effects file.

The file header is the same as the input file. Behind the input file record, add one or several columns of the surface load effects selected as the output file record. In this example, all types are selected, and there are 14 attributes added to the record.

👙 Computation of load-deformation field by spherical harmonic sys	nthesis		- 🗆 ×
Open file Save as Import parameters	nputation Save process Follow example		
Computation of various load effects by spherical harmonic synthesis	Computation of various load effects of Earth satellite or outside solid Earth	Computation of load effects time se by spherical harmonic synthesis	ries The formula of spherical harmonic synthesis of load deformation field
Open the calculated points file	>> Program Process ** Operation Prompts		Save program process as
Set the file format Number of rows of the file header Column ordinal number of the Open surface load harmonic coefficients model file Select the type of effects Geold or height anomaly (mm) Ground gravity (µGal) Ground gravity (µGal) Ground gravity (µGal) Ground displacement (EN, mm) Ordinal displacement (EN, mm) Ordinal displacement (mm) Ordinal displac	effects on the geoid or height anomaly (mm), g mas), vertical deflection (SW, to the south and displacement (mm), ground normal or orthome and to the east, 10µE) by the spherical harmon >> Open the calculated points file C:/ETide.Loa ** Look at the file information in the window b	control buttons on the top of the interface on water, and see level variation load sph pround gravity (JGal), gravity disturbance ( to the vest, mas), horizontal displacement tric height (mm), disturbing gravity gradien is synthesia. dd.0, wind-ten/examples/Loaddformharms ellow and set the row number of the file he- schwards loadd 0, wind-ten/examp an 3000 roys of data in the file! ten/examples/Loaddformharmsynth/loadfd he prograph or rine roor button [start computation] 22 ues!	rical harmonic coefficients model (m), compute the load JGa), ground till (SW, to the south and to the west, (EN, to the east and to the north, mm), ground radial t (10µE) or horizontal gravity gradient (NE, to the north ynth/calcent bt. def es/Loadeformharmsynth/ainwhCS20170315.txt.
<ul> <li></li></ul>	The type of surface load Surface air pressure	Save the results as	Import setting parameters
<ul> <li>disturbing gravity gradient (10µE)</li> <li>horizontal gravity gradient (NE, 10µE)</li> </ul>	Display of the input-output file		Save data in the text box as
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the height of the calculated point is the height relative t Using the monitoring data of global surface air pres	o the Earth's surface. sure, land water and sea level variations, determi	ine the non-tidal temporal Earth's gravity fi	g the load effects t of air pressure or land water variations, ald, as well as the non-lidal load effects on the geopotential eck the quality, reliability, and accuracy of the time-varying

## 4.4.2 Computation of various load effects of Earth satellite or outside solid Earth

[Function] From the surface air pressure, land water, and sea level variation load spherical harmonic coefficients model (m), compute the load effects on the geopotential  $(0.1m^2/s^2)$ , gravity (µGal), or gravity gradient(10µE) outside the solid Earth by the spherical harmonic synthesis.

Here the space point outside the solid Earth generally refers to the point that is not fixed to the solid Earth in ocean space, near-Earth space, or satellite altitude.

[Input files] The discrete calculated points file. The surface load spherical harmonic coefficients model file.

[Output file] The surface load effects file.

The file header is the same as the input file. Behind the input file record, add one or several columns of the surface load effects selected as the output file record.



#### 4.4.3 Computation of load effects time series by spherical harmonic synthesis

[Function] From the surface air pressure, land water, and sea level variation load spherical harmonic coefficients model (m) time series, compute the time series of the load effects on various variations on the computed points in the input file by the spherical harmonic synthesis.

[Input files] The discrete calculated points file. The surface load spherical harmonic coefficients model time series file.

The time series files of the load spherical harmonic coefficients model are extracted according to the given wildcards.

[Output file] The surface load effects files load\*\*\*.txt.

The number of output files is equal to the number of the time series files of the load spherical harmonic coefficients model. Here, \*\*\* are the wildcards of the model time series file name, whose instance can identify the sampling epoch time of the computed load effects.

The computation process needs to wait... During the computation period, you can open

the output files folder to look at the computation progress!

The last column attribute of each output file header is the instance of the wildcards of the file name of the model time series, which represents the sampling epoch time of the output file.



Using the monitoring data of global surface air pressure, land water and sea level variations, determine the non-tidal temporal Earth's gravity field, as well as the non-tidal load effects on the geopotential coefficients, and then you can calibrate various parameters of the gravity satellite's key measurement equipment, and effectively improve and check the quality, reliability, and accuracy of the time-varying monitoring of satellite gravity field.



Soil water load deformation with time in Chinese mainland (360 degree model): geoidal variation (mm)



Soil water load deformation with time in Chinese mainland (360 degree model): ground normal height variation (mm)



Soil water load deformation with time in Chinese mainland (360 degree model): gravity disturbance variation (µGal)



Soil water load deformation with time in Chinese mainland (360 degree model): disturbing gravity gradient variation (10µE)



Sea level load deformation with time in Chinese coastal zone (360 degree model): geoidal variation (mm)



Sea level load deformation with time in Chinese coastal zone (360 degree model): normal height variation (mm)



Sea level load deformation with time in Chinese coastal zone (360 degree model): gravity disturbance variation (µGal)



Sea level load deformation with time in Chinese coastal zone (360 degree model): disturbing gravity gradient variation (10µE)

# 4.5 Regional approaching of load-deformation field by Green's Integral

[Purpose] Firstly, execute the program [Computation of tide and load model value by spherical harmonic synthesis] to calculate and remove the load model values from the regional surface air pressure, land water, or sea level variation to obtain the residual load grid. Then, calculate the residual load-deformation field and the temporal gravity field grid by Green's integral. Finally, execute the program [Computation of load-deformation field by spherical harmonic synthesis] to calculate and restore the model values grid of the load effects, to approach the regional load-deformation field and temporal gravity field.

The regional load-deformation field and the temporal gravity field can be represented by the time series of the load effects on various geodetic quantities. The temporal field of one type of geodetic quantity can be represented by a set of time series files.

### 4.5.1 Computation of regional residual surface load effects by Green's Integral

[Function] From the regional residual equivalent water height variations grid (cm), compute the residual surface load effects on the geoid or height anomaly (mm), ground gravity ( $\mu$ Gal), gravity disturbance ( $\mu$ Gal), ground tilt (SW, to the south and to the west, mas), vertical deflection (SW, to the south and to the west, mas), horizontal displacement (EN, to the east and to the north, mm), ground radial displacement (mm), ground normal or orthometric height (mm), indirect effect of disturbing gravity gradient (mE) or horizontal gravity gradient (NE, to the north and to the east, mE), direct effect of disturbing gravity gradient (mE) or horizontal gravity gradient (mE) or horizontal gravity gradient (NE, to the north and to the east, mE) by the Green's integral.

[Input files] The discrete calculated points file. The regional residual equivalent water height variations grid file.

The calculated points file record format: Point number (name), longitude, latitude (decimal degrees), height....

Open the calculated points file     Set the file format     Number of rows of the file header     O     Column ordinal number of the	>> Program Process ** Operation Prompts geodetic quantities. >> Select the computation function from the 3 cont	ral huttons on the ton d			Save p	
Number of rows of the file header 0		rol buttons on the top (				orogram proces
		ol buttone on the top				
Column ordinal number of the						
	>> [Function] From the regional residual equivalen					
height in the record	geoid or height anomaly (mm), ground gravity (µGa vertical deflection (SW, to the south and to the west					
Open the residual equivalent water height grid file	displacement (mm), ground normal or orthometric					
Select the type of effects	gradient (NE, to the north and to the east, mE), dire	ect effect of disturbing	gravity gradient (m	E) or horizon	ntal gravity grad	lient (NE, to the
	north and to the east, mE) by the Green's integral ** The time of the residual load effects is the sam	ling anoch time of the	autoco equivalan	twater beigh	t (cm) arid mos	
geoid or height anomaly (mm)	>> Open the calculated points file C:/ETideLoad4.0				it (on) giù mot	101.
	** Look at the file information in the window below	and set the row numb	er of the file heade	er		
gravity disturbance (µGal)	Open the recidual equivalent water height grid t				enintg/landw20	018041112.dat
ground tilt (SW, mas) 💿	>> Save the results as C:/ETideLoad4.0_win64en/		eenintg/mtdfmrst.b	et.		
vertical deflection (SW, mas)	Click the control button [Start computation], or		mputation]			
horizontal displacement (EN, mm) •	>> Computation start time: 2022-03-04 20:16:20					
ground radial displacement (mm) 💿	>> Complete the computation!					
ground normal or orthometric height (mm) •	>> Computation end time: 2022-03-04 20:16:22					
	The type of sulface load Land water EWH (cm)	Save the re	sults as  Impo	rt setting par	ameters J	Start computat
indirect effect of disturbing gravity gradient (mE)	The type of surface load Land water EWH (cm)	<ul> <li>Save the re</li> </ul>	sults as  أي	rt setting par	ameters 🧔	Start computat
<ul> <li>☑ indirect effect of disturbing gravity gradient (mE)</li> <li>☑ indirect effect of horizontal gravity gradient (NE, mE)</li> </ul>		<ul> <li>Save the re</li> </ul>	sults as  Impo	rt setting par		Start computat
<ul> <li>☑ indirect effect of disturbing gravity gradient (mE)</li> <li>☑ indirect effect of horizontal gravity gradient (NE, mE)</li> <li>☑ direct effect of disturbing gravity gradient (mE)</li> </ul>	Display of the input-sutput file↓	<ul> <li>Save the re</li> <li>.000</li> <li>-18.6784</li> </ul>		rt setting par		
<ul> <li>☑ indirect effect of disturbing gravity gradient (mE)</li> <li>☑ indirect effect of horizontal gravity gradient (NE, mE)</li> </ul>	Display of the input supput file 1 1 97.52500 24.025000 2 97.575000 24.025000	.000 -18.6784 .000 -18.6045	-16.5696 -16.4546	-5.1436 -5.0611	Save dat -4.3762 -4.0427	a in the text bo
<ul> <li>☑ indirect effect of disturbing gravity gradient (mE)</li> <li>☑ indirect effect of horizontal gravity gradient (NE, mE)</li> <li>☑ direct effect of disturbing gravity gradient (mE)</li> <li>☑ direct effect of horizontal gravity gradient (NE, mE)</li> </ul>	Display of the input-autput file   1 97.52500 24.025000 2 97.575000 24.025000 3 97.625000 24.025000	.000 -18.6784 .000 -18.6045 .000 -18.5693	-16.5696 -16.4546 -16.4414	-5.1436 -5.0611 -5.0444	Save det -4.3762 -4.0427 -7.4921	a in the text bo 1.7864 -1.7325 -3.6576
indirect effect of disturbing gravity gradient (mE)     indirect effect of horizontal gravity gradient (NE, mE)     direct effect of disturbing gravity gradient (mE)     direct effect of horizontal gravity gradient (NE, mE)	Display of the input-supput file.           1         97.52500         24.025000         0           2         97.575000         24.025000         0           3         97.675000         24.025000         0           4         97.675000         24.025000         0         0	.000 .000 .000 .000 .000 .000 -18.6045 .18.5693 .18.7305	-16.5696 -16.4546 -16.4414 -16.6864	-5.1436 -5.0611 -5.0444 -5.1888	Save de 1 -4.3762 -4.0427 -7.4921 -9.7594	a in the text bo 1.7864 -1.7325 -3.6576 -2.6510
<ul> <li>☑ indirect effect of disturbing gravity gradient (mE)</li> <li>☑ indirect effect of horizontal gravity gradient (NE, mE)</li> <li>☑ direct effect of disturbing gravity gradient (mE)</li> <li>☑ direct effect of horizontal gravity gradient (NE, mE)</li> </ul>	Display of the input-utput file   1 97.52500 24.025000 0 2 97.575000 24.025000 0 3 97.625000 24.025000 0 4 97.67500 24.025000 0 5 97.725000 24.025000 0 6 97.775000 24.025000 0	.000 -18.6784 -18.6045 -000 -18.5693 .000 -17.1013 .000 -17.10269	-16.5696 -16.4546 -16.4414 -16.6864 -14.9461 -14.8685	-5.1436 -5.0611 -5.0444 -5.1888 -4.6283 -4.6059	Save dr -4.3762 -4.0427 -7.4921 -9.7594 12.0359 12.9279	1.7864 -1.7325 -3.6576 -2.6510 3.4856 3.4906
<ul> <li>☑ indirect effect of disturbing gravity gradient (mE)</li> <li>☑ indirect effect of horizontal gravity gradient (NE, mE)</li> <li>☑ direct effect of disturbing gravity gradient (mE)</li> <li>☑ direct effect of horizontal gravity gradient (NE, mE)</li> </ul>	Display of the input-upput file   1 97,52500 24.025000 0 2 97,57500 24.025000 0 3 97,62500 24.025000 0 4 97,675000 24.025000 0 5 97,725000 24.025000 0 6 97,775000 24.02500 0 7 97,82500 24.02500 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	.000 -18.6784 -18.6045 .000 -18.5693 .000 -17.1013 .000 -17.0269 .000 -18.4384	-16.5696 -16.4546 -16.4414 -16.6864 -14.9461 -14.8685 -16.4013	-5.1436 -5.0611 -5.0444 -5.1888 -4.6283 -4.6059 -5.1018	<ul> <li>Save de l</li> <li>-4.3762</li> <li>-4.0427</li> <li>-7.4921</li> <li>-9.7594</li> <li>12.9359</li> <li>12.9279</li> <li>-9.3838</li> </ul>	a in the text bo 1.7864 -1.7325 -3.6576 -2.6510 3.4856 3.4906 9.5971
<ul> <li>☑ indirect effect of disturbing gravity gradient (mE)</li> <li>☑ indirect effect of horizontal gravity gradient (NE, mE)</li> <li>☑ direct effect of disturbing gravity gradient (mE)</li> <li>☑ direct effect of horizontal gravity gradient (NE, mE)</li> </ul>	Display of the input-utput file   1 97.55500 24.025000 ( 2 97.575000 24.025000 ( 3 97.625000 24.025000 ( 4 97.67500 24.02500 ( 5 97.72500 24.02500 ( 6 97.77500 24.02500 ( 8 97.87500	.000 -18.6784 .000 -18.6045 .000 -18.5693 .000 -18.7305 .000 -17.1013 .000 -17.0269 .000 -18.1345	-16.5696 -16.4546 -16.4414 -16.6664 -14.9461 -14.8685 -16.4013 -16.0008	-5.1436 -5.0611 -5.0444 -5.1888 -4.6283 -4.6059 -5.1018 -4.9105	Save dr 1 -4.3762 -4.0427 -7.4921 -9.7594 12.0359 12.9279 -9.3838 -6.9118	a in the text bo 1.7864 -1.7325 -3.6576 -2.6510 3.4856 3.4906 9.5971 10.7323
<ul> <li>☑ indirect effect of disturbing gravity gradient (mE)</li> <li>☑ indirect effect of horizontal gravity gradient (NE, mE)</li> <li>☑ direct effect of disturbing gravity gradient (mE)</li> <li>☑ direct effect of horizontal gravity gradient (NE, mE)</li> </ul>	Display of the input-upput file   1 97,52500 24.025000 ( 2 97,57500 24.025000 ( 3 97,62500 24.025000 ( 4 97,67500 24.025000 ( 5 97,72500 24.02500 ( 6 97,77500 24.02500 ( 8 97,82500 24.02500 ( 9 97,92500 24.02500 ( 9 97,52500	.000 -18.6784 -000 -18.6645 .000 -18.5693 .000 -18.7305 .000 -17.0269 .000 -18.4384 .000 -18.1345 .000 -17.9360	-16.5696 -16.4546 -16.4414 -16.6864 -14.9461 -14.8685 -16.4013 -16.0008 -15.8121	-5.1436 -5.0611 -5.0611 -5.0444 -5.1888 -4.6283 -4.6059 -5.1018 -4.9105 -4.9105 -4.8771	A Save de 1 -4.3762 -4.0427 -7.4921 -9.7594 12.9359 12.9279 -9.3838 -6.9118 -3.2080	a in the text bo 1.7864 -1.7325 -3.6576 -2.6510 3.4856 3.4906 9.5971 10.7323 9.0778
<ul> <li>☑ indirect effect of disturbing gravity gradient (mE)</li> <li>☑ indirect effect of horizontal gravity gradient (NE, mE)</li> <li>☑ direct effect of disturbing gravity gradient (mE)</li> <li>☑ direct effect of horizontal gravity gradient (NE, mE)</li> </ul>	Display of the input-utput file   1 97.55500 24.025000 ( 2 97.57500 24.025000 ( 3 97.625000 24.025000 ( 4 97.67500 24.025000 ( 5 97.72500 24.02500 ( 6 97.77500 24.02500 ( 8 97.87500 24.02500 ( 9 97.825000 24.02500 ( 9 97.825000 24.02500 ( 10 97.97500 ( 10	.000 -18.6784 .000 -18.6045 .000 -18.5693 .000 -18.7305 .000 -17.1013 .000 -17.0269 .000 -18.1345	-16.5696 -16.4546 -16.4414 -16.6664 -14.9461 -14.8685 -16.4013 -16.0008 -15.8121 -15.6005	-5.1436 -5.0611 -5.0444 -5.1888 -4.6283 -4.6059 -5.1018 -4.9105	Save dr 1 -4.3762 -4.0427 -7.4921 -9.7594 12.0359 12.9279 -9.3838 -6.9118	a in the text bo 1.7864 -1.7325 -3.6576 -2.6510 3.4856 3.4906 9.5971 10.7323
<ul> <li>☑ indirect effect of disturbing gravity gradient (mE)</li> <li>☑ indirect effect of horizontal gravity gradient (NE, mE)</li> <li>☑ direct effect of disturbing gravity gradient (mE)</li> <li>☑ direct effect of horizontal gravity gradient (NE, mE)</li> </ul>	Display of the input-utput file   1 97.55500 24.025000 2 97.575000 24.025000 4 97.675000 24.025000 5 97.725000 24.025000 6 97.775000 24.025000 6 97.775000 24.02500 9 97.825000 24.025000 10 97.975000 24.025000 11 98.025000 24.025000 12 98.075000 24.025000 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	.000 -18.6784 -18.6045 -000 -18.6645 -000 -18.6853 -000 -17.1013 -17.0259 -000 -18.4384 -000 -18.1345 -000 -17.5980 -000 -17.581	-16.5696 -16.4546 -16.4414 -16.9664 -14.9461 -14.9665 -16.4013 -16.0008 -15.8121 -15.6805 -15.5810 -15.4389	-5.1436 -5.0611 -5.0444 -5.1888 -4.6283 -4.6059 -5.1018 -4.9105 -4.8771 -4.8778 -4.8487 -4.7651	<ul> <li>Save dr</li> <li>-4.3762</li> <li>-4.0427</li> <li>-7.4921</li> <li>-9.7594</li> <li>12.9279</li> <li>-9.3838</li> <li>-6.9118</li> <li>-3.2080</li> <li>-2.9563</li> <li>-2.6732</li> <li>-2.2255</li> </ul>	a in the text bo 1.7864 -1.7325 -3.6576 -2.6510 3.4856 3.4906 9.5971 10.7323 9.0778 5.8226 -0.1386
<ul> <li>☑ indirect effect of disturbing gravity gradient (mE)</li> <li>☑ indirect effect of horizontal gravity gradient (NE, mE)</li> <li>☑ direct effect of disturbing gravity gradient (mE)</li> <li>☑ direct effect of horizontal gravity gradient (NE, mE)</li> </ul>	Display of the input-upput file   97,52500 24.025000 ( 2 97,57500 24.025000 ( 3 97,62500 24.025000 ( 4 97,67500 24.025000 ( 5 97,72500 24.02500 ( 6 97,77500 24.02500 ( 7 97,82500 24.02500 ( 9 97,92500 24.02500 ( 10 97,97500 24.02500 ( 11 98.02500 24.02500 ( 12 98.07500 24.02500 ( 13 98.12500 24.02500 ( 14 98.02500 24.02500 ( 15 98.12500 24.02500 ( 15 98.12500 24.02500 ( 16 99.12500 24.02500 ( 17 98.12500 24.02500 ( 18 98.12500 24.02500 ( 19 98.12500 24.02500 ( 10 97.9500 ( 10 97.9500 24.02500 ( 10 97.9500 ( 10	.000 -18.6784 .000 -18.6045 .000 -18.6045 .000 -18.7305 .000 -17.1013 .000 -17.0269 .000 -18.1345 .000 -17.951 .000 -17.552 .000 -17.5481 .000 -17.5582 .000 -17	-16.5696 -16.4546 -16.4414 -14.9461 -14.8665 -16.4013 -15.8021 -15.8021 -15.6805 -15.4389 -15.4389 -15.3847	-5.1436 -5.0611 -5.0444 -5.1888 -4.6283 -4.6059 -5.1018 -4.9105 -4.8771 -4.8771 -4.8487 -4.6487 -4.7651 -4.7359	<ul> <li>Save de 1</li> <li>-4.3762</li> <li>-4.0427</li> <li>-7.4921</li> <li>-9.7594</li> <li>12.9279</li> <li>-9.3838</li> <li>-6.9118</li> <li>-3.2080</li> <li>-2.9563</li> <li>-2.6732</li> <li>-2.2525</li> <li>-5.0291</li> </ul>	a in the text bo 1.7864 -1.7325 -3.6576 -2.6510 3.4856 3.4906 9.5971 10.7323 9.0778 5.8226 3.0765 -0.1386 -1.8732
Indirect effect of disturbing gravity gradient (mE)     Indirect effect of horizontal gravity gradient (NE, mE)     direct effect of disturbing gravity gradient (mE)     direct effect of horizontal gravity gradient (NE, mE)	Display of the input-utput file   1 97.55500 24.025000 ( 2 97.575000 24.025000 ( 3 97.675000 24.025000 ( 5 97.775000 24.025000 ( 6 97.775000 24.025000 ( 6 97.775000 24.025000 ( 9 97.25500 24.025000 ( 10 97.375000 24.025000 ( 11 98.025000 24.025000 ( 12 98.075000 24.025000 ( 13 98.125000 24.025000 ( 14 98.175000 24.025000 ( 14 98.17500 24.025000 ( 14 98.17500 24.025000 ( 15 98.125000 24.025000 ( 16 98.125000 24.025000 ( 17 98.125000 24.025000 ( 18 98.125000 24.025000 ( 19 98.125000 24.025000 ( 10 98.125000 24.025000 ( 10 98.125000 24.025000 ( 10 98.125000 24.025000 ( 10 98.125000 24.025000 ( 10 98.125000 24.025000 ( 10 98.125000 24.025000 ( 10 98.125000 24.025000 ( 10 98.125000 24.025000 ( 10 98.125000 24.025000 ( 10 98.125000 24.025000 ( 10 98.12500 ( 10 98.125000 ( 10 98.125000 ( 10 98.125000 ( 10 98.125000 ( 10 98.125000 ( 10 98.12500 ( 10 98.12500 ( 10 98.125000  10 98.125000 ( 10 98.12500 ( 10 98.125000 ( 10 98.125000 ( 10 98.12500	.000 -13.6784 -18.6043 -18.6043 -000 -18.6043 -000 -11.013 -17.0269 -000 -18.4384 -17.9360 -17.9360 -17.521 -000 -17.5481 -000 -17.4582 -000 -17.4754	-16.5696 -16.4546 -16.4414 -14.9461 -14.9461 -14.8665 -16.4013 -16.0008 -15.8015 -15.6805 -15.5810 -15.4389 -15.3847 -15.5803	-5.1436 -5.0611 -5.0444 -5.1888 -4.6283 -4.6059 -5.1018 -4.9105 -4.8771 -4.8778 -4.8487 -4.7651 -4.7359 -4.8585	4.3762 -4.427 -7.4921 -9.7594 12.9279 -9.3838 -6.9118 -3.2080 -2.9563 -2.6732 -2.2525 -5.0291 -6.8219	a in the text bo 1.7864 -1.7325 -3.6576 -2.6510 3.4856 3.4906 9.5971 10.7323 9.0778 5.8226 3.0765 -0.1386 -1.8732 -1.1644
Indirect effect of disturbing gravity gradient (mE)     Indirect effect of horizontal gravity gradient (NE, mE)     direct effect of disturbing gravity gradient (mE)     direct effect of horizontal gravity gradient (NE, mE)	Display of the input-upput file   97,52500 24.025000 ( 2 97,57500 24.025000 ( 3 97,62500 24.025000 ( 4 97,67500 24.025000 ( 5 97,72500 24.02500 ( 6 97,77500 24.02500 ( 7 97,82500 24.02500 ( 9 97,92500 24.02500 ( 10 97,97500 24.02500 ( 11 96.02500 24.02500 ( 12 96.07500 24.02500 ( 13 96.12500 24.02500 ( 14 96.12500 24.02500 ( 15 96.22500 ( 15 96.2500 ( 15 96	.000 -18.6784 -18.6045 -18.6693 -000 -18.7305 -17.1013 000 -17.1013 000 -17.0269 -000 -18.4384 -17.9360 -17.9360 -17.521 000 -17.5481 -000 -17.4581 -000 -17.4581 -000 -17.6505 -000 -16.1832 -000 -16.1832	-16.5596 -16.4546 -16.4546 -16.4684 -14.9461 -14.9461 -14.9461 -15.4013 -15.4013 -15.6005 -15.5810 -15.4399 -15.3847 -15.5803 -14.0789 -13.9820	-5.1436 -5.0611 -5.0444 -5.1888 -4.6283 -4.6059 -5.1018 -4.9105 -4.8771 -4.8771 -4.8487 -4.6487 -4.7651 -4.7359	Save dr 1 -4.3762 -4.0427 -7.4921 -9.7594 12.8359 12.9279 -9.3838 -6.9118 -3.2080 -2.9563 -2.9563 -2.6732 -2.2525 -5.0291 -6.8219 12.1613 12.2179	a in the text bo 1.7864 -1.7325 -3.6576 -2.6510 3.4856 3.4906 9.5971 10.7323 9.0778 5.8226 3.0765 -0.1386 -1.8732
Indirect effect of disturbing gravity gradient (mE)     Indirect effect of horizontal gravity gradient (NE, mE)     direct effect of disturbing gravity gradient (mE)     direct effect of horizontal gravity gradient (NE, mE)	Display of the input-uput file; 97.52500 24.025000 0 3 97.575000 24.025000 0 4 97.62500 24.025000 0 5 97.725000 24.025000 0 6 97.775000 24.025000 0 7 97.825000 24.025000 0 9 97.925000 24.025000 0 10 97.925000 24.025000 0 10 97.925000 24.025000 0 11 98.025000 24.025000 0 12 98.075000 24.025000 0 13 98.125000 24.025000 0 14 99.125000 24.025000 0 15 99.225000 24.025000 0 16 99.275000 24.025000 0 17 99.325000 24.025000 0 17 99.325000 24.025000 0 19 99.225000 24.025000 0 10 97.925000 24.025000 0 10 97.925000 24.025000 0 10 99.225000 24.025000 0 10 99.32500 24.025000 0 10 99.325000 0 10 99.3	.000 -18.6784 .000 -18.6045 .000 -18.6693 .000 -18.5693 .000 -18.7305 .000 -17.0269 .000 -17.1013 .000 -18.1384 .000 -17.8582 .000 -17.5582 .000 -17.5682 .000 -17.6582 .000 -17.6582 .000 -17.6582 .000 -17.6582 .000 -17.6582 .000 -17.6582 .000 -17.7548 .000 -17.6582 .000 -17.7557	-16.5696 -16.4546 -16.4414 -16.6964 -14.9661 -14.9661 -14.9661 -14.8685 -16.4013 -16.0008 -15.8121 -15.6805 -15.4389 -15.5803 -15.5803 -14.0789 -13.9920 -15.2608	-5.1436 -5.0611 -5.0641 -5.0444 -5.1088 -4.6203 -4.6059 -5.1018 -4.9711 -4.8771 -4.8771 -4.8771 -4.7359 -4.7359 -4.7551 -4.3756 -4.3551 -4.3551 -4.7603	<ul> <li>Save dr 1</li> <li>-4.3762</li> <li>-4.0427</li> <li>-7.4921</li> <li>-9.7594</li> <li>12.9279</li> <li>-9.3938</li> <li>-6.9118</li> <li>-3.2080</li> <li>-2.9563</li> <li>-2.9563</li> <li>-2.6732</li> <li>-2.2525</li> <li>-5.0291</li> <li>-6.8219</li> <li>12.2179</li> <li>-6.4948</li> </ul>	a in the text bo 1.7864 -1.7325 -3.6576 -2.6510 3.4856 3.4906 9.5971 10.7323 9.0778 5.8226 3.0765 -0.1386 -1.8732 -1.1644 3.9428 3.9188 8.9695
<ul> <li>☑ Indirect effect of disturbing gravity gradient (mE)</li> <li>☑ Indirect effect of horizontal gravity gradient (NE, mE)</li> <li>☑ direct effect of disturbing gravity gradient (mE)</li> <li>☑ direct effect of horizontal gravity gradient (NE, mE)</li> </ul>	Display of the input-uput file 1 97, 52500 24, 025000 0 2 97, 57500 24, 025000 0 4 97, 62500 24, 025000 0 5 97, 72500 24, 025000 0 6 97, 77500 24, 025000 0 6 97, 77500 24, 02500 0 6 97, 72500 24, 02500 0 1 99, 245000 24, 02500 0 1 99, 24500 24, 02500 0 1 99, 25000 24, 02500 0 1 99, 22500 24, 02500 0 1 99, 32500 24, 02500 0 1 99, 37500 0 1 99, 37500 24, 02500 0 1 99, 37500 0 1	.000         -18.6784           .000         -18.6045           .000         -18.5693           .000         -18.5693           .000         -18.7305           .000         -17.0269           .000         -18.384           .000         -17.582           .000         -17.581           .000         -17.4581           .000         -17.6005           .000         -17.6052           .000         -16.1832           .000         -17.4754           .000         -17.6055           .000         -16.1832           .000         -16.992           .000         -17.2757	-16.5696 -16.4546 -16.4546 -16.4414 -14.9461 -14.9461 -14.8665 -15.4013 -15.4013 -15.6805 -15.5810 -15.4399 -15.3847 -15.5803 -14.0789 -13.9920 -15.2608 -14.8770	-5.1436 -5.0611 -5.0614 -5.0644 -5.1888 -4.6203 -4.6203 -4.9105 -4.9105 -4.9105 -4.9105 -4.9105 -4.9105 -4.9105 -4.7551 -4.7551 -4.3551 -4.3551 -4.3551	Save dr 1 -4.3762 -4.0427 -7.4921 -9.7594 12.9279 -9.3838 -6.9118 -3.2080 -2.9563 -2.6732 -2.2525 -5.0291 -6.8219 12.1613 12.2179 -6.4948 -4.5569	a in the text bo 1.7864 -1.7325 -3.6576 -2.6510 3.4956 9.5971 10.7323 9.0778 5.8226 3.0765 -0.1386 -1.8732 -1.1644 3.9428 3.9428 8.9695 9.8420
<ul> <li>☑ Indirect effect of disturbing gravity gradient (mE)</li> <li>☑ Indirect effect of horizontal gravity gradient (NE, mE)</li> <li>☑ direct effect of disturbing gravity gradient (mE)</li> <li>☑ direct effect of horizontal gravity gradient (NE, mE)</li> </ul>	Display of the input-uput file; 97.52500 24.025000 ( 2 97.57500 24.025000 ( 3 97.62500 24.025000 ( 4 97.67500 24.025000 ( 5 97.72500 24.02500 ( 6 97.77500 24.02500 ( 7 97.82500 24.02500 ( 9 97.92500 24.02500 ( 10 97.97500 24.02500 ( 10 97.97500 24.02500 ( 11 98.02500 24.02500 ( 12 98.07500 24.02500 ( 13 98.12500 24.02500 ( 14 98.17500 24.02500 ( 15 98.22500 24.02500 ( 15 98.22500 24.02500 ( 16 99.27500 24.02500 ( 17 98.32500 24.02500 ( 18 99.37500 24.02500 ( 19 99.42500 24.02500 ( 10 99.42500 24.02500 ( 10 99.42500 24.02500 ( 10 99.42500 24.02500 ( 10 99.42500 24.02500 ( 10 99.42500 24.02500 ( 10 99.42500 24.02500 ( 10 99.42500 24.02500 ( 10 99.42500 24.02500 ( 10 99.42500 24.02500 ( 10 99.42500 24.02500 ( 10 99.42500 24.02500 ( 10 99.42500 24.02500 ( 10 99.42500 24.02500 ( 10 99.42500 24.02500 ( 10 99.42500 24.02500 ( 10 99.42500 24.02500 ( 10 99.42500 ( 10 99.42500 ( 10 99.42500 24.02500 ( 10 99.42500 ( 10 99.	.000 -18.6784 .000 -18.6045 .000 -18.6693 .000 -18.5693 .000 -18.7305 .000 -17.0269 .000 -17.1013 .000 -18.1384 .000 -17.8582 .000 -17.5582 .000 -17.5682 .000 -17.6582 .000 -17.6582 .000 -17.6582 .000 -17.6582 .000 -17.6582 .000 -17.6582 .000 -17.7548 .000 -17.6582 .000 -17.7557	-16.5696 -16.4546 -16.4414 -16.6964 -14.9661 -14.9661 -14.8685 -16.6013 -16.6013 -15.6005 -15.6005 -15.6005 -15.5810 -15.4389 -15.5803 -15.5803 -14.0799 -13.9920 -14.6773	-5.1436 -5.0611 -5.0641 -5.0444 -5.1088 -4.6203 -4.6059 -5.1018 -4.9711 -4.8771 -4.8771 -4.8771 -4.7359 -4.7359 -4.7551 -4.3756 -4.3551 -4.3551 -4.7603	<ul> <li>Save dr 1</li> <li>-4.3762</li> <li>-4.0427</li> <li>-7.4921</li> <li>-9.7594</li> <li>12.9279</li> <li>-9.3938</li> <li>-6.9118</li> <li>-3.2080</li> <li>-2.9563</li> <li>-2.9563</li> <li>-2.6732</li> <li>-2.2525</li> <li>-5.0291</li> <li>-6.8219</li> <li>12.2179</li> <li>-6.4948</li> </ul>	a in the text bo 1.7864 -1.7325 -3.6576 -2.6510 3.4856 3.4906 9.5971 10.7323 9.0778 5.8226 3.0765 -0.1386 -1.8732 -1.1644 3.9428 3.9188 8.9695

[Parameter settings] Set the calculated points file format parameter, enter the load Green's integral radiu, and select the type of surface loads.

[Output file] The regional surface load effects file.

The file header is the same as the input file. Behind the input file record, add one or several columns of the surface load effects selected as the output file record. In this example, all types are selected, and there are 16 attributes added to the record.

When computing the load effects of sea level variations, the height of the calculated point is the normal or orthometric height. When computing the load effects of surface air pressure or land water variations, the height of the calculated point is the height relative to the Earth's surface.

#### 4.5.2 Computation of lakes, glaciers, and snow load effects by Green's Integral

[Function] From the load equivalent water height variations grid (cm) of the inland waterbodies such as the rivers, lakes, reservoirs, glaciers, and snow-capped mountains, compute the water-bodies load effects on the geoid or height anomaly (mm), ground gravity ( $\mu$ Gal), gravity disturbance ( $\mu$ Gal), ground tilt (SW, to the south and to the west, mas), vertical deflection (SW, to the south and to the west, mas), horizontal displacement (EN, to the east and to the north, mm), ground radial displacement (mm), ground normal or orthometric height (mm), indirect and direct effects on disturbing gravity gradient (mE) or horizontal gravity gradient (NE, to the north and to the east, mE) by the Green's Integral.

Computation of regional residual surface load effects by Green's Integral	Computation of lakes, glaciers, and snow load effects by Green's Integral	Computation of regional load time series by Green's Integr		ad effec ral
Open the calculated points file	>> Program Process ** Operation Prompts		ant un un un	me
Set the file format	>> Computation start time: 2022-03-04 20:16:20			-
umber of rows of the file header 1	>> Complete the computation!			
olumn ordinal number of the	>> Computation end time: 2022-03-04 20:16:22			
eight in the record	>> [Function] From the load equivalent water height variations			
Open the water-bodies equivalent water height grid file	mountains, compute the residual surface load effects on the ge south and to the west, mas), vertical deflection (SW, to the sou			
select the type of effects	radial displacement (mm), ground normal or orthometric height			
	(NE, to the north and to the east, mE) by the Green's Integral.	1	T-I mal	
geoid or height anomaly (mm)	** The equivalent water height variations grid of multiple water effects by Green's function integral.	-poorps at the same sampling epoch time ca		
ground gravity (µGal) •	> Open the calculated points file C:/ETideLoad4.0_win64en/e			
gravity disturbance (µGal)	ook at the file information in the window below and set the			y
ground tilt (SW, mas) 💿	>> Open the water-bodies equivalent water height grid file C:/E >> Save the results as C:/ETideLoad4.0 win64en/examples/Load4.0		greenintg/lakechgcm.dat.	
vertical deflection (SW, mas)	>> Setting parameters have been imported in the program!	adminingreeningratedinination.		
horizontal displacement (EN, mm)	** Click the control button [Start computation], or the tool butto	n [Start computation]		
ground radial displacement (mm) 💿	>> Computation start ime: 2022-03-04 20:24:22			_
ground normal or orthometric height (mm) 💿	>> Complete the computation! >> Computation end time: 2022-03-04 20:31:03			
indirect effect of disturbing gravity gradient (mE)				
indirect effect of distancing gravity gradient (ME)	Save the results as	Import setting parameters	Start computation	
direct effect of disturbing gravity gradient (mE)	Display of the input-output file		Save data in the	s tex bo
direct effect of horizontal gravity gradient (NE, mE)	111.00000000 111.80000000 32.40000000 33.00		0.0000	+
egral radiu of the Green function 300km	1 111.0020833 32.4020833 0.000 2 111.0062500 32.4020833 0.000	0.0130 0.0138 0.1031 0.0140 0.1064		-0.030
	3 111.0104167 32.4020833 0.000	0.0132 0.0141 0.1097	0.0650 0.0068 0.0086	-0.031
	4 111.0145833 32.4020833 0.000 5 111.0187500 32.4020833 0.000	0.0133 0.0142 0.1132 0.0134 0.0143 0.1167		-0.031
	6 111.0229167 32.4020833 0.000	0.0134 0.0143 0.1167		-0.031
	7 111.0270833 32.4020833 0.000	0.0136 0.0146 0.1240	0.0669 0.0067 0.0091	-0.032
107 107 104 IV	8 111.0312500 32.4020833 0.000	0.0137 0.0147 0.1278	0.0672 0.0067 0.0093	-0.032
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			** ** <b>**</b>	
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[Input files] The discrete calculated points file. The water-bodies equivalent water height variations grid file.

[Parameter settings] Set the calculated points file format parameter, and enter the load Green's integral radius.

[Output file] The inland water bodies load effects file.

The file header is the same as the input file. Behind the input file record, add one or several columns of the surface load effects selected as the output file record. In this example, the geoid or height anomaly, ground gravity, ground tilt, horizontal displacement and ground radial displacement are selected, and there are 7 attributes added to the record.

The equivalent water height variations grid of multiple water bodies at the same sampling epoch time can be sumed directly, and then you can get the total load effects by Green's function integral.

If the changes of the inland water bodies such as the rivers, lakes, reservoirs, glaciers, and snow-capped mountains are represented by the load equivalent water height variations grid, the program can accurately compute these load effects on various geodetic quantities.

Due to shortwave dominance of the residual load effects, the residual load equivalent water height grid is required to have an appropriate spatial resolution to reflect the loads shortwave characteristics. Otherwise, Green's function integral may be unstable.

## 4.5.3 Computation of regional load effects time series by Green's Integral

[Function] From the regional residual equivalent water height (cm) grids time series, compute the time series of the residual value of the load effects on various variations on the computed points in the input file by Green's integral. The residual equivalent water height variation (cm) grids time series files are extracted according to the given wildcards.

[Input files] The discrete calculated points file. The regional residual equivalent water height grids time series file.

The time series files of the equivalent water height grids are extracted according to the given wildcards.

[Parameter settings] Set the calculated points file format parameter and the wildcard patameters for the surface load equivalent water height grids time series files, enter the load Green's integral radiu, and select the type of surface loads.

[Output file] The residual surface load effects files rent \*\*\*.txt.

The time of the residual load effects is the sampling epoch time of the surface equivalent water height grid model.

The number of the output files is equal to the number of time series files of the residual equivalent water height variation grid. Here, \*\*\* are the wildcards of the variation grids time series files names, whose instance can identify the sampling epoch time of the load effects.

The computation process needs to wait...During the period, you can open the output files folder to look at the computation progress!

The last attribute of each output file header is the instance of the wildcards of the time series file name of the residual equivalent water height grid model, which represents the sampling epoch time of the output file.

Gravity gradient ultrashort waves are dominant, and its surface load effects are bigger. In order to fully display the spatial inhomogeneity of direct and indirect load effects on gravity gradient, the program divides the load effects on gravity gradient into the direct and indirect effects with their unit enlarged from 10µE to mE.



The Green integral computations show that the residual soil water variations in medium and short waves (30' spatial resolution) can cause time-varying gravity gradients above the



## mE level which is no obvious time-varying feature (difficult to model).

Indirect effects of 30'x30' Residual soil water on disturbing gravity gradient (mE) on in Chinese mainland (Green integral)









After superimposing the effects of ultrashort-wave surface water and groundwater loads, the time-varying magnitude of the ground disturbance gravity gradient can reach 100 mE, while that of the horizontal gravity gradient can reach hundreds of mE. This complex dynamic environment without obvious spatiotemporal features will seriously restrict the realization of ground gravity gradient measurement with mE level accuracy. So, it is not recommended to measure the horizontal gravity gradient directly on the ground or at low altitudes.

#### 4.6 Estimation of land water variations based on multi-monitoring networks

[Purpose] Using various geodetic variations of the ground sites such as the regional CORS network, solid Earth tide stations, or various geodetic networks as the observations, and the regional load Green's integral as the geodynamic constraints, estimate the spatiotemporal variations of the land water.

The program requires that the long-wave parts of the load effects on the geodetic variations should be removed in advance either by calculating the known load effects with the air pressure, surface water, and sea level variations, or using the temporal satellite gravity field model, to suppress the far-region effects and meet the condition of the local Green's integral.

Furtherly combining the function [Computation of tide and load model value by spherical harmonic synthesis], [Computation of load-deformation field by spherical harmonic synthesis], and [Regional approaching of the load-deformation field by Green's Integral], you can effectively monitor regional land water variations, load-deformation field, and temporal gravity field.

Please refer to the program [CORS/InSAR collaborative monitoring and ground stability variations estimation] for the unified method of spatiotemporal datum frame for various geodetic variations.

#### 4.6.1 Estimation of land water variations from various geodetic variations

[Function] Using the ground ellipsoidal height (mm), ground gravity ( $\mu$ Gal), ground normal or orthometric height (mm) variations unified in the spatiotemporal frame as the observations, and the load Green's integral as the geodynamic constraints, estimate the equivalent water height variations (cm) grid of the regional land water.

[Input files] The geodetic variation records time series file. The estimated region zero value grid file.

The geodetic variation records time series file. The file header contains the time series length and the sampling epoch time arranged with time. Record format: the site name, longitude, latitude, height, variation type, weight, ..., variations arranged in time series length (default value is 9999.0000).

Variation type = 1 represents the height anomaly (mm), = 2 represents gravity disturbance ( $\mu$ Gal), = 3 represents ground gravity ( $\mu$ Gal), = 4 represents ground ellipsoidal height (mm), = 5 represents ground normal or orthometric height (mm).

The program requires that the estimated region range must be greater than the geodetic site's distribution range to absorb the edge effects. The estimated region grid is used to specify the latitude and longitude range and spatial resolution of the estimated land water variations grid. Generally, the values of the estimated region grid are always equal to zero, which means that the estimated land water loads locate on the surface.

[Parameter settings] Set the geodetic variation records time series file format parameter

and the iteration conditio patameters, enter the column ordinal number of current variation, load Green's integral radiu and average distance between sites.

Termination condition of the iteration: the sign of the average of the residual values of the geodetic variations occurs reverse, or the difference between the current residual standard deviation and the previous iteration residual standard deviation is less than a% of the standard deviation of the source geodetic variations.



[Output files] The equivalent water height variations grid file, the iterative process statistical information file, and the residual geodetic variations file.

## 4.6.2 Estimation of land water grids time series from various geodetic variations

[Function] Using the variation records time series of the ground ellipsoidal height (mm), ground gravity ( $\mu$ Gal), ground normal or orthometric height (mm) as the observations time series, the Green's integral as the geodynamic constraints, estimate the variation grids time series of the land equivalent water height (cm).

[Input files] The geodetic variation records time series file. The estimated region zero value grid file.

[Parameter settings] Set the geodetic variation records time series file format parameter and the iteration conditio patameters, enter the load Green's integral radiu and average distance between sites.

[Output files] The estimated equivalent water height grid file ewh\*\*\*.dat, iterative process statistical information file ewh\*\*\*.sta and residual geodetic variations file rnt\*\*\*.txt. Here, \*\*\*

are the sampling epoch time that is also the 7th attribute in the header of the grid file ewh\*\*\*.dat.

The residual variations time series (a residual variations file at each sampling epoch time) can be furtherly used to evaluate the stability of the sites and the quality of the geodetic monitoring data.



After the estimation is completed, the residual value files should be opened to check the results. The first few rows of the file indicate the change information of the mean and standard deviation of the residual value with the number of iterations. If necessary, the integral radius or the number of iterations (there is a certain correlation between the two) should be adjusted, and the iterative estimation should be performed again.

# 4.7 Estimation of high-resolution land water variations from CORS/InSAR

[Purpose] Using the high-resolution InSAR variations unified in the CORS network monitoring frame as observations, the regional load Green's integral as the geodynamic constraints, estimate the land water variations with high spatiotemporal resolution.

The program requires that the long-wave parts of the load effects on the InSAR variations should be removed in advance either by calculating the known load effects with air pressure, surface water, and sea level variations, or using the temporal satellite gravity field model, to suppress the far-region effects and meet the condition of the local Green's integral.

Please refer to the program [CORS/InSAR collaborative monitoring and ground stability

variations estimation] for the unified method of the spatiotemporal monitoring frame for multisource InSAR vertical deformation.

## 4.7.1 Estimation of land water variations from InSAR variations

[Function] Using the high-resolution InSAR variations as the observations, the load Green's integral as the geodynamic constraint, estimate the equivalent water height grid (cm) of the regional land water.

[Input files] The InSAR variation records time series file. The estimated region zero value grid file.

The InSAR variation records time series file. The file header contains the time series length and the sampling epochs arranged in time series length. Record format: the point no/name, longitude, latitude, ..., InSAR variations arranged in time series length (default value is 9999.0000).

[Parameter settings] Set InSAR variation records time series file format parameter and the iteration conditio patameters, enter the column ordinal number of current variation and load Green's integral radiu.

Termination condition of the iteration: the sign of the average of the residual values of the geodetic variations occurs reverse, the difference between the current residual standard deviation and the previous iteration residual standard deviation is less than a% of the standard deviation of the source geodetic variations.



[Output files] The equivalent water height variations grid file, the iterative process

statistical information file, and the residual InSAR variations file.

#### 4.7.2 Estimation of land water variation grids time series from InSAR

[Function] Using the high-resolution InSAR variation (mm) records time series as the observations time series, the Green's integral as the geodynamic constraints, estimate the variation grids time series of the land water equivalent water height (cm).

[Input files] The InSAR variation records time series file. The estimated region zero value grid file.

[Parameter settings] Set InSAR variation records time series file format parameter and the iteration conditio patameters, enter the load Green's integral radiu.

[Output files] The estimated equivalent water height grid files ewh\*\*\*.dat, iterative process statistical information files ewh\*\*\*.sta and residual InSAR variations files rnt\*\*\*.txt. Here, \*\*\* are the sampling epoch time that is also the 7th attribute in the header of the grid file ewh\*\*\*.dat.

After the estimation is completed, the residual value files should be opened to check the results. The first few rows of the file indicate the change information of the mean and standard deviation of the residual value with the number of iterations. If necessary, the integral radius or the number of iterations (there is a certain correlation between the two) should be adjusted, and the iterative estimation should be performed again.



After the estimation is completed, the residual value files should be opened to check the results. The first few rows of the file indicate the change information of the mean and standard deviation of the residual value with the number of iterations. If necessary, the integral radius or the number of iterations should be adjusted (there is a certain correlation between the two), and the iterative estimation should be performed again.

## 4.8 Geodynamic calculation on geodetic field grids time series

[Purpose] Calculate the time difference, space horizontal gradient, or two vector grids inner product of the ground deformation field grids time series to display their spatiotemporal geodynamic characteristics.

## 4.8.1 Time difference operation on variation (vector) grids time series

[Function] Sort the input variation (vector) grids time series files according to the sampling epoch time (the seventh attribute of the file header), and then calculate the variation rate at two neighboring sampling epochs to generate the variation (vector) rate grids time series. Here, the sampling epoch time of the current grid is equal to the average of the before and after sampling epochs of the variation (vector) grids, the unit of the variation rate is per k day, and k is the given differential time scale factor.

The variation (vector) grids time series files are extracted according to the given wildcards. For the variation vector grids time series, the program requires them to be in the form of horizontal coordinates.

[Input files] The variation (vector) grids time series files.



[Parameter settings] Set the wildcard patameters for the variation (vector) grids time series files, enter the differential time scale factor k.

[Output files] The variation (vector) rate grids time series files.

# 4.8.2 Horizontal gradient calculation on batch variation grids

[Function] From batch variation grids files with the same grid specifications in the specified folder, calculate horizontal gradient vector grids (per km). The horizontal gradient vector can be output in the form of polar coordinates or EN horizontal coordinates. The variation grid files are extracted according to the given wildcards.



#### 4.8.3 Inner product operation on two groups of vector grids time series

[Function] Calculate the inner product grids time series from two groups of variation vector grids time series in the form of the EN horizontal rectangular coordinates with the same grid specifications.

The variation vector grid files are extracted according to the given wildcards.

The program allows a group of vector grid files with only one sampling time. When the two groups are both vector grids time series, the program requires one-by-one correspondence between the sampling epochs.

# 5 CORS/InSAR collaborative monitoring and stability estimation

The group of programs can be used to construct an accurate geometric and physical spatiotemporal monitoring frame with regional unification, long-term stability, and high robustness performance, and then perform scientific computations for the collaborative monitoring of the CORS network and multi-source InSAR. From the variation grids time series of the geodetic deformation field, quantitatively and continuously monitor the regional ground stability variations by constructing some quantitative criteria for the ground stability reduction.



CORS and InSAR collaborative monitoring principle for vertical deformation:

(1) Through the gross error detection, spatial filtering, and time series analysis, the InSAR vertical variation is separated into two parts, one part is the vertical deformation of the rock and soil layer several meters deep, and the other part is the expansion and contraction of the soil own. Only the former is compatible with most geodetic variations, while the latter is mainly affected by the temperature and rainfall and should not be regarded as a solid Earth deformation.

(2) Using the CORS network ellipsoidal height variations time series as the constraints on the multi-source InSAR vertical variations time series, separate the ground vertical deformation signal, and then realize the collaborative monitoring of the CORS network and multi-source InSAR.

(3) Only the vertical deformation of the rock and soil layer several meters deep is the useful information needed for monitoring of the ground subsidence, earthquakes, geological disasters, ground stability variations, solid Earth deformation, groundwater variations, and geodynamics.

Continuous quantitative monitoring scheme of ground stability variations:

(1) From the grids time series of the geodetic vertical deformation, ground gravity, and tilt variations, quantitatively and continuously monitor ground stability variations by constructing the quantitative criteria for the ground stability reduction.

(2) Quantitative criteria of the ground stability reduction can include that the ground ellipsoidal height increases, the gravity decreases, the horizontal gradient of the height or gravity variation is large, and the inner product of the tilt variations and terrain slope vector is greater than zero.

(3) According to the geological disasters that occurred, optimize and synthesize a variety of geodetic ground stability variation grids time series to adapt to the local environmental geology, and then consolidate regional stability variations monitoring capabilities.

# 5.1 Pseudo-stable adjustment of records time series for geodetic network variations

[Function] Using the variations time series of the GNSS baseline components, height differences of the leveling route, or gravity differences of the gravity control network as the observations, and a given group of sites reference values time series as the pseudo-stable references, estimate the variations time series of the coordinate component of the CORS network sites, the height of the leveling network sites or the gravity of the gravity network sites by the indirect least squares adjustment method.

The program can be used to construct an accurate geometric and physical spatiotemporal monitoring frame with regional unification, long-term stability, and high robustness performance.

The program requires that all the variations are strictly synchronized at each sampling epoch time, and the reference epochs of all the records time series of all the variations need be unique.

[Input files] The observed variation records time series file of the geodetic network. The reference variation records time series file of the reference sites.

(1) The observed variation records time series file of the geodetic network (consists of the baselines or routes). The file header includes the number of characters of the baseline

or route name, the number of characters of the site name, the sampling length, ....., all the sampling epochs arranged with time.

The record includes the baseline or route name, the starting site (longitude, latitude, height), the ending site (longitude, latitude, height), ....., all the observed variations arranged with sampling time (default value is 9999).

(2) The variation records time series file of the reference sites. The file header contains all the sampling epochs arranged with time. The record format: the site name, longitude, latitude, height, ..., all the variations arranged with sampling time (default value is 9999).

The relations between the baselines (or routes) and the pseudo-stable reference sites in the geodetic monitoring network are reflected with the composition of the characters of their name. A baseline or route name is agreed to be composed of site names A and B at both ends (B\*\*\*A), where the number of characters of all the sites names is required to be equal. Therefore, the number of characters of the baseline or route name shall not be less than twice the number of characters of the site name.



[Parameter settings] Set the records time series files format patameters for the observed variations of the geodetic network and the reference variations of the reference sites, set the

constraint mode of the pseudo-stable references.

When selecting the constraint of "weighted average with reference values", the program requires that the observed variation records time series are one-by-one correspond with the sampling epoch time of the reference value records time series.

When selecting the constraint of "weighted average with zero values", the adjusted results time series only reflect the relative deformation of the region, whose deformation properties are similar to InSAR variations time series.

[Output files] The variation adjusted value records time series file of the geodetic network sites.

The file header comes from the reference variation records time series file of the reference sites. The record format: the site name, longitude, latitude, height, all the variation adjusted values arranged with sampling epoch time.

When selecting the constraint of "weighted average with reference values", the program outputs the reference site adjusted values time series file \*\*\*.dmn into the current folder.

The file header comes from the variation records time series file of the reference sites. The record format: the site name, longitude, latitude, height, weight, all the reference site adjusted values arranged with sampling time. The last row of the file is the weighted average time series of the reference values of the source reference sites. Here, \*\*\* are the output file name of the variation adusted value records time series.

## 5.2 Gross error detection and spatial deformation analysis on InSAR variations

[Purpose] Construct InSAR variations spatial analysis algorithms according to the spatial distribution natures of the ground deformation under the action of the environmental geology and load geodynamics, separate the outliers and gross errors in InSAR variations, suppress and weaken the impact of the soil own variations, and then extract the InSAR ground vertical deformation which is compatible with the other geodetic variations.

## 5.2.1 Gross error detection and separation on InSAR variation records time series

[Function] According to the spatial high-correlation characteristics of the ground deformation, construct a reference surface respectively at each sampling epoch time with the given low-pass filter to separate the outliers, gross error, and abrupt signals from the input InSAR variation records time series.

[Input file] The InSAR variation records time series file.

InSAR variations time series is agreed in the records time series format, and the sampling epoch time is agreed in ETideLoad format.

[Parameter settings] Set the InSAR variation records time series files format patameters, select the spatial filtering mode, and enter the number of gross error detection iterations.

[Output file] The InSAR variation records time series file.

The InSAR variation records time series in the output file is the same as that in the input
file, with only the gross variations replaced by 9999.000.



The program automatically outputs the InSAR gross error records time series file in the current folder. The file format is the same as the source input InSAR time series file. The file header occupies 1 row, and the last few column properties correspond to the gross error percentage of the InSAR variations at each sampling epoch time. The default value of 9999.00 in the record represents that the InSAR variation is not a gross error. The non-default value represents that the InSAR variation is a gross error, and the value is the source InSAR variation.

The purpose of the gross error detection and separation is to separate non-deformable signals including the outliers, gross errors, and sudden changes in the InSAR variations, and eliminate the SAR multipath effects and rough surface environment interferences.

#### 5.2.2 Analysis and processing of relative spatial deformation on InSAR variations

[Function] According to the spatial distribution natures that the ground vertical deformation is inversely proportional to the distance away from the dynamic source, suppress or weaken the local changes due to non-geological dynamics on the shallow surface from the input InSAR variation records time series using the specified spatial filtering algorithm.

[Input file] The InSAR variation records time series file.

[Parameter settings] Set the InSAR variation records time series files format patameters, select the spatial filtering mode, enter spatial low-pass filter times, and set the checkbox of [use the spatial filtering value to repair the gross error].

For the moving average filter, the greater the filtering parameter n, the greater the filtering strength. For the spatial Gaussian filter, the smaller the n, the greater the filtering strength.

[Output file] The InSAR variation records time series file.

Before and after filtering, the format, time-space sampling distribution and quantity of the monitoring points of the output InSAR variation records time series file are the same as that of the input InSAR variation records time series file. The output variation = the input variation – the residual variation.



The program automatically outputs the InSAR residual variation records time series file in the current folder. The file format is the same as the source input InSAR time series file. The residual variation = the input variation – the output variation.

The purpose of the spatial deformation analysis is to suppress the surface soil's own expansion and contraction effects due to the temperature changes, rainfall, and other meteorological actions, and to suppress the short-wave effects of the atmospheric delay and surface multipath.

#### 5.2.3 Generation high-resolution grids time series from records time series

[Function] According to the given minimum number of the effective monitoring points in a grid element, generate the high-resolution variation grids time series by the direct averaging or Gaussian function interpolation method. The number of the output grids time series files are equal to the number of sampling epochs of the variation records time series. The grid value on the invalid grid element is represented by 9999.0.

[Input file] The InSAR variation records time series file.

[Parameter settings] Set the InSAR variation records time series files format patameters and enter the grid spatial resolution.

[Output file] The results file names are grid\*\*\*.dat. The number of files is equal to the sampling number of the variation records time series, and \*\*\* are the sampling epoch time in the long ineger format agreed by the ETideLoad.

#### 5.3 Cooperative monitoring and processing of CORS network and InSAR

[Purpose] Unify the reference epoch time of multi-source InSAR variations time series and CORS network height variation records time series, and then through the compatibility analysis of vertical deformation of the CORS network and InSAR, InSAR variations adjustment with the constraint of the CORS network, unify the spatiotemporal monitoring frame of the InSAR variations time series and control the accumulation of the InSAR monitoring errors over time.

The purpose of cooperative monitoring and processing of the CORS network and InSAR: (1) Repair the tidal and non-tidal load effects on the InSAR variations, compensate the spatial long-wave troposphere model errors. (2) Compensate the temporal information which spatial wavelength larger than the InSAR monitoring region, control the cumulative error of the InSAR variations over time. (3) When there are no less than 3 CORS stations, can precisely repair the InSAR differential interference scale error and compensate the other medium-long wave errors.

#### 5.3.1 Unification of reference epoch for variation records time series

[Function] Using the cubic spline interpolation, Gaussian function interpolation, or lowpass filtering method, estimate and remove the sampling value of all the variation records time series at the given reference epoch time, thereby unify the reference epoch time of all the variation records time series. At the reference epoch time, the sampling values of all the variations are always zero.

The program requires that the reference epoch time be no earlier than the first sampling time and no later than the last sampling time, otherwise automatically set to the first or last sampling time.

[Input file] The InSAR variation records time series file.

[Parameter settings] Set the InSAR variation records time series files format patameters,

select the time interpolation mode, and enter the reference epoch time.

[Output file] The InSAR variation records time series file.

When the interpolation result of a record time series at the reference epoch time is invalid, the program separates the record time series into the file \*\*\*.rep.

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3638.264 3614.724 3588.857 3747.716 3495.068 2147.368 3511.911 3170.213 2217.898 2738.596 1610.268 1597.445 2622.976	99.2434511 99.2432844 99.2429511 99.2509508 99.2447844 99.1116230 99.2631170 99.2541173 99.2302849 99.229491 99.1304556 99.1437884 99.1156229	26.3055050 26.3053383 26.3045050 26.3025051 26.2835059 26.2793394 26.2793394 26.2690065 26.2665066 26.2476740 26.22474745	113,108 102,809 -36,574 38,425 45,125 -178,770 43,796 179,906 59,076 110,316 60,312 137,279	8.7374 16.2598 10.5116 1.8613 3.9216 12.2205 2.0891 15.3391 3.1182 7.9680 1.3582	4.4519 14.5560 1.5.2354 2.5223 1.2.4003 1. 10.8640 1.9739 1.9739 2.9676 1. 8.5205 2. 0.7416 2.	3614.724           9         3608.657           3747.716           1         3495.066           2         2147.368           3511.911           4         3170.213           5         2217.898           16         2738.596           17         1610.266           19         2622.976           303.803.127         219.717	99.2432844 99.2429511 99.2509508 99.2447844 99.1116230 99.2631170 99.2631170 99.2302849 99.2302849 99.2302849 99.1304556 99.1437884 99.1156229 99.1456229 99.2016192	26.3055050 26.305383 26.3045050 26.3025051 26.2835059 26.2793394 26.2783394 26.2690065 26.265066 26.2476740 26.265066 26.2476740 26.2253415 26.2058423 26.2040091	113.108 102.809 36.574 4.425 -176.70 43.796 179.906 59.076 110.316 60.312 137.279 -415.811 -51.331	-7.2319 -6.4449 -2.5356 -2.2951 -4.6100 -1.5400 -1.5604 -2.7593 -3.6370 -4.0771 -2.2598 -2.0618 -1.0519	-12.0689 -10.7304 -4.2394 -7.5713 -3.9490 -3.0533 -2.8167 -6.4245 -3.7876 -3.5246 -2.8764 -2.5617 -2.2246	-8.1985 -7.2778 -5.3806 -5.9858 -4.5344 -4.4840 -7.3358 -5.3034 -6.5034 -2.9801 -6.3567 -3.8379 -3.4914 -3.4704	-16,3237 -13,6966 -6,4579 -11,2987 -5,9986 -4,3727 -4,1418 -8,3338 -12,8478 -5,5382 -2,1397 -5,5351 -3,2818 -10,5953	-14.84 -13.76 -7.89 -10.60 -5.87 -6.86 -6.56 -7.64 -11.47 -7.21 -9.34 -6.80 -4.80 -9.49
3638.264 3614.724 3588.857 3747.716 3495.068 2147.368 3511.911 3170.213 2217.898 2738.596 1610.268 1597.445 2622.976 3803.835	99.2434511 99.2432844 99.2429511 99.2509508 99.2447844 99.1116230 99.2531170 99.2531170 99.22302849 99.2302849 99.1304556 99.1437884 99.1156229 99.2016194	26.3055050 26.3053383 26.3045050 26.3025051 26.2835059 26.278394 26.278394 26.2690065 26.2465066 26.2476740 26.2253415 26.2056423	113,108 102,809 -36,574 38,425 45,125 -178,770 43,796 179,906 59,076 110,316 60,312 137,279 -415,811	8.7374 16.2598 10.5116 12.2205 2.0891 15.3391 3.1182 7.9680 1.3582 2.3389	4.4519 14.5560 1.5.2354 2.5223 1.2.4003 1.1.9739 1.1.9739 2.9676 1.8.5205 1.8.5205 1.8.990 2.9676 1.8.900 2.9676 1.8.900 2.97416 2.9746	8         3614.724           9         3568.857           3747.716         3747.716           11         3495.068           12         2147.368           13         3170.213           155         2217.896           160.268         1597.445           160.268         1597.445           12         242.976           12         303.835           12         219.717           2         2479.463	99.2432844 99.2429511 99.2509508 99.2447844 99.1116230 99.2631170 99.2631170 99.2631170 99.2028491 99.1304556 99.1437884 99.156229 99.2016194 99.2016194	26.3055050 26.305383 26.3045050 26.3025051 26.2835059 26.2793394 26.2630065 26.2665066 26.246740 26.2341745 26.2253415 26.205423 26.205423 26.204091	113.108 102.809 36.574 8.425 45.125 45.125 178.70 179.906 59.076 110.316 60.312 137.279 -415.811 -51.331 -40.762	-7.2319 -6.4449 -2.5356 -2.2551 -4.6100 -1.5400 -1.5604 -2.7593 -3.6370 -4.0771 -2.2598 -2.0618 -1.0519 -1.0519	-12.0689 -10.7304 -4.2394 -7.5713 -3.9490 -3.0533 -2.0167 -6.4864 -6.1245 -3.7876 -3.5246 -2.8764 -2.5617 -2.2246 -2.2246	-8.1985 -7.2778 -5.3806 -5.9858 -4.5344 -4.4840 -7.3358 -5.3034 -6.5034 -6.5034 -6.5034 -6.567 -3.8379 -3.4914 -3.4678	-16, 3237 -13, 6966 -6, 4579 -11, 2907 -4, 12907 -4, 1418 -8, 3330 -12, 8478 -5, 5382 -2, 1397 -5, 5351 -3, 2818 -3, 2818 -4, 281	-14.84 -13.76 -7.89 -10.60 -5.87 -6.86 -6.56 -7.64 -11.47 -7.21 -9.34 -6.88 -4.80 -4.80 -9.49 -10.72
3638.264 3614.724 3588.857 3747.716 3495.068 2147.368 2147.368 2511.911 3170.213 2217.898 2738.596 1610.268 1597.445 2622.976 3803.835 2519.717	99.2434511 99.2429511 99.2509505 99.2447844 99.1116230 99.2541173 99.2302849 99.2302849 99.2302849 99.1304556 99.137884 99.1156229 99.2016194 99.2016194	26.3055050 26.3053383 26.3045050 26.3025051 26.2793394 26.26793394 26.269065 26.265066 26.2476740 26.22476740 26.2253415 26.2058423 26.2040091	113.108 102.809 -36.574 38.425 45.125 -176.770 43.796 59.076 110.316 60.312 137.279 -415.811 -51.331	8,7374 16,2598 10,5116 1,8613 3,9216 12,2205 2,0891 15,3391 3,1182 7,9680 1,3582 2,389 2,3405	4.4519 14.5560 5.2354 1 2.5223 1 2.4003 1 10.8640 1 1.9739 1 2.9676 1 8.5205 1 0.7416 2 1.8390 1.1678 2	8         3614.724           9         3568.857           0         3747.716           11         3495.068           12         2147.368           13         3511.911           14         3170.213           15         2217.898           15         2217.898           16         2238.596           17         1610.260           16         1597.445           19         2622.976           3193.282         193.282	99,2432844 99,242511 99,2505508 99,2427844 99,1116230 99,2631170 99,2631170 99,2631170 99,202849 99,202849 99,1304556 99,1437884 99,1156229 99,2016129 99,1602877 99,1599544	26.3055050 26.305383 26.3025051 26.2835059 26.2793394 26.2793394 26.2690065 26.265066 26.2476740 26.2253415 26.2056423 26.2056423 26.204091 26.2035091 26.2035091	113.108 102.809 36.574 45.125 -178.70 43.796 179.906 59.076 110.316 60.312 137.279 -415.811 -51.331 -40.762 20.677	-7.2319 -6.4449 -2.5356 -2.2951 -4.6100 -1.5400 -1.5400 -1.5604 -2.7593 -3.6370 -4.0771 -2.2599 -2.0618 -1.0519 -1.0461 -1.3372	-12.0689 -10.7304 -4.2394 -7.5713 -3.9490 -3.0533 -2.8167 -6.4864 -6.1245 -3.7876 -3.5246 -2.8764 -2.5617 -2.2246 -2.2208 -2.3914	$\begin{array}{r} -8.1985\\ -7.2778\\ -5.3806\\ -5.9850\\ -4.5314\\ -4.4840\\ -7.3358\\ -5.3334\\ -6.5533\\ -2.9801\\ -2.9801\\ -2.9801\\ -3.8379\\ -3.4914\\ -3.4704\\ -3.4678\\ -3.4614 \end{array}$	$\begin{array}{c} -16,3237\\ -13,6966\\ -5,4579\\ -11,2907\\ -5,9986\\ -4,3727\\ -4,1416\\ -8,3338\\ -12,8478\\ -5,5382\\ -2,1397\\ -5,5382\\ -3,2818\\ -10,5953\\ -12,4661\\ -1,9443 \end{array}$	-14.84 -13.76 -7.89 -10.60 -5.87 -6.86 -7.64 -11.47 -7.21 -9.34 -6.88 -4.80 -9.49 -10.72 -12.60
3638.264 3614.724 3588.857 3747.716 3495.068 2147.368 3511.911 3170.213 2217.898 2738.596 1610.268 1597.445 2622.976 3803.835 2519.717 2479.463	99.2434511 99.2432511 99.2432511 99.2447844 99.1116230 99.2447844 99.1116230 99.2631170 99.2241173 99.2202491 99.1202491 99.1304556 99.1437884 99.1156229 99.2016194 99.1602877	26.3055050 26.305303 26.3045050 26.3025051 26.2835059 26.2793394 26.2783394 26.2690055 26.265066 26.2476740 26.2341745 26.2245145 26.2258423 26.22058423 26.2040091	113.108 102.809 -36.574 38.425 45.125 -178.770 43.796 179.906 59.076 110.316 60.312 137.279 -415.811 -51.331 -40.762	8.7374 16.2598 10.5116 1.8613 3.9216 12.2205 2.0891 15.3391 3.1182 7.9680 1.3582 2.3389 2.33405 2.3423	4.4519 14.5560 5.2354 2.5223 10.8640 -2.8369 11.9739 2.9676 1.8390 1.8390 1.1678 1.1678	8         3614.724           9         3688.857           10         3747.716           12         2147.368           13         3511.911           14         3170.213           15         2217.898           15         2217.898           15         2217.898           160.263         1597.455           17         1610.268           193.282         303.835           193.282         193.282           3193.282         2384.009	99.2432844 99.2429511 99.2505508 99.2447844 99.1116230 99.2631170 99.2541173 99.2302849 99.1302849 99.1302849 99.1437884 99.1437884 99.1437884 99.1602877 99.1599584 99.1427884 99.3133483	26.3055050 26.3055393 26.3055051 26.20551 26.2733394 26.2733394 26.2733394 26.263065 26.2476740 26.2476740 26.22476740 26.22476740 26.2253415 26.2056042 26.2036091 26.2036042 2	$\begin{array}{c} 113.108\\ 102.809\\ 36.574\\ 4.425\\ 45.125\\ -178.79\\ 43.796\\ 179.906\\ 59.076\\ 110.316\\ 60.312\\ 137.279\\ -415.811\\ -51.331\\ -40.762\\ 20.677\\ -470.552\\ 293.680\\ \end{array}$	-7.2319 -6.4449 -2.5356 -2.2951 -4.6100 -1.5400 -1.5604 -2.7593 -3.6370 -4.0771 -2.2598 -2.0618 -1.0519 -1.0519 -1.0611 -1.3872 -1.8393 -6.8375	-12.0689 -10.7304 -4.2394 -7.5713 -3.9490 -3.0533 -2.0167 -6.4464 -6.1245 -3.7876 -3.5246 -2.0764 -2.5617 -2.2208 -2.3914 -2.3966 -5.5578	$\begin{array}{c} -8.1985\\ -7.2778\\ -5.3806\\ -5.9858\\ -4.5344\\ -4.4940\\ -7.3358\\ -5.3334\\ -6.5034\\ -6.5034\\ -2.9801\\ -2.9801\\ -6.3567\\ -3.8379\\ -3.4914\\ -3.4704\\ -3.4678\\ -3.4614\\ -3.4716\\ -3.9371\end{array}$	$\begin{array}{c} -16, 3237\\ -13, 6966\\ -6, 4579\\ -11, 2987\\ -5, 9996\\ -4, 3727\\ -4, 1410\\ -8, 3338\\ -12, 0478\\ -5, 5352\\ -2, 1397\\ -5, 5351\\ -3, 2818\\ -10, 5953\\ -12, 4661\\ -1, 9443\\ -3, 1559\\ -5, 1133\end{array}$	$\begin{array}{c} -14.84\\ -13.76\\ -7.89\\ -10.60\\ -5.87\\ -6.86\\ -6.56\\ -6.56\\ -7.64\\ -11.47\\ -7.21\\ -9.34\\ -4.80\\ -4.80\\ -4.80\\ -12.60\\ -12.60\\ -4.84\\ -7.84\\ -7.84\end{array}$
3638.264 3614.724 3588.857 3747.716 3495.068 2147.368 3511.911 3170.213 2217.898 2738.596 1610.268 1597.445 2622.976 3803.835 2519.717 2479.463	99.2434511 99.2432544 99.2429511 99.2429511 99.2447844 99.1416230 99.2631170 99.2631170 99.2631173 99.23028491 99.1304556 99.1437884 99.1156229 99.2016194 99.1602877 99.1427884	26.3055050 26.3045050 26.3045050 26.3025051 26.2793394 26.2793394 26.2793394 26.2690065 26.2665066 26.2476740 26.2311745 26.2253415 26.2025041 26.2035091 26.2035091	113.108 102.809 -36.574 38.425 45.125 -178.770 43.796 179.906 59.076 10.316 60.312 137.279 -415.811 -51.331 -40.762 20.677	8,7374 16.2598 10.5116 1.8613 3.9216 12.2205 2.0891 15.3391 3.1182 7.9680 1.3582 2.3389 2.3405 2.3423 22.9150	4.4519 14.5560 1 5.2354 1 2.5223 1 10.6640 1 -2.8369 1 1.9739 1 2.9676 1 8.5205 1 1.8390 2 1.1678 2 1.1678 2 2.1910 2	8         3614.724           9         3568.857           0         3747.716           11         3495.068           2         2147.368           2         3170.213           15         2217.898           6         2735.596           17         1610.260           18         357.421           2         249.433           3         313.832           3         313.282           3         191.3282           3         315.4985           2         344.399           3         313.282           3         314.995           2         344.522	99.2432844 99.2429511 99.2509508 99.2447844 99.1116230 99.2541173 99.2541173 99.2302849 99.1304556 99.1437884 99.1165229 99.21016194 99.162277 99.1620277 99.1599544 99.2024527 99.333463	26.3055050 26.3053383 26.3345050 26.3025051 26.22835059 26.2793394 26.2793394 26.2793394 26.2690055 26.26476740 26.285415 26.265066 26.2341745 26.205081 26.203422 26.203422 26.203422 26.109329 26.199329	113.108 102.809 36.574 45.125 -178.79 43.799 179.906 59.076 110.316 60.312 137.279 -415.811 -51.331 -40.762 293.680 -99.672	$\begin{array}{r} -7.2319\\ -6.4449\\ -2.5356\\ -2.2951\\ -4.6100\\ -1.5400\\ -1.5400\\ -1.5400\\ -1.5604\\ -2.7593\\ -3.6370\\ -4.0771\\ -2.2599\\ -2.0618\\ -1.0519\\ -1.0519\\ -1.0519\\ -1.0872\\ -1.3872\\ -6.8375\\ -2.8312\end{array}$	$\begin{array}{r} -12.0689\\ -10.7304\\ -4.2394\\ -7.8713\\ -3.9490\\ -3.0533\\ -2.8167\\ -6.4864\\ -6.1245\\ -3.7876\\ -3.7876\\ -2.8764\\ -2.85617\\ -2.5617\\ -2.5617\\ -2.5617\\ -2.52246\\ -2.2208\\ -2.3914\\ -2.3914\\ -2.3966\\ -5.8578\\ -4.5226\end{array}$	$\begin{array}{c} -8,1985\\ -7,2776\\ -5,3806\\ -5,9950\\ -4,5344\\ -4,4840\\ -7,3358\\ -5,3034\\ -6,5034\\ -6,5034\\ -2,98011\\ -6,3567\\ -3,8379\\ -3,4914\\ -3,44704\\ -3,44704\\ -3,44704\\ -3,44716\\ -3,93711\\ -3,93716\\ -3,9376\\ -3,936\\ -3,9376\\ -3,936$	$\begin{array}{c} -16, 3237\\ -13, 6966\\ -6, 4579\\ -11, 2987\\ -5, 9996\\ -4, 3727\\ -4, 1410\\ -8, 3338\\ -12, 8478\\ -2, 1397\\ -5, 5382\\ -2, 1397\\ -5, 5351\\ -3, 2818\\ -10, 5953\\ -12, 4661\\ -1, 9443\\ -3, 1559\\ -9, 1133\\ -6, 3375\end{array}$	$\begin{array}{c} -14.84\\ -13.76\\ -7.89\\ -10.60\\ -5.87\\ -6.86\\ -6.56\\ -6.56\\ -7.64\\ -7.64\\ -9.34\\ -9.34\\ -9.49\\ -4.80\\ -4.80\\ -4.80\\ -4.84\\ -7.84\\ -7.84\\ -8.00\end{array}$
3638.264 3614.724 3588.857 3747.716 3495.068 2147.368 3511.911 3170.213 2217.898 1597.485 2622.976 1610.268 1597.445 2622.976 3803.835 2519.717 2479.463 2519.717 2479.463 2915.285	99.2434511 99.2432511 99.2432511 99.2447844 99.1116230 99.2447844 99.1116230 99.2631170 99.2241173 99.2202491 99.1202491 99.1304556 99.1437884 99.1156229 99.2016194 99.1602877	26.3055050 26.305303 26.3045050 26.3025051 26.2835059 26.2793394 26.2783394 26.2690055 26.265066 26.2476740 26.2341745 26.2245145 26.2258423 26.22058423 26.2040091	113.108 102.809 -36.574 38.425 45.125 -178.770 43.796 179.906 59.076 110.316 60.312 137.279 -415.811 -51.331 -40.762	8.7374 16.2598 10.5116 1.8613 3.9216 12.2205 2.0891 15.3391 3.1182 7.9680 1.3582 2.3389 2.33405 2.3423	4.4519 14.5560 5.2354 2.5223 10.8640 -2.8369 11.9739 2.9676 1.8390 1.8390 1.1678 1.1678	8         3614.724           9         3568.657           10         3495.068           11         3495.068           12         2147.368           13         3511.911           14         3170.213           15         2217.898           15         2217.898           16         259.745           17         1610.260           18         1597.445           23         303.835           21         219.1717           25         2344.009           26         2454.202           21         219.2479.463           22         2479.463           23         1913.282           244         3751.965           23         2446.522           21         2129.793	99,2432844 99,2429511 99,2429511 99,2447844 99,114230 99,2631170 99,2541173 99,2322491 99,1437884 99,1437884 99,145229 99,1437884 99,1427884 99,1427884 99,1427884 99,1427884 99,1427884 99,1427884 99,1427884 99,14688 99,2374889 98,8014688	26.3055050 26.3053303 26.3052051 26.22793394 26.2793394 26.2793394 26.2630055 26.2476740 26.2476740 26.2476740 26.2476740 26.2476740 26.2476740 26.235415 26.205091 26.205091 26.205091 26.205091 26.205091 26.205092 26.1195096 26.1131766	113.108 102.809 36.574 45.425 45.425 45.425 45.9076 179.906 59.076 110.316 60.312 137.279 415.811 -51.331 -40.762 20.677 293.680 -99.672 284.192	-7.2319 -6.4449 -2.5356 -2.2951 -4.6100 -1.5400 -1.5604 -2.7593 -3.6370 -4.0771 -2.2598 -2.0618 -1.0519 -1.0519 -1.0611 -1.3872 -1.8393 -6.8375	$\begin{array}{c} -12.0689\\ -10.7304\\ -4.2394\\ -7.5713\\ -3.9490\\ -3.0533\\ -2.6167\\ -6.4864\\ -6.1245\\ -3.5246\\ -2.8764\\ -2.8764\\ -2.2208\\ -2.2208\\ -2.2914\\ -2.3966\\ -2.3914\\ -2.3966\\ -5.5578\\ -4.5526\\ -5.6578\end{array}$	$\begin{array}{c} -8,1985\\ -7,2778\\ -5,3806\\ -5,9858\\ -4,5344\\ -4,4840\\ -7,3358\\ -5,3334\\ -2,9801\\ -6,5567\\ -3,4814\\ -3,4704\\ -3,4704\\ -3,4678\\ -3,4614\\ -3,4614\\ -3,4614\\ -3,4614\\ -3,4614\\ -3,4878\\ -3,1889\\ -3,5877\end{array}$	$\begin{array}{c} -16,3237\\ -13,6966\\ -13,6966\\ -4,4579\\ -11,2967\\ -5,9986\\ -4,3127\\ -4,1410\\ -8,3338\\ -12,0478\\ -5,5382\\ -2,1397\\ -5,5382\\ -2,1397\\ -5,5381\\ -3,2818\\ -10,5953\\ -3,2818\\ -10,5953\\ -3,2818\\ -12,4661\\ -1,9443\\ -3,1859\\ -5,1133\\ -6,3375\\ 18,3318\end{array}$	$\begin{array}{c} -14.84\\ -13.76\\ -7.89\\ -10.60\\ -5.87\\ -6.86\\ -6.56\\ -7.64\\ -11.47\\ -7.21\\ -9.34\\ -4.80\\ -4.80\\ -10.72\\ -12.60\\ -4.84\\ -7.84\\ -7.84\\ -8.00\\ 9.59\end{array}$
3638.264 3614.724 3588.857 3747.716 3495.068 2147.368 3511.911 3170.213 2217.898 1597.485 2622.976 1610.268 1597.445 2622.976 3803.835 2519.717 2479.463 2519.717 2479.463 2915.285	99.2434511 99.2432844 99.2429510 99.2447844 99.1116230 99.2541173 99.22541173 99.22541173 99.2204919 99.1304556 99.136529 99.2016194 99.156229 99.2016194 99.156229 99.2016194 99.156229	26.3055050 26.3053383 26.3045050 26.3025051 26.235059 26.2793394 26.2283059 26.2793394 26.22490065 26.2645066 26.2476740 26.2341745 26.225423 26.2258423 26.2058423 26.2058423 26.2058423	1113.108 102.809 -36.574 38.425 45.125 -178.770 43.796 59.076 110.316 60.312 137.279 -415.811 -51.331 -40.762 20.677 -470.552	8.7374 16.2598 10.5116 1.8613 3.9216 12.2205 2.0891 15.3391 3.1182 7.9680 1.3582 2.3389 2.3405 2.3423 2.3425 2.3425 2.3425	4.4519 14.5560 5.2354 2.5223 10.8640 1.9739 2.9676 1.9739 0.7416 2.9676 1.3390 1.1676 2.19108 2.9108 2.9668	8         3614.724           9         3568.857           0         3747.716           11         3495.068           2         2147.368           2         3170.213           15         2217.898           6         2735.596           17         1610.260           18         357.421           2         249.433           3         313.832           3         313.282           3         191.3282           3         315.4985           2         344.399           3         313.282           3         314.995           2         344.522	99.2432844 99.2429511 99.2509508 99.2447844 99.1116230 99.2541173 99.2541173 99.2302849 99.1304556 99.1437884 99.1165229 99.21016194 99.162277 99.1620277 99.1599544 99.2024527 99.333463	26.3055050 26.3053303 26.3052051 26.22793394 26.2793394 26.2793394 26.2630055 26.2476740 26.2476740 26.2476740 26.2476740 26.2476740 26.2476740 26.235415 26.205091 26.205091 26.205091 26.205091 26.205091 26.205092 26.1195096 26.1131766	113.108 102.809 36.574 45.125 -178.79 43.799 179.906 59.076 110.316 60.312 137.279 -415.811 -51.331 -40.762 293.680 -99.672	$\begin{array}{r} -7.2219\\ -6.4449\\ -2.5356\\ -2.2951\\ -4.6100\\ -1.5604\\ -1.5604\\ -2.7593\\ -3.6370\\ -4.0771\\ -2.2598\\ -2.0618\\ -1.0519\\ -1.0461\\ -1.3872\\ -1.8393\\ -6.8375\\ -2.8312\\ 14.0676\end{array}$	$\begin{array}{r} -12.0689\\ -10.7304\\ -4.2394\\ -7.8713\\ -3.9490\\ -3.0533\\ -2.8167\\ -6.4864\\ -6.1245\\ -3.7876\\ -3.7876\\ -2.8764\\ -2.85617\\ -2.5617\\ -2.5617\\ -2.5617\\ -2.52246\\ -2.2208\\ -2.3914\\ -2.3914\\ -2.3966\\ -5.8578\\ -4.5226\end{array}$	$\begin{array}{c} -8,1985\\ -7,2776\\ -5,3806\\ -5,9950\\ -4,5344\\ -4,4840\\ -7,3358\\ -5,3034\\ -6,5034\\ -6,5034\\ -2,98011\\ -6,3567\\ -3,8379\\ -3,4914\\ -3,44704\\ -3,44704\\ -3,44704\\ -3,44716\\ -3,93711\\ -3,93716\\ -3,9376\\ -3,936\\ -3,9376\\ -3,9376\\ -3,9376\\ -3,936\\ -3,$	$\begin{array}{c} -16, 3237\\ -13, 6966\\ -6, 4579\\ -11, 2987\\ -5, 9996\\ -4, 3727\\ -4, 1410\\ -8, 3338\\ -12, 8478\\ -2, 1397\\ -5, 5382\\ -2, 1397\\ -5, 5351\\ -3, 2818\\ -10, 5953\\ -12, 4661\\ -1, 9443\\ -3, 1559\\ -9, 1133\\ -6, 3375\end{array}$	$\begin{array}{c} -14.84\\ -13.76\\ -7.89\\ -10.60\\ -5.87\\ -6.86\\ -6.56\\ -7.64\\ -11.47\\ -7.21\\ -9.34\\ -4.80\\ -4.80\\ -10.72\\ -12.60\\ -4.84\\ -7.84\\ -7.84\\ -8.00\\ 9.59\end{array}$
3638.264 3614.724 3588.857 3747.716 3511.911 3170.213 2217.898 2738.596 1507.445 2622.976 2622.976 2632.835 2519.717 2479.463 1913.282 3751.985 2384.009	99.2434511 99.2432844 99.2429511 99.2509508 99.2427844 99.1116230 99.2281170 99.2281170 99.2284173 99.2302849 99.2302849 99.2302849 99.1304556 99.1437884 99.16529 99.2016194 99.1627784 99.1437884 99.2024527 99.3139483	26.3055050 26.3053383 26.3025051 26.2025051 26.2793394 26.2283059 26.2793394 26.22690065 26.2476740 26.22476740 26.22476740 26.22476740 26.22476740 26.22476740 26.22059423 26.2059423 26.2059423 26.204091 26.20359424 26.203594 27.20359424444444444444444444444444444444444	111.100 102.809 -36.574 38.425 45.125 -178.770 43.796 179.906 59.076 110.316 60.312 137.279 -415.811 -51.331 -40.762 20.677 -470.552 293.680	8.7374 16.2598 10.5116 1.8613 3.9216 12.2205 2.0091 15.3391 3.1182 2.389 2.3405 2.3423 22.9150 2.5241 4.8822	4.4519 14.5560 5.2354 12.52354 10.06400 1-2.8369 11.9739 1.1.9739 1.1676 2.9576 1.8390 1.16778 2.4916 2.9688 2.1.96888 2.1.96888 2.1.96888 2.1.96888 2.1.96888 2.1.96888 2.1.96888 2.1.96888 2.1.968888 2.1.968888 2.1.968888 2.1.968888888888 2.1.9688888888888888888888888888888888888	8         3614.724           9         3568.657           10         3495.068           11         3495.068           12         2147.368           13         3511.911           14         3170.213           15         2217.898           15         2217.898           16         259.745           17         1610.260           18         1597.445           23         303.835           21         219.1717           25         2344.009           26         2454.202           21         219.2479.463           22         2479.463           23         1913.282           244         3751.965           23         2446.522           21         2129.793	99,2432844 99,2429511 99,2429511 99,2447844 99,114230 99,2631170 99,2541173 99,2322491 99,1437884 99,1437884 99,145229 99,1437884 99,1427884 99,1427884 99,1427884 99,1427884 99,3333463 99,2974889 98,8014688	26.3055050 26.3053303 26.3052051 26.22793394 26.2793394 26.2793394 26.2630055 26.2476740 26.2476740 26.2476740 26.2476740 26.2476740 26.2476740 26.235415 26.205091 26.205091 26.205091 26.205091 26.205091 26.205092 26.1195096 26.1131766	113.108 102.809 36.574 45.425 45.425 45.425 45.9076 179.906 59.076 110.316 60.312 137.279 415.811 -51.331 -40.762 20.677 293.680 -99.672 284.192	$\begin{array}{r} -7.2219\\ -6.4449\\ -2.5356\\ -2.2951\\ -4.6100\\ -1.5604\\ -1.5604\\ -2.7593\\ -3.6370\\ -4.0771\\ -2.2598\\ -2.0618\\ -1.0519\\ -1.0461\\ -1.3872\\ -1.8393\\ -6.8375\\ -2.8312\\ 14.0676\end{array}$	$\begin{array}{c} -12.0689\\ -10.7304\\ -4.2394\\ -7.5713\\ -3.9490\\ -3.0533\\ -2.6167\\ -6.4864\\ -6.1245\\ -3.5246\\ -2.8764\\ -2.8764\\ -2.2208\\ -2.2208\\ -2.2914\\ -2.3966\\ -2.3914\\ -2.3966\\ -5.5578\\ -4.5526\\ -5.6578\end{array}$	$\begin{array}{c} -8,1985\\ -7,2778\\ -5,3806\\ -5,9858\\ -4,5344\\ -4,4840\\ -7,3358\\ -5,3334\\ -2,9801\\ -6,5567\\ -3,4814\\ -3,4704\\ -3,4704\\ -3,4678\\ -3,4614\\ -3,4614\\ -3,4614\\ -3,4614\\ -3,4614\\ -3,4878\\ -3,1889\\ -3,5877\end{array}$	$\begin{array}{c} -16,3237\\ -13,6966\\ -13,6966\\ -4,4579\\ -11,2967\\ -5,9986\\ -4,3127\\ -4,1410\\ -8,3338\\ -12,0478\\ -5,5382\\ -2,1397\\ -5,5382\\ -2,1397\\ -5,5381\\ -3,2818\\ -10,5953\\ -3,2818\\ -10,5953\\ -3,2818\\ -12,4661\\ -1,9443\\ -3,1859\\ -5,1133\\ -6,3375\\ 18,3318\end{array}$	$\begin{array}{c} -14.84\\ -13.76\\ -7.89\\ -10.60\\ -5.87\\ -6.86\\ -6.56\\ -6.56\\ -7.64\\ -9.34\\ -9.34\\ -9.34\\ -4.80\\ -4.80\\ -4.80\\ -4.80\\ -4.80\\ -7.84\\ -7.84\\ -8.00\\ 9.59\\ -9.50\end{array}$
	99.2434511 99.2432544 99.2425511 99.24050508 99.2447844 99.1116240 99.253170 99.2541173 99.2202849 99.22028491 99.1304556 99.1437884 99.1156229 99.156229 99.159544 99.1202857 99.3139483	26.3055050 26.305383 26.3045050 26.3025051 26.2835052 26.2793394 26.2793394 26.2793394 26.2293415 26.265066 26.2476740 26.2341745 26.205423 26.2040091 26.203424 26.203444 26.203444 26.203444 26.203444 26.203444 26.203444 26.203444 26.203444 26.203444 26.203444 26.203444 26.203444 26.203444 26.203444 26.203444 26.2034444 26.2034444 26.2034444 26.2034444 26.20344444444444444444444444444444444444	1113.108 102.809 -36.574 38.425 45.125 -178.770 -179.906 59.076 10.316 60.312 137.279 -415.811 -51.331 -40.762 20.677 -470.552 293.680	8,7374 16,2598 10,5116 1,8613 3,9216 12,2205 2,0891 15,3391 3,1182 2,360 1,3582 2,3405 2,3423 2,3405 2,3423 2,3423 2,3425 2,3423 2,5241 4,8822 CORS network	4.4519 14.5560 5.2354 1 2.5223 10.0640 1 1.9739 1 2.9676 0.7416 2.9576 1.18390 1.1676 2 1.1676 2 1.1678 2 1.1676 2 1.1676 2 1.1678 1.16788 1.16788 1.16788 1.16788 1.16788 1	B         3614.724           9         3560.657           0.3747.716         3455.060           1.3455.060         3511.911           3.511.911         3511.911           3.512.738.596         22738.596           6         2738.596           6         2738.596           1.610.268         1597.445           1.622.976         2622.976           1.313.71.915         251.717           1.222.976         2193.282           2.3191.3282         2344.002           2.229.798         2129.793           1.2         2479.463           2.2         2464.522           2.2         249.793           1.2         249.793	99,2432844 99,2425511 99,2447844 99,2447844 99,2447844 99,2631170 99,2631170 99,22641173 99,2302849 99,2302849 99,2302849 99,1302856 99,1437884 99,1437884 99,1437884 99,1437884 99,1437884 99,1427884 99,1427884 99,1427884 99,1427884 99,1427884 99,143784 99,143784 99,14688 99,14688 99,14688 98,8016354	26.3055050 26.3053383 26.3045050 26.2733394 26.2733394 26.2733394 26.2733394 26.2733394 26.2733394 26.2845065 26.2457740 26.2341745 26.2253415 26.2253425 26.12545 26.125545 26.125545 26.125545 26.125545 26.125545 26.125545 26.125545 26.125545 26.125545 26.125545 26.125545 26.125545 26.125545 26.1255555 26.1255555 26.12555555 26.1255555555555555555555555555555555555	113.108 102.809 36.574 45.425 45.425 45.425 45.9076 179.906 59.076 110.316 60.312 137.279 415.811 -51.331 -40.762 20.677 293.680 -99.672 284.192	$\begin{array}{r} -7.2219\\ -6.4449\\ -2.5356\\ -2.2951\\ -4.6100\\ -1.5604\\ -1.5604\\ -2.7593\\ -3.6370\\ -4.0771\\ -2.2598\\ -2.0618\\ -1.0519\\ -1.0461\\ -1.3872\\ -1.8393\\ -6.8375\\ -2.8312\\ 14.0676\end{array}$	$\begin{array}{c} -12.0689\\ -10.7304\\ -4.2394\\ -7.5713\\ -3.9490\\ -3.0533\\ -2.6167\\ -6.4864\\ -6.1245\\ -3.5246\\ -2.8764\\ -2.8764\\ -2.2208\\ -2.2208\\ -2.2914\\ -2.3966\\ -2.3914\\ -2.3966\\ -5.5578\\ -4.5526\\ -5.6578\end{array}$	$\begin{array}{c} -8,1985\\ -7,2778\\ -5,3806\\ -5,9858\\ -4,5344\\ -4,4840\\ -7,3358\\ -5,3334\\ -2,9801\\ -6,5567\\ -3,4814\\ -3,4704\\ -3,4704\\ -3,4678\\ -3,4614\\ -3,4614\\ -3,4614\\ -3,4614\\ -3,4614\\ -3,4878\\ -3,1889\\ -3,5877\end{array}$	$\begin{array}{c} -16,3237\\ -13,6966\\ -13,6966\\ -4,4579\\ -11,2967\\ -5,9986\\ -4,3127\\ -4,1410\\ -8,3338\\ -12,0478\\ -5,5382\\ -2,1397\\ -5,5382\\ -2,1397\\ -5,5381\\ -3,2818\\ -10,5953\\ -3,2818\\ -10,5953\\ -3,2818\\ -12,4661\\ -1,9443\\ -3,1859\\ -5,1133\\ -6,3375\\ 18,3318\end{array}$	$\begin{array}{c} -14.84\\ -13.76\\ -7.89\\ -7.89\\ -10.60\\ -5.87\\ -6.86\\ -6.56\\ -7.64\\ -11.47\\ -9.34\\ -6.86\\ -9.49\\ -9.49\\ -9.49\\ -9.49\\ -10.722\\ -12.60\\ -4.80\\ -9.49\\ -8.00\\ -9.59\\ 9.559\end{array}$
3638.264 3614.724 3588.857 3747.716 345.068 2147.368 2147.368 2137.213 2217.898 2738.596 1507.445 2622.976 2622.976 2622.976 2632.977 303.835 2519.717 2479.463 1913.282 3751.985 2384.009	99.2434511 99.2432844 99.2429511 99.2509508 99.2427844 99.1116230 99.2281170 99.2281170 99.2281170 99.2284173 99.2302849 99.2302849 99.2302849 99.130556 99.1437884 99.162279 99.162977 99.162977 99.1437884 99.2024527 99.3139483	26.3055050 26.305383 26.3045050 26.3025051 26.2835052 26.2793394 26.2793394 26.2793394 26.2293415 26.265066 26.2476740 26.2341745 26.205423 26.2040091 26.203424 26.203444 26.203444 26.203444 26.203444 26.203444 26.203444 26.203444 26.203444 26.203444 26.203444 26.203444 26.203444 26.203444 26.203444 26.203444 26.2034444 26.2034444 26.2034444 26.2034444 26.20344444444444444444444444444444444444	1113.108 102.809 -36.574 38.425 45.125 -178.770 -179.906 59.076 10.316 60.312 137.279 -415.811 -51.331 -40.762 20.677 -470.552 293.680	8,7374 16,2598 10,5116 1,8613 3,9216 12,2205 2,0891 15,3391 3,1182 2,360 1,3582 2,3405 2,3423 2,3405 2,3423 2,3423 2,3425 2,3423 2,5241 4,8822 CORS network	4.4519 14.5560 5.2354 1 2.5223 10.0640 1 1.9739 1 2.9676 0.7416 2.9576 1.18390 1.1676 2 1.1676 2 1.1678 2 1.1676 2 1.1676 2 1.1678 1.16788 1.16788 1.16788 1.16788 1.16788 1	B         3614.724           9         3560.657           0.3747.716         3455.060           1.3455.060         3511.911           3.511.911         3511.911           3.512.738.596         22738.596           6         2738.596           6         2738.596           1.610.268         1597.445           1.622.976         2622.976           1.313.71.915         251.717           1.222.976         2193.282           2.3191.3282         2344.002           2.229.798         2129.793           1.2         2479.463           2.2         2464.522           2.2         249.793           1.2         249.793	99,2432844 99,2425511 99,2447844 99,2447844 99,2447844 99,2631170 99,2631170 99,22641173 99,2302849 99,2302849 99,2302849 99,1302856 99,1437884 99,1437884 99,1437884 99,1437884 99,1437884 99,1427884 99,1427884 99,1427884 99,1427884 99,1427884 99,143784 99,143784 99,14688 99,14688 99,14688 98,8016354	26.3055050 26.3053383 26.3045050 26.3025051 26.2733394 26.2733394 26.2733394 26.2733394 26.22340745 26.22450065 26.2476740 26.2341745 26.2253415 26.2253425 26.2254525 27.255555 27.25555555555555555555555	113.108 102.809 36.574 45.425 45.425 45.425 45.9076 179.906 59.076 110.316 60.312 137.279 415.811 -51.331 -40.762 20.677 293.680 -99.672 284.192	$\begin{array}{r} -7.2219\\ -6.4449\\ -2.5356\\ -2.2951\\ -4.6100\\ -1.5604\\ -1.5604\\ -2.7593\\ -3.6370\\ -4.0771\\ -2.2598\\ -2.0618\\ -1.0519\\ -1.0461\\ -1.3872\\ -1.8393\\ -6.8375\\ -2.8312\\ 14.0676\end{array}$	$\begin{array}{c} -12.0689\\ -10.7304\\ -4.2394\\ -7.5713\\ -3.9490\\ -3.0533\\ -2.6167\\ -6.4864\\ -6.1245\\ -3.5246\\ -2.8764\\ -2.8764\\ -2.2208\\ -2.2208\\ -2.2914\\ -2.3966\\ -2.3914\\ -2.3966\\ -5.5578\\ -4.5526\\ -5.6578\end{array}$	$\begin{array}{c} -8,1985\\ -7,2778\\ -5,3806\\ -5,9858\\ -4,5344\\ -4,4840\\ -7,3358\\ -5,3334\\ -2,9801\\ -6,5567\\ -3,4814\\ -3,4704\\ -3,4704\\ -3,4678\\ -3,4614\\ -3,4614\\ -3,4614\\ -3,4614\\ -3,4614\\ -3,4878\\ -3,1889\\ -3,5877\end{array}$	$\begin{array}{c} -16,3237\\ -13,6966\\ -13,6966\\ -4,4579\\ -11,2967\\ -5,9986\\ -4,3127\\ -4,1410\\ -8,3338\\ -12,0478\\ -5,5382\\ -2,1397\\ -5,5382\\ -2,1397\\ -5,5381\\ -3,2818\\ -10,5953\\ -3,2818\\ -10,5953\\ -3,2818\\ -12,4661\\ -1,9443\\ -3,1859\\ -5,1133\\ -6,3375\\ 18,3318\end{array}$	$\begin{array}{c} -14.84\\ -13.76\\ -7.89\\ -10.60\\ -5.87\\ -6.86\\ -6.56\\ -6.56\\ -7.64\\ -9.34\\ -9.34\\ -9.34\\ -4.80\\ -4.80\\ -4.80\\ -4.80\\ -4.80\\ -7.84\\ -7.84\\ -8.00\\ 9.59\\ -9.50\end{array}$
3638.264 3614.724 3588.857 3747.716 3951.091 3170.213 3511.911 3170.213 2217.898 2738.596 1610.268 1597.445 2229.976 1610.268 1597.445 2238.409 1913.282 2384.009 The purpos	99.243511 99.2435244 99.242551 99.250508 99.2427844 99.1116230 99.253170 99.2541173 99.2202451 99.2202451 99.1202451 99.13784 99.156229 99.2016194 99.162277 99.156259 99.162277 99.159544 99.142784 99.2024527 99.3139483 99.2024527 99.3139483	26.3055050 26.305383 26.3045050 26.3025051 26.2235051 26.2235059 26.2793394 26.2793394 26.2793394 26.2793394 26.265066 26.2476740 26.2341745 26.2059423 26.2059423 26.2059423 26.2059424 26.2015992 26.201592 26.2015	1113.108 102.809 -36.574 38.425 45.125 -178.770 43.796 59.076 100.316 60.312 137.279 -415.811 -51.331 -40.762 2.93.680 processing of the on the InSAR var	8.7374 16.2598 10.5116 1.8613 3.9216 12.2205 2.0991 15.3391 3.1182 7.9680 1.3582 2.3389 2.3405 2.3403 2.3423 2.29150 0.5241 4.8822 CORS network iations, compe	4.4519 14.5560 5.2354 2.5234 10.840 -2.8369 1.2.9276 1.2.9276 1.2.9276 1.2.9476 1.1.978 2.9476 1.1678 2.9476 1.1678 2.1.9108 2.1.9	B 3614.724 9 3586.857 01 3747.716 13 3455.068 12 2147.368 13 3511.911 31311.911 31311.911 31311.911 3131.911 45 2170.896 15 277.455 160.266 15 577.455 10 2622.976 3303.835 11 2519.717 2 4479.463 33 1913.282 4 3751.985 2 4479.463 33 1913.282 2 4479.463 33 1913.282 2 4479.463 33 1913.282 2 4479.463 33 1913.282 2 4479.463 3 2129.793 10 249.793 2 2	99.242811 99.242811 99.240508 99.2429511 99.242114230 99.242114230 99.24214173 99.24214173 99.2420249 99.2420249 99.1304256 99.143784 99.16529 99.161249 99.	26, 3055050 26, 3055383 26, 3045050 26, 3025051 26, 225051 26, 2253334 26, 2793394 26, 2793394 26, 2793394 26, 2793394 26, 22476740 26, 2253415 26, 2203424 26, 203424 26, 21903429 26, 1903429 26, 1801766 26, 18017666 26, 18017666 26, 18017666 26,	$\begin{array}{c} 113.109\\ 102.009\\ 36.574\\ 4.25\\ 4.574\\ 4.78.59\\ -178.59\\ -178.59\\ -178.59\\ -178.59\\ -178.59\\ -178.59\\ -178.59\\ -178.59\\ -178.59\\ -178.59\\ -178.59\\ -178.59\\ -415.811\\ -40.762\\ -293.609\\ -99.672\\ -293.609\\ -294.192\\ -294.$	-7,2349 -7,2356 -2,2951 -4,6100 -1,4600 -1,4600 -1,4600 -1,4600 -2,7593 -3,6370 -4,0771 -2,2599 -2,0618 -1,0519 -1,0519 -1,0519 -1,0519 -2,8332 -2,8312 -2,8312 -2,8312 -1,4,1219	-12.069 -10.7394 -4.2394 -7.5713 -3.9490 -3.0533 -2.916 -3.0543 -2.916 -3.226 -2.2764 -2.2091 -2.2914	$\begin{array}{c} -8,1985\\ -7,2778\\ -5,3806\\ -5,9858\\ -4,5344\\ -4,4840\\ -7,3358\\ -5,334\\ -2,9801\\ -6,5567\\ -3,4814\\ -3,4704\\ -3,4704\\ -3,4678\\ -3,4614\\ -3,4614\\ -3,4614\\ -3,4614\\ -3,4614\\ -3,4878\\ -3,1889\\ -3,5877\end{array}$	$\begin{array}{c} -16,3237\\ -13,6966\\ -13,6966\\ -4,4579\\ -11,2967\\ -5,9986\\ -4,3127\\ -4,1410\\ -8,3338\\ -12,0478\\ -5,5382\\ -2,1397\\ -5,5382\\ -2,1397\\ -5,5381\\ -3,2818\\ -10,5953\\ -3,2818\\ -10,5953\\ -3,2818\\ -12,4661\\ -1,9443\\ -3,1859\\ -5,1133\\ -6,3375\\ 18,3318\end{array}$	$\begin{array}{c} -14.84\\ -13.76\\ -7.282\\ -7.086\\ -6.66\\ -5.87\\ -6.66\\ -6.66\\ -7.24\\ -7.21\\ -9.34\\ -7.21\\ -9.34\\ -4.80\\ -4.80\\ -4.80\\ -10.72\\ -12.66\\ -7.84\\ -7.84\\ -7.84\\ -8.00\\ 9.50\end{array}$
a638.264 3614.724 3580.857 3747.716 3851.911 3170.213 3511.911 3170.213 3217.898 7238.596 1610.268 1597.445 2622.976 1610.268 1597.445 2622.976 3803.835 2519.717 2479.463 1913.282 3751.985 2384.009 The purpos Repair th Compensition	99.2434511 99.2432844 99.24050508 99.2429511 99.250508 99.241784 99.1116230 99.2541173 99.222491 99.222491 99.2431784 99.1156229 99.216194 99.2161	26.3055050 26.3053383 26.3045050 26.3025051 26.2835051 26.2835051 26.2835052 26.2793394 26.2793394 26.2793394 26.229065 26.2247540 26.2341745 26.2258423 26.2059423 26.2059423 26.2059423 26.2059423 26.2059424 26.205944	1113.108 102.809 -36.574 38.425 45.125 45.125 178.770 43.796 59.076 100.316 60.312 137.279 -415.811 -51.331 -40.762 293.680 processing of the on the InSAR var	8.7374 16.2598 10.5116 1.8613 3.9216 12.2205 2.0991 15.3391 15.3391 1.3582 2.3423 2.3423 2.3423 2.3423 2.5241 4.8822 CORS networl tiations, compe ingth larger tha	4.4519 14.5560 5.2354 2.5234 1.2.5223 10.8400 1.2.8369 11.9739 1.3990 1.3990 1.1678 1.1676 2.5076 0.7416 2.5076 1.1678 2.5016 1.9668 5.1619 2.5016 1.9668 5.1619 2.5016 1.9668 5.1619 2.5016 1.9668 5.1619 2.5016 1.9668 5.1619 2.5016 1.9668 5.1619 2.5016 1.9668 5.1619 2.5016 1.9668 5.1619 2.5016 1.9668 5.1619 2.5016 1.9668 5.1619 5.1618	<ul> <li>B 3614,724</li> <li>B 3568,657</li> <li>B 3568,657</li> <li>B 3568,657</li> <li>B 3568,657</li> <li>B 3568,657</li> <li>B 3568,657</li> <li>B 3561,911</li> <li>B 351,911</li> <li>B 356,22,976</li> <li>B 356,356</li> <l< td=""><td>99.242811 99.242851 99.242951 99.242951 99.242784 99.24784 99.24784 99.24784 99.24784 99.24784 99.147844 99.147844 99.147844 99.147844 99.147844 99.147844 9</td><td>2c. 3055050 2d. 3053383 2d. 3045080 2d. 3025081 2d. 2733394 2d. 2733394 2d. 2733394 2d. 2733394 2d. 2733394 2d. 2733394 2d. 22476740 2d. 2476740 2d. 2476740000000000000000000000000000000000</td><td>113.109 102.809 36.574 4.425 4.574 4.425 4.574 4.175,506 175,506 5.5,074 4.175,506 5.5,074 4.175,506 4.175,506 4.175,507 4.155,511 -61,331 -40,762 2.23,609 2.241,192 2.241,192 2.241,192 2.241,192</td><td>-7,2319 -7,2319 -2,2356 -2,2951 -1,5400 -1,4602 -1,6402 -2,15614 -2,15614 -2,2519 -2,0519 -1,0519 -1,0519 -1,0519 -1,0519 -1,0519 -1,0519 -2,0519 -2,2315 -2,3315 -2,3</td><td>-12.063 -10.7394 -4.2394 -7.5713 -3.4400 -3.0533 -2.0147 -6.4864 -6.12976 -6.4864 -6.12976 -6.4864 -3.2764 -3.52764 -2.2914 -2.2914 -2.2914 -2.5275 -5.528 -5.528 -5.528 -5.528 -3.6476 9.6476 9.6477</td><td><math display="block">\begin{array}{c} -8,1985\\ -7,2778\\ -5,3806\\ -5,9858\\ -4,5344\\ -4,4840\\ -7,3358\\ -5,334\\ -2,9801\\ -6,5567\\ -3,4814\\ -3,4704\\ -3,4704\\ -3,4678\\ -3,4614\\ -3,4614\\ -3,4614\\ -3,4614\\ -3,4614\\ -3,4878\\ -3,1889\\ -3,5877\end{array}</math></td><td><math display="block">\begin{array}{c} -16,3237\\ -13,6966\\ -13,6966\\ -4,4579\\ -11,2967\\ -5,9986\\ -4,3127\\ -4,1410\\ -8,3338\\ -12,0478\\ -5,5382\\ -2,1397\\ -5,5382\\ -2,1397\\ -5,5381\\ -3,2818\\ -10,5953\\ -3,2818\\ -10,5953\\ -3,2818\\ -12,4661\\ -1,9443\\ -3,1859\\ -5,1133\\ -6,3375\\ 18,3318\end{array}</math></td><td><math display="block">\begin{array}{c} -14.84\\ -13.76\\ -7.282\\ -7.086\\ -6.66\\ -5.87\\ -6.66\\ -6.66\\ -7.24\\ -7.21\\ -9.34\\ -7.21\\ -9.34\\ -4.80\\ -4.80\\ -4.80\\ -10.72\\ -12.66\\ -7.84\\ -7.84\\ -7.84\\ -8.00\\ 9.50\end{array}</math></td></l<></ul>	99.242811 99.242851 99.242951 99.242951 99.242784 99.24784 99.24784 99.24784 99.24784 99.24784 99.147844 99.147844 99.147844 99.147844 99.147844 99.147844 9	2c. 3055050 2d. 3053383 2d. 3045080 2d. 3025081 2d. 2733394 2d. 2733394 2d. 2733394 2d. 2733394 2d. 2733394 2d. 2733394 2d. 22476740 2d. 2476740 2d. 2476740000000000000000000000000000000000	113.109 102.809 36.574 4.425 4.574 4.425 4.574 4.175,506 175,506 5.5,074 4.175,506 5.5,074 4.175,506 4.175,506 4.175,507 4.155,511 -61,331 -40,762 2.23,609 2.241,192 2.241,192 2.241,192 2.241,192	-7,2319 -7,2319 -2,2356 -2,2951 -1,5400 -1,4602 -1,6402 -2,15614 -2,15614 -2,2519 -2,0519 -1,0519 -1,0519 -1,0519 -1,0519 -1,0519 -1,0519 -2,0519 -2,2315 -2,3315 -2,3	-12.063 -10.7394 -4.2394 -7.5713 -3.4400 -3.0533 -2.0147 -6.4864 -6.12976 -6.4864 -6.12976 -6.4864 -3.2764 -3.52764 -2.2914 -2.2914 -2.2914 -2.5275 -5.528 -5.528 -5.528 -5.528 -3.6476 9.6476 9.6477	$\begin{array}{c} -8,1985\\ -7,2778\\ -5,3806\\ -5,9858\\ -4,5344\\ -4,4840\\ -7,3358\\ -5,334\\ -2,9801\\ -6,5567\\ -3,4814\\ -3,4704\\ -3,4704\\ -3,4678\\ -3,4614\\ -3,4614\\ -3,4614\\ -3,4614\\ -3,4614\\ -3,4878\\ -3,1889\\ -3,5877\end{array}$	$\begin{array}{c} -16,3237\\ -13,6966\\ -13,6966\\ -4,4579\\ -11,2967\\ -5,9986\\ -4,3127\\ -4,1410\\ -8,3338\\ -12,0478\\ -5,5382\\ -2,1397\\ -5,5382\\ -2,1397\\ -5,5381\\ -3,2818\\ -10,5953\\ -3,2818\\ -10,5953\\ -3,2818\\ -12,4661\\ -1,9443\\ -3,1859\\ -5,1133\\ -6,3375\\ 18,3318\end{array}$	$\begin{array}{c} -14.84\\ -13.76\\ -7.282\\ -7.086\\ -6.66\\ -5.87\\ -6.66\\ -6.66\\ -7.24\\ -7.21\\ -9.34\\ -7.21\\ -9.34\\ -4.80\\ -4.80\\ -4.80\\ -10.72\\ -12.66\\ -7.84\\ -7.84\\ -7.84\\ -8.00\\ 9.50\end{array}$
(38, 264 (614, 724 (58, 857) (747, 716 (495, 068 (511, 911) (170, 213) (217, 898 (597, 445) (622, 976 (610, 268 (597, 445) (622, 976 (803, 835) (519, 717) (479, 463) (913, 228) (751, 985) (384, 009) <b>he purpos</b> (Acompendition of the second	99.243511 99.2435244 99.242551 99.250508 99.2427844 99.1116230 99.253170 99.2541173 99.2202451 99.2202451 99.1202451 99.13784 99.156229 99.2016194 99.162277 99.156259 99.162277 99.159544 99.142784 99.2024527 99.3139483 99.2024527 99.3139483	26.3055050 26.3053383 26.3045050 26.3025051 26.2835051 26.2835051 26.2835052 26.2793394 26.2793394 26.2793394 26.229065 26.2247540 26.2341745 26.2258423 26.2059423 26.2059423 26.2059423 26.2059423 26.2059424 26.205944	1113.108 102.809 -36.574 38.425 45.125 45.125 178.770 43.796 59.076 100.316 60.312 137.279 -415.811 -51.331 -40.762 293.680 processing of the on the InSAR var	8.7374 16.2598 10.5116 1.8613 3.9216 12.2205 2.0991 15.3391 15.3391 1.3582 2.3423 2.3423 2.3423 2.3423 2.5241 4.8822 CORS networl tiations, compe ingth larger tha	4.4519 14.5560 5.2354 2.5234 1.2.5223 10.8400 1.2.8760 1.2.8760 1.2.8760 1.4778 2.4083 1.4778 2.4083 1.4778 1.4776 2.5776 1.4778 2.5767 1.4778 2.5716 2.57	<ul> <li>B 3614,724</li> <li>B 3568,657</li> <li>B 3568,657</li> <li>B 3568,657</li> <li>B 3568,657</li> <li>B 3568,657</li> <li>B 3568,657</li> <li>B 3561,911</li> <li>B 351,911</li> <li>B 356,22,976</li> <li>B 356,356</li> <l< td=""><td>99.242811 99.242851 99.242951 99.242951 99.242784 99.24784 99.24784 99.24784 99.24784 99.24784 99.147844 99.147844 99.147844 99.147844 99.147844 99.147844 9</td><td>2c. 3055050 2d. 3053383 2d. 3045080 2d. 3025081 2d. 2733394 2d. 2733394 2d. 2733394 2d. 2733394 2d. 2733394 2d. 2733394 2d. 22476740 2d. 2476740 2d. 2476740000000000000000000000000000000000</td><td>113.109 102.809 36.574 4.425 4.574 4.425 4.574 4.175,506 175,506 5.5,074 4.175,506 5.5,074 4.175,506 4.175,506 4.175,507 4.155,511 -61,331 -40,762 2.23,609 2.241,192 2.241,192 2.241,192 2.241,192</td><td>-7,2319 -7,2319 -2,2356 -2,2951 -1,5400 -1,4602 -1,6402 -2,15614 -2,15614 -2,2519 -2,0519 -1,0519 -1,0519 -1,0519 -1,0519 -1,0519 -1,0519 -2,0519 -2,2315 -2,3315 -2,3</td><td>-12.063 -10.7394 -4.2394 -7.5713 -3.4400 -3.0533 -2.0147 -6.4864 -6.12976 -6.4864 -6.12976 -6.4864 -3.2764 -3.52764 -2.2914 -2.2914 -2.2914 -2.5275 -5.528 -5.528 -5.528 -5.528 -3.6476 9.6476 9.6477</td><td><math display="block">\begin{array}{c} -8,1985\\ -7,2778\\ -5,3806\\ -5,9858\\ -4,5344\\ -4,4840\\ -7,3358\\ -5,334\\ -2,9801\\ -6,5567\\ -3,4814\\ -3,4704\\ -3,4704\\ -3,4678\\ -3,4614\\ -3,4614\\ -3,4614\\ -3,4614\\ -3,4614\\ -3,4878\\ -3,1889\\ -3,5877\end{array}</math></td><td><math display="block">\begin{array}{c} -16,3237\\ -13,6966\\ -13,6966\\ -4,4579\\ -11,2967\\ -5,9986\\ -4,3127\\ -4,1410\\ -8,3338\\ -12,0478\\ -5,5382\\ -2,1397\\ -5,5382\\ -2,1397\\ -5,5381\\ -3,2818\\ -10,5953\\ -3,2818\\ -10,5953\\ -3,2818\\ -12,4661\\ -1,9443\\ -3,1859\\ -5,1133\\ -6,3375\\ 18,3318\end{array}</math></td><td><math display="block">\begin{array}{c} -14.84\\ -13.76\\ -7.89\\ -7.89\\ -10.60\\ -5.87\\ -5.87\\ -6.86\\ -6.56\\ -6.56\\ -7.64\\ -11.47\\ -7.21\\ -9.34\\ -6.80\\ -4.80\\ -4.80\\ -12.60\\ -7.84\\ -8.00\\ 9.59\\ -5.50\end{array}</math></td></l<></ul>	99.242811 99.242851 99.242951 99.242951 99.242784 99.24784 99.24784 99.24784 99.24784 99.24784 99.147844 99.147844 99.147844 99.147844 99.147844 99.147844 9	2c. 3055050 2d. 3053383 2d. 3045080 2d. 3025081 2d. 2733394 2d. 2733394 2d. 2733394 2d. 2733394 2d. 2733394 2d. 2733394 2d. 22476740 2d. 2476740 2d. 2476740000000000000000000000000000000000	113.109 102.809 36.574 4.425 4.574 4.425 4.574 4.175,506 175,506 5.5,074 4.175,506 5.5,074 4.175,506 4.175,506 4.175,507 4.155,511 -61,331 -40,762 2.23,609 2.241,192 2.241,192 2.241,192 2.241,192	-7,2319 -7,2319 -2,2356 -2,2951 -1,5400 -1,4602 -1,6402 -2,15614 -2,15614 -2,2519 -2,0519 -1,0519 -1,0519 -1,0519 -1,0519 -1,0519 -1,0519 -2,0519 -2,2315 -2,3315 -2,3	-12.063 -10.7394 -4.2394 -7.5713 -3.4400 -3.0533 -2.0147 -6.4864 -6.12976 -6.4864 -6.12976 -6.4864 -3.2764 -3.52764 -2.2914 -2.2914 -2.2914 -2.5275 -5.528 -5.528 -5.528 -5.528 -3.6476 9.6476 9.6477	$\begin{array}{c} -8,1985\\ -7,2778\\ -5,3806\\ -5,9858\\ -4,5344\\ -4,4840\\ -7,3358\\ -5,334\\ -2,9801\\ -6,5567\\ -3,4814\\ -3,4704\\ -3,4704\\ -3,4678\\ -3,4614\\ -3,4614\\ -3,4614\\ -3,4614\\ -3,4614\\ -3,4878\\ -3,1889\\ -3,5877\end{array}$	$\begin{array}{c} -16,3237\\ -13,6966\\ -13,6966\\ -4,4579\\ -11,2967\\ -5,9986\\ -4,3127\\ -4,1410\\ -8,3338\\ -12,0478\\ -5,5382\\ -2,1397\\ -5,5382\\ -2,1397\\ -5,5381\\ -3,2818\\ -10,5953\\ -3,2818\\ -10,5953\\ -3,2818\\ -12,4661\\ -1,9443\\ -3,1859\\ -5,1133\\ -6,3375\\ 18,3318\end{array}$	$\begin{array}{c} -14.84\\ -13.76\\ -7.89\\ -7.89\\ -10.60\\ -5.87\\ -5.87\\ -6.86\\ -6.56\\ -6.56\\ -7.64\\ -11.47\\ -7.21\\ -9.34\\ -6.80\\ -4.80\\ -4.80\\ -12.60\\ -7.84\\ -8.00\\ 9.59\\ -5.50\end{array}$

When there are more noise or missing samples in the variation records time series, Gaussian function interpolation is recommended.

When the reference epoch time exceeds the effective time range of a record time series, if the cubic spline interpolation is still selected, the program automatically extrapolates the sampling value of the reference epoch time of the records time series by the Gaussian basis function method.

#### 5.3.2 Compatibility analysis on InSAR vertical deformation using CORS network

[Function] Calculate the ellipsoidal height variations time series on the CORS site from InSAR variations time series near the CORS site by the direct average method. Interpolate the CORS site ellipsoidal height variations at sampling epochs of the InSAR time series from the CORS site ellipsoidal height variations time series. And then construct the CORS baselines by the complete combinations of the CORS sites, calculate all the doubledifference time series respectively from the two kinds of CORS site ellipsoidal height variations time series. Evaluate the compatibility of the vertical deformation between the CORS network and InSAR and analyze the effectiveness of the InSAR variations gross error detection and spatial analysis algorithm.

The double-difference algorithm of the InSAR variations time series on the CORS baseline: firstly, calculate the InSAR variation at the current epoch time on the CORS site by the direct average method using the InSAR variations around the CORS site, and then calculate the InSAR variation difference between the two ends of the CORS baseline at the current epoch time, and finally calculate the time difference between the InSAR variation differences after and before the epoch time to obstain the InSAR variation double-differences time series of the CORS baseline.

[Input file] The InSAR variation records time series file. The CORS site ellipsoidal height variation records time series file.



[Parameter settings] Set the InSAR and CORS site variation records time series files format patameters, select the time interpolation mode, and enter the minimum number of InSAR points around CORS site and surrounding search radius.

When there are more noise or missing samples in the CORS height variation records time series, Gaussian function interpolation is recommended.

[Output file] The comparison file CORSInSARpntcomp.txt between the CORS site ellipsoidal height variations and InSAR variations time series.

The file header contains the total number of the CORS sites in the InSAR monitoring range, the number of InSAR monitoring points, and all the sampling epochs. The comparison information consists of 3 rows records for each CORS site. The first row is the CORS site ellipsoidal height variation time series at all the InSAR sampling epochs, the second row is the time series of the CORS site ellipsoidal height variations averaged from neighboring InSAR variations, and the third row is the number time series of the InSAR monitoring points involved in the calculation for the second row.

The program simultaneously outputs the double-differences time series file dblediff\*.txt, \*=1~n/2 represents the multiple number of the sampling interval, n is the number of sampling epochs. The file header includes the number of the difference sampling epochs n/2, n/2 sampling epochs. Each CORS baseline double-difference records time series consists of two rows. The first row is the InSAR variation double-differences time series of the CORS baseline, and the second row is the ellipsoidal height variation double-differences time series time series of the CORS baseline.

# 5.3.3 InSAR variations time series adjustment with spatiotemporal frame constraints

[Function] From the comparison file CORSInSARpntcomp.txt output by the function [Compatibility analysis of vertical deformation from CORS network and InSAR], estimate spatiotemporal monitoring datum transfer parameters, construct spatiotemporal frame constraint equations, perform the adjustment for the InSAR variation records time series, so as to unify the spatiotemporal monitoring frame of the InSAR variation records time series into the CORS network spatiotemporal monitoring frame.

[Input files] The InSAR variation records time series file. The geodetic variations time series file to be reconstructed. The comparison file CORSInSARpntcomp.txt between the CORS site ellipsoidal height variations and InSAR variations time series. The two files can be automatically called by the program without manual input.

[Parameter settings] Set the checkbox [The linear space scale constraint of the height difference variation].

[Output file] The InSAR variation adjusted value records time series file. Whose format is same as the input InSAR variation records time series file.

The program outputs the InSAR variations calibration file \*\*\*.scl in the current folder. Here \*\*\* are the output adjusted results file name.

The header of the file is the same as the adjusted results file. The second row is the records time series of the scale factors of the InSAR variations spatial difference, and the third row is the number time series of the CORS baselines used to estimate the scale factor. When the space scale constraint is not selected, the scale factor at each epoch time is

#### always 1.0, and the third row is all 0.

variation records time series	r		Compatibility analy deformation using	sis on InSAR vertical CORS network				ions time serie mporal frame o		>
Open InSAR variation records time series	file	>> Program F	Process ** Operation Pro	mpts				â#	Save program	n process
Set format parameters of the file			the computation of the c ion end time: 2022-02-27		of vertical defo	ormation from (	CORS networ	k and InSAR!		
olumn ordinal number of first epoch time in header	-	>> [Function]	From the comparison file	CORSInSARpntcor						
olumn ordinal number of the first variation in record	5		rk and InSAR], estimate prorm the adjustment for							
Open the CORS site ellipsoidal height varial records time series file	ton	InSAR variati	on records time series in r space scale constraint of	o the CORS network	spatiotempor	al monitoring f	frame.		•	
et format parameters of the file		valid CORS s	sites within the range of the	e InSAR monitoring						
olumn ordinal number of first epoch time in header	6	Save the	nce of the InSAR variatio results as C:/ETideLoad	0_win64cn/cxample	DynCORScr	ntrtmInSAR/gu	ass6flt2019-1	01-12adj.txt.	1	
olumn ordinal number of the first variation in record	5	The progr	ram outputs the InSAR va he second row is the reco	riations calibration fi	e *.scl in the c	urrent folder.	The header of	the file is the s		
Set time interpolation mode Gaussian function		<ul> <li>number time</li> </ul>	series of the CORS base	lines used to estimat	e the scale fac					
nimum number of InSAR points around CORS site			n epoch time is always 1. Irameters have been imp		all 0.					
Surrounding search radius 500 m	2	** Click the	control button [Start cor	outation], or the tool t	outton [Start co	omputation]				
ouroancing search radius add III			ion start time: 2022-02 the computation of the r		series adiustr	nent with spati	otemporal fra	me constraints	,	
The linear space scale constraint of the height difference variation			ion end time: 2022-02-27		,,,,,,,					
the neight difference variation		iii	Save the results as	Se Import	setting parame	eters		J St	art computatio	on
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		Display of the	e input-output file	- Inport				💱 Sa	ave data in the	e text bo
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647.981         99.2412845         26.3083382         1           638.931         99.2412845         26.3081716         1           688.435         99.2432844         26.3073383         1	138.029	20190217 -4.1820	20190301 2019031 19.0016 27.467	20190325 suss6f1t2019-101 1 20190506 2 3647.981 3 3638.931	-12ep. txt 2 12 5 99.2412845 99.2412845	20190430 28 26.3083382 26.3081716	20190124 138.029 138.029	20190524 20190205 2 1.6340 2.1989	20190605 0190217 20 4.5938 4.5324	201 190301 8.2610 8.0765
647.981 99.2412845 26.3083382 1 638.931 99.2412845 26.3081716 1 688.435 99.2432844 26.3073383 1 693.478 99.2432847 26.3066716 641.662 99.2437844 26.3061716 1	138.029 138.029 151.494 91.102 122.215	20190217 -4.1820 -3.6183 -4.4788 -1.5946 1.5859	20190301         20190301           19.0016         27.467           18.9393         27.282           17.5821         27.462           19.7165         29.242           18.9767         27.727	20190325 guass6f12019-101 1 2019050 2 3647.981 3 3638.931 4 3668.435 5 3693.478	-12ep. txt 2 12 5 99.2412845 99.2412845 99.2432844 99.2436177	20190430 28 26.3083382 26.3081716 26.3073383 26.3066716	20190124 138.029 138.029 151.494 91.102	20190524 20190205 2 1.6340 2.1989 1.3589 4.2504	20190605 0190217 20 4.5938 4.5324 3.1835 5.3221	201 8.2610 8.0765 8.2572 10.0397
647.981         99.2412845         26.3083382         1           638.931         99.2412845         26.3081716         1           688.435         99.2432844         26.307383         1           693.478         99.2432844         26.307383         1           693.478         99.2432844         26.3066716         1           641.662         99.2437844         26.306716         1           638.264         99.2437811         26.306050         1	138.029 138.029 151.494 91.102 122.215 105.500	20190217 -4.1820 -3.6183 -4.4788 -1.5946 1.5859 2.8533	20190301 2019031 19.0016 27.467 18.9393 27.282 17.5821 27.462 19.7165 29.242 18.9767 27.727 18.8481 27.796	201901325 guass6f11003-101 1 2019050f 2 3647,981 3 3638,931 4 3688,435 5 3693,479 6 3641.662 7 3638,264	-12ep.txt 2 99.2412845 99.2412845 99.2432844 99.2436177 99.2437844 99.2437844	28 26.3083382 26.3081716 26.3061716 26.3061716 26.3060716 26.306050	20190124 138.029 138.029 151.494 91.102 122.215 105.500	20190524 20190205 22 1.6340 2.1989 1.3589 4.2504 7.4359 8.7021	20190605 0190217 20 4.5938 4.5324 3.1835 5.3221 4.5853 4.4570	201 190301 8.2610 8.0765 8.2572 10.0397 8.5269 8.5968
647.881         99.2412845         26.3083322         1           688.931         99.2412845         26.3081716         1           688.435         99.2432844         26.3081716         1           689.435         99.2432844         26.3081716         1           641.662         99.2432174         26.3061716         1           638.264         99.2432144         26.3060100         1           614.724         99.2432841         26.3050505         1           638.857         99.2422841         26.3055050         1	138.029 138.029 151.494 91.102 122.215 105.500 113.108 102.809	20190217 -4.1820 -3.6183 -4.4788 -1.5946 1.5859 2.8533 3.4229 2.8871	20190301         2019031           19.0016         27.467           19.9393         27.282           17.5821         27.462           19.7165         29.242           18.9767         27.727           18.8481         27.796           18.8260         27.505           18.8403         27.510	201901225 201901225 2 3647.961 3 3630.931 4 3668.435 5 3693.478 5 3634.784 9 3568.857	-12ep. txt 2 12 5 99.2412845 99.242845 99.2432844 99.2432844 99.2437844	20190430 28 26.3083382 26.3081716 26.3073383 26.3061716 26.3061716	20190124 138.029 138.029 151.494 91.102 122.215	20190524 20190205 2: 1.6340 2.1989 1.3589 4.2504 7.4359	20190605 0190217 20 4.5938 4.5324 3.1835 5.3221 4.5853	201 8.2610 8.0765 8.2572 10.0397 8.5269
647.081         99.241245         26.30831         99.241245         26.308116         11           668.435         99.241245         26.308116         11         16	138.029 138.029 151.494 91.102 122.215 105.500 113.108 102.809 -36.574	20190217 -4.1820 -3.6183 -4.4788 -1.5946 1.5859 2.8533 3.4229 2.8871 10.3461	20190301         2019031           19.0016         27.467           19.3939         27.282           17.5821         27.462           19.7165         29.242           18.9461         27.767           18.8461         27.766           18.8260         27.505           18.8403         27.710           28.9247         32.617	20190325 ■ guass671003-100 1 20190500 1 20190500 1 3 3638.931 4 3 668.435 5 3 663.4796 6 3 664.1662 7 3 638.264 9 3 558.857 10 3747.716	12ep.txt 2 99.2412845 99.2412845 99.2432844 99.2432844 99.2437844 99.2434511 99.2432844 99.2432844 99.2432844	20190430 26.308382 26.3081716 26.3061716 26.3061716 26.3061716 26.306050 26.3055050 26.3055050 26.3055383 26.3045050	20190124 138.029 138.029 151.494 91.102 122.215 105.500 113.108 102.809 -36.574	20190205 2 1.6340 2.1989 1.5589 4.2504 7.4359 8.7021 9.2743 8.7374 16.2598	20190605 0190217 20 4.5938 4.5324 3.1835 5.3221 4.5953 4.4570 4.4373 4.4570 4.4519 14.5560	201 8.2610 8.2572 10.0397 8.5269 8.5968 8.3077 7.9045 13.4148
647,001         99,241245         26.3063126         1           689,435         99,2412454         26.3061716         1           689,435         99,242244         26.307383         1           681,435         99,242244         26.307383         1           641,662         99,2437844         26.306716         1           633,264         99,2437844         26.306505         1           641,474         99,2437844         26.305505         1           641,474         99,242784         26.3053030         1           641,474         99,242784         26.3025051         1           641,474         99,242784         26.3025051         1	138.029 138.029 151.494 91.102 122.215 105.500 113.108 102.809 -36.574 -38.425	20190217 -4.1820 -3.6183 -4.4788 -1.5946 1.5859 2.8533 3.4229 2.8871 10.3461 4.6270	20190301         2019031           19.0016         27.467           18.9393         27.282           19.7165         27.462           19.7165         27.462           18.9767         27.727           18.8481         27.796           18.8260         27.505           18.8403         27.710           28.9242         32.617           19.6049         26.007	20190325 ■ guass@flt003-101 5 1 20190501 1 20190501 2 3647.961 3 3638.931 4 3668.435 5 3663.479 6 3641.662 7 3638.264 9 3588.857 10 3747.716 11 3495.068 12 2147.368	12ep.txt 2 99.2412845 99.2412845 99.2432844 99.2432844 99.2437844 99.2437844 99.2432844 99.2432844 99.2429511 99.2509508 99.2447844 99.116230	20190430 28 26.308382 26.3081716 26.3066716 26.3066716 26.3066716 26.305050 26.305383 26.3055850 26.305383 26.30559	20190124 138.029 138.029 151.494 91.102 122.215 105.500 113.108 102.809 -36.574 38.425 45.125	201300524 20190205 22 1.6340 2.1989 4.2504 7.4359 8.7021 9.2743 8.7374 16.2598 10.5116 1.6613	20190605 0190217 20 4.5538 4.5324 3.1835 5.3221 4.5853 4.4570 4.4373 4.4519 14.5560 5.2354 2.5223	201 8.2610 8.0765 8.2572 10.0397 8.5269 8.5968 8.3077 7.9045 13.4148 6.8209 1.9369
647,081         99,241245         26.30831         92.308716         1           668,435         99,241245         26.3081716         1         3         1           668,435         99,2412454         26.3081716         1         3         1           668,435         99,2432644         26.3073833         1         3         1           661,662         99,2437644         26.3064716         1         3         3           633,664         99,2437644         26.306050         1         3         3           641,662         99,2437644         26.3050550         1         3         3         3           747,716         99,2432644         26.3055050         2         3         3         3         3           747,716         99,250500         26.3045050         -         5         9         3         5	20190300 -3.3881 -2.29 -2.215 -2.215 -2.215 -2.215 -2.215 -3.3881 -3.3881	20190217 -4.1820 -3.6183 -4.4788 -1.5946 1.5859 2.8533 3.4229 2.8871 10.3461 4.6270 -6.587 -5.88	20190301         2019031           19.0016         27.467           18.9393         27.282           17.5821         27.462           19.7165         29.242           18.9767         27.727           18.4841         27.796           18.8260         27.505           18.8403         27.100           28.9247         32.617           19.6049         26.007           29.232         32.94946           2019646         20.39446           27         3.9354	20190325 ■ guass@flt003-101 5 1 20190501 1 20190501 2 3647.961 3 3638.931 4 3668.435 5 3663.479 6 3641.662 7 3638.264 9 3588.857 10 3747.716 11 3495.068 12 2147.368	12ep.txt 2 99.2412845 99.2412845 99.2432844 99.2432844 99.2436177 99.2437844 99.243284511 99.2432844 99.2429511 99.2509508 99.2447844	20190430 28 26.3083382 26.3081716 26.3066716 26.3066716 26.306050 26.3055050 26.3055050 26.3055038 26.3045050	20190124 138.029 151.494 91.102 122.215 105.500 113.108 102.809 -36.574 38.425	20190524 20190205 2: 1.6340 2.1989 1.3589 4.2504 7.4359 8.7021 9.2743 8.7374 16.2598 10.5116	20190605 0190217 20 4.5938 4.5324 3.1835 5.3221 4.5853 4.4570 4.4373 4.4519 14.5560 5.2354	201 8.2610 8.2670 8.2572 10.0397 8.5269 8.5968 8.3077 7.9045 13.4148 6.8209 1.9369 0.9776
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647.081         99.241245         26.003382         1           689.435         99.2412454         26.0081716         1           689.435         99.2412454         26.0081716         1           689.435         99.2412454         26.0081716         1           681.455         99.2432744         26.007383         1           641.662         99.2437744         26.0061716         1           633.264         99.2437744         26.006050         1           641.4724         99.2432744         26.005050         1           641.4724         24.529511         26.003383         1           747.716         99.2432744         26.005305         1           7603         96.447744         22.0055051         1           7614         94.447844         26.005308         1           7613         96.447744         20.0055051         1           7614         94.447744         20.0055051         1           7614         94.447744         20.0055051         1           7614         94.447744         20.0055051         1           7614         94.447744         20.0055051         1           7614         94.447744 <td>238.029 38.029 51.494 91.102 122.215 105.500 13.108 102.809 36.574 38.425 2019030 -3.3881 -9.1400</td> <td>20190217 -4.1820 -3.6183 -4.4788 -1.5946 -1.5549 2.8533 3.4229 2.8871 10.3461 4.6270 -6.5837 -5.88 -15.6493 2.79</td> <td>20190301         2019031           19.0016         27.467           18.9393         27.282           17.5821         27.462           19.7165         29.242           18.8481         27.7282           18.8481         27.7382           18.8481         27.7482           18.8481         27.7482           18.8481         27.7482           19.8403         27.100           28.9247         32.617           27.3595         4.618           41.345431         -17.935           41.345431         -17.935           19.35433         -17.935           19.35433         -17.935           19.353344         21.9443</td> <td>20120275 20120275 20429500 20429500 20429500 2042950 204500 204500 204500 204500 204500 204500 2040</td> <td>12ep. tat 23 12 5 99. 2412845 99. 2412845 99. 2412845 99. 2412845 99. 2432844 99. 243817 99. 2437844 99. 243817 99. 243817 99. 2447844 99. 111630 99. 244173 99. 2541173 99. 2541173 99. 254173 99. 254174 99. 254174 9</td> <td>20190430 28 26,308382 26,3081716 26,306716 26,306716 26,306716 26,306716 26,306050 26,305383 26,3045050 26,2283505 26,2283394 26,2783394 26,2783394 26,2783394 26,3019 26,3019 26,305 37,405 26,305 26,305 37,405 26,305 26,305 26,305 26,20</td> <td>20190124 138.029 151.494 91.102 122.215 105.500 113.108 102.809 -36.574 38.425 45.125 -178.770 43.796 21.0372 16.2865 30.1978</td> <td>20190205 2 1.6340 2.1989 4.2504 7.4359 8.7021 9.2743 8.7374 16.2598 10.5116 1.6613 3.9216 1.6513 1.6513 0.5116 1.6513 1.6513 1.6513 1.6513 1.6513 1.6513 1.5598 1.6513 1.5598</td> <td>20190217 20 4.5538 4.55324 3.1835 5.3221 4.5853 4.4570 4.4570 4.4570 4.4519 14.5560 5.2354 2.5223 2.4003 10.6640 -0.5519 -0.5547</td> <td>201 190301 8.2610 8.2672 10.0397 8.5269 8.5968 8.3077 7.9045 13.4148 6.8209 1.9369 0.9776 6.3449 -8 -8</td>	238.029 38.029 51.494 91.102 122.215 105.500 13.108 102.809 36.574 38.425 2019030 -3.3881 -9.1400	20190217 -4.1820 -3.6183 -4.4788 -1.5946 -1.5549 2.8533 3.4229 2.8871 10.3461 4.6270 -6.5837 -5.88 -15.6493 2.79	20190301         2019031           19.0016         27.467           18.9393         27.282           17.5821         27.462           19.7165         29.242           18.8481         27.7282           18.8481         27.7382           18.8481         27.7482           18.8481         27.7482           18.8481         27.7482           19.8403         27.100           28.9247         32.617           27.3595         4.618           41.345431         -17.935           41.345431         -17.935           19.35433         -17.935           19.35433         -17.935           19.353344         21.9443	20120275 20120275 20429500 20429500 20429500 2042950 204500 204500 204500 204500 204500 204500 2040	12ep. tat 23 12 5 99. 2412845 99. 2412845 99. 2412845 99. 2412845 99. 2432844 99. 243817 99. 2437844 99. 243817 99. 243817 99. 2447844 99. 111630 99. 244173 99. 2541173 99. 2541173 99. 254173 99. 254174 99. 254174 9	20190430 28 26,308382 26,3081716 26,306716 26,306716 26,306716 26,306716 26,306050 26,305383 26,3045050 26,2283505 26,2283394 26,2783394 26,2783394 26,2783394 26,3019 26,3019 26,305 37,405 26,305 26,305 37,405 26,305 26,305 26,305 26,20	20190124 138.029 151.494 91.102 122.215 105.500 113.108 102.809 -36.574 38.425 45.125 -178.770 43.796 21.0372 16.2865 30.1978	20190205 2 1.6340 2.1989 4.2504 7.4359 8.7021 9.2743 8.7374 16.2598 10.5116 1.6613 3.9216 1.6513 1.6513 0.5116 1.6513 1.6513 1.6513 1.6513 1.6513 1.6513 1.5598 1.6513 1.5598	20190217 20 4.5538 4.55324 3.1835 5.3221 4.5853 4.4570 4.4570 4.4570 4.4519 14.5560 5.2354 2.5223 2.4003 10.6640 -0.5519 -0.5547	201 190301 8.2610 8.2672 10.0397 8.5269 8.5968 8.3077 7.9045 13.4148 6.8209 1.9369 0.9776 6.3449 -8 -8
647.081         99.2412445         26.3083182.1         26.3083182.1           668.435         99.2412445         26.3081716         31.308716           668.435         99.2412444         26.3073838.1         31.308716           668.435         99.2432444         26.3073838.1         31.308716           661.662         99.2437444         26.3064716         31.308716           631.664         99.2437444         26.3060550         31.308716           631.676         99.2432444         26.3055050         31.308716           747.716         99.2505500         26.30450550         -           7450.68         99.2447444         26.3045050         -           747.716         99.2407444         20.3055051         -           748         24.304764         24.3045055         -           769.68         92.447444         20.305501         -           769.78         26.314764         26.3045055         -           710         99.447444         26.3045055         -           710         99.447444         26.3045055         -           710         99.447444         26.3045055         -           710         99.447444         24.30456         - <td>38.029 38.029 31.494 91.102 22.215 105.500 13.108 102.809 36.574 38.425 2019030 -3.3881 -9.1400 53 -4.9710 11.7049 5 -4.1335</td> <td><math display="block">\begin{array}{c} 20190217\\ -4,1820\\ -3,6183\\ -4,4786\\ -1,5946\\ 1,5946\\ 1,5946\\ 2,6533\\ 3,4229\\ 2,8871\\ 10,3461\\ 4,6270\\ -5,637\\ -7,6137\\ -7</math></td> <td>20190301         2019031           19.0016         27.467           18.9393         27.282           17.5821         27.462           19.7165         29.242           18.8491         27.722           18.8491         27.462           18.9393         27.282           18.9767         27.727           18.8481         27.402           18.8481         27.100           28.9247         32.610           29.462.00         -1.939           29.319446         201446           29.443         -1.9453           29.319446         201446           29.443         -1.9453           29.3244         -1.9463           29.33944         -1.9463           29.345431         -1.9464           29.441         -1.9464           29.44645         -1.9464           29.44645         -1.9464           29.44645         -1.9464</td> <td>20100128</td> <td>12ep. tat 22 12 5 99. 2412845 99. 2412845 99. 2412845 99. 2432844 99. 243511 99. 243511 99. 243511 99. 2437844 99. 2437844 99. 2437844 99. 2437847 99. 2250550 33. 3936 25. 7888</td> <td>20100430 28 26.3008322 26.3008716 26.3066716 26.3066716 26.3066716 26.3056050 26.3055050 26.3055050 26.3055050 26.3055050 26.3055050 26.3055050 26.3293394 27.00370 17.0179 31.4933 22.3789</td> <td>20190124 138.029 151.494 91.102 122.215 105.500 102.809 -36.574 38.425 45.125 -178.770 43.736 27.9372 16.2865 30.1978 21.2818</td> <td>20190205 2 1.6340 2.1989 1.589 4.2504 4.2504 4.2504 5.274 6.2598 105116 1.2613 2.205 0.0150 12.5379 1.7921</td> <td>20190217 20 4.5338 4.5325 3.1335 5.3221 4.5653 4.4575 4.4575 4.4575 4.4575 4.4575 4.4575 4.4575 4.4575 4.4575 4.4575 4.4575 4.4575 4.4555 5.2554 2.5525 4.4555 5.2554 2.5555 7</td> <td>201 190301 8.2610 8.0765 8.2572 10.0397 8.5268 8.3077 7.9045 13.4148 6.8209 0.9776 6.3449 0.9776 6.3449 -8 -8 -8 -8 -6</td>	38.029 38.029 31.494 91.102 22.215 105.500 13.108 102.809 36.574 38.425 2019030 -3.3881 -9.1400 53 -4.9710 11.7049 5 -4.1335	$\begin{array}{c} 20190217\\ -4,1820\\ -3,6183\\ -4,4786\\ -1,5946\\ 1,5946\\ 1,5946\\ 2,6533\\ 3,4229\\ 2,8871\\ 10,3461\\ 4,6270\\ -5,637\\ -7,6137\\ -7$	20190301         2019031           19.0016         27.467           18.9393         27.282           17.5821         27.462           19.7165         29.242           18.8491         27.722           18.8491         27.462           18.9393         27.282           18.9767         27.727           18.8481         27.402           18.8481         27.100           28.9247         32.610           29.462.00         -1.939           29.319446         201446           29.443         -1.9453           29.319446         201446           29.443         -1.9453           29.3244         -1.9463           29.33944         -1.9463           29.345431         -1.9464           29.441         -1.9464           29.44645         -1.9464           29.44645         -1.9464           29.44645         -1.9464	20100128	12ep. tat 22 12 5 99. 2412845 99. 2412845 99. 2412845 99. 2432844 99. 243511 99. 243511 99. 243511 99. 2437844 99. 2437844 99. 2437844 99. 2437847 99. 2250550 33. 3936 25. 7888	20100430 28 26.3008322 26.3008716 26.3066716 26.3066716 26.3066716 26.3056050 26.3055050 26.3055050 26.3055050 26.3055050 26.3055050 26.3055050 26.3293394 27.00370 17.0179 31.4933 22.3789	20190124 138.029 151.494 91.102 122.215 105.500 102.809 -36.574 38.425 45.125 -178.770 43.736 27.9372 16.2865 30.1978 21.2818	20190205 2 1.6340 2.1989 1.589 4.2504 4.2504 4.2504 5.274 6.2598 105116 1.2613 2.205 0.0150 12.5379 1.7921	20190217 20 4.5338 4.5325 3.1335 5.3221 4.5653 4.4575 4.4575 4.4575 4.4575 4.4575 4.4575 4.4575 4.4575 4.4575 4.4575 4.4575 4.4575 4.4555 5.2554 2.5525 4.4555 5.2554 2.5555 7	201 190301 8.2610 8.0765 8.2572 10.0397 8.5268 8.3077 7.9045 13.4148 6.8209 0.9776 6.3449 0.9776 6.3449 -8 -8 -8 -8 -6
647.98.1         99.241245         26.08312         1           689.435.931         92.241245         26.081716         1           689.435         99.2412454         26.001716         1           689.437         99.242244         26.001716         1           681.436         99.242244         26.001716         1           641.662         99.2437744         26.006716         1           70.837.64         99.243784         26.000550         1           71.837.64         99.243784         26.000550         1           71.837.64         99.242784         26.000550         1           71.84         99.242784         26.000550         1           71.71         99.242784         26.005501         1           71.71         10.0005         10.0005         10.0005           71.71         20.00055         1.0006         10.0006           71.84         20.00055         1.0006         1.0006           70.000         20.00055         1.0006         1.0006           70.000         20.00055         1.0006         1.0006           70.000         20.00055         1.0006         1.0006           70.000         20.	38.029 38.029 38.029 31.494 91.102 22.215 55.500 13.108 102.809 36.574 38.425 2019030 -3.3881 -9.1400 53 -4.9710 11.7049 5 -4.935 5.567 3	$\begin{array}{c} 20190217\\ -4,1820\\ -3,6183\\ -4,4788\\ -1,5946\\ 1,5959\\ 2,8533\\ 3,4229\\ 2,8871\\ 10,3461\\ 4,6270\\ \end{array}$	$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	$\begin{array}{c} \begin{array}{c} 20140129, \\ \hline m \\ m \\ m \\ m \\ m \\ m \\ m \\ m \\ m \\$	-12ep tat [2] 12 5 99.2412845 99.2412845 99.2412845 99.2412845 99.2412844 99.2432844 99.2437844 99.2432844 99.2432844 99.2432844 99.2432841 99.2249511 99.224173 22.6055 33.3936 25.7888 28.9538 22.8747	20190430 26 26, 309382 26, 309382 26, 3061716 26, 306716 26, 306050 26, 305053 26, 305053 26, 305053 26, 305053 26, 293394 26, 2293394 27, 00350 26, 2793394 27, 00350 26, 3793 22, 3799 25, 4711 23, 3045	20190124 138.029 136.029 151.454 91.102 151.500 102.809 -36.574 45.125 -178.770 43.796 2372 2281	20190205 2 1.6340 2.190920 2 1.5899 4.2504 7.4359 8.7021 9.2743 8.7374 16.2598 10.5116 1.8613 3.9216 12.2205 2.0137 0.0150 12.5379 1.7921 2.2347 1.6400	20190217 20 4.5938 4.51221 4.5523 4.5523 4.5553 4.4570 4.4519 14.5560 5.2354 2.5223 2.4093 10.8640 -0.55747 -0.5359 -0.5359	201 8.2610 8.0765 8.2572 10.0397 8.5269 8.5307 7.9045 13.4148 6.8209 1.9369 0.9776 6.3449 -8 -8 -8 -7
647.080         99.2412445         26.003382         1           689.435         99.2412454         26.0031716         1           689.435         99.2412454         26.0031716         1           689.435         99.2412454         26.0031716         1           681.455         99.2412544         26.0073183         1           641.662         99.2432744         26.006716         1           633.64         99.2432744         26.005505         1           64.79         99.2432844         26.005308         1           747.716         99.2432844         26.005505         1           745.068         92.2447844         26.005505         1           745.068         92.447844         26.005505         1           745.068         92.447844         20.005501         1           718         94.44784         100.6         -554           7013         94.44784         100.6         -554           7013         94.44784         100.6         -554           7013         94.44784         100.6         -554           7013         94.44784         100.6         -554           7013         94.44784         1	38.029 38.029 31.494 91.102 22.215 105.500 13.108 102.809 36.574 38.425 2019030 -3.3881 -9.1400 53 -4.9710 11.7049 5 -4.1335	$\begin{array}{c} 20190217\\ -4,1820\\ -3,6183\\ -4,4786\\ -1,5946\\ 1,5946\\ 1,5946\\ 2,6533\\ 3,4229\\ 2,8871\\ 10,3461\\ 4,6270\\ -5,637\\ -7,6137\\ -7$	20190301         2019031           19.0016         27.467           18.9393         27.282           17.5821         27.462           19.7165         29.242           18.8491         27.722           18.8491         27.462           18.9493         27.282           18.9767         27.722           18.8481         27.462           18.8481         27.100           28.9247         32.610           29.424         20.6407           29.445         -1.628           41.945431         -1.7.935           29.345431         -1.7.935           29.445431         -1.7.935           29.45431         -1.7.935           29.45431         -1.7.935           29.45431         -1.7.935           29.45431         -1.7.935           29.4645         -6.007           29.4645         -6.007           29.4645         -6.007           29.4645         -6.007           29.4645         -7.0459	20160125 	12ep ut 2 12 5 99.2412845 99.2412845 99.2412845 99.2412845 99.2412845 99.2432844 99.243517 99.2437844 99.2437844 99.2437844 99.2447844 99.2447844 99.2631170 99.2241173 99.2241173 99.224173 22.6055 33.3936 25.9788 28.9538 22.8747 25.9434	20130430 28 26.308382 26.30116 36.30126 26.30126 26.30126 26.305050 26.305505 26.305505 26.305505 26.305505 26.305505 26.302505 27.3026 27	20190124 138.029 138.029 151.454 91.102 122.215 105.500 113.108 102.809 -36.574 38.425 45.125 -178.770 43.796 21.0312 16.2865 30.1978 21.2818 24.5621 17.3604 20.1224	20190205 2 1.6340 2.90989 1.3569 4.2504 7.4359 8.7021 9.2743 8.7374 1.6615 1.2205 1.25379 1.7921 1.25379 1.7921 1.22347 1.6400 2.1661	20190217 20 4.5393 4.5328 4.5328 4.5328 4.5328 4.4570 4.4373 4.4519 14.5560 5.2324 2.5223 10.6500 -0.5519 -0.5519 -0.5351 -0.5357	201 190301 8.2610 8.2572 10.0397 8.55269 8.3077 7.55269 8.3077 13.4148 6.8209 0.9776 6.3449 0.9776 6.3449 -8 -8 -6 -8 -7 -6 -6 -8
647.081         99.2412445         26.003382         1           668.435         99.2412445         26.0031716         1           668.435         99.242244         26.001716         1           668.435         99.242244         26.001716         1           661.652         99.2423744         26.001716         1           631.76         99.2423744         26.006716         1           631.664         99.243744         26.006050         1           638.264         99.2423744         26.005050         1           747.716         99.2509500         26.033383         1           7465.066         99.244744         26.0305051         -           746         99.240744         100.6         -         -5544           760.067         99.240744         100.6         -         -5544           763.06         9.2474744         26.0305051         -         -           747.716         99.2474744         100.6         -         -5544           763.06         9.2474744         100.6         -         -5544           763.07         747474         26.04764         -         -         -         -	88.029 188.029 198.029 191.02 122.215 105.500 13.108 12.809 36.574 38.425 2019030 -4.9710 11.7049 -4.1335 5.5667 -8.2683 -8.2683 -1.7531 2.1.9583	20190217 -4,1820 -3,6183 -4,4788 -1,5946 1,5959 2,68533 3,4229 2,6871 10,3461 4,6270 4,6583 -5,648 2,7,613 -6,583 -5,648 2,7,613 -6,583	$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	$\begin{array}{c} \begin{array}{c} 20140129, \\ \hline m \\ m \\ m \\ m \\ m \\ m \\ m \\ m \\ m \\$	-12ep tat [2] 12 5 99.2412845 99.2412845 99.2412845 99.2412845 99.2412844 99.2432844 99.2437844 99.2432844 99.2432844 99.2432844 99.2432841 99.2249511 99.224173 22.6055 33.3936 25.7888 28.9538 22.8747	20190430 26 26, 309382 26, 309382 26, 3061716 26, 306716 26, 306050 26, 305053 26, 305053 26, 305053 26, 305053 26, 293394 26, 2293394 27, 00350 26, 2793394 27, 00350 26, 3793 22, 3799 25, 4711 23, 3045	20190124 138.029 136.029 151.454 91.102 151.500 102.809 -36.574 45.125 -178.770 43.796 2372 2281	20190205 2 1.6340 2.190920 2 1.5899 4.2504 7.4359 8.7021 9.2743 8.7374 16.2598 10.5116 1.8613 3.9216 12.2205 2.0137 0.0150 12.5379 1.7921 2.2347 1.6400	20190217 20 4.5938 4.51221 4.5523 4.5523 4.5553 4.4570 4.4519 14.5560 5.2354 2.5223 2.4093 10.8640 -0.55747 -0.5359 -0.5359	201 190301 8.2610 8.2572 10.0397 8.5269 8.5968 8.3077 7.9045 1.34148 6.8209 1.9369 0.9776 6.3449 -8 -8 -8 -8 -7 -6 -17
647.081         99.2412445         26.003322         1           539.33         99.2412445         26.0031716         1           688.435         99.2422442         26.0031716         1           689.437         99.2423244         26.0031716         1           641.662         99.2423744         26.004716         1           641.662         99.2437844         26.004501         1           717.715         99.2437844         26.005501         1           717.716         99.2437844         26.005501         1           717.716         99.2447844         26.005501         1           717.716         99.2447844         26.005501         1           717.716         99.2447844         26.005501         1           718.717         99.2447844         26.005501         1           718.718         91.241784         100425         101491           718.718         91.241784         101425         101491           718.718         91.241784         10145         10145           718.719         91.241784         10149         101491           718.719         91.241784         10149         101491           718.719	88.029 38.029 51.494 91.102 12.215 105.500 13.108 102.807 38.425 2019030 -3.3881 -9.1400 11.7049 5.5667 -4.135 5.5667 -1.752 -1.1588 -1.2566	20190217 -4,1820 -3,6183 -4,4728 -1,5549 1,5549 1,5549 1,5549 2,8871 10,3461 -6,6270 -7,6137 -7,6137 -7,6137 -2,2288 -15,6493 2,739 -6,674 -2,2288 -0,378 -2,2288 -0,378 -2,2288 -0,578	$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	20190125 Hereard 1031-015 1 2019556 2 3019556 3 3019556 4 3068-453 5 4 3068-453 5 5 4 3051,475 1 3 3045,451 1 3 4055,451 1 4 4055,45	$\begin{array}{c} -12 \\$	20190430 28 26,3091392 26,3091392 26,3091392 26,3061716 26,3066716 26,3066716 26,3066050 26,3064050 26,30550 26,30500 26,30500 26,30500 26,30500 26,30500 26,30500 26,30500 26,30500 26,30500 26,30500 26,30500 26,30500 26,30500 26,30500 27,305000 27,305000 27,305000 27,305000 27,305000 27,305000 27,305000 27,305000 27,305000 27,3050000 27,3050000 27,30500000000000000000000000000000000000	20190124 20190124 138,029 138,029 138,029 138,029 138,029 138,029 138,029 138,029 102,809 -36,525 45,125 -178,770 43,796 21,2218 21,2218 24,5621 17,3604 20,1224 -2,215 -	20190205 2 1.630 2.1909 2.1909 1.3569 4.3504 4.3504 7.7021 5.7021 1.6259 1.6259 1.6259 1.6259 1.6259 1.6254 1.6254 1.6254 1.6254 1.6254 1.6254 1.6254 1.6254 1.6254 1.6254 1.6254 1.6254 1.6254 1.6254 1.6255 1.6254 1.6255 1.6254 1.62555 1.62555 1.62555 1.62555 1.6255555 1.625555 1.62555555555 1.6255555555	20190605 0190217 20 4.5324 4.5324 4.3135 5.3221 4.4370 4.44770 4.44770 4.4570 4.44770 4.4570 4.4570 4.4570 -0.5519 -0.5519 -0.5519 -0.5559 -0.5529	2011 190301 8.2610 8.2765 8.2572 10.0397 8.5269 8.5968 8.59788 8.59788 8.59788 8.59788 8.59788 8.59788 8.59788 8.59788 8.59788 8.59788 8.59788 8.59788 8.59788 8.
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The scale factor is an important quantitative indicator to evaluate the performance of the InSAR deformation monitoring. At sampling epoch time whose scale factor exceeds (0.5, 2.0), the vertical deformation separation of the InSAR variations is insufficient, or the quality of the InSAR variations is poor.

The linear space scale constraint of the height difference variation: Only at the sampling epoch time when there are no less than 3 valid CORS sites within the range of the InSAR monitoring point, the program can be allowed to use the space scale constraint to the space difference of the InSAR variations.

### 5.4 Deep fusion and time series analysis on multi-source InSAR variations

[Purpose] Firstly, deeply fuse multi-source InSAR variation records time series into the uniform spatiotemporal monitoring frame and reference epoch represented by the CORS variations time series respectively in time and space, and then perform time series analysis for all InSAR variation monitoring points, to realize multi-source InSAR collaborative monitoring.

### 5.4.1 Long-time connection of the same-track InSAR variation time series

[Function] From the two InSAR variation records time series in the same region and with the same reference epoch time, respectively supplement the sampling values of each time series by the Gaussian interpolation method, and then generate the one InSAR variations time series by resampling with the given spatial resolution.

[Input files] The two InSAR variation records time series files in the same region and with the same reference epoch time.

[Parameter settings] Set the two InSAR variation records time series files format patameters and enter the resampling spatial resolution.

[Output file] The connected InSAR variation records time series file.

The output file format and reference epoch are same as that of the input InSAR variation records time series file.



#### 5.4.2 Seamless spatial fusion on multi-source InSAR variations

[Function] According to the given spatial resolution, resample the input multi-source InSAR variation records time series to generate a new InSAR variation records time series. The input InSAR variation records time series files are extracted according to the given wildcards, and all the input files are in the same format.

Before deep fusion of multi-source InSAR variation records time series, it is necessary to ensure that the reference epochs of all InSAR time series are unified.

[Input files] Multi-source InSAR variation records time series files.

In this example, two InSAR variation records time series are on adjacent areas, and a small number in the two groups of InSAR monitoring points are cross-distributed.

[Parameter settings] Set the file name wildcards and file format patameters of multisource InSAR variation records time series and enter the resampling spatial resolution.

[Output file] The fused InSAR variation records time series file. The format is the same as that of the input InSAR variation records time series file.



#### 5.4.3 Analysis and filtering on variation records time series

[Function] Using the continuous Chebyshev and triangular basis function combination method, estimate the low-pass filtering parameters for variation records time series on each monitoring point, and then calculate the filtering value and the linear variation (per year, /a) at source sampling epochs.

[Input files] The InSAR variation records time series files.

[Parameter settings] Set the file format patameters of InSAR variation records time series and enter the ratio of the number of sampling epochs to filter parameters.

[Output file] The filtered InSAR variation records time series file \*\*\*.txt. The InSAR

variation first-order time-derivative (per week, /wk) records time series file \*\*\*.dft. Here, \*\*\* are the output file name.

The filtered variation records time series file. The file format is the same as that of the input InSAR variation records time series file and the fourth column in the file record is the linear variation (per year, /a).

The InSAR variation first-order time-derivative (per week, /wk) records time series file \*.dft. The file format is the same as that of the output InSAR variation records time series file, and the fourth column in the record is the linear variation (per year, /a).

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### 5.4.4 Reconstruction of time series with given sampling specifications

[Function] Using the continuous Chebyshev and triangular basis function combination method, estimate the filtering parameters for variation records time series of each monitoring point, and then reconstruct the variation records time series according to the given time series sampling specifications.

The program has time-domain interpolation and short-time forecasting capabilities.

[Input files] The InSAR variation records time series files.

[Parameter settings] Set the file format patameters of InSAR variation records time series and enter the ratio of the number of sampling epochs to filter parameters and time series sampling specifications.

When the starting time is earlier than the first sampling epoch time of the source variation

records time series, the program lets the starting time = the first sampling epoch time - sampling interval \* total number of the samples \* 5%.

When the ending time is later than the last sampling epoch time of the source variation records time series, the program lets the ending time = the last sampling epoch time + sampling interval \* total number of the samples \* 5%.

[Output file] The reconstructed InSAR variation records time series file \*\*\*.txt. The InSAR variation first-order time-derivative (per week, /wk) records time series file \*\*\*.dft. Here, \*\*\* are the output file name.

The filtered variation records time series file. The file format is the same as that of the input InSAR variation records time series file and the fourth column in the file record is the linear variation (per year, /a).

The InSAR variation first-order time-derivative (per week, /wk) records time series file \*.dft. The file format is the same as that of the output InSAR variation records time series file, and the fourth column in the record is the linear variation (per year, /a).



#### 5.5 Calculation of ground stability variation based on vertical deformation

[Purpose] From the ground vertical deformation rate and its horizontal gradient grid model, using the normalized statistical synthesis algorithm, quantitatively estimate the ground stability variations grid according to the quantitative criteria of the ground stability reduction defined by ETideLoad.

Quantitative criteria defined by ETideLoad for the ground stability reduction based on the vertical deformation grids time series are in the following.

(1) The ground vertical deformation rate is relatively large (greater than zero). At this time, the ground here is rising upward.

(2) The horizontal gradient (modulus) of the vertical deformation rate is relatively large. At this time, the ground is twisting locally.

(3) The terrain slope value is relatively large.

#### 5.5.1 Estimation of normalized ground stability variations grid

[Function] From the ground vertical deformation rate grid and ground digital elevation model with the same grid specifications, calculate the horizontal gradient of the ground vertical deformation rate and the terrain slope vector grid, and then quantitatively estimate the ground stability variations grid by the normalized statistical synthesis algorithm according to the quantitative criteria of the ground stability reduction.

[Input files] The ground vertical deformation rate grid file and ground digital elevation model file with the same grid specifications.



[Parameter settings] Set the weights and exponents for ground vertical deformation rate, horizontal gradient of the ground vertical deformation rate and terrain slope.

The ground vertical deformation rate is the variation rate of the ground vertical deformation with time. The horizontal gradient of the ground vertical deformation rate is the horizontal gradient vector of the ground vertical deformation rate.

[Output file] The normalized ground stability variations grid file.

The weights and exponent parameters do not change with time, which are only used to roughly distinguish the responses of different types of the variations to the geological environment. Rough value can meet the needs.

#### 5.5.2 Estimation of ground stability variation grids time series

[Function] From the ground vertical deformation rate grids time series and ground digital elevation model with the same grid specifications, calculate the terrain slope vector grid and the vector grids time series of the horizontal gradient of the ground vertical deformation rate, and then quantitatively estimate the ground stability variation grids time series by the normalized statistical synthesis algorithm according to the quantitative criteria of the ground stability reduction.



The ground stability variation is a dimensionless continuous real variable. At any sampling epoch time, the grid value of a grid element is greater than zero, indicates that the stability at this time is decreasing, and the grid value less than zero indicates that the stability at this time is improving.

[Input files] The ground vertical deformation rate grid time series files and ground digital elevation model file with the same grid specifications.

[Parameter settings] Set the wildcard patameters for the deformation rate grids time series files, enter the weights and exponents for ground vertical deformation rate, horizontal gradient of the ground vertical deformation rate and terrain slope.

[Output file] The normalized ground stability variations grid time series files.

The ground vertical deformation may be the ground ellipsoidal height variation, or the ground normal or orthometric height variation. The normalized statistical synthesis algorithm can be found in the program [Statistical synthesis and prediction of ground stability variations].

The ground stability variation is a dimensionless continuous real variable. At any sampling epoch time, the grid value of a grid element is greater than zero, indicates that the stability at this time is decreasing, and the grid value less than zero indicates that the stability at this time is improving.

The ground stability variation grids time series can quantitatively express the time and location of the ground stability reduction phenomenon, the continuous influence time, and the spatial influence range.

### 5.6 Calculation of ground stability variation based on gravity variations

[Purpose] From the ground gravity (or gravity disturbance) variation rate and its horizontal gradient grid model, using the normalized statistical synthesis algorithm, quantitatively estimate the ground stability variations grid according to the quantitative criteria of the ground stability reduction defined by ETideLoad.

Quantitative criteria defined by ETideLoad for the ground stability reduction based on the gravity variation grids time series are in the following.

(1) The ground gravity variation rate is relatively large (less than zero). At this time, the ground here is rising upward.

(2) The horizontal gradient (modulus) of the gravity variation rate is relatively large. At this time, the ground is twisting locally.

(3) The local terrain effect of the gravity disturbance is relatively large (less than zero).

The ground gravity variation may be the ground gravity variation, or the ground gravity disturbance variation.

#### 5.6.1 Normalized ground stability variations grid estimation

[Function] From the ground gravity variation rate grid and ground digital elevation model, calculate the horizontal gradient vector grid of the ground gravity variation rate and the local terrain effect grid of the gravity disturbance, and then quantitatively estimate the ground stability variations grid by the normalized statistical synthesis algorithm according to the quantitative criteria of the ground stability reduction.

[Input files] The ground gravity variation rate grid file. The ground digital elevation model grid file.

[Parameter settings] Set the weights and exponents for ground gravity variation rate, horizontal gradient of the ground gravity variation rate and local terrain effect, set the checkbox [Taking into account the local terrain effects of gravity disturbance].

The ground gravity variation is the variation rate of the ground gravity variation with time. The horizontal gradient of the ground gravity variation rate is the horizontal gradient vector of the ground gravity variation rate.

H Follow examp Start computation Open a ground gravity variation rate grid file Estimation normalized ground stability variations grid Estimation of ground stability variation grids time series Taking into account the local terrain effects of gravity disturbance >> Program Process \*\* Operation Prompts Open a ground digital elevation model file Save program process as >> Function From the ground gravity variation rate grid and ground digital elevation model, calculate the horizontal gradient vector grid of the ground gravity variation rate and the local terrain effect grid of the gravity disturbance, and then quantitatively elevatimate the ground stability variations rate by the normalized statistical synthesis algorithm according to the quantitative criteria of the ground stability variations rate in the statistical synthesis algorithm according to the quantitative criteria of the ground stability variations. The program requires that the latitude and longitude range of the ground digital elevation model gravity disturbance is used to quantify the severity of the topographical undulations. The program requires that the latitude and longitude range of the ground digital elevation model gravity variations grid for the computation of the local terrain effect using the numerical integration method. "The ground ravity variation rate is the variation rate of the ground gravity variation rate is the variation rate of the ground gravity variation rate." Chart coad the unification rate of the ground gravity variation rate of the ground gravity variation rate of the ground gravity variation rate. "The ground quarkity the severity of the complex Dynamic variation fraction". One of the complex Dynamic variation fraction of the local terrain effect using the numerical integration method. "The ground quarkity variation rate of the ground varity and the severity of the gravity variation rate of the gravity variation rate of the gravity variation rate of the gravity variation rate of the gravity variation rate of the gravity variation rate of the gravity variation rate of the gravity variation rate of the gravity variation rate of the gravity variation rate of the gravity variation rate of the gravity variation rate of the gravity variation rate of the gravity variation rate of the gravity variation rate of the gravity variation rate of the gravity variation rate of the gravity variatio Weight of ground gravity variation rate 3.00 C Exponent 0.5 • Weight of horizontal gradient of the rate 5.00 C Exponent 0.5 Weight of local terrain effects 2.00 + Exponent 0.5 : A The weights and exponent parameters do not change with time, which are y used to roughly distinguish the responses of different types of the varia Den a ground gravity variation rate grid file C/CTideLoad4.0\_win64en/exa >> Open a ground digital elevation model file C/ETideLoad4.0\_win64en/exa >> Save the results as C/ETideLoad4.0\_win64en/examples/Dyngmgravstal y gravrate/diff2015013106.dat. tions to the geological environment. Rough value can meet the nee >> Setting parameters have been imported in the program! Click the control button [Start computation], or the tool button [Start computation].
 >> Computation start time: 2022-03-05 10:26:33 >> Complete the computation! >> Computation end time: 2022-03-05 10:26:57 Note the results as Import setting paran Start computat Display of the input-output file Save data in the text bo 0.01666667 2015013106 6431 0.6340 0.460 Quantitative criteria defined by ETideLoad for the ground stability reduction ba large (less than zero). At this time, the grou d on the gravity variation grids time series: (1) The ground gravity here is rising upward. (2) The horizontal gradient (modulus) of the gravity variation rate is relatively large. At th time, the gro lly. (3) The local terrain effect of the gravity disturbance is relatively large (less us real va At any sampling ep ity at this time is decreasing, and the value less than zero indicates that the stability at this time is improving.

[Output file] The normalized ground stability variations grid file.

### 5.6.2 Estimation of ground stability variation grids time series

[Function] From the ground gravity variation rate grids time series and ground digital elevation model, calculate the local terrain effect grid of the gravity disturbance and the vector grids time series of the horizontal gradient of the ground gravity variation rate, and then quantitatively estimate the ground stability variation grids time series by the normalized statistical synthesis algorithm according to the quantitative criteria of the ground stability reduction.

[Input files] The ground gravity variation rate grid time series files and ground digital elevation model file.

[Parameter settings] Set the wildcard patameters for the gravity variation rate grids time

series files, enter the weights and exponents for ground gravity variation rate, horizontal gradient of the ground gravity variation rate and local terrain effect.

Here, the local terrain effect of the gravity disturbance is used to quantify the severity of the topographical undulations. The program requires that the latitude and longitude range of the ground digital elevation model grid should be expanded by no less than 50km out of the ground gravity variations grid for the computation of the local terrain effect using the numerical integration method.

The weights and exponent parameters do not change with time, which are only used to roughly distinguish the responses of different types of the variations to the geological environment. Rough value can meet the needs.

[Output file] The normalized ground stability variations grid time series files.



### 5.7 Calculation of ground stability variation based on variation vectors

[Purpose] From the ground tilt (vertical deflection or horizontal displacement) variation rate vector grid and ground digital elevation model, using the normalized statistical synthesis algorithm, quantitatively estimate the ground stability variations grid according to the quantitative criteria of the ground stability reduction defined by ETideLoad.

Quantitative criteria defined by ETideLoad for the ground stability reduction based on the variation vector grids time series are in the following.

(1) The directions of the ground tilt (vertical deflection or horizontal displacement) variations are gathering or diverging. At this time, the ground nearby here is being squeezed or stretched.

(2) The vector inner product of the ground tilt (vertical deflection or horizontal displacement) variation rate and the terrain horizontal gradient is greater than zero. At this time, the ground here is being pulled along the terrain slope direction.

The variation vector may be the ground tilt variation, vertical deflection variation, or ground horizontal displacement.

### 5.7.1 Estimation of normalized ground stability variations grid

[Function] From the ground tilt (vertical deflection or horizontal displacement) variation rate vector grid and ground digital elevation model, calculate the horizontal gradient vector grid of the variation rate, the horizontal gradient vector grid of the terrain and the two vectors inner product grid, and then quantitatively estimate the ground stability variations grid by the normalized statistical synthesis algorithm according to the quantitative criteria of the ground stability reduction.

[Input files] The ground variation rate vector grid file and ground digital elevation model file with the same grid specifications.



[Parameter settings] Set the weights and exponents for the rate gradient and two vectors inner product, select the vector type.

[Output file] The normalized ground stability variations grid file.

#### 5.7.2 Estimation of ground stability variation grids time series

[Function] From the ground tilt (vertical deflection or horizontal displacement) variation rate vector grids time series and ground digital elevation model, calculate the horizontal gradient vector grids time series of the variation rate, the horizontal gradient vector grid of the terrain, and the two vectors inner product grids time series, and then quantitatively estimate the ground stability variation grids time series by the normalized statistical synthesis algorithm according to the quantitative criteria of the ground stability reduction.

[Input files] The ground variation rate vector grids time series files and ground digital elevation model file with the same grid specifications.

[Parameter settings] Set the wildcard patameters for the rate vector grids time series files, enter the weights and exponents for the rate gradient and two vectors inner product, select the vector type.

[Output file] The normalized ground stability variations grid time series files.



Quantitative criteria defined by ETideLoad for the ground stability reduction based on the variation vector grids time series: (1) The directions of the ground tilt (vertical deflection or horizontal displacement) variations are gathering or diverging. At this time, the ground nearby here is being squeezed or stretched. (2) The vector inner product of the ground tilt (vertical deflection or horizontal displacement) variation rate and the terrain horizontal gradient is greater than zero. At this time, the ground here is being pulled along the terrain slope direction.
 The ground stability variation is a dimensionless continuous real variable. At any sampling epoch time, the grid value of a grid element is greater than zero, indicates that the stability at this time is improving.

#### 5.8 Statistical synthesis and prediction of ground stability variations

[Purpose] According to historical disasters events during the monitoring period, by adjusting the weights and exponents of multiple stability variations based on various geodetic variations, optimize the ground stability variation grids time series by the statistical normalized synthesis algorithms, to reflect the spatial distribution and temporal natures of the regional ground stability variations.

#### 5.8.1 Optimized synthesis of two geodetic variation grids time series

[Function] From two groups of geodetic variation grids time series with the same spacegrid and time-sampling specifications, generate the coupled geodetic variation grids time series by the statistical normalized synthesis algorithms, to reflect the spatiotemporal dynamic effects of the two kinds of geodetic joint monitoring.

[Input files] The two groups of geodetic variation grids time series files with the same space-grid and time-sampling specifications.

[Parameter settings] Set the wildcard patameters for grids time series files, enter the weights and exponents.



[Output file] The synthesized variation grids time series files.

If all the characters of the file name are set as wildcards, the variation grids time series only is an epoch sampling grid. In this case, the program can realize the normalized synthesis between a group of the grids time series and a single grid.

With the two geodetic variation grids time series a, b, the synthesized variation grids time series x can be calculated by the following formula.

 $x = sgn(A)|A|^{n_a}Q_a + sgn(B)|B|^{n_b}Q_b$ , Where, sgn(\*) is a sign function,

$$A = (a - \overline{a})/\sigma_a, B = (b - \overline{b})/\sigma_b, Q_a = \frac{q_b}{q_a + q_b}, Q_a = \frac{q_b}{q_a + q_b}.$$

#### 5.8.2 Optimized synthesis of three stability variation grids time series

[Function] From three groups of ground stability variation grids time series with the same space-grid and time-sampling specifications, generate the ground stability variation grids time series with spatiotemporal dynamic feature information, higher sensitivity, and reliability by the statistical normalized synthesis algorithms.

[Input files] The three groups of stability variation grids time series files with the same space-grid and time-sampling specifications.

[Parameter settings] Set the wildcard patameters for grids time series files, enter the weights and exponents.

[Output file] The synthesized stability variation grids time series files.



The ground stability variations based on the vertical deformation have a large spatial influence range, but weak close-range sensitivity. The ground stability variations based on the gravity variations have a strong close-range sensitivity, but a small spatial influence

range. The ground stability variations based on the tilt variations can describe ground stability change information in different directions. The further synthesis of the three ground stability variations can effectively improve the sensitivity and reliability of the ground stability variation grids time series.

#### 5.8.3 spatiotemporal characteristics synthesis of ground stability variations

[Function] From the ground stability variation grids time series, calculate its spatial horizontal gradient and time-derivative grids time series. And then using the low-pass filtering and statistical normalization synthesis methods, generate the grids time series files stachr\*.dat of the ground stability variations that fuse spatiotemporal characteristics according to the given sampling specifications and statistical parameters.

[Input files] The ground stability variation grids time series files.



[Parameter settings] Enter the weights and exponents for the ground stability variation, its horizontal gradient and time-derivative, set spatial and time domain filter parameters, and set the sampling specificationsl parameters.

When the starting time is earlier than the first sampling epoch time of the source variation grids time series, the program lets the starting time = the first sampling epoch time - sampling

interval \* total number of the samples \* 5%.

When the ending time is later than the last sampling epoch time of the source variation grids time series, the program lets the ending time = the last sampling epoch time + sampling interval \* total number of the samples \* 5%.

[Output file] The synthesized ground stability variation grids time series files stachr\*.dat, filtered ground stability variation grids time series files staflt\*.dat, ground stability variation horizontal gradient (modulus, per km) grids time series files stagrd\*.dat and its time-derivative (per week) grids time series files stadft\*.dat.

Repeatedly use the function [two groups of grid timing statistics normalization synthesis] n-1 times, which can realize the statistical normalization synthesis of the n geodetic variation grids time series. In this case, you can design n geodetic variations weights and exponents at one time in advance. When the m (<n) synthesis is performed, the variation weights after m-1 synthesis are the sum of the previous m-1 weights, and the exponent is 1.

## 6 Editing, calculation and visualization for geodetic data files

The group of programs can be used to construct of geodetic data files in ETideLoad format, convert between data formats, and edit, interpolate, grid, extract, separate, merge, detect the gross errors, directly calculate, and visualize on geodetic data files.



### 6.1 Conversion of general ASCII data into ETideLoad format

[Function] Convert the general ASCII data records file from different sources and nonstandard formats into the discrete geodetic records file in ETideLoad format.

[Input file] The general ASCII data records file.

After entering the number of rows of the input file header, click the control button [Exact and edit data] to open the dialog [Exact and edit data from the source text file].

Set the format parameters about the target file header, record table header, and record attributes.

When the target file does not need the record table header, please clear the text corresponding to the input text box.

Click the button [Ok] to close the dialog. Click the control button [Organize and display results file] to count the maximum number of each column characters of the target record attributes, and then display the target file header, record table header, and all the records. It takes some time to organize the target record attributes, please wait...

Complete the statistics of the maximum number of characters of the target record

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attributes, and display the target file header, record table header, and all the records.

[Output file] The discrete geodetic records file in ETideLoad format.

Check the target records file displayed in the editable textbox. Click the control button [Save data in the textbox as] to save the contents in the textbox above as the target file...

The program is the important interface for ETideLoad to accept the external text data.

# 6.2 Data interpolation, extracting and separation of land and sea

# 6.2.1 Changing of grid resolution by interpolation

[Function] Increase or decrease the grid spatial resolution according to the given grid resolution and specified interpolation method.

[Input file] The geodetic numerical grid file.

[Parameter settings] Enter the spatial resolution for target grid and select the interpolation mode.

[Output file] The target geodetic numerical grid file.

The grid direct averaging method is that sums up all the effective source grid element values within the target grid element, and then divided them by the number of the effective source elements. The grid equal-area averaging method is that sums up all the effective source grid element values within the target element, and then divided by the total number of source elements.

It is recommended to adopt the grid equal-area averaging method when decreasing the

spatial resolution of the surface loads.



The grid direct averaging method or the grid equal-area averaging method can be used to decrease grid resolution. When the resolution of the target grid is lower than that of the source grid, the program automatically adopts the inverse distance weighted interpolation method.

### 6.2.2 Interpolating of geodetic sites attribute from grid

[Function] From a numerical grid, interpolate the attribute values of the geodetic sites according to the specified interpolation method.

[Input files] The discrete geodetic points file to be interpolated. The geodetic numerical grid file for interpolation.

[Parameter settings] Enter number of rows of the discrete geodetic points file header and select the interpolation mode.

[Output file] The interpolated discrete geodetic points file.

The file format is the same as the input discrete geodetic points file file. Behind the input file record, add one column of the interpolated value as the output file record.

#### 6.2.3 Selecting of records based an attribute condition

[Function] Select the geodetic records from a geodetic records file according to the maximum and minimum range of the specified attribute.

[Parameter settings] Enter number of rows of the input file header, colmun ordinal number of the condition attribute in the file record, and minimum and maximum of the attribute.



#### 6.2.4 Separating of (vector) grid data to two different regions

[Function] According to the maximum and minimum range of the specified reference grid value, replace the source (vector) grid values with the given constant when the reference grid values are out of the range, to separate the source (vector) grid.

The program requires that the reference grid can distinguish the target region by the maximum and minimum value range.

The program can realize the separation of land or sea (vector) grid. The resolution of the source grid may be different from that of the reference grid.

[Input files] The source geodetic (vector) grid file. The reference grid file whose grid range and resolution are not smaller than that of the source grid file.



## 6.3 Simple and direct calculation on geodetic data files

### 6.3.1 Weighted operations on two specified attributes in records file

[Function] Perform weighted plus, minus, or multiply operations on two specified attributes in the discrete points file.

[Input file] The discrete geodetic points file.

[Parameter settings] Enter number of rows of the discrete geodetic points file header, colmun ordinal number and weight of the attribute 1, and colmun ordinal number and weight of attribute 2. Select operation mode.

[Output file] The operated discrete geodetic points file.

The file format is the same as the input discrete geodetic points file file. Behind the input file record, add one column of the computed result as the output file record.

Simple and direct calculation on geodetic data files			- 🗆 X
Open file Save as Import parameters	Save process	low example	
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11578 106.395833 27.020833 1 11579 106.437500 27.020833 1 11580 106.479167 27.020833 1	.183.494         0.0998         0.796           .109.535         -0.2633         -0.369           .000.613         -0.6156         -2.145           .135.735         -0.9730         -3.212	3 0.8961 0 -0.6323 1 -2.7607 9 -4.1859	
11578 106.395833 27.020833 1 11579 106.437500 27.020833 1 11580 106.479167 27.020833 1 11581 106.520833 27.020833 1	.183.494 0.0998 0.796 .109.535 -0.2633 -0.369 .000.613 -0.6156 -2.145	3 0.8961 0 -0.6323 1 -2.7607 9 -4.1859 3 -4.2207	
11578         106.395833         27.020833         1           11579         106.437500         27.020833         1           11580         106.479167         27.020833         1           11581         106.520833         27.020833         1           11582         106.520833         27.020833         1           11582         106.620503         27.020833         1           11582         106.604167         27.020833         1	183.494         0.0998         0.796           109.535         -0.2633         -0.369           000.613         -0.6156         -2.145           135.735         -0.9730         -3.212           249.869         -1.4044         -2.816           .251.986         -1.8931         -1.341           .289.077         -2.2829         0.550	3 0.8961 -0.6323 -2.7607 9 -4.1859 -4.2207 4 -3.2345 -2.235	
11578         106.395833         27.020833         1           11579         106.437500         27.020833         1           11580         106.479167         27.020833         1           11581         106.520833         27.020833         1           11582         106.525003         27.020833         1           11583         106.64167         27.020833         1           11583         106.604163         27.020833         1	183.494         0.0998         0.796           109.535         -0.2633         -0.369           000.613         -0.6156         -2.145           135.735         -0.9730         -3.212           249.869         -1.4044         -2.816           251.986         -1.8931         -1.341	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	

### 6.3.2 Weighted operations on two geodetic grid files

[Function] Perform weighted plus, minus, or multiply operations on grid elements in two (vectors) grid files with the same specifications.

### 6.3.3 Product operations on two vector grid files

[Function] Perform outer product or inner product operations on vectors grid elements in two vectors grid files with the same specifications.

### 6.3.4 Weighted operations on two harmonic coefficients files

[Function] Perform weighted operations on two normalized spherical harmonic

### coefficients model files.

Open file Save a	s Import param	start computation	n Save proces	Follow example		
Weighted opera attributes in rec	ations on two spec ords file	cified Weighte two geod	d operations on detic grid files	Produ two ve	uct operations on ector grid files	Weighted operations on two harmonic coefficients files
Open the first s	spherical harmoni odel file	ic >> Program Proces	s ** Operation Pr	rompts		Save program process a
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	loue	CS50.dat.				-
Plus +			d spherical harmo	onic coefficients model fi	ile C:/ETideLoad4.0_wir	n64en/examples/EdFlgeodatacalculate/
The first weight	1.00	CS60.dat.	as C:/ETidel oad	d4.0 win64en/examples/	EdElgeodatacalculate/	CSadd60 dat
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			Dutton Lotant con	inputationil, or the toor bu		]
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	- <b>output file</b> ↓	>> Computation sta >> Complete the co >> Computation en	art time: 2022-03 omputation! id time: 2022-03-0	3-05 17:01:22 05 17:01:24		- Start computation
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$\begin{array}{c} 3.986004415d0\\ 2&0&-9.68\\ 2&1&-4.13\\ 2&2&4.87\\ 3&0&1.91\\ 3&1&4.06\\ 3&2&1.80\\ 3&3&1.44\\ 4&0&1.07\\ \end{array}$	6378136.3d0 33302875816E-04 8376714656E-06 4322414187E-06 50924020958E-06 92575789619E-06 92543514243E-06	<ul> <li>&gt;&gt; Computation sta</li> <li>&gt;&gt; Complete the cc</li> <li>&gt;&gt; Computation en</li> <li>&gt;&gt; Computation en</li> <li>2.768827782760E-09</li> <li>2.80647407718E-06</li> <li>0.00000000000E+00</li> <li>4.96400817138E-07</li> <li>1.238010950355E-06</li> <li>2.82669523858E-06</li> <li>0.0000000000000000000</li> </ul>	7.4812E-12         7.4812E-12           7.4812E-12         7.0637E-12           5.7314E-12         5.7344E-12           6.0291E-12         6.0291E-12           4.4312E-12         4.4312E-12	<ul> <li>LÓ5 17:01:22</li> <li>D5 17:01:24</li> <li>Import</li> <li>0.0000E+00</li> <li>7.3848E-12</li> <li>0.0000E+02</li> <li>0.9767E-12</li> <li>0.4019E-12</li> <li>0.4019E-12</li> <li>0.0000E+00</li> </ul>		- Start computation
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$\begin{array}{c} 3.986004415d0\\ 2&0-9.68\\ 2&1-4.13\\ 2&2&4.87\\ 3&0&1.91\\ 3&1&4.06\\ 3&2&1.80\\ 3&3&1.44\\ 4&0&1.07\\ 4&1&-1.07\\ 4&2&7.01\\ \end{array}$	6378136.3d0 33302875816E-04 32310181484E-10 876714656E-05 50924020958E-06 50924020958E-06 12643514243E-06 19931733278E-06 12314778778E-06 1032479252E-07	<ul> <li>&gt;&gt; Computation sta &gt;&gt; Complete the cc</li> <li>&gt;&gt; Complete the cc</li> <li>&gt;&gt; Computation en</li> <li>1</li> <li>1</li> <li>1</li> <li>1</li> <li>1</li> <li>1</li> <li>1</li> <li>2</li> <li>1</li> <li>2</li> <li< td=""><td>rt time: 2022-03 omputation1 d time: 2022-03-0 time: 2022-03-0 s as 7.4812E-12 7.0637E-12 5.7314E-12 6.3747E-12 6.3747E-12 4.4312E-12 4.4312E-12 4.53078E-12</td><td><ul> <li>↓05 17:01:22</li> <li>D5 17:01:24</li> <li>D5 17:01:24</li> <li>D5 17:01:24</li> <li>0.0000E+00</li> <li>0.3434E-12</li> <li>0.0000E+00</li> <li>0.9767E-12</li> <li>0.0000E+02</li> <li>0.0000E+02</li> <li>0.0000E+02</li> <li>0.1961E-12</li> </ul></td><td></td><td>- Start computation</td></li<></ul>	rt time: 2022-03 omputation1 d time: 2022-03-0 time: 2022-03-0 s as 7.4812E-12 7.0637E-12 5.7314E-12 6.3747E-12 6.3747E-12 4.4312E-12 4.4312E-12 4.53078E-12	<ul> <li>↓05 17:01:22</li> <li>D5 17:01:24</li> <li>D5 17:01:24</li> <li>D5 17:01:24</li> <li>0.0000E+00</li> <li>0.3434E-12</li> <li>0.0000E+00</li> <li>0.9767E-12</li> <li>0.0000E+02</li> <li>0.0000E+02</li> <li>0.0000E+02</li> <li>0.1961E-12</li> </ul>		- Start computation
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$\begin{array}{c} \textbf{3.986004415d0}\\ \textbf{2}  0 \ -9.68\\ \textbf{2}  1 \ -4.13\\ \textbf{2}  2 \ 4.87\\ \textbf{3}  0 \ 1.91\\ \textbf{3}  1 \ 4.06\\ \textbf{3}  2 \ 1.80\\ \textbf{3}  \textbf{3}  1.44\\ \textbf{4}  0 \ 1.07\\ \textbf{4}  1 \ -1.07\\ \textbf{4}  2 \ 7.01\\ \textbf{4}  \textbf{3}  1.98\\ \textbf{4}  \textbf{4} \ -3.77\end{array}$	6378136.3d0 13302875816E-04 12310181484E-10 18767146566E-06 14322414187E-06 10924020958E-06 12643514243E-06 1993173278E-06 10032479252E-07 1071353345E-06 10322660460E-07 192626666666666666666666666666666666666	<ul> <li>&gt;&gt; Computation state</li> <li>&gt;&gt; Complete the cc</li> <li>&gt;&gt; Computation en</li> <li>&gt;&gt; Computation en</li> <li>&gt;&gt; Computation en</li> <li>2.768827782760E-09</li> <li>2.800547407718E-06</li> <li>0.000000000000000</li> <li>4.964008317138E-07</li> <li>2.38010950355E-06</li> <li>0.00000000000000000</li> <li>4.964003252E-07</li> <li>1.324960052552E-06</li> <li>-4.019134471350E-07</li> <li>7.617807764298E-07</li> </ul>	art time: 2022-03 omputation1 d time: 2022-03-0 d time: 2022-03-0 is as 7,4812E-12 7,0637E-12 7,2302E-12 5,7314E-12 6,3747E-12 4,5681E-12 4,5681E-12 4,5681E-12 5,3078E-12 5,3202E-12	L-05 17:01:22 D5 17:01:24		- Start computation
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The file header occupies a row and consists of two attributes for scaling parameters of the spherical harmonic coefficients model, namely the geocentric gravitational constant *GM* (×10<sup>14</sup>m<sup>2</sup>/s<sup>2</sup>) and equatorial radius of the Earth a (m).

### 6.4 Operations on geodetic time series with same specifications

#### 6.4.1 Weighted operations on two records time series with same specifications

[Function] Perform weighted plus, minus, or multiply operations on two variations at the same sampling epochs from two records time series.

The program requires that the records of two groups of time series are one-by-one correspondence in location and sampling epoch.

[Input files] The two groups of variation records time series files.

[Parameter settings] Set the records time series file format parameters, enter the weighs, and select operation mode..

If some a sampling epoch is not in both of two group records time series, the corresponding variation time series is neglected.

[Output file] The operated discrete geodetic points file.

The file header is composed of the weighted operation type (0 - plus, 1 - minus, 2 - multiply), number n of attribute columns of the variation location information in the record, number m of sampling epochs, and m sampling epochs.

Behind top n columns attributes of the first records time series, add m variations of result time series as the output record.

Operations on geodetic time series with same specifications				- 🗆 X
Open file Save as Import parameters	utation Save process Follow example			
Weighted operations on two records time series with same specifications	Construction of red from batch discrete		Weighted operation of grids time series	ns on two groups s files
Open the geodetic records time series file 1	>> Program Process ** Operation Prompt	S		Save program process as
Column ordinal number of first epoch time in header 3 Column ordinal number of the first variation in record a Open the records time series file 2 with the same specifications Column ordinal number of first epoch time in header 2 Column ordinal number of the first variation in record 5 Select operation mode Plus + The first weight 1.00 The second weight 1.00	<ul> <li>series. The program requires that the recovery of some a sampling epoch is not in bot &gt;&gt; Open the geodetic records time series &gt;&gt; Look at the input life information in the "The window below only shows the roc &gt;&gt; Open the records time series file 2 will "Look at the input life information in the "The window below only shows the roc &gt;&gt; Open the records time series file 2 will "Look at the input life information in the "The window below only shows the roc &gt;&gt; Open the records time series file 2 will "Look at the input life information in the "The window below only shows the roc &gt;&gt; Open the records time series and mugations of result time series, add mugations of result time &gt;&gt; Setting parameters have been importe &gt;&gt; Click the control button [Stat computation start times. 2022-03-06 12 &gt;&gt; Complete the weighted operatings of (</li> </ul>	h of two group records time series. If file 1 C/ETIGLAAd, 0, wind-fanixx; text box below, set the file format p ords time series with no more than 2 wind-text box below, set the file format p ords time series with no more than 2 wind-text box below, set the file format p ords time series with no more than 2 wind-text box below, set the file format p ords time series with no more than 2 wind-text box below, set the file format p ords time series with no more than 2 wind-text box below, set the file format p ords time series the set the set of the set text box below, set the file format p text box below, set text box below,	he corresponding variation time se amples/Edimesriesfilescalc/tmre arameters (900 rows! calcf.mcreaded.txt. (900 rows! calc/tmrcrdad.txt. inus, 2 - multiply), number n of att ling epochs. Behind top n column tation]	rifes is neglected. cord 1.txt. seriesfilescalc/tmrecord2.txt. ribute columns of the variation attributes of the first records
1 5 37 20141103 20141127 2 -9.310 117.3445416 39.0251902 -2.793	20141221	Maport setting parameter	rs	J Start computation
3 -12.799 117.3457082 38.0251902 -2.304 4 -7.402 117.3467185 38.0251902 -3.460 5 -6.699 117.3467163 38.0251902 -2.582 6 -7.643 117.3467163 39.0251902 -2.802 7 -8.001 117.346716 39.0251902 -3.400 8 -0.736 117.349201 39.0251902 -3.400 8 -0.736 117.3495414 39.0251902 -4.123	-0.1796 -0.3846 -0.3325 -0.1876 isplay of the input-output file↓	112700 2014122100 2015011400	2015050200 2015052600 2	

### 6.4.2 Construction of records time series from batch discrete points files

[Function] From a series of discrete points files with the same specifications including the sampling epoch time, extract the specified attribute variation, and compose a time series by sorting with time, and then generate a records time series file with several kinds of variations.

[Input files] A series of discrete points files with the same specifications.

The program requires that the file header occupies a row that contains a sampling epoch in ETideLoad format.

The program also requires that the locations of the variations in all the geodetic record files are one-by-one correspondence, but the record length may be different.

[Parameter settings] Set the wildcard patameters for a series of discrete points files and the file format parameters, enter column ordinal number of the epoch time in the input file header and target attributes time series in the input file record.

[Output file] The variation records time series file.

The output file header: The number of the sites, number (n) of attributes for the site location information in the record, sampling number (m), m sampling epoch times.

The output file record format: The first n columns of attributes of the record in the first discrete points file, m sampling variations of the result record time series.

Weight time se	ed operations on two records ries with same specifications		Construction of from batch discr	records time series ete points files		Weighted of grids time	perations on two groups e series files
📕 Open any dis	crete points file with time	>> Pro	ogram Process ** Operation Prompts				Save program process a
	sampling epoch in header 7 target variation in record 6	<ul> <li>&gt;&gt; Op</li> <li>&gt;&gt; Sa</li> <li>** Th</li> <li>epoch</li> <li>record</li> <li>** Th</li> <li>C:/E</li> <li>C:/E</li> </ul>	e diffecent. ee any discrete points file with time C: we the results as C+E_[[del.oad4.0_win e file header: The numDer-dthe sites, times The file record format: The-teg time series. e discrete points file searched by wild E1deL.oad4.0_win64en/examples/Edit	n64en/examples/Edtimeseries number (n) of attributes for the n columns attributes of the re card instantiation: meseriesfilescalo/loadin/2017 meseriesfilescalo/loadin/2017	filescalc/pntfitm ne site location in cord in the first 0315 txt 0415 txt	record.txt. nformation in the reco	rd, sampling number (m), m sampling
		>> Set ** Cli >> Col >> Col	ETIdeLoad4.0_win64en/examples/Edit titing parameters have been imported i ick the control button [Start computatio mputation start time: 2022-03-05 17.46 mputation end time: 2022-03-05 17.46	n the program! n], or the tool button [Start co 45:54 e series! There are 3 location 31	mputation] and time files in	volved.	
		>> Set ** Cli >> Col >> Col	tting parameters have been imported i ick the control button [Start computatio mputation start time: 2022-03-05 17:4 mplete the construction of records time	n the program! in], or the tool button [Start co 45:54 e series! There are 3 location	mputation] and time files in	volved.	Start computation
		>> Set ** Cli >> Col >> Col >> Col Displa	tting parameters have been imported i ick the control button [Start computatio imputation start time: 2022-03-05 17: implete the construction of records time imputation end time: 2022-03-05 17:46	n the program! n], or the tool button [Start co 1554 e series! There are 3 location :31	mputation] and time files in	volved.	Start computation

## 6.4.3 Weighted operations on two groups of grids time series

[Function] From two groups of variation grids time series with the same specifications, sort the two groups of grids with time and then perform weighted plus, minus, or multiply operations.

Open file Save as Import parameters Start computation	Save process Follow example			
Weighted operations on two records time series with same specifications	Construction of n from batch discret	ecords time series ete points files	Weighted operation of grids time ser	tions on two groups
Open any grid time series file of the group 1	>> Program Process ** Operation Prompts			Save program process :
Andhal number of the first wildcards in the file name 10 Lumber of consecutive wildcards in the file name 10 Consecutive wildcards in the file name 10 Set the wildcard of the file names Andhal number of the first wildcards in file name 11 Set the wildcard of the file name 2 Set the wildcard of the file name 2 Set on secutive wildcards in file name 2 Set operation mode Plus + The first weight 1.00 The second weight 1.00	The grids time series files of the group 2 s C/ETdeLoad 0, win64en/examples/Ethin C/ETdeLoad 0, win64en/examples/Ethin Setting parameters have been imported in "Citck the control button (Start computation >> Compute the weighted operations of two >> Complete the weighted operations for two >> Complete the weighted operations for two	eseriesfilescalutmprid2/dmzgYDh20150 eseriesfilescalutmprid2/dmzgYDh20150 eseriesfilescalutmprid2/dmzgYDh20150 eseriesfilescalutmprid2/dmzgYDh20150 eseriesfilescalutmprid2/dmzgYDh20150 eseriesfilescalutmprid2/dmzgYDh20150 eseriesfilescalutmprid2/dmzgYDh20150 eseriesfilescalutmprid2/dmzgYDh20150 eseriesfilescalutmprid2/dmzgYDh20150 (1), or the tool button (Start computation) 556 roups of grid time series filest	201 dat 302 dat 403 dat 504 dat 605 dat 807 dat 906 dat 908 dat	operated.
	>> Computation end time: 2022-03-05 17:56:			
	our the results londer	Import setting parameters		Terr computation
	Display of the input-output file	Import setting parameters		Start computation

The program automatically ignores the grid file whose sampling epoch is not one-byone correspondence.

## 6.5 Generating and constructing of regional geodetic grid

### 6.5.1 Gridding of discrete geodetic data by simple interpolation

[Function] From a geodetic discrete point records file, generate the specified attributes grid file according to the specified interpolation method and grid specifications.

[Input files] The discrete geodetic points file to be interpolated. The geodetic numerical grid file for interpolation.

[Parameter settings] Enter number of rows of the discrete points file header, colnum ordinal number of the target attribute in the file record, interpolation search radius (multiple of the grid element) and grid specifications parameters. Select the interpolation mode.

[Output file] The operated discrete geodetic points file.

The file format is the same as the input discrete points file. Behind the input file record, add one column of the interpolated result as the output file record.



### 6.5.2 Gridding of high-resolution record attributes by direct averaging

[Function] Using the direct averaging method, grid the high-resolution discrete observations.

### 6.5.3 Interpolation of vector grid from two attributes in geodetic records

[Function] From a geodetic discrete points file, generate the vector grid file according to the two specified component attributes, specified interpolation method, and given grid specifications.

Open file Save as Import parameters Star	art computation Save process Follow example	
Gridding of discrete geodetic data by simple interpolation	ding of high-resolution record interpolation of vector grid from two geodetic grid file Stata accc	
Open a vector points file	>> Program Process ** Operation Prompts	process a
component 1 in the file record	<ul> <li>&gt;&gt; Computation start time: 2022-02-28 13:52:31</li> <li>&gt;&gt; Computation start time: 2022-02-28 13:52:32</li> <li>&gt;&gt; Computation and time: 2022-02-28 13:52:32</li> <li>&gt;&gt; Computation from a geodelic records file, generate the vector grid file according to the two specified component attributes, sp interpolation method, and given grid specifications.</li> <li>&gt;&gt; C/ETIdeLoad4.0_win64en/examples/Edareageodelic/datal/load/fmrst.txt.</li> <li>&gt;&gt; Save the results as C/ETIdeLoad4.0_win64en/examples/Edareageodelic/datal/wing/d5m.dat.</li> <li>&gt;&gt; Computation start time: 2022-02-28 13:58:27</li> <li>&gt;&gt; Computation start time: 2022-02-28 13:58:28</li> </ul>	ecified
1 104.041667 25.041667 0.000 -3.6195		esults as
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	3.7225 3.1230 1.7717 3.1469 0.2711 0.7469 0.2211 3.7717 3.1469 0.2711 0.7469 0.2211 3.7717 3.1469 0.211 0.7469 0.2111 0.7469 0.2111 0.7469 0.2111 0.7469 0.2211 0.21111 0.2111 0.2111 0.2111 0.2111 0.21111 0.2111 0.2	
1         104.041667         25.041667         0.000         -3.6195           2         104.125000         25.041667         0.000         -3.6308           3         104.20533         25.041667         0.000         -3.6308           4         104.20533         25.041667         0.000         -3.6338           4         104.20533         25.041667         0.000         -3.6338           6         104.305467         5.041667         0.000         -3.6338           6         104.458333         25.041667         0.000         -3.6195           7         104.541667         5.041667         0.000         -3.6195	3.7225 3.1230 1.7717 3.1460 0.4711 0.7460 0.2211 3.7717 3.1460 0.4711 0.7460 0.2211 3.7717 3.1460 0.4711 0.7460 0.2211 3.7717 3.1460 0.4717 0.2260 1.2460 0.2260 1.144.000° ↓ 114.000° ↓ Import the pi 3.5956 3.2590 0.5200 0.4860 0.2370 3.5956 3.2590 0.5200 0.5480 0.2370 3.5956 3.2590 0.5200 0.5246 0.2370 3.5956 0.5270 0.5200 0.5246 0.2370	

## 6.5.4 Constructing of general geodetic grid file

[Function] According to the given latitude and longitude range and spatial resolution, generate the constant values, random number, 2D array index values, or Gaussian surface grid file.



## 6.5.5 Extracting of data according to latitude and longitude range

[Function] According to the given latitude and longitude range, extract data from the geodetic discrete points file, grid file, or vectors grid file. The program can extract data from batch files.

	4	( A.			
open no euro es imperiparametere	computation Save proce	ss Follow example			
Gridding of discrete geodetic data by simple interpolation	ng of high-resolution record tes by direct averaging	Interpolation of vector grid from attributes in geodetic records	two Constructin geodetic gri		Extracting of data according to latitude and longitude range
The source file format	>> Program Process **	Operation Prompts			ar Save program process a
Dicrete points file	>> Setting parameters h	ave been imported in the program! on [Start computation], or the tool bi	utton (Start computation	l	
Open a source data file	>> Computation start tin	ne: 2022-02-28 14:01:29			
Process batch files with the same specifications Iumber of ros of the file header 0					
	>> Complete the compu >> Computation end tim				
	Maxin	num latitude	33.000	•	Save the results as
	Maxin Minimum longitude	num latitude	33.000°	113.000°	
	Minimum longitude	num latitude		113.000*	
	Minimum longitude	num latitude	105.000° 🗧	113.000*	Import the parameter

# 6.6 Constructing and transforming of vector grid file

## 6.6.1 Combining of two grid files into a vector grid file

[Function] Combine two grids with the same specifications as the two components of the vector into a vector grid.

Open file Sav	e as Import p	parameters S	Start computat	ion Save pro	cess Follow e	example					
	ning of two grid rector grid file	files	File into	posing of vector two grid files	r grid	for vector g	ng of vector for prid file	m	Converting of into discrete	of vector grid fil points file	le
Open the grid	file 1 with the :	same specifical		igram Process	** Operation Pro	mpts			解 Sav	e program pro	cess a
			>> Op compo >> Sa >> Set	en the grid file : onent2.dat. ve the results a tting parameter	ile information in 2 with the same s s C:/ETideLoad4 s have been imp outton [Start comp	specifications C .0_win64en/exported in the pro	:/ETideLoad4.0 amples/EdVecti gram!	_win64en/exa orgridtransf/ <mark>ve</mark>	mples/EdVecto	rgridtransf/	
			>> Co >> Co	mputation start mplete computa	time: 2022-02-1 ation! time: 2022-02-11	15:57:06					
Save the vec	ctor grid as		>> Co >> Co	mputation start mplete computa	time: 2022-02-1 ation!	15:57:06				J Start comp	utatio
Save the vec			>> Co >> Co	mputation start mplete computa	time: 2022-02-1 ation! time: 2022-02-11	15:57:06				J Start compo	
Display of the inp	put-output file	25.000000	>> Co >> Co >> Co >> Co	nputation start mplete comput mputation end 0.04166667	time: 2022-02-1 ation! time: 2022-02-11 Import setting	15:57:06 parameters	0.2451		Save Save	data in the text	t box
Display of the inj 104.000000 -0.3925	put-output file; 114.000000 0.1308	0.6249	>> Co >> Co >> Co >> Co	0.04166667 1.0472	time: 2022-02-1 ation! time: 2022-02-11 Import setting	15:57:06 parameters	-0.3451	-1.3375	€2.2115	data in the text	t box
isplay of the inj 104.000000 -0.3925 -4.1123	put-output file; 114.000000 0.1308 -4.4295	0.6249	>> Co >> Co >> Co >> Co	0.04166667 1.0472 -5.3562	time: 2022-02-1 ation! time: 2022-02-11 Import setting 0.04166667 0.9152 -5.3154	15:57:06 parameters 0.4482 -4.3021	-2.3624	-1,3375 0,0198	-2.2115 1.9917	-2.8023 3.1146	t box
isplay of the in 104.000000 -0.3925 -4.1123 4.7775	put-output file; 114.000000 0.1308 -4.4295 6.0556	0.6249 -4.7667 7.2082	>> Co >> Co >> Co >> Co -> Co	mputation start mplete comput mputation end 1 0.04166667 1.0472 -5.3562 7.6580	time: 2022-02-1 ation1 ime: 2022-02-11 ime: 20	15:57:06 parameters 0.4482 -4.3021 5.7227	-2.3624 4.3219	-1.3375 0.0198 2.9311	-2.2115 1.9917 1.6431	data in the text	t box
isplay of the inp 104.000000 -0.3925 -4.1123 4.7775 -3.4491	put-output file; 114.000000 0.1308 -4.4295 6.0556 -2.6666	0.6249 -4.7667 7.2082 -1.1987	>> Co >> Co >> Co >> Co >> Co	0.04166667 1.0472 7.5362 7.6580 1.9997	time: 2022-02-1 ation! ime: 2022-02-11 Import setting 0.04166667 0.9152 -5.3154 6.9067 2.7165	15:57:06 parameters 0.4482 -4.3021 5.7227 2.8804	-2.3624 4.3219 2.6050	-1.3375 0.0198 2.9311 2.1267	-2.2115 1.9917 1.6431 1.5135	data in the text	t box
isplay of the inj 104.000000 -0.3925 -4.1123 4.7775 -3.4491 -3.0411	put-output file; 114.000000 0.1308 -4.4295 6.0556 -2.6666 -3.2056	0.6249 -4.7667 7.2082 -1.1987 -3.2628	>> Co >> Co >> Co >> Co >> Co -> Co	0.04166667 1.0472 -5.352 -2.6580 1.9997	time: 2022-02-1 ation! Import setting 0.04166667 0.9152 -5.3154 6.9067 2.7165 -1.6204	15:57:06 parameters 0.4482 -4.3021 5.7227 2.8804 -0.0657	-2.3624 4.3219 2.6050 1.6299	-1.3375 0.0198 2.9311 2.1267 2.9278	-2.2115 1.9917 1.6431 1.5135 3.2196	-2.8023 3.1146 0.4930 0.7329 2.1959	t box
isplay of the inj 104.000000 -0.3925 -4.1123 4.7775 -3.4491 -3.0411 0.7549	put-output file; 114.000000 0.1308 -4.4295 6.0556 -2.6666 -3.2056 2.7751	0.6249 -4.7667 7.2082 -1.1987 -3.2628 3.6802	>> Co >> Co >> Co >> Co -> Co 0.9540 -5.1225 -7.9471 0.5665 -3.1711 3.4925	mputation start mplete comput mputation end i 0.04166667 1.0472 -5.3562 7.6580 1.9997 -2.6898 2.4620	time: 2022-02-1 ation] ime: 2022-02-11 ime: 20	15:57:06 parameters 0.4482 -4.3021 5.7227 2.8804 -0.0657 0.0232	-2.3624 4.3219 2.6050 1.6299 -0.7063	-1.3375 0.0198 2.9311 2.1267 2.9278 -1.0192	-2.2115 1.9917 1.6431 1.5135 3.2196 -1.0505	-2.8023 3.1146 0.4930 0.7329 2.1959 -0.8639	t box
isplay of the inj -0.3925 -4.1123 4.7775 -3.4491 -3.0411 0.7549 -1.3899	put-output file. 114.000000 0.1308 -4.4295 6.0556 -2.6666 -3.2056 2.7751 -0.9508	0.6249 -4.7667 7.2082 -1.1987 -3.2628 3.6802 -0.5012	>> Co >> Co >> Co 0 >> Co 0.5540 0.5545 -5.1225 7.8471 0.5665 -3.1711 3.4925 -0.6881	0.04166667 1.0472 7.5530 1.9997 -2.6898 2.4620 -1.7360	time: 2022-02-1 ation! Import setting 0.04166667 0.9152 -5.3154 6.9067 2.7165 -1.6204 1.1620 -3.2512	15:57:06 parameters 0.4482 -4.3021 5.7227 2.8804 -0.0657 0.0232 -4.5168	-2.3624 4.3219 2.6050 1.6299 -0.7063 -4.6346	-1.3375 0.0198 2.9311 2.1267 2.9278 -1.0192 -3.8730	-2.2115 1.9917 1.6431 1.5135 3.2196 -1.0505 -2.7957	-2.8023 3.1146 0.4930 0.7329 2.1959 -0.8639 -1.9350	t box
isplay of the inp 104.000000 -0.3925 -4.1123 4.7775 -3.4491 -3.0411 0.7549 -1.3899 0.0223	put-output file; 114.000000 0.1308 -4.4295 6.0556 -2.6666 -3.2056 2.7751 -0.9508 -0.7894	0.6249 -4.7667 7.2082 -1.1987 -3.2628 3.6802 -0.5012 -1.8763	>> Co >> Co >> Co >> Co 0.9540 -5.1225 -7.8471 0.9565 -3.1711 3.4925 -0.6881 -2.3868	0.04166667 1.0472 -5.3562 7.6580 1.9997 -2.6598 2.4620 -1.7360	<ul> <li>itime: 2022-02-1</li> <li>ation!</li> <li>Import setting</li> <li>0.04166667</li> <li>0.9152</li> <li>-5.3154</li> <li>-5.3154</li> <li>-6.9667</li> <li>2.7165</li> <li>-1.6204</li> <li>1.1620</li> <li>-3.2512</li> <li>-0.4668</li> </ul>	15:57:06 parameters 0.4482 -4.3021 5.7227 2.8804 -0.0657 0.0232 -4.5168 0.935	-2.3624 4.3219 2.6050 1.6299 -0.7063 -4.6346 1.6885	-1.3375 0.0198 2.9311 2.1267 -3.8730 1.5897	-2.2115 1.9917 1.6431 1.5135 3.2196 -1.0505 -2.7957 0.9994	-2.8023 3.1146 0.4930 0.7329 2.1959 -0.8639 -1.9350 0.0861	t box
104.000000 -0.3925 -4.1123 4.7775 -3.4491 -3.0411 0.7549 -1.3899	put-output file. 114.000000 0.1308 -4.4295 6.0556 -2.6666 -3.2056 2.7751 -0.9508	0.6249 -4.7667 7.2082 -1.1987 -3.2628 3.6802 -0.5012	>> Co >> Co >> Co 0 >> Co 0.5540 0.5545 -5.1225 7.8471 0.5665 -3.1711 3.4925 -0.6881	0.04166667 1.0472 7.5530 1.9997 -2.6898 2.4620 -1.7360	time: 2022-02-1 ation! Import setting 0.04166667 0.9152 -5.3154 6.9067 2.7165 -1.6204 1.1620 -3.2512	15:57:06 parameters 0.4482 -4.3021 5.7227 2.8804 -0.0657 0.0232 -4.5168	-2.3624 4.3219 2.6050 1.6299 -0.7063 -4.6346	-1.3375 0.0198 2.9311 2.1267 2.9278 -1.0192 -3.8730	-2.2115 1.9917 1.6431 1.5135 3.2196 -1.0505 -2.7957	-2.8023 3.1146 0.4930 0.7329 2.1959 -0.8639 -1.9350	t box
isplay of the inp 104.000000 -0.3925 -4.1123 4.7775 -3.4491 -3.0411 -3.0411 -1.3899 0.0223 -0.2582 0.9317	put-output file; 114.000000 0.1308 -4.4295 6.0556 -2.6666 -3.2056 -3.2056 -0.7518 -0.5508 -0.7894 0.3857 0.8853	0.6249 -4.7667 7.2082 -1.1987 -3.2628 3.6802 -0.5012 -1.8763 0.8903 0.1592	>> Co >> Co >> Co >> Co => Co	0.04166667 1.0472 -5.3562 7.6580 1.9997 -2.6898 2.4620 -1.7663 0.3425 -1.1252	2022-02-1 ation! time: 2022-02-11 Import setting 0.04166667 0.9152 -5.3154 6.9067 2.7165 -1.6204 1.1620 -3.2512 -0.4668 -0.6010 -1.1305	15:57:06 parameters 0.4482 -4.3021 5.7227 2.8804 -0.0657 0.0232 -4.5168 0.6935 -1.5352 -0.9017	-2.3624 4.3219 2.6050 1.6299 -0.7063 -4.6346 1.6885 -2.1983 -0.6602	-1.3375 0.0198 2.9311 2.1267 -3.8730 1.5597 -2.6233 -0.7023	-2.2115 1.9917 1.6431 1.5135 -2.7957 -2.7957 -2.9994 -2.9577 -1.1980	-2.8023 3.1146 0.4930 0.7329 2.1959 -0.8639 -1.9350 0.0861 -3.2139 -2.0812	t box
104.00000 -0.3925 -4.1123 4.7775 -3.4491 -3.0411 0.7549 -1.3899 0.0223 -0.2582	put-output file; 114.00000 0.1308 -4.4295 6.0556 -2.6666 0.32056 2.7751 -0.9508 -0.7894 0.3857	0.6249 -4.7667 7.2082 -1.1987 -3.2628 3.6802 -0.5012 -1.8763 0.8903	>> Co >> Co >> Co 0,5540 -5.1225 7.8471 0.5665 -3.1711 3.4925 -0.6881 -2.3868 0.9141	0.04166667 1.0472 -5.3562 7.6580 1.9997 -2.6898 2.4620 -1.7360 -1.7663 0.3425	0.04166667 0.9152 	15:57:06 parameters 0.4482 -4.3021 5.7227 2.8804 -0.0657 0.0232 0.4.5168 0.9935 -1.5352	-2.3624 4.3219 2.6050 1.6299 -0.7063 -4.6346 1.6885 -2.1983	-1.3375 0.0198 2.9311 2.1267 2.9278 -1.0192 -3.8730 1.5597 -2.6233	-2.2115 1.9917 1.6431 1.5135 3.2196 -1.0505 -2.7957 0.8994 -2.9577	-2.8023 3.1146 0.4930 0.7329 2.1959 -0.8639 -1.9350 0.0861 -3.2139	t box
104.00000 -0.3925 -4.1123 4.7775 -3.4491 -3.0411 -3.0411 -3.0411 -1.3899 0.0223 -0.2582 0.9317	put-output file; 114.000000 0.1308 -4.4295 6.0556 -2.6666 -3.2056 -3.2056 -0.7518 -0.5508 -0.7894 0.3857 0.8853	0.6249 -4.7667 7.2082 -1.1987 -3.2628 3.6802 -0.5012 -1.8763 0.8903 0.1592	>> Co >> Co >> Co >> Co => Co	0.04166667 1.0472 -5.3562 7.6580 1.9997 -2.6898 2.4620 -1.7663 0.3425 -1.1252	2022-02-1 ation! time: 2022-02-11 Import setting 0.04166667 0.9152 -5.3154 6.9067 2.7165 -1.6204 1.1620 -3.2512 -0.4668 -0.6010 -1.1305	15:57:06 parameters 0.4482 -4.3021 5.7227 2.8804 -0.0657 0.0232 -4.5168 0.6935 -1.5352 -0.9017	-2.3624 4.3219 2.6050 1.6299 -0.7063 -4.6346 1.6885 -2.1983 -0.6602	-1.3375 0.0198 2.9311 2.1267 7.9278 -1.0192 -3.8730 1.5597 -2.6233 -0.7023	-2.2115 1.9917 1.6431 1.5135 -2.7957 -2.7957 -2.9994 -2.9577 -1.1980	-2.8023 3.1146 0.4930 0.7329 2.1959 -0.8639 -1.9350 0.0861 -3.2139 -2.0812	t box
Display of the inj 104.000000 -0.3925 -4.1123 4.7775 -3.4491 0.7549 -1.3899 0.0223 -0.2582 0.9317 -1.8977	put-output file; 114.000000 0.1308 -4.4295 6.0556 -2.6666 2.7751 -0.9508 -0.7894 0.3857 0.8853 -1.1169	0.6249 -4.7667 7.2082 -1.1987 -3.2628 3.6802 -0.5012 -1.8763 0.8903 0.1592 -0.6554	>> Co >> Co >> Co 0.9540 -5.1225 7.8471 0.5665 -3.1711 3.4925 -0.6681 -2.3868 0.9141 -0.6640 -0.1844	0.04166667 1.0472 -5.3562 -7.6580 1.9997 -2.6698 2.4620 -1.7360 -1.7663 0.3425 -1.1252 0.6645	2022-02-1 ation ime: 2022-02-11 ime: 2022-02-11 ime: 2022-02-11 ime: 2022-02-11 0.04166667 0.9152 - 5.3154 6.9067 2.7165 - 1.6204 1.1620 0.3.2512 - 0.4668 - 0.6010 - 1.1305 1.9103	15:57:06 parameters 0.4482 -4.3021 5.7227 2.8804 -0.0657 0.0232 -4.518 0.6935 -1.5352 -0.9017 3.1100	-2.3624 4.3219 2.6050 1.6299 -0.7063 -4.6346 1.6885 -2.1983 -0.6602 3.6536	-1.3375 0.0198 2.9311 2.1267 7.2278 -1.0192 -3.8730 1.5897 -2.6233 -0.7023 3.5731	-2.2115 1.9917 1.6431 1.5135 3.2196 -1.0505 -2.7957 0.8994 -2.9577 -1.1980 3.6610	-2.8023 3.1146 0.4930 0.7329 -0.8639 -0.8639 -1.9350 0.0661 -3.2139 -2.0812 4.3358	t box 

## 6.6.2 Decomposing of vector grid file into two grid files

[Function] Decompose a vector grid file into two components grid files.

Constructing and t	transforming	of vector grid file								- 0	)
Open file Sav	<u>)</u> /e as Imp	Import parameters Start computation Save process Follow ex				example					
Combining of two grid files into a vector grid file Decomposing of vector grid file file into two grid files				grid	Transformi for vector g	ng of vector for grid file	m	Converting of into discrete	of vector grid fil points file	e	
Open a vecto		>> Program Proc	ess ** Operatio	on Prompts					🚑 Sav	e program pro	cess
		>> Complete con >> Computation >> [Function] De >> Open a vector >> Save the com	end time: 2022 compose a vec r grid file C:/ET ponent 1 grid a	tor grid file into ideLoad4.0_wints C:/ETideLoad	two components n64en/examples/ d4.0_win64en/ex	EdVectorgridtra amples/EdVect	torgridtransf.db	mchpcs.dat.			
		>> Computation = >> Complete com >> Computation	heters have been trol button [Star start time: 202 nputation! end time: 2022	en imported in t t computation], 2-02-11 15:59: -02-11 15:59:55	he program! or the tool butto 55	n [Start comput	tation]				
Save the con	mponent 1	>> Setting param ** Click the cont >> Computation >> Complete con >> Computation	neters have been trol button [Star start time: 202 nputation!	en imported in t t computation], 2-02-11 15:59: -02-11 15:59:55	he program! or the tool butto 55	n [Start comput				J Start compo	utatio
-		>> Setting param ** Click the cont >> Computation >> Complete con >> Computation grid as Save	heters have been trol button [Star start time: 202 nputation! end time: 2022	en imported in t t computation], 2-02-11 15:59: -02-11 15:59:55	he program! or the tool butto 55	n [Start comput	tation]		Ar Save	J Start compo	
hisplay of the inp	put-output	>> Setting param ** Click the cont >> Computation >> Complete con >> Computation grid as Save file 00 25.000000	the component att, 000000 att, 000000 att, 000000 att, 000000	en imported in t t computation], :2-02-11 15:59:55 -02-11 15:59:55 2 grid as	he program! or the tool button 55 0.04166667	n [Start comput	setting paramet	lers		data in the text	box
isplay of the inp 104.000000 -1.4332	put-output 114.0000 -3.65	>> Setting param 	teters have been trol button [Star start time: 2022 nputation! end time: 2022: the component	en imported in t t computation], :2-02-11 15:59:56 2 grid as	0.04166667 1.4282	2.8178	setting paramet	1.3077	-1.2866	data in the text	box
isplay of the inp 104.000000 -1.4332 -0.8636	put-output 114.0000 -3.65 -1.83	>> Setting param •• Click the conf >> Computation >> Complete conf >> Computation grid as Save file] 00 25.000000 11 -4.2491 37 -1.6178	ieters have been trol button [Star start time: 2022 nputation! end time: 2022: the component 34.000000 -3.0568 0.7910	en imported in t t computation], 12-02-11 15:59:50 2 grid as 0.04166667 -0.8138 4.2344	he program! or the tool button 55 0.04166667 1.4282 7.0215	2.8178 7.2157	Lation] setting paramet	1.3077 1.8768	-1.2866 0.2369	data in the text	box
isplay of the inp 104.000000 -1.4332 -0.8636 -1.1199	put-output 114.0000 -3.65 -1.83 -2.70	<ul> <li>&gt; Setting param</li> <li>* Click the continues</li> <li>&gt;&gt; Computation</li> <li>&gt;&gt; Computation</li> <li>&gt;&gt; Computation</li> <li>grid as</li> <li>file1</li> <li>00 25.000000</li> <li>11 -4.2491</li> <li>37 -1.6178</li> <li>74 -4.4938</li> </ul>	eters have been trol button [Star start time: 2022 nputation! end time: 2022: the component 34.000000 -3.0568 0.7910 -6.2618	en imported in t t computation], 2:202-11 15:59:50 2 grid as 0.04166667 -0.8138 4.2344 -7.1936	0.04166667 1.4282 7.0215 -6.6895	2.8178 7.2157 -4.4944	2.8572 4.8918 -1.1828	1.3077 1.8768 2.1142	-1.2866 0.2369 4.3333	data in the text	box
isplay of the inp 104.000000 -1.4332 -0.8636 -1.1199 3.6134	put-output 114.0000 -3.65 -1.83 -2.70 1.77	>> Setting param → Click the cont >> Computation >> Computation >> Computation grid as Save file↓ 00 25.000000 11 -4.2491 37 -1.6178 74 -4.4938 42 -0.2415	eters have bee trol button [Star start time: 202 nputation! end time: 2022: the component 34.000000 -3.0568 0.7910 -6.2618 -1.2126	en imported in t t computation], 22-02-11 15:59:51 2 grid as 0.04166667 -0.8138 4.2344 -7.1936 -0.6743	0.04166667 1.4282 7.0215 -6.6895 0.3909	2.8178 7.2157 -4.4944 0.6795	2.8572 4.8918 -1.1828 -0.3748	1.3077 1.8768 2.1142 -1.9201	-1.2866 0.2369 4.3333 -2.3764	-3.6499 0.3571 5.0747 -1.3402	box
isplay of the inp 104.000000 -1.4332 -0.8636 -1.1199 3.6134 -2.3659	put-output 114.0000 -3.65 -1.83 -2.70 1.77 -2.02	>> Setting param ** Click the con >> Computation >> Computation grid as ** Save file 00 25.000000 11 -4.2491 17 -1.6178 14 -4.4938 24 -0.24152 16 -1.5521	ieters have bee trol button [Star start time: 202 nputation! end time: 2022: the component 34.000000 -3.0568 -3.0568 -1.2126 -1.9785	en imported in t t computation], 2:202-11 15:59:57 2 grid as 0.04166667 -0.8138 4.2344 -7.1936 -0.6743 -2.7592	0.04166667 1.4282 7.0215 -6.6895 0.3909 -2.4427	2.8178 7.2157 -4.4944 0.6795 -0.3348	2.8572 4.9918 -1.1828 -0.3748 2.6427	1.3077 1.8768 2.1142 -1.9201 4.5972	-1.2866 0.2369 4.3333 -2.3764 4.0639	-3.6499 0.3571 5.0747 -1.3402 1.3431	box
104.000000 -1.4332 -0.8636 -1.1199 3.6134 -2.3659 1.5151	put-output 114.0000 -3.65 -1.83 -2.70 1.77 -2.02 1.98	>> Setting param          Click the com          Click the com           >> Complete con           >> Computation:           >> Computation:           >> Computation:           grid as          Somplete con           grid as          Somplete con           1           -1.6178           7           -1.6178           24           -0.2415           56           -1.5821           6           -1.5821	ieters have bee trol button [Star start time: 202 nputation! end time: 2022: the component 34.000000 -3.0568 0.7910 -6.2618 -1.2126 -1.9785 1.0222	n imported in t t computation], 2:02-11 15:59:50 2 grid as 0.04166667 -0.8138 4.2344 -7.1936 -0.6743 -2.7592 -0.3285	0.04166667 1.4282 7.0215 -6.6995 0.3909 -2.4427	2.8178 7.2157 4.4944 0.6795 -0.3348	2.8572 4.9918 -1.1828 -0.3748 2.6427 -3.4277	1.3077 1.8768 2.1142 -1.9201 4.5972 -2.4846	-1.2866 0.2369 4.3333 -2.3764 4.0639 -1.5008	-3.6499 0.3571 5.0747 -1.3402 1.3431 -1.2868	box
isplay of the inp 104.000000 -1.4332 -0.8636 -1.1199 3.6134 -2.3659 1.5151 1.8340	put-output 114.0000 -3.65 -1.83 -2.70 1.77 -2.02 1.98 2.65	>> Setting param           "Click the cont           >> Computation:           >> Complete cont           >> Complete cont           official           00         25.000000           11         -4.2491           37         -1.6178           47         -4.438           42         -0.2415           66         -1.5821           66         -1.5821           26         -1.6182           26         -2.6452	ieters have bee trol button [Star start time: 202 nputation! end time: 2022: the component 34.000000 -3.0568 -0.7910 -6.2618 -1.2126 -1.9785 1.0222 2.4825	en imported in t t computation], 2-02-11 15:59:50 2 grid as 0.04166667 -0.8138 -0.6743 -2.7592 -0.3285 2,4377	0.04166667 1.4292 7.0215 -6.6995 -2.4427 -2.0617 2.5159	2.8178 7.2157 -4.4944 -3.3488 2.5286	2.8572 4.9918 -1.1828 -0.3748 2.6427 -3.4277 2.5014	1.3077 1.8768 2.1142 -1.9201 4.5972 -2.4846 2.5651	-1.2866 0.2369 4.3333 -2.3764 4.0639 -1.5008 2.3487	-3.6499 0.3571 5.0747 -1.3402 1.3431 -1.2868 1.1494	box
isplay of the inp 104.000000 -1.4332 -0.8636 -1.1199 3.6134 -2.3659 1.5151 1.8340 -0.6055	put-output 114.0000 -3.65 -1.83 -2.70 1.77 -2.02 1.98 2.65 -0.10	>> Setting param           "Click the cont           "Click the cont           >> Computation           >> Complete cont           file"           00         25.000000           11         -4.2491           7         -1.6178           74         -4.4938           66         1.7591           32         2.6662           7         -2.0308	ieters have bee rice to have been start time: 202 nputation! end time: 2022: the component 34.000000 -3.0568 0.7910 -6.2619 -1.2126 -1.9785 1.0222 2.4825 -4.8279	en imported in t t computation], 2-02-11 15:59:57 2 grid as 0.04166667 -0.8138 4.2344 -7.1936 -0.6743 -2.7592 -0.3285 2.4377 -5.5277	0.04166667 1.4282 7.0215 6.6895 0.3909 -2.4427 -2.0617 2.5159 -3.3950	2.8178 7.2157 -4.454 0.6795 -0.3348 2.5286 0.4519	2.8572 4.9918 -1.1828 -0.3748 2.6427 -3.4277 2.5014 3.7296	1.3077 1.8768 2.1142 -1.9201 -2.4846 2.5651 4.5873	-1.2866 0.2369 4.3333 -2.3764 4.0639 -1.5008 2.3487 3.6930	-3.6499 0.3571 5.0747 -1.3402 1.3431 -1.2868 1.1494 2.8407	box
isplay of the inp 104.000000 -1.4332 -0.8636 -1.1199 3.6134 -2.3659 1.5151 1.8340 -0.6055 -1.2153	put-output 114.0000 -3.65 -1.83 -2.70 1.77 -2.02 1.98 2.65 -0.10 -1.91	>> Setting param * Click the cont >> Computation >> Computation >> Computation (III) (I	ieters have bee trol button [Star start time: 202 nputation! end time: 2022: the component 34.000000 -3.0568 0.7910 -6.2618 -1.2126 -1.9785 1.0222 2.4425 -4.8279 0.6649	en imported in t t computation], 2-02-11 15:59:59 2 grid as 0.04166667 -0.6138 4.2344 -7.1936 -0.6743 -2.7592 -0.3285 2.4377 -5.5277 0.7233	0.04166667 1.4282 7.0215 0.3909 -2.4427 -2.0617 -3.3950 -0.9452	2.8178 7.2157 -4.4944 0.6795 -0.3348 2.5286 0.4519 -3.0408	2.8572 4.9918 -1.1828 -0.3748 2.6427 -3.4277 -3.4277 -3.5014 3.7296 -3.9305	1.3077 1.8768 2.1142 -1.9201 4.5972 -2.4846 2.5651 4.5873 -3.3174	-1.2866 0.2369 4.3333 -2.3764 4.0639 -1.5008 2.3487 3.6930 -2.2773	-3.6499 0.3571 5.0747 -1.3402 1.3431 -1.2868 1.1494 2.8407 -1.8480	box
isplay of the inp 104.000000 -1.4332 -0.8636 -1.1199 3.6134 -2.3659 1.5151 1.8540 -0.6055 -1.2153 0.1091	put-output 114.0000 -3.65 -1.83 -2.70 1.77 -2.02 1.98 2.65 -0.10 -1.91 0.05	>>> Setting param           "Click the cont           "Click the cont           >>> Computation           >>> Complete cont           >>> Control           00         25.000000           11         -4.2491           7         -1.6178           74         -4.4938           26         -1.5821           26         -1.5821           12         -0.824           11         -0.824           6         -0.7564	ieters have bee start time: 202 nputation! end time: 2022: the component 34.000000 -3.0568 0.7910 -6.2618 -1.2126 -1.9785 1.0222 2.4825 -4.8279 0.6499 -1.2620	nn imported in t computation], 2-02-11 15:59:57 2 grid as 0.04166667 -0.8138 4.2344 -7.1936 -0.6743 -2.7592 2.4377 -5.5277 0.7233 -0.4835	0.04166667 1.4292 7.0215 -6.6995 -2.4427 -2.0617 -2.0617 -2.0617 -3.3950 -0.9452 1.6292	2.8178 7.2157 4.4944 0.6795 0.3348 2.5286 2.5286 2.5286 4.2997	2.8572 4.9918 -1.1828 -0.3748 2.6427 -3.4277 2.5014 3.7296 -3.9305 6.2029	1.3077 1.8768 2.1142 -1.9201 4.5972 -2.4846 2.5651 4.5873 -3.3174 6.1576	-1.2866 0.2369 4.3333 -2.3764 4.0639 -1.5008 2.3487 3.6930 -2.2773 4.1138	-3.6499 0.3571 5.0747 -1.3402 1.3431 -1.2868 1.1494 2.8407 -1.8480 1.4343	box
Display of the inp 104.000000 -1.4332 0.8636 -1.1199 3.6134 -2.3659 1.5151 1.5151 1.8340 -0.6055 -1.2153 0.1091 0.0868	put-output 114.0000 -3.65 -1.83 -2.70 1.77 -2.02 1.98 2.65 -0.10 -1.91 0.05 -1.10	>> Setting param           ** Click the cont           ** Click the cont           >> Computation           >> Computation           grid as         ** ave           file           00         25.000000           1         -4.2411           37         -1.6328           6         -1.5821           6         -1.5821           2         -6.662           37         -2.0308           1         -0.8244           66         -0.7564           67         -1.8044	ieters have bee root button [Star start time: 202 nputation] end time: 2022 the component 34.000000 -3.0568 0.7910 -6.2618 -1.2126 -1.9785 1.0222 2.4425 -4.8279 0.6499 -1.2620 -1.7144	n imported in t computation], 2-02-11 15:59:50 2 grid as 0.04166667 -0.0138 4.2344 -7.1936 -0.6743 -2.7592 -0.3285 2.4377 -5.5277 0.7233 -0.4235 -1.7798	0.04166667 1.4282 7.0215 0.3309 0.3406 0.3909 -2.4427 -2.6159 -3.3950 -0.9452 1.6292 -3.1191	2.8178 2.8178 7.2157 7.4944 0.6795 0.3348 3.3488 2.5286 0.4519 3.0408 4.2297 5.5676	2.8572 4.9918 -1.1828 -0.3748 2.6427 -3.4277 2.5014 3.7296 -3.9305 6.2029 -6.9368	1.3077 1.8768 2.1142 -1.9201 4.5972 -2.4846 2.5651 4.5873 -3.3174 6.1576 -4.9237	-1.2866 0.2369 4.3333 -2.3764 4.0639 -1.5008 2.3487 3.6930 -2.2773 4.1138 -0.3275	-3.6499 0.3571 5.0747 -1.3402 1.3431 -1.2868 1.1494 2.8407 -1.8480 1.4343 5.7436	box
Display of the inp 104.000000 -1.4332 -0.8636 -1.1199 3.6134 -2.3659 1.5151 1.8340 -0.6055 -1.2153 0.1091 0.0866 -4.4835	put-output 114.0000 -3.65 -1.83 -2.70 1.77 -2.02 1.98 2.65 -0.10 -1.91 0.05 -1.10 -3.01	>> Setting param           ** Click the cont           ** Click the cont           >> Computation           >> Computation           gnd as         ▲ Save*           file           00         25.000000           1         -4.2491           37         -1.6178           4         -4.932           22         -0.2415           26         -1.5821           66         1.7592           27         -2.0308           11         -0.8244           4         -0.7564           7         -1.60790	ieters have bee rool button [Star start time: 202 nputation! end time: 2022: the component 34.000000 -3.0568 0.7910 -6.2618 -1.2126 -1.9785 1.0222 2.4825 -4.8279 0.6499 -1.2620 -1.7144 2.3893	n imported in t computation], 2-02-11 15:59:52 2 grid as 0.04166667 -0.8138 -0.0418 -0.6743 -0.71936 -0.6743 -0.7233 -0.4835 -1.7798 3.2160	0.04166667 1.4282 7.0215 -6.6995 -2.4427 -2.0617 -2.0617 -3.3950 -0.9452 -0.9452 -3.1191 2.6051	2.8178 7.2157 4.4944 5.795 0.3348 2.5286 0.4519 -3.0408 4.2997 -5.5676 1.6975	2.8572 4.8918 -1.1828 -0.3748 2.6427 2.5014 3.7296 -3.9305 6.2029 -6.9368 1.1395	1.3077 1.8768 2.1142 2.4846 2.5651 4.5973 -3.3174 6.3174 6.3174 0.7001	-1.2866 0.2369 4.3333 -2.3764 4.0639 -1.5008 2.3487 3.6930 -2.2773 4.1138 -0.3275 0.2473	-3.6499 0.3571 5.0747 -1.3402 1.3431 -1.2868 1.1494 2.8407 -1.8480 1.4343 5.7436 -0.3589	box
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### 6.6.3 Transforming of vector form for vector grid file

[Function] Transform the vectors in a vector grid file between plane coordinates (inphase/cross-phase amplitude) and polar coordinates (amplitude/phase).

#### 6.6.4 Converting of vector grid file into discrete points file

[Function] Convert the (vectors) grid file into the discrete points file.

Open file Save as Import parameter	Decomposing of vector grid	Follow example		nverting of vector g		
into a vector grid file     Convert the grid into discrete points	file into two grid files	into discrete points file				
Open a vector grid file	>> Program Process ** Operation Prompt		Save program process			
	>> Complete computation! >> Computation end time: 2022-02-11 16: >> (Function) Convert the (vectors) grid file >> Open a geodetic grid file C:/ETideLoad >> Save the results as C:/ETideLoad4.0_v >> Setting parameters have been importer	e into the discrete records file. 4.0_win64en/examples/EdVectorgridtrai vin64en/examples/EdVectorgridtranst		. ]		
	** Click the control button [Start computa >> Computation start time: 2022-02-11 16 >> Complete computation! >> Computation end time: 2022-02-11 16:	tion], or the tool button [Start computation 6:05:14	n]			
Save the results as	** Click the control button [Start computa >> Computation start time: 2022-02-11 16 >> Complete computation! >> Computation end time: 2022-02-11 16:1	tion], or the tool button [Start computation 6:05:14	m]	J Start co	omputatio	
Save the results as	** Click the control button [Start computa >> Computation start time: 2022-02-11 16 >> Complete computation! >> Computation end time: 2022-02-11 16:1	tion], or the tool button [Start computatio :05:14 05:16	n]	J Start or Save data in the	omputatio text box	

## 6.7 Statistical analysis on various geodetic data file

[Purpose] Extract the latitude and longitude range, mean, standard deviation, minimum, maximum, and other statistical information from the specified attributes of the discrete points file, geodetic grid file, or vector grid file.

🖆 Statistical analysis on various geodetic data file	- 🗆 X	n various	geodetic data file				- D	×
Open file Import parameters Start statistic Save statistical information	Follow example	Open file Import param	neters Start statist	Save statistical information	tion Follow e	and the second sec		
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The discrete points file		The site time series file	~					
Open the discrete points file minimum, maximum, and other st of the discrete points file, geodetic	> [Purpose] Extract the latitude and longitude range, mean, standard deviation, minimum, maximum, and other statistical information from the specified attributes of the discrete points file, geodetic grid file, or vector grid file. * Please selects the file type used for statistics firstly >> Statistics on the specified attributes		S Open the site time series file     **Minimum longitude: 102.3455*     Maximum longitude: 103.4253*     Maximum longitude: 103.4253*					
Column ordinal number of the >> Statistics on the specified attril			Column ordinal number of the attribute to be statistic "Maximum laitude: 25.4877" "Mean: -0.1007					
attribute to be statistic 5 >> Open the discrete points file C Tistatisticanalysis/GNSSiksirent b	/ETideLoad4.0_win64en/examples/ t.	Import setting part	rameters	Standard deviation: 0.0308				- 14
Import setting parameters ** Look at the input file information parameters	on in the text box above, set the file format	J Start statis		Minimum: -0.1550 Maximum: -0.0459				
Stars statistic     So Setting parameters have been     "Cick the control fourtion [Start     "Cick the control fourtion [Start     "Start start time: 2022     Start start time: 2022     Start start time: 2023     Start start deviation: 0.300     Start start start deviation: 0.300     Start start deviation: 0.300     Start start deviation: 0.300     Start start deviation: 0.300     Start start deviation: 0.300     Start start deviation: 0.300     Start start deviation: 0.300     Start start deviation: 0.300     Start start deviation: 0.300     Start start deviation: 0.300     Start start deviation: 0.300     Start start deviation: 0.300     Start start deviation: 0.300     Sta			>> Tis >> >>	Statistics on the specified a Ohen the site time series fit tatisk-analysis/DONT.tt. Setting-parameters have be Click the-control button [5ts Computative start time: 20 Statistic results: Mean: 0.9904 Statistic results: Mean: 0.9904 Statistic results: Mean: 0.9904 Statistic results: Mean: 0.9904 Statistic results: Mean: 0.9904 Statistic results: Mean: 0.9904 Mean: 0.	C:/ETideLoad4 en imported in th t statistic], or th 12-02-28 14:53:5	I.0_win64en/exa he program! ie tool button [St 59		
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### 6.8 Gross error detection and weighted basis function gridding

#### 6.8.1 Gross error detection on observations based on low-pass reference surface

[Function] Select the low-pass grid as the reference surface, interpolate the reference value of the specified attribute value at the discrete point, and then detect and separate the gross error records according to the statistical properties of the differences between the specified attribute value and reference value.

[Input files] The discrete geodetic points file to be detected. The low-pass reference surface grid file.

The reference surface can be constructed from discrete data by simple gridding and then low-pass filtering, and can also be the specified attribute grid constructed by weighted basis function gridding.

[Parameter settings] Enter number of rows of the discrete geodetic points file header, column ordinal number of the attribute to be detected in the record, and beyond multiples of the standard deviation.

When the absolute value of the difference between the attribute and its mean is greater than n times the attribute standard deviation, the record in which attribute is a gross error record.

[Output file] The operated discrete geodetic points file without gross error, whose format is the same with the input discrete points file. The gross error points file, whose file header include the average, standard deviation, minimum and maximum of the differences.
Gross error detection and weighted basis function gridding		-	-				. — · · · · · · ·
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	timation of observation	weight DRP	Bridding by basis fund	tion 🔢		by basis function	Gridding of records time series by ba
based on low-pass reference surface wit	h given reference attribu	ute	veighted interpolation		weighted interp	olation	function weighted interpolation
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umber of rows of the file header 1	>> Select the comput	tation function fron	the 5 control buttons	on the top of the	e interface		
							ibute value at the discrete point, and then
blumn ordinal number of the attribute 5			ords according to the ructed from discrete d				e given attribute and reference value.
eyond multiples number of 3.0	>> Open the discrete						
e standard deviation			he text box below, sel			indata.txt.	
(II) Once the reference surface and file	>> Open the reference					gridate/lowpass.dat	
Open the reference surface grid file	>> Save no error resi						
	>> Save the gross er			/examples/AppC	Serrweighgridat	te pntdataerror.txt.	
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38 102.650330 24.901415 1906.8332	1.3251 13		9771 24.667079	2157.7877	-1.0165	-4.2396	
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#### 6.8.2 Estimation of observation weight with given reference attribute

[Function] Using the weight function defined by ETideLoad, estimate the observation weight according to the statistical property of the specified reference attribute in the input geodetic records file.

Weight function defined by ETideLoad4.0  $w(x, a) = 10\sigma\sqrt{\sigma^2 + (ax)^2}$ , here x is the reference attribute, a is the given smoothing factor of the weight function,  $\sigma$  is the standard deviation of x calculated automatically by the program.

The larger the weight function smoothing factor a, the slower the weight function w decays with distance.

# 6.8.3 Gridding by basis function weighted interpolation

[Function] According to the given grid specifications (grid range and spatial resolution), and speccified basis function, grid the sepecified attribute in the input discrete geodetic records file by the weighted basis function interpolation method.

[Input files] The discrete geodetic points file.

[Parameter settings] Enter number of rows of the discrete points file header, colnum ordinal number of the target attribute in the file record, and grid specifications parameters. And set the base function and its parameters.

The smaller the kurtosis is (the slower the basis function decays with distance), the larger the number of neighboring points in the interpolation, the smoother the interpolation,

the weaker the edge effect, and the stronger the interpolation ability for sparse data.

The interpolation weight is equal to the product of the attribute weight and base function. [Output file] The geodetic grid file.



The program of the gridding by basis function weighted interpolation is specially designed by ETideload 4.0 based on the properties of general geophysical fields, and it is suitable for griding of single types of multi-source heterogeneous geophysical fields.

### 6.8.4 Batch gridding by basis function weighted interpolation

[Function] According to the given grid specifications, base function, and other parameters, respectively grid the specified attribute in each of the input discrete points files saved in a folder by the weighted basis function interpolation method.

[Input files] Batch discrete geodetic points files with same format.

[Parameter settings] Set the wildcard patameters for batch discrete geodetic points files, Enter number of rows of the discrete points file header, colnum ordinal number of the target attribute in the file record, and grid specifications parameters. Select the base function, and set the number of the neighboring points and kurtosis of base function.

[Output files] A series of numerical grid files bsfgrd\*\*\*.dat that correspond one-to-one with the input discrete point value files. Here, \*\*\* are the instance of the input discrete points file name wildcards.

Open file	Save as Imp	ort parameters	Start cor	<b>P</b> nputation	Save proces	-	-							
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to be grided Set the wild Ordinal numb		0		: >:		the results fold hts files search win64en/exam win64en/exam win64en/exam win64en/exam	er C:/ETidel ed by wildca ples/AppGe ples/AppGe ples/AppGe	.oad4.0_wir ard instantia arrweighgric arrweighgric arrweighgric arrweighgric	n64en/exa ation: Jate/FH20 Jate/FH20 Jate/FH20 Jate/FH20 Jate/FH20	amples/App 1180103121 1180110122 1180117122 1180124121	Gerrweighgridate/gridtm. xt xt xt xt			
ielect the b	ase function	Equal weight of	observation	ns >> (	Setting parameter Click the control Computation sta Complete the gri Computation end	button [Start co t time: 2022-0 dding of 5 disc	omputation] 02-28 16:23 rete points f	, or the tool 07 lles by basis	button [S					
					rameters of base					Maximum	latitude		25.500°	0
					nber of the neigh ts for interpolati		4	Minim	num longit	ude Resolu	ution Maximum longitude	99.000°	\$ 1.000'	↓ 101,500°
					kurtosis of base		:			Minimun			24.500°	
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Display of the	e input-output f	file↓			$\mathbf{\Lambda}$								🐳 Save dat	a in the text box
7782 95 7783 99 7784 99 7785 99 7786 95 7787 95 7788 95 7788 95 7789 95 7790 95 7790 95 7791 95 7792 95 7794 95 7794 95 7795 95	9,00416670 9,01250000 9,02083330 9,02916670 9,04583330 9,045416670 9,06250000 9,07916670 9,0875000 9,07916670 9,0858330 9,10416670 9,11250000 9,12083330 9,12916670 9,12916670 9,12916670	24.50416670 24.50416670 24.50416670 24.50416670 24.50416670 24.50416670 24.50416670 24.50416670 24.50416670 24.50416670 24.50416670 24.50416670 24.50416670 24.50416670 24.50416670	0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000	-1.581 -1.580 -1.580 -1.577 -1.577 -1.577 -1.576 -1.575 -1.573 -1.572 -1.572 -1.572 -1.570 -1.569 -1.569 -1.569	-1.007 0. -1.009 0. -1.011 0.	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	-1.555 -1.556 -1.559 -1.559 -1.560 -1.562 -1.564 -1.565 -1.566 -1.568 -1.568 -1.568	0.064 0.064 0.065 0.065 0.065 0.065 0.066 0.066 0.066 0.067 0.068 0.069 0.071 0.072	-0.154 -0.153 -0.153 -0.151 -0.150 -0.149 -0.149 -0.147 -0.146 -0.145 -0.145 -0.145 -0.144 -0.143 -0.142 -0.142 -0.142	1.775 1.774 1.773 1.773 1.773 1.771 1.771 1.771 1.770 1.769 1.769 1.768 1.766 1.766 1.765 1.765 1.764	3,356 3,354 3,353 3,351 3,340 3,340 3,345 3,346 3,345 3,345 3,345 3,345 3,345 3,345 3,345 3,338 3,338 3,338 3,338 3,334 3,334 3,334 3,333			

**6.8.5 Gridding of records time series by basis function weighted interpolation** [Function] According to the given grid specifications, weight function and other

parameters, respectively grid the variations of each sampling epoch in the input records time series file by the weighted basis function interpolation method, generate variation grids time series files.

Display of the input-output file_		<b>H</b>	*	-		¥ (	-	)							
Based on low-pass reference surface         *** with given reference attituuts         *** weighted interpolation         *** weighted interpolation         *** weighted interpolation           Open a variation records time series file         *** Program Process         *** Program Process         *** weighted interpolation           Open a variation records time series file         ***	Open file	Save as Im	port parameters	start compu	sav	e process	niow example	·				-			
Open and analysis of the instant of the in							Gridding t weighted	by basis function interpolation	n 📓 🖁	latch gridding by veighted interpol	/ basis function lation				bas
Set the results folder       >> Computation start time: 2022-02-28 16:55:11         >> Computation number of the set function       >> Computation number of the set function         >> Computation number of the set function       >> Computation number of the set function         >> Computation number of the set function       >> Computation number of the set function         >> Set function       >> Computation number of the set function         >> Computation number of the set function       >> Computation number of the set function         >> Computation number of the set function       >> Computation number of the set function         >> Computation number of the set function       >> Computation number of the set function         >> Computation number of the set function       >> Computation number of the set function         >> Computation number of the set function       >> Computation number of the set function         >> Computation number of the negation of the set function       Number of the set function         >> Computation number of the negation of the set function       Number of the negation of the set function         Number of the negation of the set function       Number of the negation of the set function         Number of the negation of the set function       Numer of the negation of the set function         Number of the negation of the set function       Numer of the negation of the set function         Number of the negation of the set func	Open a	a variation reco	rds time series file	>> Program	m Process **	Operation Prom	npts						🚑 Save p	rogram proce	855
Number of the negloboring 25         21         21         Maxmmi latitude         9         50         0.000         9         9000         2         9         0000         2         9         0000         2         9         0000         2         9         0000         2         9         0000         2         9         0000         2         9         0000         2         9         0000         2         4         5000         2         0.0000         2         9         0000         2         4         5000         2         0.0000         2         9         0000         2         4         5000         2         0.0000         2         9         0000         2         4         5000         2         0.0000         2         9         0000         2         4         5000         2         0.0000         2         9         0.0000         2         4         0.0000         2         0.0000         2         9         0.0000         2         0.0000         2         0.0000         2         0.0000         2         0.0000         2         0.0000         2         0.0000         2         0.0000         2         0.0000	Column or first variati Select the	dinal number of ion in record base function	of the 5	>> Compl >> Compu >> [Functi input reco >> Open t ** Look a >> Create >> Setting ** Click t >> Compu >> Compl	ete the griddin station end tim ion] According rds time serie: the variation re at the input file or select the i parameters I he control but station start tim ete the compu	g of 5 discrete p e: 2022-02-28 1 to the given grin s file by the weig coords time serie information in ti results folder C: ave been impor on [Start compu ne: 2022-02-28 tation! Output 2	points files by b 16:55:35 d specifications ghted basis fun es file C:/ETide he text box beli /ETideLoad4.0 rted in the prog tation], or the t 3 16:59:12 18 grid time seri	, weight functio ction interpolati Load4.0_win64 bw, set the file f win64en/exam am! ool button [Star	n and other pa on method, ge en/examples/A ormat paramet ples/AppGerry	arameters, respense nerate variation AppGerrweighgr ters weighgridate/grid	grids time serie idate/guass6fit2	s files.		poch in the	
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The scales of base function         2         Maintenant latitude         24 500°         C           Set the results told         Import the parameters         State comparison         State comparis				Paramete	ers of base fur	nction			1.4	laximum latitude			25 500°		
Postpart of the input-output flag         Save data in the text           1000000000000000000000000000000000000				Number o	f the neighbor			Minir				de 98.500°			
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$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	Display of I	the input-outpu	it file:	Number o points for The kultor rameters	f the neighbor interpolation sis of base fur	ing 25	20190313		num longitude	Resolution M	aximum longitui		<ul> <li>0.500'</li> <li>24.500°</li> <li>₩</li> <li>Save data</li> </ul>	\$ 99.500°	xoo

# 6.9 Visualization plot tools for various geodetic data files

#### 6.9.1 Visualization for multi-attributes in groud variation time series

[Function] Plot multi-variations time series curves stored in a groud geodetic variations time series file.

The program can plot less than 15 time series curve each time.

[Parameter settings] Select the sampling epoch time format, enter the column number of the sampling epoch time in the file record, set the location parameters of the time series plotted, and enter minimum-maximum of the plotted variations and row ordinal number of the starting-ending sampling epochs.

When the location parameter corresponding to the column ordinal number in the record is greater than the record maximum column number, the program automatically sets the location parameter as the serial number of the record maximum column.

When the column ordinal number of the end sampling variations is greater than the number of samples of the time series, the program automatically sets the number of samples of the time series as the column ordinal number of the end sampling variations.



Hold down the left mouse button to rotate the plot, hold down the right button or scroll the middle mouse button to zoom the plot, and hold down the middle button to pan the plot.

#### 6.9.2 Visualization for variation records time series on geodetic network

[Function] Plot multi-variations time series curves stored in a variation records time series file.

[Parameter settings] Enter the ordinal number of the first sampling epoch in file header and the first sampling variation in record, set the location parameters of the time series plotted, and enter the ordinal number of starting-ending sampling epochs and minimummaximum of the plotted variations.

When the location parameter corresponds to the row ordinal number of the record is greater than the number of rows of the file records, the program automatically sets number of rows of the file records as the row ordinal number of the last record.

The program can plot less than 15 time series curve each time. When different groups of location parameters correspond to the same variation, the program is automatically merged, counted and plot according to one variation.



### 6.9.3 Visualization for specified attribute in discrete point records file

[Function] Displays the point locations and their specified attributes in a geodetic discrete points file.

After changing the input data file, z attribute, or other parameters, you need to click the control button [Import setting parameters] again to update the graph.

If needing a larger scale plot, enlarge the graphics window on the right firstly, and then click the control button [Scatter plot].

Hold down the left mouse button to rotate the plot, hold down the right button or scroll the middle mouse button to zoom the plot, and hold down the middle button to pan the plot.



You can unify the scales by fixing the scale range for batch plots. Adjust the size of the plot window on the right and the plot requirements to an appropriate state before drawing batch plots. During plot period, the parameters and the size of the plot window are kept unchanged, and no mouse operation is performed on the plot.

# 6.9.4 Visualization for geodetic grid and variation grids time series file

[Function] Plot for geodetic grid or grid time series files.

[Parameter settings] Select display style and set the checkbox [Custom scale range (used for grids time series plots)].





Allows the first component of a vector grid to be displayed as grid data. After seting the custom scale range, you can plot a series of figures for grids time series.

# 6.9.5 Visualization for the geodetic vector grid file

The X-axis and Y-axis of the plotting coordinate system respectively point east and north (EN), which is the same with horizontal displacement vector.

Vector form: East-North (EN, e.g., horizontal displacement vector), South-West (SW, e.g., vertical deflection vector), North - East (NE, e.g., Tangential gravity gradient vector).



# 7 Data files format, geophysical models and numerical standards

# 7.1 Geodetic Data Files in ETideLoad own Format

ETideLoad only recognizes the five kinds of geodetic stationary data and five kinds of geodetic variation time series data in ETideLoad own format. The geodetic stationary data files include the discrete geodetic records file, geodetic network observation records file, numerical grid file, vector grid file, and spherical harmonic coefficients (Stokes coefficients) file. The variation time series files include the ground variations time series file, geodetic network site records time series file, geodetic network observations time series file, variation (vector) grids time series files, and spherical harmonic coefficient (Stokes coefficient) models time series files.

The program [Conversion of general ASCII records data into ETideLoad format], and the function [Normalized extraction of batch time series of geodetic monitoring network] are the important interfaces for ETideLoad to accept external text data. Using the function [Global prediction of solid earth tidal effects on various geodetic quantities], or [lobal prediction of surface air pressure tidal load effects on various geodetic quantities], you can construct a ground variations time series with the given location and sampling specifications. Using the program [Generating and constructing of regional geodetic grid], you can construct a numerical grid with the given grid specifications. The other programs or functions only accept the format data generated by ETideLoad own.

# 7.2 The files format of 5 kinds of stationary geodetic data

### 7.2.1 The discrete geodetic records file

A discrete geodetic records data is represented by a one-dimensional array.

🔚 rdgra	avpritmindin.	txt⊠						
1	1	102.392927	24.494402	2227.4900	25.8548	22.8415	2210.7385	22.9157
2	2	102.395920	24.508898	2169.5000	19.2278	23.3482	2220.1556	23.1268
3	3	102.392718	24.529614	2012.6300	-2.5982	23.5704	2112.7810	23.1433
4	4	102.396602	24.545253	2121.8000	8.5305	22.2493	2071.2506	22.4506
5	5	102.396873	24.563563	1970.5800	-7.6153	21.1752	2045.8186	20.8999
6	6	102.393754	24.581317	1939.6100	-9.4593	19.2625	1962.1555	19.1874
7	7	102.395223	24.603553	1964.8800	-7.7358	16.3706	1985.6935	16.3132
8	8	102.393104	24.617811	1997.0200	-5.1529	14.5630	1978.1810	14.6096
9	9	102.393520	24.638369	1915.4500	-11.6028	12.4719	1947.9042	12.4048
10	10	102.397107	24.653500	2009.9700	-0.2375	10.8712	1974.4709	10.9325
11	11	102.396963	24.675343	1945.3300	-7.3841	9.6422	1981.4985	9.5877
12	12	102.395819	24.692939	1980.3300	-3.7480	9.0670	1966.7684	9.0868
13	13	102.395371	24.708913	2029.0300	2.5687	8.8403	1957.6558	8.9453
14	14	102.395350	24.727566	1902.2900	-12.2454	9.0661	1903.0214	9.0650
15	15	102.396700	24.745993	1869.7500	-15.8731	8.9810	1891.7180	8.9468
16	16	102.395841	24.764933	2083.6400	7.3406	8.5926	2073.5757	8.6092
17	17	102.393966	24.781787	2268.9800	26.9402	8.1585	2196.5105	8.2855
18	18	102.394006	24.801727	1938.9900	-7.5474	7.5344	2020.5270	7.3956
19	19	102.398417	24.817405	1904.2900	-10.6788	4.8800	1984.9395	4.7832
20	20	102.396456	24.874484	1880.3900	-11.4857	-2.6543	1930.2448	-2.6614

(1) Multiple rows of the file headers are allowed, whose content and format are not restricted.

(2) One record represents the geodetic data of one site. The attributes of each record include site number (name), longitude (degree decimal), latitude (degree decimal), attribute 4, ..., attribute n.

(3) The attribute convention is a numeric format, the number of the attributes (n) is not more than 80, and the attributes are separated by spaces.

(4) A record reading statement in Fortran language is:

read(fileno,\*)(record(i),i=1,n) ! real\*8 record(n)

# 7.2.2 The geodetic network observations file

A geodetic network observations file can store the baseline component data for the CORS network, height differences for the levelling network, or travity differences for the gravity network.

(1) The file header occupies a row and includes the number of characters of the baseline or route name, number of characters of the site name, .....

(2) The file record includes the baseline or route name, starting site (longitude, latitude, height), ending site (longitude, latitude, height), ....., observations (default value is 9999).

(3) The relations between the baselines (or routes) and the sites in the geodetic monitoring network are reflected with the composition of the characters of their name. A baseline or route name is agreed to be composed of site names A and B at both ends (B\*\*\*A), where the number of characters of all the sites names is required to be equal.

Therefore, the number of characters of the baseline or route name shall not be less than twice the number of characters of the site name.

# 7.2.3 The geodetic numerical grid file

The geodetic numerical grid data is represented by a two-dimensional array.

(1) There is a row of file header at the beginning of the file. The file header contains minimum longitude, maximum longitude, minimum latitude, maximum latitude, grid cell interval along longitude, grid cell interval along latitude. The units of all the attributes are decimal degrees.

(2) The grid elements are sequentially stored in an increasing manner of row latitude and column longitude until all data is stored. The elements are separated by spaces.

(3) The Fortran reading program for the entire grid data in a geodetic grid file:

```
open(unit=fileno,file=filename,status="old")

read(fileno,*)(hd(i),i=1,6) ! hd(6) - the file header

nlon=nint((hd(2)-hd(1))/hd(5)) ! nlon - the number of grid columns along longitude direction

nlat=nint((hd(4)-hd(3))/hd(6)) ! nlat - the number of grid rows along latitude direction

do i=1,nlat

read(fileno,*)(gr(i,j),j=1,nlon) ! gr(nlat,nlon)- two dimension array used to store grid values

enddo
```

The grid value of grid cell represents the average value of the grid cell. In the numerical integral operation, the location of the center point of the grid cell is used to calculate the integral distance from the grid cell to the calculation point.

📑 dbmhş	gt150s. da	t 🔀					
1	104.	000000	114.000000 25	.000000 34	000000 0.0416666	7 0.04166667	
2	1	880.623	3 1872.6612	1910.7203	3 1931.7653	1992.7665	1897.719
3	1	579.515	8 1478.5360	1457.573	5 1610.5877	1703.5435	1392.440
4	1	127.086	2 1141.1257	1156.1979	1181.3065	1335.4466	1400.590
5		530.326	4 562.3283	484.3702	478.4546	553.5518	717.637
6		542.5849	9 575.7052	629.8202	654.9330	694.0609	807.198
7	· ·	726.967	439.0212	598.0862	604.1542	596.2404	510.352
8		320.403	667.4105	588.4110	585.4184	661.4350	557.449
9		194.455	9 433.5850	353.7288	430.9312	723.1754	821.395
10		128.922	3 219.0560	175.1799	152.2779	137.3618	113.466
11		156.247	1 331.3871	360.5383	451.7036	575.8641	698.990
12		151.780	5 150.9271	208.1023	343.2925	296.4793	343.689
13		20.4542	560.7228	752.932	5 548.0788	375.1834	295.282
14		267.707	3 300.9139	596.138	5 576.3569	569.5556	559.730
15		466.160	8 254.1723	224.2118	236.2868	250.4018	331.558
16		509.112	504.2678	607.459	873.6999	972.9491	777.160
17		129.821	6 112.8806	145.996	223.1369	239.2738	219.400
18	1	868.624	1859.6737	1903.7419	2051.7911	2088.7992	1910.760
19	1	175.512	4 1382.5200	1476.5441	1626.5437	1580.4903	1318.384
20	1	155.215	8 1193.2735	1209.3569	1255.4640	1365.5851	1386.700
21		503.237	489.2430	499.3152	525.4287	630.5491	820.648
22		136.436	8 493.5515	611.6602	584.7656	649,9001	678.057

#### 7.2.4 The geodetic vector grid file

A vector grid file is composed of the first components grid and the second components grid of the vector. The header file and the first components grid in the vectors grid file are same as that in the geodetic grid file, and the second components grid follow the first components grid closely with the same way.

Vector grid such as vertical deviation and horizontal gradient vector grid in ETideLoad are stored in the form of vector grid file.

#### 7.2.5 The spherical harmonic coefficients file

(1) The file header occupies a row and consists of two attributes for scaling parameters of the spherical harmonic coefficients model, namely the geocentric gravitational constant GM (×10<sup>14</sup>m<sup>2</sup>/s<sup>2</sup>) and equatorial radius of the Earth *a* (m).

(2) The Earth's geopotential coefficients model and surface loads spherical harmonic coefficients model in ETideLoad are stored in the form of spherical harmonic coefficients file.

(3)The spherical harmonic coefficients correspond to the scaling parameters of GM and a. For different spherical harmonic coefficient models, GM and a are not necessarily the same.

(4) The n-th degree m-th order spherical harmonic coefficient is expressed by a record with the format "degree n, order m,  $C_{nm}$ ,  $S_{nm}$  (,  $C_{nm}$  error,  $S_{nm}$  error)".

ETideLoad does not require the degrees and orders of harmonic coefficients to be arranged and allows to exist insufficient orders. For the harmonic coefficient of insufficient order, ETideLoad automatically sets to zero.

#### 7.3 The files format of 5 kinds of geodetic variations time series

The variation time series files adopt the ETideLoad own format, which includes the ground variations time series file, geodetic network site records time series file, geodetic network observation records time series file, variation (vector) grids time series files, and spherical harmonic coefficient (Stokes coefficient) models time series files.

### 7.3.1 The ground variations time series file

A ground variations time series file can store the time series data of several kinds of variations of a certain site, a certain baseline or route, and the sampling epochs (here, the epoch is an instantaneous time) of these variations are the same. Such as CORS station coordinate solution time series, solid tide station observation or analysis result time series, GNSS baseline solution time series, etc.

(1) The file header occupies a row and contains site name, longitude (degree decimal), latitude (degree decimal), height (m) relative to the ellipsoidal surface (sea level, or the ground), the starting MJD (optional), .....

(2) Starting from the second row of the file, each row of records stores the sampling values of all the variations at one sampling epoch time. At least one column of attribute in the record is the sampling epoch time.

(3) Each attribute in the record (except the sampling epoch time) represents a type of variations time series, and the sampling epoch time of different types of variations is the same.

(4) The sum of the starting MJD0 in the header and the sampling epoch time (day) is equal to the sampling epoch time of MJD day in the record. When the sampling epoch time is in ETideLoad format, the starting MJD0 is not necessary in the file header.

📒 tms	uurst. txt⊠								
1	NYB 101.230000	29.910000	47.218	58484.00000	D				
2	2019010100	0.000000	2.764	5.0173	1.5712	0.3849	10.3234	-5.2424	19.3396
3	2019010101	0.041667	2.778	57.5174	23.2452	10.8146	12.7102	-3.1452	23.8048
4	2019010102	0.083333	2.762	75.5361	30.5675	14.2375	13.9736	0.1439	26.1911
5	2019010103	0.125000	2.724	49.9989	19.8264	8.9137	13.8655	3.6134	26.0285
6	2019010104	0.166667	2.675	-14.8626	-7.1040	-4.1257	12.4479	6.1922	23.4162
7	2019010105	0.208333	2.626	-102.4140	-43.2138	-21.3751	10.0693	7.0460	18.9862
8	2019010106	0.250000	2.582	-187.9254	-78.2261	-37.8487	7.2674	5.8002	13.7343
9	2019010107	0.291667	2.546	-245.0339	-101.3204	-48.4404	4.6323	2.6332	8.7685
10	2019010108	0.333333	2.517	-252.6506	-103.9667	-49.2598	2.6643	-1.7744	5.0436
11	2019010109	0.375000	2.489	-200.5663	-82.1562	-38.6091	1.6655	-6.4133	3.1473
12	2019010110	0.416667	2.455	-92.4143	-37.5190	-17.4012	1.6833	-10.1887	3.1848
13	2019010111	0.458333	2.410	54.6679	22.8880	11.0186	2.5175	-12.1759	4.7817
14	2019010112	0.500000	2.354	213.5656	88.0350	41.5647	3.7816	-11.8314	7.1990
15	2019010113	0.541667	2.288	353.0904	145.2782	68.4536	5.0033	-9.1200	9.5289
16	2019010114	0.583333	2.223	444.9509	183.1245	86.4011	5.7439	-4.5343	10.9299
17	2019010115	0.625000	2.169	470.2372	193.8160	91.7570	5.7101	1.0003	10.8461
18	2019010116	0.666667	2.139	423.9270	175.1684	83.3590	4.8356	6.3198	9.1633
19	2019010117	0.708333	2.140	316.2909	131.2080	62.8992	3.3117	10.2823	6.2600
20	2019010118	0.750000	2.176	170.7224	71.3813	34.6611	1.5535	12.0396	2.9335
21	2019010119	0.791667	2.245	18.3457	8.4289	4.6113	0.1037	11.2554	0.2101
22	2019010120	0.833333	2.337	-109.4070	-44.6375	-20.9983	-0.5077	8.2071	-0.9215
23	2019010121	0.875000	2.439	-188.4457	-77.7247	-37.1906	0.0868	3.7328	0.2122
24	2019010122	0.916667	2.535	-207.9073	-86.1738	-41.5571	1.9732	-0.9763	3.7572
25	2019010123	0.958333	2.611	-172.6479	-71.8776	-34.8890	4.9074	-4.6886	9.2487
26	2019010124	1.000000	2.657	-101.5732	-42.6368	-20.9177	8.3545	-6.4671	15.6899
27	2019010201	1.041667	2.671	-22.1804	-9.8860	-5.2050	11.6122	-5.9287	21.7785
28	2019010202	1.083333	2.655	37.2344	14.5931	6.5038	13.9841	-3.3501	26.2240
29	2019010203	1.125000	2.617	55.5611	22.0431	9.9729	14.9570	0.4130	28.0700
30	2019010204	1.166667	2.568	24.8430	9.2293	3.7078	14.3301	4.1694	26.9320

#### 7.3.2 The geodetic site variation records time series file

A geodetic site variation records time series file can store the time series data of one kind of variations for a group of geodetic sites. Such as the station coordinates time series for the CORS network, benchmark heights time series for the levelling network, observations time series for the tide station network, and InSAR monitoring time series, etc.

(1) The file header occupies a row and contains all the sampling epochs arranged with time.

(2) The file Record: the site name, longitude, latitude, height, ....., all the sampling variations arranged with sampling time.

(3) ETideLoad stipulates that the number of sampling epochs in the file header is equal to the number of sampling variations in the record, and the sampling epochs are one-by-one correspondence with the sampling variations.

(4) When receiving the input record time series file from the program interface, it is generally required to specify the column ordinal number of the first sampling epoch in the file header and the column ordinal number of the first sampling variation in the record.

😸 Tsqa	avrRowU. f	txt 🗵 🔚 Tsqavr	bslnV. txt 🗵										
1	4	0 36				20150116	12 2015	021500	2015031612	201504160	0 201505	51612 2	015061600
2	JINH	119.6426	29.2178	1191.60	1.0	-4.91	45	9.3944	3.7319	0.472	01.	1566	2.7777
3	JINX	119.3792	29.0709	84.79	1.0	-4.37	24	1.6001	6.6220	0.837	2 2.	9622	1.8461
4	JNJZ	119.6375	27.9764	286.78	1.0	-4.16	80	3.2284	3.1467	-0.477	72.	3145	1.8212
5	JSAN	118.6086	28.7279	71.54	1.0	4.83	94 1	0.8248	7.4036	2.482	в о.	3532	-2.2769
6	LISH	119.9295	28.4613	71.54	1.0	4.83	94 1	0.8248	7.4036	2.482	в о.	3532	-2.2769
7	LONQ	119.1331	28.0807	233.28	1.0	-4.99	87	3.4121	3.3682	-2.045	в — 2.	0137	-1.6199
8	OIYU	119.0793	27.6213	412.75	1.0	-2.97	13	5.7773	7.2012	1.187	4 -3.	3157	-3.4728
9	ONYN	118,9638	27.6157	429.39	1.0	0.74	46	7.2540	6.9323	0.250	0 -1.	3013	-1.8433
10	OUZH	118,8908	28,9937	90.79	1.0	-1.08	15	5.9656	5,1221	-1.157	2 0.	5323	-1.6064
11	OZLY	119,1858	29.0336	73.91	1.0			6.4829	8.4987	1,920		5578	0.7378
12	SHNO	119,5028	27.4576	827.01	1.0			3.4134	3.8402	1.047		2554	-2.4524
13	SNYN	119,5093	28.4546	182.77	1.0			3.1365	4.4180	0.428		1431	2.2420
14	YAYA	120.0425	27.3930	555.71	1.0			5.1836	4.0938	3.624		5640	1,2865
15	YONK	120.0168	28,9055	116.22	1.0			4.7569	7.1178	2.720		1517	0.6173
16	ZJYH	119,6900	28.2660		1.0			4.5552	3.8968	-0.297		4079	-0.3378
10	20111	110.0000	20.2000	100.00	1.0	0.20	02	1.0002	0.0000	0.207	· ·	1075	0.0070
🗐 Tsgav	rRowU. txt	🛛 🔚 Tsgavrhslulf	tzt 🖂 😸 InSAB	sndfarst tytX									
1	5					20141103	20141127	2014122	1 20150114	20150207	20150408	20150502	20150526
2		0 117.3445416	39.0251902	-2.79		-0.3091	0.0866	0.048		0.2865	0.5720	0.3395	
3	-12.79	0 117.3457082	39.0251902			-0.1796	0.2752	0.190		0.3340	0.5632	0.2861	0.2759
4	-7.48	2 117.3480415	39.0251902	-3.660	)	-0.3846	9999.0000	-0.052	3 0.0135	0.1783	-0.0167	-0.5455	
5		9 117.3487081	39.0251902			-0.2325	0.2301	0.070		0.4179	0.7154	0.4377	
6		3 117.3488748	39.0251902			-0.1876	0.3087	0.175		0.5347	0.9182	0.6967	
7		1 117.3492081	39.0251902			-0.2356	0.2486	0.228		0.5863	1.0390	0.8643	
8		6 117.3495414 4 117.3497081	39.0251902			-0.2211 -0.2530	0.1605	0.097		0.4816	1.0206	0.9163	
10		3 117.3498747	39.0251902			-0.2530	0.0627	-0.017		0.3072	0.8895	0.9182	
11		1 117.3503747	39.0251902			-0.2906	0.0654	0.035		0.2907	0.8569	0.8558	
12		5 117.3507080	39.0251902			-0.1282	0.2632	0.191		0.4738	1.0386	1.0551	
13	-12 21	7 117 2509747	20 0251002	-2.10		-0.0641	0 9909	0 246	E 0.4214	0 5472	1 1 2 2 1	1 1659	1 2199

0.3303

0.3831

0.3579

0.2179

0.1493

0.0288

0.1919

0.4859

0.5127

9999.0000

0.2465

0.2929 0.2776 0.2478

0.1862

0.1503

0.1581 0.2553 0.4448

0.4497

0.6632

6954

0.4314

0.4991

0.4951 0.4952 0.4779

0.4278

0.3968

0.3671

0.5395

0.5472

0.7978

0.5473

0.6149 0.6110 0.5912

0.5167

0.4565

0.4031

0.5774

0.5783

0.9730

1,1231

1.2231

1.2806

1.2285

1,1697

1.0231

1.1620

1.3511

1,2854

2956

344

2489

1.1658

1.3072

1.3458

1.3846

1.3064

1.2314

1.0748

1.2013

1.2092

1.6207

6312

633

1.2188

1.3714

1.3795

1.2891

1.2168

1.0342 1.0074 1.0798

1.1608

1.6274

#### 7.3.3 The geodetic network observation records time series file

-0.0641

0.0039

0.0099

-0.0670

-0.1241

-0.1866

-0.0956

-0.0689

0.1071

0.1224

-3,191

-3.067

-2.943

-3.121

-3.357

-4.331

-4.173

-3.783

-3.938

-3.980

-13.217 117.350/080 -13.217 117.3508747 -12.657 117.3510413 -12.424 117.3512080 -12.475 117.3513747 -12.682 117.3515413

-12.511 117.3517080 -11.102 117.3520413 -10.425 117.352080 -7.999 117.3525413 -3.661 117.3528746

-13,428 117,3543745

3545412

39.0251902

39.0251902

39.0251902 39.0251902 39.0251902

39.0251902

39,0251902

39.0251902 39.0251902

39.0251902

39.0251902

39.0251902

A geodetic network observation records time series file can store the variation records time series of the baseline component for the CORS network, the variation records time series of the height difference for the levelling network, or the variation records time series of the gravity difference for the gravity network.

(1) The file header occupies a row and includes the number of characters of the baseline or route name, number of characters of the site name, sampling length, ……, all the sampling epochs arranged with time.

(2) The file record includes the baseline or route name, starting site (longitude, latitude, height), ending site (longitude, latitude, height), ....., all the observed variations arranged with sampling time (default value is 9999).

(3) The relations between the baselines (or routes) and the sites in the geodetic monitoring network are reflected with the composition of the characters of their name. A baseline or route name is agreed to be composed of site names A and B at both ends (B\*\*\*A), where the number of characters of all the sites names (such as A and B) is required to be equal.

Therefore, the number of characters of the baseline or route name shall not be less than twice the number of characters of the site name.

🔚 Tsq:	avrRowU. txt 🛛 🚦	🚽 TsqavrbslnV	. txt 🛛										
1	9 0 3	6						2015011612	2015021500	2015031612	2015041600	2015051612	2015061600
2	CANN DONT	120.4247	27.5226	0.00	121.1503	27.8346	0.00	6.4092	3.5311	-0.6494	3.4802	1.9057	-0.3761
3	CANN FDIQ	120.4247	27.5226	0.00	120.2073	27.3353	0.00	7.5566	9999.0000	9.8866	4.9806	-3.7116	0.3579
4	CANN_JHYW	120.4247	27.5226	0.00	120.0784	29.2727	0.00	3.3886	1.7941	-0.5867	-0.4076	0.7054	-0.2796
5	CANN_JINH	120.4247	27.5226	0.00	119.6426	29.2178	0.00	2.8530	-0.7712	-1.3292	1.3058	-1.2947	-2.4476
6	CANN JINX	120.4247	27.5226	0.00	119.3792	29.0709	0.00	4.3333	1.6376	2.9746	3.5908	1.9899	-1.6367
7	CANN JNJZ	120.4247	27.5226	0.00	119.6375	27.9764	0.00	4.9006	3.1138	1.0930	0.3909	0.8296	-1.6116
8	CANN JSAN	120.4247	27.5226	0.00	118.6086	28.7279	0.00	2.5860	0.7616	-0.7290	-0.5568	-4.1410	-5.3632
9	CANN LHAI	120.4247	27.5226	0.00	121.1895	28.9059	0.00	1.0756	-1.6069	-1.8127	-0.4355	-0.0362	-0.7623
10	CANN LISH	120.4247	27.5226	0.00	119.9295	28.4613	0.00	13.8711	10.5885	3.5993	4.5791	-0.7531	-6.0081
11	CANN LONQ	120.4247	27.5226	0.00	119.1331	28.0807	0.00	7.3816	6.1923	2.8486	1.8460	-1.9823	-3.9091
12	CANN LUOY	120.4247	27.5226	0.00	119.7051	27.5525	0.00	8.8132	9.4984	3.5027	4.0624	0.1673	-1.3212
13	CANN PANA	120.4247	27.5226	0.00	120.4367	29.0542	0.00	0.2485	-2.0512	-4.4740	-2.9385	-0.0623	-0.7816
14	CANN PCHQ	120.4247	27.5226	0.00	118.5422	27.9232	0.00	5.5253	5.7473	3.2665	1.6373	-1.4516	-6.3300
15	CANN_PCJM	120.4247	27.5226	0.00	118.4454	28.1680	0.00	14.2248	12.7588	7.9740	8.5291	3.1970	1.6813
16	CANN_QINT	120.4247	27.5226	0.00	120.2900	28.1394	0.00	7.1517	4.5782	2.4621	4.4460	-0.4966	-3.3975
17	CANN_QIYU	120.4247	27.5226	0.00	119.0793	27.6213	0.00	7.1481	6.6956	4.4206	1.9230	-5.9045	-7.7402
18	CANN_QNYN	120.4247	27.5226	0.00	118.9638	27.6157	0.00	10.9311	7.9043	4.5820	1.4154	-3.5702	-5.8564
19	CANN_QUZH	120.4247	27.5226	0.00	118.8908	28.9937	0.00	8.1029	5.9283	1.7235	1.2962	-0.8214	-5.2339
20	CANN_QZLY	120.4247	27.5226	0.00	119.1858	29.0336	0.00	7.1312	6.3296	4.8051	4.9249	0.4817	-2.6667
21	CANN_RUIA	120.4247	27.5226	0.00	120.6490	27.7833	0.00	8.9624	7.8483	0.2735	0.8812	-0.2184	-3.3412
22	CANN_SHNQ	120.4247	27.5226	0.00	119.5028	27.4576	0.00	4.8563	4.6628	0.3999	3.4718	0.5071	-6.6786
23	CANN_SNYN	120.4247	27.5226	0.00	119.5093	28.4546	0.00	3.3183	3.1267	1.3992	1.8621	1.0732	-1.1970
24	CANN_SUIC	120.4247	27.5226	0.00	119.2693	28.5951	0.00	14.7246	7.6386	10.1070	4.5706	6.3427	0.2411
25	CANN TAIZ	120.4247	27.5226	0.00	121.4164	28.6183	0.00	4.0291	3.2741	0.3639	1.5962	-0.2033	-1.0270

### 7.3.4 The variation grids time series files for geodetic field

A group of variation grids time series files are composed of a series of numerical grid model files of a certain kind of variation (vector), and the seventh attribute of the header in each grid file is agreed to be the sampling epoch time. Such as the grids time series of land water equivalent height, sea level variation, and grids time series of various regional loaddeformation fields or temporal gravity fields, etc.

📄 zwdx20	0150331. dat 🔀 📘	zwdx20150531. dati	🛛 🔚 zwdx20150831.	. dat 🛛						
1	118.500000	121.500000	27.000000 2	29.000000 1.	66666667E-02	1.66666667E-02	2 201503	3118		
2	-0.374	6 -0.5686	-0.6666	-0.9356	-1.0686	-1.0836	-1.0606	-1.0586	-1.0586	-1.0566
3	-0.544	5 -0.4746	-0.4986	-0.6746	-0.8176	-0.8646	-0.9356	-0.9356	-0.9575	-0.9565
4	-0.932	6 -0.9128	-0.9132	-0.8647	-0.7606	-0.7255	-0.6170	-0.5403	-0.4534	-0.4873
5	-0.562	2 -0.5214	-0.4842	-0.4644	-0.4832	-0.4767	-0.5045	-0.4994	-0.4972	-0.4458
6	-0.177	6 -0.0795	0.0535	0.0904	0.1088	0.0885	-0.0087	-0.1460	-0.2341	-0.2686
7	-0.068	5 0.1893	0.3498	0.4787	0.5169	0.4660	0.2675	0.1964	0.1144	0.0974
8	0.124	B -0.0175	-0.1520	-0.2620	-0.3917	-0.4810	-0.5751	-0.6501	-0.7137	-0.7640
9	-0.291	8 -0.1304	0.0015	0.1363	0.2607	0.3785	0.4382	0.4686	0.4562	0.3953
10	-0.499	B -0.6231	-0.7580	-0.8453	-0.9315	-0.9857	-1.0331	-1.0529	-1.0680	-1.0697
11	-1.079	6 -1.0936	-1.0966	-1.0966	-1.0996	-1.1006	-1.1006	-1.0996	-1.0997	-1.0978
12	-1.018	4 -0.9872	-0.9330	-0.8807	-0.8047	-0.7382	-0.6460	-0.5719	-0.4788	-0.3955
13	-0.251	3 -0.3094	-0.3723	-0.4617	-0.5417	-0.6397	-0.7159	-0.7967	-0.8500	-0.8985
14	-0.464	7 -0.6176	-0.7077	-0.9746	-1.0456	-1.0596	-1.0546	-1.0526	-1.0576	-1.0416
15	-0.453	6 -0.3635	-0.4356	-0.6346	-0.7596	-0.8306	-0.9016	-0.9016	-0.9385	-0.9385
16	-0.908	6 -0.9138	-0.9142	-0.8636	-0.7696	-0.7325	-0.6810	-0.6283	-0.5264	-0.5533
17	-0.576	2 -0.5344	-0.5152	-0.4914	-0.5093	-0.5217	-0.5505	-0.5446	-0.5243	-0.4589
18	-0.198	2 -0.1410	-0.0271	0.0068	0.0242	0.0178	-0.0763	-0.1896	-0.2368	-0.2702
19	-0.097	0.1349	0.3035	0.4214	0.4327	0.4208	0.2203	0.1393	0.0803	0.0864
20	0.086	8 -0.0434	-0.1649	-0.2578	-0.4047	-0.5100	-0.5791	-0.6770	-0.7527	-0.7781

### 7.3.5 The spherical harmonic coefficient models time series files

A group of spherical harmonic coefficient models time series files can store the time series of the spherical harmonic coefficient (Stokes' coefficient) models of global surface load variations, global load-deformation fields, or temporal global gravity field.

(1) The header file occupies one row and consists of three attributes, namely the geocentric gravitational constant GM (×10<sup>14</sup>m<sup>2</sup>/s<sup>2</sup>), equatorial radius of the Earth *a* (m), and sampling epoch (in ETideLoad format).

(2) The spherical harmonic coefficients correspond to the scaling parameters of GM and a. For different spherical harmonic coefficients models, GM and a are not necessarily

the same.

(3) The n-th degree m-th order spherical harmonic coefficient is expressed by a record with the format: degree n, order m,  $C_{nm}$ ,  $S_{nm}$  (,  $C_{nm}$  error,  $S_{nm}$  error). At different sampling epochs, n of the model files can be not the same.

(4) ETideLoad does not require the degrees and orders of harmonic coefficients to be arranged and allows to exist insufficient orders. For the harmonic coefficient of insufficient order, ETideLoad automatically sets to zero.

# 7.4 Geophysical models and numerical standards in ETideLoad4.0

ETideLoade4.0 is mainly based on the geophysical models and numerical standards recommended by IERS Conventions (2010). You can update them from the program [geophysical models and numerical standards settings]. These geophysical models and numerical standards settings].

# 7.4.1 The surface air pressure tidal load spherical harmonic coefficients model file

The 360-degree surface air pressure tidal load spherical harmonic coefficients model file ECMWF2006.dat is stored in the folder C:\ETideLoad4.0\_win64en\iers in FES2004 format, which were constructed by the spherical harmonic analysis programs of ETideLoad4.0 using  $0.5^{\circ} \times 0.5^{\circ}$  global harmonic parameter grids of four atmospheric tidal constituents, to meet the basic needs of centimeter-level geodesy. The four tidal constituents are respectively the diurnal, semi-diurnal, semi-annual and annual periodic tidal constituents ( $S_1$ ,  $S_2$ ,  $Ss_a$ , Sa) whose harmonic parameter grids come from ECMWF-DCDA2006 of European Centre for Medium-Range Weather Forecasts.

😑 ECI	MVF2006. dat🛛											
1					ECMWF-DCDA2006	normalized mod	del up to (360	,360) in hPa				
2	半日/周日	/半年/	年周期	3								
3	Doodson	Darw	n	m	Csin+	Ccos+	Csin-	Ccos-	C+	eps+	C-	eps-
4	164.556	<b>S</b> 1	1	0	-0.01055351	0.00555959	-0.01055351	0.00555959	0.01192835	297.7803	0.01192835	297.7803
5	164.556	S1	2	0	-0.00898730	0.02713172	-0.00898730	0.02713172	0.02858149	341.6727	0.02858149	341.6727
6	164.556	<b>S</b> 1	3	0	0.02416514	0.01232573	0.02416514	0.01232573	0.02712707	62.9756	0.02712707	62.9756
7	164.556	<b>S</b> 1	4	0	0.01971779	-0.01808456	0.01971779	-0.01808456	0.02675523	132.5261	0.02675523	132.5261
8	164.556	S1	5	0	0.00538826	-0.01556217	0.00538826	-0.01556217	0.01646859	160.9021	0.01646859	160.9021
9	164.556	S1	6	0	-0.01896560	-0.00055330	-0.01896560	-0.00055330	0.01897366	268.3289	0.01897366	268.3289
10	164.556	<b>S</b> 1	7	0	0.00163224	0.00711629	0.00163224	0.00711629	0.00730108	12.9183	0.00730108	12.9183
11	164.556	S1	8	0	0.00341644	0.00607435	0.00341644	0.00607435	0.00696920	29.3550	0.00696920	29.3550
12	164.556	<b>S</b> 1	9	0	-0.00469730	-0.00311697	-0.00469730	-0.00311697	0.00563739	236.4331	0.00563739	236.4331
13	164.556	<b>S</b> 1	10	0	0.00442735	-0.01563001	0.00442735	-0.01563001	0.01624496	164.1847	0.01624496	164.1847
14	164.556	<b>S</b> 1	11	0	0.00941838	-0.00082619	0.00941838	-0.00082619	0.00945455	95.0132	0.00945455	95.0132
15	164.556	S1	12	0	-0.00454013	0.00688423	-0.00454013	0.00688423	0.00824654	326.5953	0.00824654	326.5953
16	164.556	S1	13	0	-0.01227672	0.00310149	-0.01227672	0.00310149	0.01266243	284.1781	0.01266243	284.1781
17	164.556	<b>S</b> 1	14	0	0.00203678	0.00166923	0.00203678	0.00166923	0.00263340	50.6638	0.00263340	50.6638
18	164.556	<b>S</b> 1	15	0	0.00253994	0.00381849	0.00253994	0.00381849	0.00458608	33.6306	0.00458608	33.6306
19	164.556	<b>S1</b>	16	0	0.00613602	-0.00041704	0.00613602	-0.00041704	0.00615017	93.8882	0.00615017	93.8882
20	164.556	<b>S1</b>	17	0	-0.00113104	-0.00413462	-0.00113104	-0.00413462	0.00428652	195.2992	0.00428652	195.2992
21	164.556	S1	18	0	-0.00311700	0.00136741	-0.00311700	0.00136741	0.00340375	293.6868	0.00340375	293.6868
22	164.556	S1	19	0	-0.00217138	0.00053937	-0.00217138	0.00053937	0.00223737	283.9498	0.00223737	283.9498
23	164.556	S1	20	0	-0.00017645	0.00369644	-0.00017645	0.00369644	0.00370065	357.2671	0.00370065	357.2671
24	164.556	<b>S</b> 1	21	0	0.00068441	-0.00165216	0.00068441	-0.00165216	0.00178831	157.4980	0.00178831	157.4980
25	164.556	<b>S1</b>	22	0	0.00100221	-0.00214635	0.00100221	-0.00214635		154.9703	0.00236881	154.9703
26	164.556	<b>S1</b>	23	0	0.00461395	-0.00179653	0.00461395	-0.00179653	0.00495136	111.2744	0.00495136	111.2744
27	164.556	<b>S</b> 1	24	0	-0.00143873	0.00014453	-0.00143873	0.00014453	0.00144597	275.7366	0.00144597	275.7366
28	164.556	S1	25	0	-0.00083151	-0.00001238	-0.00083151	-0.00001238	0.00083160	269.1470	0.00083160	269.1470
29	164.556	S1	26	0	-0.00272792	-0.00095240	-0.00272792	-0.00095240	0.00288940	250.7543	0.00288940	250.7543
30	164.556	S1	27	0	-0.00183890	0.00217563	-0.00183890	0.00217563	0.00284868	319.7946	0.00284868	319.7946

In ECMWF-DCDA2006 model, the diurnal and semidiurnal constituents  $(S_1, S_2)$  of atmospheric pressure can constitute RP03 model.

The surface air pressure tides, their tidal constituent harmonic parameters and tidal load spherical harmonic coefficients are all in hPa as unit.

#### 7.4.2 The ocean tidal load spherical harmonic coefficients model file

The 100-degree ocean tidal load spherical harmonic coefficients model file FES2004S1.dat is stored in the folder C:\ETideLoad4.0\_win64en\iers in FES2004 format. The relationship between the ocean tidal load normalized spherical harmonic coefficients and the geopotential coefficients is as the formula (6.15) in the IERS Conventions (2010).

😑 ECM	WF2006. dat 🗵	📄 F	ES2004	4S1. dat 🗵									
1	Ocean tid	le mo	del:	FES200	4 norma	lized model	l (fev. 2004)	up to (	100,100) i	in cm			
2	(long per	iod	from	FES200	2 up to	(50,50) +	equilibrium	Om1/Om2,	atmospher	ric tide	NOT inc	luded)	
3	Doodson D	arw	n	m	Csin+	Ccos+	Csin-	Ccos-	C+	eps+	C-	eps-	
4	55.565	Om1	2	0 -0.	540594	0.000000	0.000000	0.000000	0.5406	270.000	0.0000	0.000	
5	55.575	Om2	2	0 -0.	005218	0.000000	0.000000	0.000000	0.0052	270.000	0.0000	0.000	
6	56.554	Sa	1	0 0.	017233	0.000013	0.000000	0.000000	0.0172	89.957	0.0000	0.000	
7	56.554	Sa	2	0 -0.	046604	-0.000903	0.000000	0.000000	0.0466	268.890	0.0000	0.000	
8	56.554	Sa	3	0 -0.	000889	0.000049	0.000000	0.000000	0.0009	273.155		0.000	
9	56.554	Sa	4	0 0.	012069	-0.000413	0.00000	0.000000	0.0121	91.960	0.0000	0.000	
10	56.554	Sa	5	0 -0.	009780	-0.000421	0.000000	0.000000	0.0098	267.535	0.0000	0.000	
11	56.554	Sa	6	0 0.	006895	0.000043	0.000000	0.000000	0.0069	89.643	0.0000	0.000	
12	56.554	Sa	7	0 -0.	010515	-0.000287	0.000000	0.000000	0.0105	268.437	0.0000	0.000	
13	56.554	Sa	8	0 0.	002067	-0.000011	0.000000	0.000000	0.0021	90.305	0.0000	0.000	
14	56.554	Sa	9			-0.000110	0.00000	0.000000	0.0042	268.512	0.0000	0.000	
15	56.554		10	0 -0.	001781	-0.000085	0.000000	0.000000		267.268		0.000	
16	56.554		11			-0.000068	0.000000	0.000000		267.163		0.000	
17	56.554	Sa	12	0 -0.	004081	-0.000048	0.000000	0.000000	0.0041	269.326	0.0000	0.000	
18	56.554	Sa	13	0 -0.	000116	-0.000041	0.000000	0.000000	0.0001	250.534	0.0000	0.000	
19	56.554		14	0 -0.	003043	-0.000007	0.00000	0.000000	0.0030	269.868	0.0000	0.000	
20	56.554		15	0 0.	001109	-0.000028	0.000000	0.000000			0.0000	0.000	
21	56.554	Sa	16	0 -0.	002596	-0.000034	0.000000	0.000000	0.0026	269.250	0.0000	0.000	
22	56.554	Sa	17	0 -0.	000674	0.000022	0.000000	0.000000	0.0007	271.870	0.0000	0.000	
23	56.554	Sa	18	0 0.	000546	0.000006	0.000000	0.00000	0.0005	89.370	0.0000	0.000	
24	56.554	Sa	19	0 -0.	000024	0.000023	0.000000	0.000000	0.0000	313.781	0.0000	0.000	
25	56.554	Sa	20	0 0.	000867	0.000014	0.000000	0.000000	0.0009	89.075	0.0000	0.000	

In order to meet the basic needs of satellite, coastal zone and ocean gravity gradient data processing, we adopted AVISO+'s FES2014b global tidal height harmonic parameters grid models and constructed the 360-degree ocean tidal height spherical harmonic coefficients model file FES2014cs.dat in FES2004 format by the spherical harmonic analysis programs of ETideLoad4.0.

FES2014cs.dat includes spherical harmonic coefficients of the 36 tidal constituents ( $\Omega$ 1,  $\Omega$ 2; 2N2, Eps2, J1, K1, K2, L2, La2, M2, M3, M4, M6, M8, Mf, MKS2, Mm, MN4, MS4, MSf, MSqm, Mtm, Mu2, N2, N4, Nu2, O1, P1, Q1, R2, S1, S2, S4, Sa, Ssa, T2), in which the spherical harmonic coefficients of the two balance tidal constituents ( $\Omega$ 1,  $\Omega$ 2) come from FES2004S1.dat.

The ocean tidal height, harmonic parameters of the tidal constituent and tidal load spherical harmonic coefficients are all in cm as unit.

#### 7.4.3 The Earth's Load Love numbers file

The Earth's load Love numbers also called the load deformation coefficients (LDC) can be calculated using the spherically symmetric non-rotating elastic earth model REF6371. The Load Love numbers in ETideLoad4.0 come from a Regional EIRstic Rebound calculator (REAR1.0, 2015.11), using the file Love\_load\_cm.dat stored in the folder C:\ETideLoad4.0\_win64en\iers. The file includes the load Love numbers of the radial displacement, horizontal displacement and geopotential  $(h'_n, l'_n, k'_n), n = 1, \dots, 32768$  from 1 to 32768 degree, as shown in the figure.

In order to suppress the high-degree oscillations of the load Green's function, the load

Green's function is calculated to 54000 degree in ETideLoad, and the load Love numbers exceeding 32768 degree (n>32768) are calculated with the following asymptotic formula

 $h'_n = -6.209114, \ l'_n = 1.890061/n, \ k'_n = -2.682697/n.$ 

🔚 Love	_load_cm.	dat🛛		
1	The lo	ad Love numbers fro	m the REAR package	are attached. There are no
2	more o	f these oscillation	s at high degree,	and they go up to degree 32768.
3	Novemb	er 20, 2015, Jean-P	aul	
4	CM: ce	nter of mass refere	nce frame	
5	n	h' (vert)	l' (horiz)	k' (potent)
6	0	0.000000000D+00	0.000000000D+00	-1.000000000D+00
7	1	-0.0287112988D+01	0.1045044062D+00	-1.000000000D+00
8	2	-0.9945870591D+00	0.2411251588D-01	-0.3057703360D+00
9	3	-0.1054653021D+01	0.7085493677D-01	-0.1962722363D+00
10	4	-0.1057783895D+01	0.5958723183D-01	-0.1337905897D+00
11	5	-0.1091185915D+01	0.4702627503D-01	-0.1047617976D+00
12	6	-0.1149253656D+01	0.3940811757D-01	-0.9034958051D-01
13	7	-0.1218363201D+01	0.3499400649D-01	-0.8205733906D-01
14	8	-0.1290473661D+01	0.3225123202D-01	-0.7652348967D-01
15	9	-0.1361847865D+01	0.3038562458D-01	-0.7239287690D-01
16	10	-0.1430981761D+01	0.2902258995D-01	-0.6907768441D-01
17	11	-0.1497377458D+01	0.2798156018D-01	-0.6629382122D-01
18	12	-0.1560934855D+01	0.2716367080D-01	-0.6388475059D-01
19	13	-0.1621715593D+01	0.2650554043D-01	-0.6175536119D-01
20	14	-0.1679770379D+01	0.2596800569D-01	
21	15	-0.1735198310D+01	0.2551661917D-01	
22	16	-0.1788088250D+01	0.2512667367D-01	-0.5647488828D-01
23	17	-0.1838448069D+01	0.2478452380D-01	-0.5496610314D-01
24	18	-0.1886440474D+01	0.2447083426D-01	
25	19	-0.1932084480D+01	0.2417919471D-01	
26	20	-0.1975465902D+01	0.2389862142D-01	
27	21	-0.2016677975D+01	0.2362510597D-01	
28	22	-0.2055800328D+01	0.2335504487D-01	-0.4853059813D-01

#### 7.4.4 The IERS Earth orientation parameters time series file

The IERS Earth orientation parameters (EOP) time series file IERSeopc04.dat (ITRF2008) were stored in the folder C:\ETideLoad4.0\_win64en\iers. You can update the EOP time series from the IERS website. For future epochs, the forecast EOP products can be used. Considering the non-tidal nature of the polar motion, the forecast time should be controlled within half a year.

			1		L EARTH ROTA RIENTATION H		FERENCE SYSTE	EMS SERVICE							
					(ERS) 14 CO4										
				BOF (1	14 00										
		,	FORMAT (	3(14),17,2(1	F11.6),2(F12	2.7),2(F11.6	),2(F11.6),2	(F11.7),2(F	12.6))						
****	*****						***********								
	Date	8	MJD	x	У	UT1-UTC	LOD	dX	dY	x Err		UT1-UTC Err	LOD Err	dX Err	dY Err
						S	S	-				s	S		
	(0h (	JTC)													
2001 2001		1	51910	-0.073506 -0.072651	0.398095	0.0931626	0.0006630	0.000150	-0.000109 -0.000092	0.000061	0.000048		0.0000131	0.000028	0.00003
2001			51911 51912	-0.071557	0.399806	0.0924546 0.0916573	0.0008515	0.000141	-0.000092	0.000061 0.000061		0.0000034		0.000028	0.00003
2001		4	51912	-0.071024	0.403840	0.0910373	0.0008969	0.000132	-0.000084	0.000061			0.0000131	0.000028	0.00003
2001			51914	-0.070723	0.405333	0.0897667	0.0008872		-0.000103	0.000060		0.0000163		0.000029	0.00003
2001			51915	-0.070378	0.406725	0.0889292	0.0008068	0.000199	-0.000122	0.000060		0.0000221		0.000029	0.00003
2001		7	51916	-0.070068	0.408041	0.0882375	0.0006463	0.000224	-0.000141	0.000060		0.0000163	0.0000132	0.000029	0.00003
2001			51917	-0.070205	0.409479	0.0876861	0.0004933	0.000250	-0.000160	0.000060	0.000047		0.0000132	0.000029	0.00003
2001			51918	-0.070220	0.410814	0.0872445	0.0004441	0.000275	-0.000179	0.000060		0.0000046		0.000029	0.00003
2001	1	10	51919	-0.069861	0.412336	0.0868199	0.0004186	0.000270	-0.000158	0.000060	0.000046	0.0000043	0.0000133	0.000029	0.0000
2001	1	11	51920	-0.069330	0.414004	0.0864003	0.0004447	0.000155	-0.000180	0.000059	0.000046	0.000039	0.0000133	0.000029	0.00003
2001			51921	-0.068456	0.416120	0.0858451	0.0005855	0.000106	-0.000203	0.000059		0.000088	0.0000133	0.000028	0.00003
2001		13	51922	-0.067463	0.418251	0.0851161	0.0007422	0.000095	-0.000222	0.000059	0.000046		0.0000133	0.000028	0.00003
2001			51923	-0.066479	0.420226	0.0842390	0.0008823	0.000084	-0.000241	0.000059		0.0000112		0.000028	0.00002
2001			51924	-0.065406	0.422044	0.0833100	0.0009404	0.000072	-0.000259	0.000059		0.0000086		0.000027	0.00002
2001			51925	-0.063999	0.423541	0.0824180	0.0009155	0.000061	-0.000278	0.000059		0.0000060	0.0000134	0.000027	0.00002
2001		17	51926	-0.062602	0.425076	0.0816384	0.0007815	0.000050	-0.000297	0.000059		0.0000034		0.000027	0.00002
2001 2001		18 19	51927 51928	-0.061434 -0.060301	0.426438	0.0809369	0.0005717 0.0004021	0.000307	-0.000078	0.000060		0.0000060 0.0000114	0.0000135	0.000026	0.00002
2001		20	51929	-0.059175	0.429380	0.0801026	0.0002618	0.000335	-0.000045	0.000060		0.0000197		0.000025	0.00002
2001		21	51930	-0.058122	0.430418	0.0799970	0.0000786	0.000284	-0.000085	0.000060		0.0000198	0.0000136	0.000025	0.00002
2001		22	51931	-0.056745	0.431190	0.0799904	-0.0000387	0.000232	-0.000124	0.000060		0.0000199	0.0000136	0.000024	0.00002
2001		23	51932	-0.055378	0.432515	0.0800354	-0.0000794	0.000180	-0.000164	0.000061		0.0000200	0.0000137	0.000024	0.00002
2001		24	51933	-0.054038	0.434299	0.0801054	-0.0000531	0.000189	-0.000183	0.000061		0.0000090	0.0000137	0.000024	0.0000
2001		25	51934	-0.052227	0.436048	0.0801105	0.0000481	0.000130	-0.000240	0.000061	0.000047	0.0000025	0.0000137	0.000023	0.00002
2001		26	51935	-0.050435	0.438026	0.0799589	0.0001715	0.000101	-0.000252	0.000062	0.000048		0.0000137	0.000023	0.00002
2001		27	51936	-0.049130	0.439812	0.0796787	0.0002940	0.000094	-0.000242	0.000062	0.00048		0.0000137	0.000022	0.00002
2001			51937	-0.047602	0.441607	0.0792944	0.0004503	0.000086	-0.000232	0.000062	0.00048			0.000022	0.00001
2001		29	51938	-0.045537	0.443509	0.0788172	0.0005621		-0.000221	0.000063	0.00048		0.0000138	0.000021	0.00001
2001		30	51939	-0.043660	0.444974	0.0782782	0.0006019	0.000072	-0.000211	0.000063	0.00048		0.0000138	0.000021	0.00001
2001			51940	-0.042067	0.446396	0.0777060	0.0005437	0.000254	-0.000159	0.000063	0.000049		0.0000138	0.000021	0.00001
2001		1	51941	-0.040683	0.447325	0.0772066	0.0004689	0.000298	-0.000141	0.000064	0.000049			0.000022	0.0000
2001		2	51942	-0.039012	0.448060	0.0767917	0.0003692	0.000290	-0.000134	0.000064	0.000049			0.000022	0.00002
2001 2001		4	51943 51944	-0.037722 -0.036102	0.448868	0.0764837 0.0763497	0.0002097 0.0000712	0.000283	-0.000128 -0.000122	0.000064	0.000049	0.0000284	0.0000138	0.000023	0.00002
	6	9	01944	-0.030102	0.449025	0.0/0349/	-0.0000019	0.000275	-0.000122	0.000064			0.0000138	0.000023	0.00002

#### 7.4.5 The geocentric motion parameters time series file

The geocentric motion parameters time series file GCN\_L1\_L2\_30d\_CF-CM.txt (ITRF2005) were stored in the folder C:\ETideLoad4.0\_win64en\iers, which are monthly variation time series products of geocentric motion parameters measured by 5 satellite laser ranging (SLR) provided by UT/CSR. For future epochs, the forecast products can be used, but the forecast time should be controlled within three months.

_					_			
🗄 ECI	WF2006. dat 🗵 📒	FES2004S1	.dat 🗵 🔚	IERSeopc04	4. dat 🗵 🔚	GCN_L1_L2	_30d_CF-CM. t	xt🛛
1	Year	Х	Y	Z	X sig	Y sig	Z sig	
2	2001.0402	2.50	2.00	5.40	1.78	1.48	4.24	
3	2001.1248	0.65	-1.35	10.75	1.61	1.34	3.68	
4	2001.2128	-0.10	-3.40	3.05	1.61	1.41	3.51	
5	2001.2932	-0.85	-3.55	-4.10	2.82	2.15	3.79	
6	2001.3784	0.40	-2.50	-7.00	1.70	2.30	3.05	
7	2001.4646	-1.65	-1.60	-6.60	1.62	3.30	3.11	
8	2001.5456	-1.55	-2.45	-3.35	1.27	1.85	3.00	
9	2001.6278	-4.45	-0.40	-2.80	1.44	1.90	3.22	
10	2001.7120	-2.05	0.85	-4.05	1.44	1.95	3.34	
11	2001.7911	-1.20	2.05	0.25	1.27	2.05	3.28	
12	2001.8708	0.05	2.05	-2.60	1.44	1.55	3.11	
13	2001.9569	0.05	3.70	-4.60	1.53	1.41	3.39	
14	2002.0399	3.85	4.05	-6.05	1.70	1.75	3.39	
15	2002.1250	1.10	0.25	1.75	1.36	1.27	3.17	
16	2002.2103	0.40	-1.45	3.30	1.44	1.20	2.94	
17	2002.2899	0.50	-2.20	3.10	1.53	1.27	3.34	
18	2002.3769	0.95	-3.45	-0.80	1.44	1.55	5.36	
19	2002.4625	-1.15	-4.50	-5.75	1.62	1.27	2.94	
20	2002.5412	-3.30	-4.90	-4.80	2.16	1.48	2.94	
21	2002.6263	-1.85	0.15	-5.55	1.78	2.35	3.17	
22	2002.7114	-1.85	0.05	0.70	1.53	2.05	3.90	
23	2002.7952	-2.80	-0.30	0.55	1.44	1.90	3.73	
24	2002.8744	-2.75	1.70	0.15	1.44	3.10	3.62	
25	2002.9543	1.75	3.45	9.15	1.95	1.56	5.72	
26	2003.0438	1.40	-0.35	2.40	1.61	1.95	4.19	
27	2003.1279	0.70	0.75	2.30	1.44	1.25	3.28	
28	2003.2108	1.90	-0.05	4.10	1.36	1.55	2.77	
29	2003.2952	1.60	-1.70	2.35	1.78	1.48	3.28	
30	2003.3796	0.50	-3.75	1.35	1.53	1.27	3.16	

#### 7.4.6 Ocean tidal constituent harmonic parameters grid model files

(1) The ocean tidal height model is composed of multiple grids models of all tidal constituent harmonic parameters. Each tidal constituent harmonic parameters are stored as a vector grid file.

(2) All the tidal constituent grids files from an ocean tidal height model should be in a folder with the same grid specifications.

(3) The 10 vector grid files in the folder C:\ ETideLoad4.0\_win64cn\OceanTide represent the ocean tide model GOT4.8 with 10 global grid models of 10 tidal constituent harmonic parameters.

(4) The type of the tidal constituent is identified by the seventh attribute (Doodson constant) in its grid file header. These files can be named at will.

🚽 M2_got	:4. 8. dat 🔀												
1	0.000000	360.000	0000 -90	.000000	90.000000	0.5000	0000 0.50	0000000	255555				
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

(5) The ocean tidal height model can be global or regional, and the ETideLoad program can be automatically identified. The ocean tidal height and the harmonic parameters are all in cm as unit.

# 7.4.7 The JPL Planetary Ephemeris DE405 file

The JPL Planetary Ephemeris DE405 file JEPH.405 was stored in the folder C:\ETideLoad4.0\_win64en\iers. The ephemeris starts at 0:00 on 9 December 1599 (JD2305424. 5) and ends at 0:00 on 20 February 2201 (JD2525008. 5).

#### 7.4.8 The corrections file of frequency dependence for Love numbers

The corrections file IERS2010T65.dat of frequency dependence was generated from Table 6.5a, 6.5b and 6.5c in IERS Conventions (2010), to calculate the corrections of frequency dependence of geopotential Love numbers to obtain the high-accuracy solid tide effect on the Earth's external geopotential.

### 7.4.9 The Desai ocean pole tide coefficients file

The ocean pole tide is generated by the centrifugal effect of polar motion on the oceans. Desai (2002) presents a self-consistent equilibrium model of the ocean pole tide. This model accounts for continental boundaries, mass conservation over the oceans, self-gravitation, and loading of the ocean floor. Using this model, the ocean pole tide produces the following perturbations to the normalized geopotential coefficients, as a function of the pole shift parameters  $(m_1, m_2)$ .

🗄 ECN	/F2006.d	lat 🗵 📔	🖥 FES2004S1. dat 🗷 🔚 IERSeop	oc04. dat 🗷 🔚 GCN_L1_L2_30d_	CF-CM. txt 🗵 🔚 desaiscopole	coef. txt🛛
1	n	m	Anm(Real)	Bnm(Real)	Anm(Imaginary)	Bnm(Imaginary)
2	1	0	1.8736759805448e-02	0.000000000000e+00	2.9688884960424e-02	0.000000000000e+00
3	1	1	2.8258913146935e-02	2.1774643075236e-02	2.3898264393684e-02	5.6771602236635e-02
4	2	0	-3.9555099024374e-03	0.0000000000000e+00	6.8390464271953e-04	0.000000000000e+00
5	2	1	-2.4325330521304e-01	5.4680741193318e-03	5.4680741193318e-03	-1.9252111185300e-01
6	2	2	1.9102047023374e-02	1.1158297399424e-02	-1.5123770169928e-02	-2.4857839911518e-04
7	3	0	-2.0869478248378e-02	0.0000000000000e+00	-1.0775272844125e-02	0.000000000000e+00
8	3	1	3.0809252024501e-02	7.4552838003486e-03	5.5937937407386e-03	6.6496877724041e-02
9	3	2	2.3295703062692e-02	3.7984356463618e-02	-2.1678456242839e-03	1.1232359168959e-02
10	3	3	7.9776020803848e-03	1.2502542787182e-02	-2.2341399966187e-02	-2.2979590161975e-02
11	4	0	-1.0612668622736e-02	0.0000000000000e+00	-1.5569196271270e-02	0.000000000000e+00
12	4	1	1.3606306893006e-04	2.2051992576636e-03	2.0130037501025e-03	1.6323514549038e-02
13	4	2	1.1139374002795e-02	1.7031544962514e-02	-7.9621127289889e-03	-8.4440848505132e-04
14	4	3	-1.6100794768731e-02	1.4681986705593e-02	9.5178410813713e-03	-2.1017136590507e-02
15	4	4	4.3132021252707e-03	-4.6836271624465e-03	-2.9309550249205e-03	1.3175690530653e-02
16	5	0	7.0731357453056e-03	0.0000000000000e+00	-1.8023029843730e-03	0.000000000000e+00
17	5	1	2.5644907587134e-03	-1.0076857169607e-02	-9.6273922883022e-03	-1.1684145258283e-02
18	5	2	-7.9615162895536e-03	2.0820461332209e-03	-3.0274671879191e-03	-1.0475800274156e-02
19	5	3	-1.1818705609675e-02	1.2063416189422e-02	-1.6584597520384e-02	-2.8253596831795e-02
20	5	4	9.2731253376468e-03	1.8353138561674e-02	-1.0870088052722e-02	4.7120935900411e-03
21	5	5	1.4460712839068e-02	-8.5510747244577e-03	8.9167437380844e-04	1.6048852898081e-02
22	6	0	7.4439256593180e-03	0.0000000000000e+00	-1.0670986469176e-03	0.0000000000000e+00
23	6	1	1.8261459881891e-02	-3.7775168887123e-03	-3.6768761254667e-03	-1.4329108864964e-03
24	6	2	-8.4568708595335e-03	2.5640802224787e-03	8.0976103423504e-03	-6.3983905389798e-03
25	6	3	-1.5355186088842e-02	1.8642889355748e-03	-9.6956523287846e-03	-2.2353328754893e-02
26	6	4	1.4142224508565e-03	-2.2076728030274e-03	-6.1060835758971e-03	1.4301205310949e-02
27	6	5	3.7744391579465e-03	1.6205935938625e-02	-7.4210466275681e-03	-2.8879881476777e-03
28	6	6	3.2420227193323e-03	-1.0204123402364e-03	6.5738366845630e-03	-6.6744309720085e-03
29	7	0	-1.3403793397592e-03	0.00000000000000e+00	-8.9119937331666e-04	0.000000000000e+00
30	7	1	-1.1987665799148e-02	3.7952628984046e-03	3.0548620901213e-03	-2.4656687484472e-02
31	7	2	1.3964996790643e-03	1.7659797083036e-03	-9.6345882913594e-04	5.1931284495957e-04
32	7	3	-1.7567622661385e-02	6.8385783341764e-04	9.3943264784830e-03	4.5672879067042e-03
33	7	4	2.8083751020130e-03	4.6098055178789e-04	-9.4429840592558e-03	2.6160014372180e-03
34	7	5	1.3438573148260e-02	-4.9709663788905e-03	5.4401137615611e-03	1.2610209142217e-02
35	7	6	2.3574978727809e-03	-1.8507773876743e-03	-8.8485482473243e-03	-1.7275571315203e-03
36	7	7	1.7687501823906e-03	-3.8588288830715e-03	5.1311168222451e-03	-3.4729764622333e-03
37	8	0	2.4179833053297e-03	0.000000000000e+00	6.3989330948214e-04	0.000000000000e+00
38	8	1	5.4747795444986e-03	-4.1645492784766e-03	-3.5505342447356e-03	9.2109717009068e-03
39	8	2	-3.5541696851032e-03	-1.0507455458039e-02	-2.8591215118039e-03	-5.7895937048006e-05
40	8	3	-3.6234392832446e-03	5.2650936441460e-03	2.0052526194323e-03	5.9074589159813e-03

The Desai calculating formula of the ocean pole tide adopts the formula (6.23) in the

IERS Convertions (2010), and the 360-degree ocean pole tide coefficients file desaiscopolecoef.txt is stored in the folder C:\ETideLoad4.0\_win64en\iers.

# 7.4.10 The center of mass correction coefficients file for the ocean tide

(1) The center of mass correction formula of ocean tide adopts the formula (1.17) in the IERS Convertions (2010). The object of correction is the three-dimensional coordinates of the ground site in the terrestrial reference frame  $_{\circ}$ 

(2) When different tidal models are used to calculate the tidal load effect on the ground site displacement, the corresponding correction coefficients of ocean tide should be used to calculate the center of mass correction.

(3) There are some center of mass correction coefficients files for common ocean tide models stored in the folder C:\ETideLoad4.0\_ win64en\ CmcOtide. In which, the center of mass correction coefficients for the ocean tide model FES2004:

😑 ECI	[WF200	ô. dat 🗵 🔚 FES2004SI	. dat 🗵 🔚 IERSeopc	04. dat 🗵 🔚 GCI	(_L1_L2_30d_CF-CM. txt 🗵 🔚 desaise	opolecoef.txt 🛛 🔚 FES2004.cmc🖂
1	(a,1	p,t42,3(2x,2e12	.4))			
2	M2	NCDF FES2004	-1.2661E-03	-1.4298E-03	-1.3724E-03 8.2077E-04	1.1479E-03 2.3005E-04
3	<b>S</b> 2	NCDF FES2004	-1.7763E-04	-5.7273E-04	-5.3350E-04 -3.1591E-04	-5.1370E-05 2.8184E-04
4	N2	NCDF FES2004	-3.2372E-04	-2.8986E-04	-2.7121E-04 1.9849E-04	2.6018E-04 -1.4302E-04
5	K2	NCDF FES2004	-1.1814E-04	-1.5250E-04	-1.1223E-04 -1.0889E-05	-1.5751E-05 1.2367E-04
6	К1	NCDF FES2004	-1.1370E-03	4.4839E-03	-1.8539E-03 -8.6426E-04	-9.1022E-04 -1.7823E-03
7	01	NCDF FES2004	-1.6802E-04	2.9702E-03	-1.3985E-03 -2.2975E-04	-8.8858E-04 -6.4989E-04
8	P1	NCDF FES2004	-3.6495E-04	1.4941E-03	-6.1436E-04 -2.9129E-04	-2.9261E-04 -5.7461E-04
9	Q1	NCDF FES2004	3.0709E-05	4.5472E-04	-2.7831E-04 -2.9313E-05	-2.1734E-04 -4.1637E-05
10	Mf	NCDF FES2004	-5.0643E-04	-7.3040E-05	-2.2065E-04 4.1472E-04	-1.0212E-04 8.2276E-05
11	Mm	NCDF FES2004	-2.7885E-04	2.0596E-05	4.6882E-05 1.8399E-04	-7.4897E-06 1.3209E-05
12	Ssa	NCDF FES2004	-1.4899E-04	2.6146E-06	1.3687E-04 3.5475E-05	-2.4093E-05 3.1666E-07
13		-				

# 8 Main Algorithms and Formulas used in ETideLoad4.0

# 8.1 Solid tidal effects on various geodetic quantities outside solid Earth

#### 8.1.1 The tidal generating potentials of celestial bodies

The celestial bodies' tidal direct effects on the Earth's external geopotential can be expressed by the variations of geopotential coefficients in the Earth-fixed coordinate system

$$\Delta \bar{C}_{nm} - i\Delta \bar{S}_{nm} = \frac{1}{2n+1} \sum_{j=2}^{10} \frac{GM_j}{GM} \left(\frac{a}{r_j}\right)^{n+1} \bar{P}_{nm}(\sin\varphi_j) e^{im\lambda_j},\tag{1}$$

where  $j = 2 \sim 10$  represent the moon, sun, Mercury, Venus, Mars, Jupiter, Saturn, Uranus and Neptune.  $\Delta \bar{C}_{nm} - i\Delta \bar{S}_{nm}$  are the variations of the normalize geopotential coefficients with degree *n* and order *m* (with  $\Delta \bar{S}_{n0} = 0$ ),  $\bar{P}_{nm}$  are the normalized associated Legendre functions, n = 2,3 for the moon, and n = 2 for the other celestial bodies.  $GM_j, r_j, \varphi_j, \lambda_j$  are respectively the gravitational parameter, distance from geocenter, geocentric latitude, and longitude (from Greenwich) of the celestial body *j*. GM, a are respectively the geocentric gravitational constant and Equatorial radius of the Earth.

#### 8.1.2 Nominal values of solid Earth tide external geopotentials

The tidal generating potentials cause the deformation of the solid Earth, leading to the re-adjustment of the Earth's mass, resulting in additional external geopotentials, known as the indirect effects of the external geopotential, whose can be quantitatively represented by the geopotential Love numbers.

The solid earth tide effects of geopotential coefficients are equal to the sum of the direct effects and indirect effects of the tidal generating potentials.

For the elastic earth, the Love numbers are independent of the frequency, and such a Love number is called the nominal Love number, as shown in Table 1.

n	т	periods of tidal constituents	$k_{nm}$	$h_{nm}$	$l_{nm}$
2	0	long period	0.29525	0.6078	0.0847
2	1	diurnal	0.29470	0.6078	0.0847
2	2	semi-diurnal	0.29801	0.6078	0.0847
3	0	long period	0.093	0.2920	0.0150
3	1	diurnal	0.093	0.2920	0.0150
3	2	semi-diurnal	0.093	0.2920	0.0150
3	3	1/3-diurnal	0.094	0.2920	0.0150

Table 1 Nominal values of solid Earth tidal external potential Love numbers

(1) Nominal solid tidal effects on geopotential coefficients

$$\Delta \bar{C}_{nm} - i\Delta \bar{S}_{nm} = \frac{1+k_{nm}}{2n+1} \sum_{j=2}^{10} \frac{GM_j}{GM} \left(\frac{a}{r_j}\right)^{n+1} \bar{P}_{nm}(\sin\varphi_j) e^{im\lambda_j},\tag{2}$$

where  $k_{nm}$  are the nominal geopotential love numbers with degree n and order m. (2) Nominal solid tidal effect on beight anomaly/geoid beight

(2) Nominal solid tidal effect on height anomaly/geoid height  

$$\zeta = \frac{GM}{\gamma r} \sum_{n=2}^{3} \left(\frac{a}{r}\right)^{n} \sum_{m=0}^{n} (1 + k_{nm}) (\Delta \bar{C}_{nm} cosm\lambda + \Delta \bar{S}_{nm} sinm\lambda) \bar{P}_{nm}.$$

(3)

(3) Nominal solid tidal effect on ground gravity

$$g_t = \frac{GM}{r^2} \sum_{n=2}^{3} (n+1) \left(\frac{a}{r}\right)^n \sum_{m=0}^{n} \left(1 + \frac{2}{n}h_{nm} - \frac{n+1}{n}k_{nm}\right) (\Delta \bar{C}_{nm} cosm\lambda + \Delta \bar{S}_{nm} sinm\lambda) \bar{P}_{nm},$$
(4)

- (4) Nominal solid tidal effect on gravity disturbance  $\delta g = \frac{GM}{r^2} \sum_{n=2}^{3} (n+1) \left(\frac{a}{r}\right)^n \sum_{m=0}^n (1+k_{nm}) (\Delta \bar{C}_{nm} cosm\lambda + \Delta \bar{S}_{nm} sinm\lambda) \bar{P}_{nm}.$ (5)
- (5) Nominal solid tidal effects on ground tilt

South: 
$$\xi^{s} = \frac{GM}{\gamma r^{2}} \sin \theta \sum_{n=2}^{3} \left(\frac{a}{r}\right)^{n} \sum_{m=0}^{n} (1 + k_{nm} - h_{nm}) (\Delta \bar{C}_{nm} \cos m\lambda + \Delta \bar{S}_{nm} \sin m\lambda) \frac{\partial}{\partial \theta} \bar{P}_{nm}$$
(6)

West: 
$$\eta^{s} = \frac{_{GM}}{_{\gamma r^{2} sin \, \theta}} \sum_{n=2}^{3} \left(\frac{a}{r}\right)^{n} \sum_{m=1}^{n} (1 + k_{nm} - h_{nm}) m (\Delta \bar{C}_{nm} sinm\lambda - \Delta \bar{S}_{nm} cosm\lambda) \bar{P}_{nm}.$$
(7)

(6) Nominal solid tidal effects on vertical deflection

South: 
$$\xi = \frac{GM}{\gamma r^2} \sin \theta \sum_{n=2}^{3} \left(\frac{a}{r}\right)^n \sum_{m=0}^{n} (1+k_{nm}) (\Delta \bar{C}_{nm} \cos n\lambda + \Delta \bar{S}_{nm} \sin n\lambda) \frac{\partial}{\partial \theta} \bar{P}_{nm}.$$
 (8)

West: 
$$\eta = \frac{GM}{\gamma r^2 \sin \theta} \sum_{n=2}^{3} \left(\frac{a}{r}\right)^n \sum_{m=1}^n (1 + k_{nm}) m (\Delta \bar{C}_{nm} \sin n\lambda - \Delta \bar{S}_{nm} \cos n\lambda) \bar{P}_{nm}.$$
 (9)  
(7) Nominal solid tidal effects on ground site displacement (•)

East:  $e = -\frac{GM}{m^2 \sin a} \sum_{n=2}^{3} \left(\frac{a}{r}\right)^n \sum_{m=0}^n l_{nm} m(\Delta \bar{C}_{nm} sinm\lambda - \Delta \bar{S}_{nm} cosm\lambda) \bar{P}_{nm}.$  (10)

North: 
$$n = -\frac{GM}{\gamma r^2} \sin \theta \sum_{n=2}^{3} \left(\frac{a}{r}\right)^n \sum_{m=0}^{n} l_{nm} (\Delta \bar{C}_{nm} \cos m\lambda + \Delta \bar{S}_{nm} \sin m\lambda) \frac{\partial}{\partial \theta} \bar{P}_{nm}.$$
 (11)

Radial: 
$$r = \frac{GM}{\gamma r} \sum_{n=2}^{3} \left(\frac{a}{r}\right)^n \sum_{m=0}^n h_{nm} (\Delta \bar{C}_{nm} cosm\lambda + \Delta \bar{S}_{nm} sinm\lambda) \bar{P}_{nm}.$$
 (12)

(8) Nominal solid tidal effect on disturbing gravity gradient  

$$T_{nn} = -\frac{GM}{r^3} \sum_{n=2}^{3} (n+1)(n+2) \left(\frac{a}{r}\right)^n \sum_{m=0}^n (1+k_{nm}) (\Delta \bar{C}_{nm} cosm\lambda + \Delta \bar{S}_{nm} sinm\lambda) \bar{P}_{nm}.$$
(13)

(9) Nominal solid tidal effect on horizontal gravity gradient  
North: 
$$T_{\varphi\varphi} = -\frac{GM}{r^3} \sum_{n=2}^{3} \left(\frac{a}{r}\right)^n \sum_{m=0}^{n} (1+k_{nm}) (\Delta \bar{C}_{nm} cosm\lambda + \Delta \bar{S}_{nm} sinm\lambda) \frac{\partial^2}{\partial \theta^2} \bar{P}_{nm}.$$
 (14)

East: 
$$T_{\lambda\lambda} = -\frac{_{GM}}{_{r^3cos^2\varphi}} \sum_{n=2}^{3} \left(\frac{a}{r}\right)^n \sum_{m=1}^n (1+k_{nm}) m^2 (\Delta \bar{C}_{nm} sinm\lambda + \Delta \bar{S}_{nm} cosm\lambda) \bar{P}_{nm}.$$
(15)

The geodetic quantities above marked with  $\odot$  are valid only when the sites are fixed to the solid Earth. The other geodetic quantities can be on ground or outside the solid Earth.

#### 8.1.3 The frequency dependent corrections to geopotential coefficients

In order to represent the variations of geopotential coefficients caused by the external geopotentials of the anelastic Earth, three forms of the geopotential Love numbers are needed, namely  $k_{nm}^{(0)}, k_{nm}^{(\pm)}$  (n > 2), and here  $k_{2m}^{(-)} = 0$  due to the mass conservation of the deformation Earth, as shown in Table 2.

n	т	periods of tidal	Elasti	c Earth	Anelastic Earth			
n	т	constituents	k <sub>nm</sub>	$k_{nm}^{(+)}$	$Re(k_{nm})$	$\operatorname{Im}(k_{nm})$	$k_{nm}^{(+)}$	
2	0	long period	0.29525	-0.00087	0.30190	-0.00000	-0.00089	
2	1	diurnal	0.29470	-0.00079	0.29830	-0.00144	-0.00080	
2	2	semi-diurnal	0.29801	-0.00057	0.30102	-0.00130	-0.00057	
3	0	long period	0.093					
3	1	diurnal	0.093					
3	2	semi-diurnal	0.093					
3	3	1/3-diurnal	0.094					

Table 2 The frequency dependent of external potential Love numbers

The viscous nature of the mantle causes a delay in the response of the Earth's external potential, so that the Love number k varies with frequency, and  $k_{nm}^{(0)}$  and  $k_{2m}^{(+)}$  have small imaginary parts. The following two steps are usually used to deal with the variations of geopotential coefficients caused by additional external geopotentials.

(1) Using of the geopotential Love numbers  $k_{2m}^{(+)}$ , (m = 0,1,2) with the frequency dependent, compute the variations of degree 4 geopotential coefficients from the degree 2 geopotential

$$\Delta \bar{C}_{4m} - i\Delta \bar{S}_{4m} = \frac{k_{2m}^{(+)}}{5} \sum_{j=2}^{10} \frac{GM_j}{GM} \left(\frac{a}{r_j}\right)^3 \bar{P}_{2m}(\sin\varphi_j) e^{im\lambda_j}.$$
(16)

(2) Using the frequency dependent corrections  $\delta k_{2m}^{(0)} = k_{2m}^{(0)} - k_{2m}$  for degree 2 Love numbers, compute the corrections of degree 2 geopotential coefficients. The corrections involve the contributions of 71 tidal constituents including the long period, diurnal and semidiurnal tidal constituents to the imaginary parts of the geopotential Love numbers.

#### 8.1.4 The solid Earth tidal effects on ground site displacement

The tidal generating potentials' indirect effects on the site displacement can be quantitatively represented by the displacement Love numbers. For the viscoelastic Earth, the displacement Love numbers depend on both station latitude and tidal frequency. The solid Earth tidal effects on ground site displacement are usually computed in two steps.

(1) Using the Nominal displacement Love numbers  $h_{2m}^{(0)}$ ,  $l_{2m}^{(0)}$  (m = 0,1,2), compute the indirect effects of the degree 2 and 3 tidal generating potentials on site displacement by formula (10) ~ (12).

(2) Considering the deviation between the frequency-dependent degree 2 displacement Love numbers and their nominal value, compute the corrections to results of step 1. The corrections involve the contributions of all tidal constituents to the imaginary parts of the displacement Love numbers.

#### 8.2 Earth pole shift effects on various geodetic quantities outside solid Earth

The Earth pole shift parameters  $(m_1, m_2)$  can be accurately measured by the space geodetic method. In modern geodesy, the pole shift parameters are expressed by the non-tidal variations of geopotential coefficient  $(\Delta \bar{C}_{21}, \Delta \bar{S}_{21})$  after removing the effects of the solid Earth tide and load tide.

#### 8.2.1 The pole shift effect on the external geopotential

The pole shift effect on the external geopotential is caused by the centrifugal effect of the pole shift, the pole shift effect is non-tidal. The direct effect  $\Delta V$  of the pole shift on the external geopotential can be expressed as

$$\Delta V = -\frac{\omega^{2}r^{2}}{2}\sin 2\theta Re[(m_{1} - im_{2})(\cos\lambda + i\sin\lambda)], \qquad (1)$$

where  $r, \theta, \lambda$  are respectively the distance from geocenter, geocentric co-latitude, and longitude of the calculated point,  $\omega$  is the angular velocity of the Earth's rotation.

The pole shift causes the solid earth to deform, resulting in the additional geopotential, that is, the indirect effect  $V^a$  of the pole shift on the external geopotential, which can be quantitatively represented by the degree 2 Love number  $k_2$ 

$$V^{a} = k_{2}\Delta V = -\frac{\omega^{2}r^{2}}{2}sin2\theta Re[k_{2}(m_{1} - im_{2})(cos\lambda + isin\lambda)].$$
(2)

The total effect  $V_t$  of the pole shift on the external geopotential is equal to the sum of its direct and indirect effects

$$V_{t} = (1 + k_{2})\Delta V = -\frac{\omega^{2}r^{2}}{2}sin2\theta Re[(1 + k_{2})(m_{1} - im_{2})(cos\lambda + isin\lambda)]$$
  
=  $-\frac{\omega^{2}r^{2}}{2}sin2\theta Re\{(1 + k_{2})[(m_{1}cos\lambda + m_{2}sin\lambda) + i(m_{1}sin\lambda - m_{2}cos\lambda)]\}.$  (3)

#### 8.2.2 The pole shift effects on height anomaly/geoid

Given the degree 2 Love numbers,  $k_2 = 0.3077 + 0.0036i$ ,  $h_2 = 0.6207$ ,  $l_2 = 0.0836$ , the pole shift effects on various physical and geometric geodetic quantities on the ground and outside the solid Earth can be calculated.

$$\begin{aligned} \zeta_t &= \frac{1+k_2}{\gamma} \Delta V = -\frac{\omega^2 r^2}{2\gamma} sin2\theta Re[(1+k_2)(m_1 cos\lambda + m_2 sin\lambda) + i(m_1 sin\lambda - m_2 cos\lambda)] \\ &= -\frac{\omega^2 r^2}{2\gamma} sin2\theta Re\{(1.3077 + 0.0036i)[(m_1 cos\lambda + m_2 sin\lambda) + i(m_1 sin\lambda - m_2 cos\lambda)]\} \\ &= -\frac{\omega^2 r^2}{2\gamma} sin2\theta [(1.3077m_1 + 0.0036m_2)cos\lambda + (1.3077m_2 - 0.0036m_1)sin\lambda], \end{aligned}$$

where  $\gamma$  is the normal gravity on the calculated point.

8.2.3 The pole shift effect on ground gravity   

$$g_{t} = -\frac{\left(1+h_{2}-\frac{3}{2}k_{2}\right)\partial\Delta V}{\partial r} = \omega^{2}rsin2\theta Re\left[\left(1+h_{2}-\frac{3}{2}k_{2}\right)(m_{1}-im_{2})(cos\lambda+isin\lambda)\right]$$

$$= \omega^{2}rsin2\theta Re\{(1.15915-0.0054i)[(m_{1}cos\lambda+m_{2}sin\lambda)+i(m_{1}sin\lambda-m_{2}cos\lambda)]\}$$

$$= \omega^{2}rsin2\theta[(1.15915m_{1}-0.0054m_{2})cos\lambda+(1.15915m_{2}+0.0054m_{1})sin\lambda].$$
(5)

#### 8.2.4 The pole shift effect on gravity disturbance

$$\delta g_t = -(1+k_2)\frac{\partial\Delta V}{\partial r} = \omega^2 r sin 2\theta Re[(1+k_2)(m_1 - im_2)(cos\lambda + isin\lambda)] = -\frac{2\gamma}{r}\zeta_t$$
  
=  $\omega^2 r sin 2\theta [(1.3077m_1 + 0.0036m_2)cos\lambda + (1.3077m_2 - 0.0036m_1)sin\lambda].$  (6)

# 8.2.5 The pole shift effects on ground tilt •

South: 
$$\xi_t^s = (1 + k_2 - h_2) \frac{\partial \Delta V}{\gamma r \partial \theta} = -\frac{\omega^2 r}{\gamma} cos 2\theta Re[(1 + k_2 - h_2)(m_1 - im_2)(cos\lambda + isin\lambda)]$$
  
 $= -\frac{\omega^2 r}{\gamma} cos 2\theta [(0.687m_1 + 0.0036m_2)cos\lambda + (0.687m_2 - 0.0036m_1)sin\lambda].$  (7)  
West:  $\eta_t^s = (1 + k_2 - h_2) \frac{\partial \Delta V}{\gamma rsin\theta \partial \lambda} = \frac{\omega^2 r}{\gamma} cos \theta Re[(1 + k_2 - h_2)(m_1 - im_2)(sin\lambda - icos\lambda)]$   
 $= \frac{\omega^2 r}{\gamma} cos \theta Re\{(0.687 + 0.0036i)[(m_1 sin\lambda + m_2 cos\lambda) - i(m_1 cos\lambda + m_2 sin\lambda)]\}$   
 $= \frac{\omega^2 r}{\gamma} cos \theta [(0.687m_1 + 0.0036m_2)sin\lambda + (0.0036m_1 + 0.687m_2)cos\lambda].$  (8)

# 8.2.6 The pole shift effects on vertical deflection

South: 
$$\xi_t = \frac{(1+k_2)\partial\Delta V}{\gamma r\partial\theta} = \frac{-\omega^2 r}{\gamma} cos2\theta [(1+k_2)(m_1 - im_2)(cos\lambda + isin\lambda)] = \frac{2\zeta_t}{r} ctg2\theta$$
. (9)  
West:  $\eta_t = (1+k_2)\frac{\partial\Delta V}{\gamma rsin\theta\partial\lambda} = \frac{\omega^2 r}{\gamma} cos\theta Re[(1+k_2)(m_1 - im_2)(sin\lambda - icos\lambda)]$   
 $= \frac{\omega^2 r}{\gamma} cos\theta [(1.3077m_1 + 0.0036m_2)sin\lambda + (0.0036m_1 + 1.3077m_2)cos\lambda].$  (10)

# 8.2.7 The pole shift effects on ground site displacement •

East: 
$$e = \frac{l_2 \partial \Delta V}{\gamma \sin \theta \partial \lambda} = l_2 \frac{\omega^2 r^2}{\gamma} \cos \theta Re[(m_1 - im_2)(\sin \lambda - i\cos \lambda)]$$
  
=  $0.0836 \frac{\omega^2 r^2}{\gamma} \cos \theta (m_1 \sin \lambda - m_2 \cos \lambda).$  (11)

North: 
$$n = -\frac{l_2 \partial \Delta V}{\gamma \partial \theta} = -l_2 \frac{\omega^2 r^2}{\gamma} cos 2\theta Re[(m_1 - im_2)(cos\lambda + isin\lambda)]$$
  
=  $-0.0836 \frac{\omega^2 r^2}{\gamma} cos 2\theta (m_1 cos\lambda + m_2 sin\lambda).$  (12)

Radial: 
$$r = \frac{h_2 \Delta V}{\gamma} = -0.6207 \frac{\omega^2 r^2}{2\gamma} sin 2\theta (m_1 cos \lambda + m_2 sin \lambda).$$
 (13)

# 8.2.8 The pole shift effect on disturbing gravity gradient

$$T_{nn} = -\frac{(1+k_2)\partial^2 \Delta V}{\partial r^2} = \omega^2 \sin 2\theta Re[(1+k_2)(m_1 - im_2)(\cos \lambda + i\sin \lambda)] = \frac{\delta g_t}{r}$$
  
=  $\omega^2 \sin 2\theta [(1.3077m_1 + 0.0036m_2)\cos \lambda + (1.3077m_2 - 0.0036m_1)\sin \lambda].$  (14)

#### 8.2.9 The pole shift effects on horizontal gravity gradient

North: 
$$T_{\varphi\varphi} = -T_{\theta\theta} = -(1+k_2)\omega^2 sin2\theta[(m_1 - im_2)(cos\lambda + isin\lambda)]$$
  
 $= -\omega^2 sin2\theta[(1.3077m_1 + 0.0036m_2)cos\lambda + (1.3077m_2 - 0.0036m_1)sin\lambda].$  (15)  
East:  $T_{\lambda\lambda} = \frac{(1+k_2)\partial^2 \Delta V}{r^2 sin^2 \theta \partial \lambda^2} = (1+k_2)\omega^2 ctg\theta[(m_1 - im_2)(cos\lambda + isin\lambda)]$   
 $= 2T_{nn}cos^2\theta = -2T_{\varphi\varphi}cos^2\theta = 2\frac{\delta g_t}{r}cos^2\theta.$  (16)

The geodetic quantities above marked with  $\odot$  are valid only when the sites are fixed to the solid Earth. The other geodetic quantities can be on the ground or outside the solid Earth.

The pole shift is the polar location shift of the instantaneous relative to a certain reference epoch (such as the epoch J2000.0) after removing all the solid Earth tidal and loading tidal effects. Both the pole shift and geocentric movement do not include various

tidal effects. Non-tidal effects are difficult to be modeled and are generally measured using geodetic techniques. In most fast or real-time geodetic applications, short-time forecast estimations are adopted.

The Earth orientation parameters product EOP\_C04 recommended by the IERS Conventions (2010), has not removed the annual and semi-annual tidal effects of the atmospheric load. Therefore, the Earth pole shift parameters  $(m_1, m_2)$  calculated by the product EOP\_C04 obviously contain annual and semi-annual components.

#### 8.3 Spherical harmonic synthesis on load deformation field

# 8.3.1 The surface loads and the effects on geopotential coefficients

In the Earth surface system, surface non-tidal load variations such as soil and vegetation water, lake water, glacier and snow, groundwater, atmosphere, and sea level variations can be uniformly expressed by variations of the surface equivalent water height. The equivalent water height variation  $h_w$  at the surface point  $(R, \theta, \lambda)$  can be expressed as a load normalized spherical harmonic series

$$h_{w}(R,\theta,\lambda) = R \sum_{n=1}^{\infty} \sum_{m=0}^{n} [\Delta C_{nm}^{w} cosm\lambda + \Delta S_{nm}^{w} sinm\lambda] \bar{P}_{nm}(cos\theta),$$
(1)

where *R* is the mean radius of the Earth,  $\Delta C_{nm}^w, \Delta S_{nm}^w$  are the load normalized spherical harmonic coefficients with degree *n* and order *m*,  $\overline{P}_{nm}(t = \cos\theta) = \overline{P}_{nm}$  are the normalized associated Legendre functions with degree *n* and order *m*.

The variations of global surface equivalent water height directly cause the variations of the surface geopotential

$$\Phi^{d}(R,\theta,\lambda) = \sum_{n=1}^{\infty} \frac{4\pi G \rho_{w} R^{2}}{2n+1} \sum_{m=0}^{n} [\Delta C_{nm}^{w} cosm\lambda + \Delta S_{nm}^{w} sinm\lambda] \bar{P}_{nm},$$
(2)

where G is the Newtonian gravitational constant,  $\rho_w$  is the density of the water.

According to the theory of the earth's gravity field, the variations of the surface geopotential  $\Phi^d$  can also be expressed by the variations of the geopotential coefficients  $(\Delta \bar{C}_{nm}, \Delta \bar{S}_{nm})$  as

$$\Phi^{d} = \frac{_{GM}}{_{R}} \sum_{n=1}^{\infty} \sum_{m=0}^{\infty} (\Delta \bar{C}_{nm} cosm\lambda + \Delta \bar{S}_{nm} sinm\lambda) \bar{P}_{nm} (cos\theta).$$
(3)

Comparing the formulas (2) and (3), we have

$$\Delta \bar{C}_{nm} = \frac{4\pi R^3}{M} \frac{\rho_w}{2n+1} \ \Delta C_{nm}^w = \frac{4\pi R^3}{\rho_e V} \frac{\rho_w}{2n+1} \ \Delta C_{nm}^w = \frac{4\pi R^3}{4\pi R^3 \rho_e/3} \frac{\rho_w}{2n+1} \ \Delta C_{nm}^w = \frac{3}{2n+1} \frac{\rho_w}{\rho_e} \ \Delta C_{nm}^w,$$
  
similarly, we have  $\Delta \bar{S}_{nm} = \frac{3}{2n+1} \frac{\rho_w}{\rho_e} \ \Delta S_{nm}^w.$  (4)

Where  $\rho_e, M, V$  are the mean density, total mass, and total volume of the Earth, respectively.

The surface load effects on various geodetic quantities on the ground or outside the solid Earth can also be expressed by the variations of the geopotential coefficients  $(\Delta \bar{C}_{nm}, \Delta \bar{S}_{nm})$ .

#### 8.3.2 The surface load effect on height anomaly/geoid

$$\zeta = \frac{_{GM}}{_{\gamma r}} \sum_{n=2}^{\infty} \left(\frac{a}{r}\right)^n (1 + k'_n) \sum_{m=0}^n (\Delta \bar{C}_{nm} cosm\lambda + \Delta \bar{S}_{nm} sinm\lambda) \bar{P}_{nm}.$$
(5)

#### 8.3.3 The surface load effect on ground gravity •

$$g_t = \frac{GM}{r^2} \sum_{n=2}^{\infty} (n+1) \left( 1 + \frac{2}{n} h'_n - \frac{n+1}{n} k'_n \right) \left( \frac{a}{r} \right)^n \sum_{m=0}^n (\Delta \bar{C}_{nm} cosm\lambda + \Delta \bar{S}_{nm} sinm\lambda) \bar{P}_{nm}.$$
 (6)

# 8.3.4 The surface load effect on gravity disturbance

$$\delta g = \frac{GM}{r^2} \sum_{n=2}^{\infty} (n+1)(1+k'_n) \left(\frac{a}{r}\right)^n \sum_{m=0}^n (\Delta \bar{C}_{nm} cosm\lambda + \Delta \bar{S}_{nm} sinm\lambda) \bar{P}_{nm}.$$
(7)

# 8.3.5 The surface load effects on ground tilt

South: 
$$\xi^{s} = \frac{GM}{\gamma r^{2}} \sin \theta \sum_{n=2}^{\infty} (1 + k_{n}' - h_{n}') \left(\frac{a}{r}\right)^{n} \sum_{m=0}^{n} (\Delta \bar{C}_{nm} \cos m\lambda + \Delta \bar{S}_{nm} \sin m\lambda) \frac{\partial}{\partial \theta} \bar{P}_{nm}.$$
(8)

West: 
$$\eta^{s} = \frac{GM}{\gamma r^{2} \sin \theta} \sum_{n=2}^{\infty} (1 + k_{n}' - h_{n}') \left(\frac{a}{r}\right)^{n} \sum_{m=1}^{n} m (\Delta \bar{C}_{nm} sinm\lambda - \Delta \bar{S}_{nm} cosm\lambda) \bar{P}_{nm}.$$
(9)

# 8.3.6 The surface load effects on vertical deflection

South: 
$$\xi = \frac{GM}{\gamma r^2} \sin \theta \sum_{n=2}^{\infty} (1 + k'_n) \left(\frac{a}{r}\right)^n \sum_{m=0}^n (\Delta \bar{C}_{nm} \cos m\lambda + \Delta \bar{S}_{nm} \sin m\lambda) \frac{\partial}{\partial \theta} \bar{P}_{nm}.$$
 (10)

West: 
$$\eta = \frac{GM}{\gamma r^2 \sin \theta} \sum_{n=2}^{\infty} (1 + k'_n) \left(\frac{a}{r}\right)^n \sum_{m=1}^n m(\Delta \bar{C}_{nm} sinm\lambda - \Delta \bar{S}_{nm} cosm\lambda) \bar{P}_{nm}.$$
 (11)

# 8.3.7 The surface load effects on ground site displacement •

East: 
$$e = -\frac{GM}{\gamma r^2 \sin \theta} \sum_{n=2}^{\infty} l'_n \left(\frac{a}{r}\right)^n \sum_{m=1}^n m(\Delta \bar{C}_{nm} sinm\lambda - \Delta \bar{S}_{nm} cosm\lambda) \bar{P}_{nm}.$$
 (12)

North: 
$$n = -\frac{GM}{\gamma r^2} \sin \theta \sum_{n=2}^{\infty} l'_n \left(\frac{a}{r}\right)^n \sum_{m=0}^n (\Delta \bar{C}_{nm} \cos m\lambda + \Delta \bar{S}_{nm} \sin m\lambda) \frac{\partial}{\partial \theta} \bar{P}_{nm}.$$
 (13)

Radial: 
$$r = \frac{GM}{\gamma r} \sum_{n=2}^{\infty} \left(\frac{a}{r}\right)^n h'_n \sum_{m=0}^n (\Delta \bar{C}_{nm} cosm\lambda + \Delta \bar{S}_{nm} sinm\lambda) \bar{P}_{nm}.$$
 (14)

### 8.3.8 The surface load effect on disturbing gravity gradient

$$T_{nn} = -\frac{GM}{r^3} \sum_{n=2}^{\infty} (n+1)(n+2)(1+k'_n) \left(\frac{a}{r}\right)^n \sum_{m=0}^n (\Delta \bar{C}_{nm} cosm\lambda + \Delta \bar{S}_{nm} sinm\lambda) \bar{P}_{nm}.$$
(15)

# 8.3.9 The surface load effects on horizontal gravity gradient

North: 
$$T_{\varphi\varphi} = -\frac{GM}{r^3} \sum_{n=2}^{\infty} (1 + k'_n) \left(\frac{a}{r}\right)^n$$
  
 $\sum_{m=0}^n (\Delta \bar{C}_{nm} cosm\lambda + \Delta \bar{S}_{nm} sinm\lambda) \frac{\partial^2}{\partial \theta^2} \bar{P}_{nm}.$  (16)

East: 
$$T_{\lambda\lambda} = -\frac{GM}{r^3 cos^2 \varphi} \sum_{n=2}^{\infty} (1+k'_n) \left(\frac{a}{r}\right)^n \sum_{m=1}^n (1+k_{nm}) m^2 (\Delta \bar{C}_{nm} sinm\lambda + \Delta \bar{S}_{nm} cosm\lambda) \bar{P}_{nm}.$$
 (17)

The geodetic quantities above marked with  $\odot$  are valid only when the sites are fixed to the solid Earth. The other geodetic quantities can be on the ground or outside the solid Earth.

In the Formulas (5) ~ (17),  $h'_n$ ,  $l'_n$ ,  $k'_n$  are the radial displacement, horizontal displacement and geopotential load Love numbers, respectively.

#### 8.4 Surface load effects on various geodetic quantities by Green's Integral

#### 8.4.1 The Integral formulas of the direct effects of surface loads

(1) The integral formula of the direct effect on geopotential of surface loads

Given the surface load equivalent water heights  $h_w$ , whose direct effect  $V_w$  on the geopotential near Earth space directly given by the universal gravitation formula

$$V_{w} = G\rho_{w} \int_{S} \frac{h_{w}}{L} dS, \quad L = \sqrt{r^{2} + r'^{2} - 2rr' \cos\psi},$$
(1)

where *L* is the spatial distance between the calculated point  $(r, \theta, \lambda)$  near Earth space and the center  $(r', \theta', \lambda')$  of integral area element on the surface,  $r, \theta, \lambda$  are the spherical geocentric coordinates of the calculated point, namely distance from geocenter, co-latitude and longitude, respectively. *G* is Newton's gravitational constant,  $\rho_w = 1000 kg/m^3$  is the water density.  $\psi$  is the spherical angle between the calculated point  $(r, \theta, \lambda)$  and the center  $(r', \theta', \lambda')$  of the area element.

$$cos\psi = cos\theta cos\theta' + sin\theta sin\theta' cos(\lambda' - \lambda), \quad sin\psi = sin\theta cos\theta' + cos\theta sin\theta' cos(\lambda' - \lambda), (2)$$
  

$$sin\psi cos\alpha = sin\theta cos\theta' - cos\theta sin\theta' cos(\lambda' - \lambda), \quad sin\psi sin\alpha = sin\theta' sin(\lambda' - \lambda), \quad (3)$$

$$\frac{\partial\psi}{\partial\theta} = -\frac{\partial\psi}{\partial\varphi} = \cos\alpha, \quad \frac{\partial\psi}{\partial\lambda} = -\sin\alpha\sin\theta. \tag{4}$$

When the calculated point is located on the surface and overlaps with the center of integral area element, we have

$$L = r\psi, \ r - r'\cos\psi = r\psi^2/2, \tag{5}$$

$$A = dS = r^2 \int_{\alpha=0}^{2\pi} \int_0^{\psi_0} \psi d\psi d\alpha = \pi r^2 \psi_0^2 \to \psi_0 = \frac{1}{r} \sqrt{\frac{A}{\pi}},$$
(6)

here A = dS is the area of integral area element. In this case, the formula (1) on the calculated point is an integral singularity

$$V_{0} = G\rho_{w}r^{2}\int_{\alpha=0}^{2\pi}\int_{0}^{\psi_{0}}\frac{h_{w}}{r\psi}\psi d\psi d\alpha = 2\pi G\rho_{w}h_{w}r\psi_{0}.$$
(7)

(2) The integral formula of the direct effect on gravity disturbance of surface loads According to the definition of gravity disturbance, we have

$$\delta g = -\frac{\partial V_w}{\partial r} = -G\rho_w \int_S h_w \frac{\partial}{\partial r} \left(\frac{1}{L}\right) dS = G\rho_w \int_S h_w \frac{r - r' \cos\psi}{L^3} dS.$$
(8)

When the calculated point is located on the surface and overlaps with the center of integral area element, the formula (8) on the calculated point is an integral singularity

$$\delta g_0 = 2\pi G \rho_w h_w \int_0^{\psi_0} \frac{\psi^2/2}{\psi^3} \psi d\psi = \pi G \rho_w h_w \psi_0.$$
(9)

(3) The integral formula of the direct effect on vertical deflection of surface loads

$$\Theta = \frac{1}{\gamma r} \frac{\partial V_w}{\partial \psi} = \frac{G\rho_w}{\gamma r} \int_S h_w \frac{\partial}{\partial \psi} \left(\frac{1}{L}\right) dS = -\frac{G\rho_w}{\gamma} \int_S h_w r' \frac{\sin\psi}{L^3} dS,$$
(10)

$$\xi = \Theta \frac{\partial \psi}{\partial \theta} = -\frac{G\rho_w}{\gamma} \int_S h_w r' \frac{\sin\psi}{L^3} \cos\alpha dS, \quad \eta = -\Theta \frac{\partial \psi}{\partial \lambda} = -\frac{G\rho_w}{\gamma} \sin\theta \int_S h_w r' \frac{\sin\psi}{L^3} \sin\alpha dS.$$
(11)

Where  $\gamma$  is the normal gravity on the calculated point.

(4) The integral formula of the direct effect on disturbing gravity gradient of surface loads According to the definition of disturbing gravity gradient, we have

$$T_{nn} = -T_{rr} = -\frac{\partial^2 V_w}{\partial r^2} = G\rho_w \int_S h_w \frac{\partial}{\partial r} \left(\frac{r-r'\cos\psi}{L^3}\right) dS = G\rho_w \int_S h_w \left[\frac{1}{L^3} - \frac{3(r-r'\cos\psi)^2}{L^5}\right] dS, (12)$$
$$\frac{\partial}{\partial r} \left(\frac{r-r'\cos\psi}{L^3}\right) = \frac{1}{L^3} - \frac{3(r-r'\cos\psi)}{L^4} \frac{\partial}{\partial r} L = \frac{1}{L^3} - \frac{3(r-r'\cos\psi)^2}{L^5}, \quad \frac{\partial}{\partial r} L = \frac{r-r'\cos\psi}{L}.$$

When the calculated point is located on the surface and overlaps with the center of

integral area element, the formula (12) on the calculated point is an integral singularity

$$T_{nn}^{0} = 2\pi G \rho_{w} h_{w} r^{2} \int_{0}^{\psi_{0}} \left(\frac{1}{r^{3} \psi^{3}} - \frac{3\psi^{4}}{4r^{3} \psi^{5}}\right) \psi d\psi = \frac{2\pi G \rho_{w} h_{w}}{r} \int_{0}^{\psi_{0}} \left(\frac{1}{\psi^{2}} - \frac{3}{4}\right) d\psi \approx -\frac{\pi G \rho_{w} h_{w}}{r \psi_{0}^{2}}.$$
(?)(13)

(5) The integral formula of the direct effect on horizontal gravity gradient of surface loads

$$\Gamma = \frac{\partial^2 V_W}{r^2 \partial \psi^2} = -\frac{G\rho_W}{r} \int_S h_W r' \frac{\partial}{\partial \psi} \left(\frac{\sin\psi}{L^3}\right) dS = -\frac{G\rho_W}{r} \int_S h_W r' \left(\frac{\cos\psi}{L^3} - \frac{3rr'\sin^2\psi}{L^5}\right) dS, \tag{14}$$

$$T_{\varphi\varphi} = -\Gamma \frac{d^2\psi}{d\theta^2} = \frac{G\rho_w}{r} \int_S h_w r' \left(\frac{\cos\psi}{L^3} - \frac{3rr'\sin^2\psi}{L^5}\right) ctg\psi(1 - \cos\alpha)dS, \tag{15}$$

$$T_{\lambda\lambda} = \Gamma \frac{\partial^2 \psi}{\partial \lambda^2} = \frac{G \rho_W}{r} \int_S h_W r' \left( \frac{\cos\psi}{L^3} - \frac{3rr'\sin^2\psi}{L^5} \right) \left[ ctg\psi - ctg\psi (sin\theta sin\alpha)^2 - \frac{\cos\theta cos\theta'}{sin\psi} \right] dS, \quad (16)$$

$$\frac{\partial^2 \psi}{\partial \theta^2} = \frac{\partial}{\partial \theta} \cos\alpha = \frac{\partial}{\partial \theta} \frac{\sin\theta \cos\theta - \cos\theta \sin\theta \cos(\lambda^2 - \lambda)}{\sin\psi} = ctg\psi(1 - \cos^2\alpha), \tag{17}$$

$$\frac{\partial^{2}\psi}{\partial\lambda^{2}} = -\sin\theta \frac{\partial}{\partial\lambda}\sin\alpha = -\sin\theta\sin\theta' \frac{\partial}{\partial\lambda}\frac{\sin(\lambda'-\lambda)}{\sin\psi} = \sin\theta\sin\theta' \left[\frac{\cos(\lambda'-\lambda)}{\sin\psi} - \frac{\sin(\lambda'-\lambda)\cos\psi}{\sin^{2}\psi}\sin\alpha\sin\theta\right] \\ = \frac{\cos\psi-\cos\theta\cos\theta'}{\sin\psi} - \frac{\cos\psi}{\sin\psi}(\sin\theta\sin\alpha)^{2} = (1 - \sin^{2}\theta\sin^{2}\alpha)ctg\psi - \frac{\cos\theta\cos\theta'}{\sin\psi}.$$
 (18)

#### 8.4.2 Green's functions formula of the indirect effects of surface loads

The effects of unit point-mass load  $q_w = \rho_w h_w (kg/m^2)$  on various ground geodetic quantities can be expressed by load Green's function. Let  $t = cos\psi$ ,  $k'_n, h'_n, l'_n$  represent the load love numbers of geopotential, ground radial displacement, and horizontal displacement, respectively. The Green's functions algorithm formula of the load indirect effects on various ground geodetic quantities are given in following.

(1) Green's function of the indirect effect on ground geopotential / height anomaly 
$$(G_i^V/G_i^\zeta)$$

$$G_{i}^{V}(\psi) = \gamma G_{i}^{\zeta}(\psi) = \frac{a\gamma}{M} \frac{k_{\infty}'}{2sin\frac{\psi}{2}} + \frac{a\gamma}{M} \sum_{n=0}^{\infty} (k_{n}' - k_{\infty}') P_{n}(t),$$
(19)

where *M* is the total mass of the Earth, *a* is the Equatorial radius of the Earth, and  $P_n(t)$  is *n* degree Legendre function with *t* as its independent variable.

(2) Green's function of the indirect effect on ground gravity

$$G_i^g(\psi) = -\frac{\gamma}{M} \frac{k'_{\infty} - 2h'_{\infty}}{2sin\frac{\psi}{2}} - \frac{\gamma}{M} \sum_{n=0}^{\infty} [(n+1)k'_n - k'_{\infty} - 2(h'_n - h'_{\infty})]P_n(t).$$
(20)

(3) Green's function of the indirect effect on gravity disturbance

$$G_i^{\delta g}(\psi) = -\frac{\gamma}{M} \frac{k'_{\infty}}{2sin\frac{\psi}{2}} - \frac{\gamma}{M} \sum_{n=0}^{\infty} [(n+1)k'_n - k'_{\infty}] P_n(t).$$
(21)

(4) Green's function of the indirect effect on ground tilt

$$G_{i}^{t}(\psi) = -\frac{1}{M} \frac{h_{\infty}^{\prime} \cos\frac{\psi}{2}}{4sin^{2}\frac{\psi}{2}} + \frac{1}{M} \frac{k_{\infty}^{\prime} \cos\frac{\psi}{2} (1+2sin\frac{\psi}{2})}{2sin\frac{\psi}{2} (1+sin\frac{\psi}{2})} - \frac{1}{M} \sum_{n=1}^{\infty} \left(k_{n}^{\prime} - \frac{k_{\infty}^{\prime}}{n} - h_{n}^{\prime} + h_{\infty}^{\prime}\right) \frac{\partial P_{n}(t)}{\partial \psi}.$$
 (22)

(5) Green's function of the indirect effect on vertical deflection

$$G_{i}^{\Theta}(\psi) = \frac{1}{M} \frac{k_{\infty}' \cos\frac{\psi}{2} (1+2\sin\frac{\psi}{2})}{2\sin\frac{\psi}{2} (1+\sin\frac{\psi}{2})} - \frac{1}{M} \sum_{n=1}^{\infty} \left( k_{n}' - \frac{k_{\infty}'}{n} \right) \frac{\partial P_{n}(t)}{\partial \psi}.$$
 (23)

(6) Green's function of the indirect effect on ground horizontal displacement

$$G^{l}(\psi) = -\frac{a}{M} \frac{l_{\infty}^{\prime} \cos\frac{\psi}{2} (1+2\sin\frac{\psi}{2})}{2\sin\frac{\psi}{2} (1+\sin\frac{\psi}{2})} + \frac{a}{M} \sum_{n=1}^{\infty} \left( l_{n}^{\prime} - \frac{l_{\infty}^{\prime}}{n} \right) \frac{\partial P_{n}(t)}{\partial \psi}.$$
(24)

(7) Green's function of the indirect effect on ground radial displacement

$$G^{r}(\psi) = \frac{a}{M} \frac{h'_{\infty}}{2\sin\frac{\psi}{2}} + \frac{a}{M} \sum_{n=0}^{\infty} (h'_{n} - h'_{\infty}) P_{n}(t).$$
(25)

# (8) Green's function of the indirect effect on disturbing gravity gradient

$$G^{T_{nn}}(\psi) = -\frac{\gamma}{aM} \sum_{n=0}^{\infty} (n+1)(n+2)k'_n P_n(t)$$
(26)

(9) Green's function of the indirect effect on horizontal gravity gradient

$$G_i^{T_{ss}}(\psi) = \frac{\gamma}{aM} \sum_{n=0}^{\infty} k'_n \frac{\partial^2 P_n(t)}{\partial \psi^2}.$$
(27)

Let  $G_i(l) = 2asin\frac{\psi}{2}G_i(\psi) = lG_i(\psi)$ , then after substituting the load Love numbers into the formula (19) ~ (27), obtain the Green's function values, such as table 1.

l(km)	$\mathcal{G}_i^{\zeta} \times 10^{-13}$	$\mathcal{G}_i^g  imes 10^{-17}$	$\mathcal{G}_i^{\delta g}$ ×10 <sup>-18</sup>	$G_i^t \times 10^{-14}$	$\mathcal{G}_i^{\Theta} \times 10^{-19}$	$G^{l} \times 10^{-12}$	$G^{r} \times 10^{-11}$	$\mathcal{G}_i^{nn}  imes 10^{-15}$	$\mathcal{G}_i^{ss}  imes 10^{-15}$
0.1	-0.0249	-11.3315	15.8795	42.2955	-2.1192	-0.8369	-42.1264	40.7525	20.0337
0.2	-0.0439	-9.8972	29.6981	21.1510	-8.0632	-3.1842	-41.9553	73.6102	34.1831
0.3	-0.0625	-8.8334	39.7946	14.1058	-16.6878	-6.5901	-41.7788	92.3770	37.9744
0.4	-0.0804	-8.2348	45.2182	10.5853	-26.3601	-10.4097	-41.5956	93.8712	29.4189
0.5	-0.0975	-8.1095	45.8894	8.4739	-35.3064	-13.9425	-41.4057	78.5612	9.4993
0.6	-0.1139	-8.3807	42.5773	7.0657	-41.9834	-16.5790	-41.2101	50.3867	-18.0490
0.7	-0.1294	-8.9073	36.7009	6.0583	-45.3905	-17.9241	-41.0109	15.8142	-47.6055
0.8	-0.1444	-9.5157	30.0034	5.3006	-45.2558	-17.8704	-40.8109	-17.6468	-72.9744
1.0	-0.1727	-10.3454	20.4992	4.2343	-36.8762	-14.5596	-40.4173	-55.8494	-91.9157
1.2	-0.1998	-10.1321	21.4749	3.5210	-26.2416	-10.3574	-40.0402	-39.6641	-61.0517
1.4	-0.2261	-9.1669	30.0077	3.0153	-22.8895	-9.0304	-39.6752	8.4433	-7.5471
1.6	-0.2518	-8.3519	37.0350	2.6419	-28.6871	-11.3158	-39.3091	42.4515	24.9158
2.0	-0.3003	-8.9633	28.5858	2.1198	-40.5309	-15.9830	-38.5476	-4.3817	-24.2022
2.5	-0.3570	-9.1242	24.1119	1.6843	-25.9871	-10.2232	-37.6133	-17.0612	-27.2278
3.0	-0.4112	-7.9718	32.8632	1.4080	-35.2424	-13.8576	-36.7093	28.7167	17.2271
3.5	-0.4621	-8.9437	20.3140	1.2022	-32.5321	-12.7629	-35.7866	-31.1746	-40.2655
4.0	-0.5112	-7.7218	29.8481	1.0465	-28.2814	-11.0562	-34.9109	22.8507	15.9355
5.0	-0.6036	-7.8959	22.7679	0.8291	-26.3578	-10.2305	-33.1702	-5.9459	-11.1019
6.0	-0.6903	-7.8527	18.1028	0.6858	-29.9324	-11.5649	-31.5082	-23.6048	-28.4842
7.0	-0.7725	-7.2943	18.8748	0.5827	-33.7803	-12.9988	-29.9389	-13.5281	-18.2480
8.0	-0.8510	-6.5206	22.0921	0.5013	-33.1161	-12.6452	-28.4652	9.3638	5.3150
10.0	-0.9991	-6.0125	18.9937	0.3784	-24.7530	-9.1540	-25.7982	5.3162	2.8950
12.0	-1.1387	-5.9045	13.1167	0.2999	-27.9718	-10.2454	-23.5296	-16.1892	-18.4692

Table 1 Green's function values of the indirect effects of surface loads

14.0	-1.2726	-4.9048	17.3988	0.2398	-26.5722	-9.5373	-21.6664	13.0654	11.2087
16.0	-1.4019	-4.8896	12.8941	0.1911	-21.0009	-7.2164	-20.1480	-4.3047	-5.5888
20.0	-1.6520	-4.0437	14.8205	0.1306	-20.9145	-7.0582	-18.0179	12.2601	11.2369
25.0	-1.9534	-3.6904	13.7959	0.0872	-19.8016	-6.6584	-16.5317	10.0949	9.3198
30.0	-2.2455	-3.5544	12.9067	0.0638	-18.9897	-6.5141	-15.7982	5.5325	4.9129
35.0	-2.5296	-3.5250	12.0811	0.0505	-18.1729	-6.4230	-15.4331	0.0753	-0.4331
40.0	-2.8059	-3.5272	11.4345	0.0423	-17.1945	-6.2698	-15.2297	-4.7358	-5.1568
50.0	-3.3365	-3.4643	11.2395	0.0322	-14.9772	-5.7725	-14.9607	-8.1685	-8.4622
60.0	-3.8395	-3.2518	12.5464	0.0262	-13.6029	-5.4612	-14.6941	-2.7549	-2.9775
70.0	-4.3177	-3.0073	14.0654	0.0229	-13.9783	-5.7205	-14.3923	4.6469	4.4506
80.0	-4.7741	-2.8804	14.3310	0.0210	-15.3999	-6.3101	-14.0649	6.2127	6.0235
100.0	-5.6311	-2.9117	11.9306	0.0171	-15.7804	-6.3810	-13.3843	-4.6763	-4.8316
120.0	-6.4270	-2.6545	12.4755	0.0129	-14.0249	-5.5346	-12.7235	0.1761	0.0607
140.0	-7.1738	-2.4359	12.7461	0.0120	-15.5946	-5.9880	-12.0989	3.7448	3.6348
160.0	-7.8804	-2.4586	10.7233	0.0100	-14.9953	-5.5941	-11.5133	-4.4893	-4.5820
180.0	-8.5536	-2.2087	11.5710	0.0080	-13.8312	-4.9933	-10.9748	1.9062	1.8299
200.0	-9.1986	-2.0952	11.1758	0.0080	-15.1075	-5.3733	-10.4758	1.7439	1.6689
250.0	-10.7136	-1.8097	10.7082	0.0058	-14.0435	-4.7072	-9.3924	3.2869	3.2307
300.0	-12.1238	-1.5962	10.1419	0.0042	-12.9077	-4.0819	-8.5118	3.2916	3.2481
350.0	-13.4587	-1.4397	9.5227	0.0030	-11.9089	-3.5581	-7.7994	2.1184	2.0836
400.0	-14.7375	-1.3210	8.9521	0.0023	-11.1503	-3.1625	-7.2265	0.4258	0.3969
500.0	-17.1749	-1.1331	8.3207	0.0016	-10.3019	-2.7029	-6.4078	-2.1612	-2.1831
600.0	-19.4980	-0.9603	8.5053	0.0014	-9.8691	-2.4641	-5.9044	-2.3040	-2.3219
800.0	-23.8986	-0.6720	9.9646	0.0010	-9.0007	-2.0628	-5.4405	0.1041	0.0908

# 8.4.3 Legendre function and its first and second derivatives to $\,\psi$

Let 
$$t = \cos \psi$$
,  $u = \sin \psi$ , (26)

$$P_n(t) = \frac{2n-1}{n} t P_{n-1}(t) - \frac{n-1}{n} P_{n-2}(t),$$
(27)

$$P_1 = t, \quad P_2 = \frac{1}{2}(3t^2 - 1).$$
 (28)

$$\frac{\partial}{\partial\psi}P_n(t) = \frac{2n-1}{n}t\frac{\partial}{\partial\psi}P_{n-1}(t) - \frac{2n-1}{n}uP_{n-1}(t) - \frac{n-1}{n}\frac{\partial}{\partial\psi}P_{n-2}(t).$$
(29)

$$\frac{\partial}{\partial \psi} P_1(t) = -u, \quad \frac{\partial}{\partial \psi} P_2(t) = -3ut. \tag{30}$$

$$\frac{\partial^2}{\partial\psi^2}P_n(t) = \frac{2n-1}{n} \left( t \frac{\partial^2}{\partial\psi^2} P_{n-1} - 2u \frac{\partial}{\partial\psi} P_{n-1} - t P_{n-1} \right) - \frac{n-1}{n} \frac{\partial^2}{\partial\psi^2} P_{n-2}, \tag{31}$$

$$\frac{\partial^2}{\partial \psi^2} P_1(t) = -t, \quad \frac{\partial^2}{\partial \psi^2} P_2(t) = 3(1 - 2t^2).$$
(32)

#### 8.5 Algorithms for global tidal load spherical harmonic coefficients model

#### 8.5.1 Construction of tidal load spherical harmonic coefficients model

General procedure of construction of the global ocean tidal load normalized spherical harmonic coefficients model (in FES2004 format) from global ocean tidal height harmonic parameters grids are:

(1) From the global ocean tidal harmonic parameters grid model of each tidal constituent, generate the normalized spherical harmonic coefficients model of each tidal constituent by spherical harmonic analysis method.

(2) According to the astronomical tide height algorithm, convert the normalized spherical harmonic coefficients based on the harmonic parameters of the tidal constituent into the normalized spherical harmonic coefficient based on the tidal load of the tidal constituent.

(3) Merging the global tidal load normalized spherical harmonic coefficients of all tidal constituents, generate the global ocean tide load normalized spherical harmonic coefficients model in FES2004 format.

Astronomical tidal height T(t), expressed as the height of the astronomical tidal level relative to the local long-term mean sea surface, is equal to the sum of M tidal constituent heights

$$T(\varphi,\lambda,t) = \sum_{i=1}^{M} T_i(\varphi,\lambda,t) = \sum_{i=1}^{M} H_i(\varphi,\lambda) \cos[\theta_i(t) - g_i(\varphi,\lambda)],$$
(1)

where *M* is the number of the ocean tidal constituents,  $\theta_i$ ,  $H_i$ ,  $g_i$  are respectively the astronomical argument, the amplitude and the phase of the tidal constituent *i*.

The astronomical tide height  $T_i$  of the tidal constituent *i* can be expanded as

$$T_{i}(\varphi,\lambda,t) = H_{i}(\varphi,\lambda)cosg_{i}(\varphi,\lambda)cos\theta_{i}(t) + H_{i}(\varphi,\lambda)sing_{i}(\varphi,\lambda)sin\theta_{i}(t)$$
  
=  $H_{i}^{+}(\varphi,\lambda)cos\theta_{i}(t) + H_{i}^{-}(\varphi,\lambda)sin\theta_{i}(t) = H_{i}^{+}cos\theta_{i} + H_{i}^{-}sin\theta_{i}.$  (2)

Through the spherical harmonic analysis, the tidal height  $T_i$  of the tidal constituent *i* can be also expressed as the normalized spherical harmonic series

$$T_i(\varphi,\lambda,t) = \sum_{n=1}^N \sum_{m=0}^n \bar{P}_{nm}(sin\varphi) [T_{i,nm}^+(\lambda,t) + T_{i,nm}^-(\lambda,t)],$$
(3)

where 
$$T_{i,nm}^+(\lambda,t) = C_{i,nm}^+ \cos(\theta_i + m\lambda) + S_{i,nm}^+ \sin(\theta_i + m\lambda),$$
 (4)

$$T_{i,nm}^{-}(\lambda,t) = \bar{C}_{i,nm}^{-}\cos(\theta_i - m\lambda) + \bar{S}_{i,nm}^{-}\sin(\theta_i - m\lambda).$$
(5)

Expand the trigonometric functions in the formulas (4) and (5), we have

$$T_{i,nm}^{+}(\lambda,t) = \bar{C}^{+}[\cos\theta_{i}\cos m\lambda - \sin\theta_{i}\sin m\lambda] + \bar{S}^{+}[\sin\theta_{i}\cos m\lambda + \cos\theta_{i}\sin m\lambda]$$

$$= [\bar{C}^{+} cosm\lambda + \bar{S}^{+} sinm\lambda] cos\theta_{i} + [-\bar{C}^{+} sinm\lambda + \bar{S}^{+} cosm\lambda] sin\theta_{i},$$
(6)

$$T_{i,nm}^{-}(\lambda,t) = \bar{C}^{-}[\cos\theta_{i}\cos m\lambda + \sin\theta_{i}\sin m\lambda] + \bar{S}^{-}[\sin\theta_{i}\cos m\lambda - \cos\theta_{i}\sin m\lambda]$$

 $= [\bar{C}^{-} cosm\lambda - \bar{S}^{-} sinm\lambda] cos\theta_{i} + [\bar{C}^{-} sinm\lambda + \bar{S}^{-} cosm\lambda] sin\theta_{i}.$ <sup>(7)</sup>

Comparing the formula (2) and formula (3), for the tidal constituent i, (any tidal constituent number i is omitted below), we have

$$H^{+} = \sum_{n=1}^{N} \sum_{m=0}^{n} \bar{P}_{nm} \left( \bar{C}^{+} cosm\lambda + \bar{S}^{+} sinm\lambda + \bar{C}^{-} cosm\lambda + \bar{S}^{-} sinm\lambda \right),$$
(8)

$$H^{-} = \sum_{n=1}^{N} \sum_{m=0}^{n} \bar{P}_{nm} \left( -\bar{C}^{+} sinm\lambda + \bar{S}^{+} cosm\lambda + \bar{C}^{-} sinm\lambda + \bar{S}^{-} cosm\lambda \right), \tag{9}$$

$$H^{+} = \sum_{n=1}^{N} \sum_{m=0}^{n} \bar{P}_{nm} \left[ (\bar{C}^{+} + \bar{C}^{-}) cosm\lambda + (\bar{S}^{+} - \bar{S}^{-}) sinm\lambda \right],$$
(10)

$$H^{-} = \sum_{n=1}^{N} \sum_{m=0}^{n} \bar{P}_{nm} \left[ (\bar{S}^{+} + \bar{S}^{-}) cosm\lambda + (-\bar{C}^{+} + \bar{C}^{-}) sinm\lambda \right],$$
(11)

$$\bar{C}^+ = \hat{C}^+ \sin\varepsilon^+, \quad \bar{C}^- = \hat{C}^- \sin\varepsilon^-, \quad \bar{S}^+ = \hat{C}^+ \cos\varepsilon^+, \\ \bar{S}^- = \hat{C}^- \cos\varepsilon^-. \tag{12}$$

Similarly, from the global surface air pressure tidal harmonic parameter grid models, can construct the surface air pressure tidal load spherical harmonic coefficients model by the spherical harmonic analysis. The 360-degree surface air pressure tidal load spherical harmonic coefficients model ECMWF2006.dat in ETideLoad4.0 were constructed according to the process above from the  $0.5^{\circ} \times 0.5^{\circ}$  global harmonic parameter grids of the four atmospheric pressure tidal constituents ( $S_1$ ,  $S_2$ ,  $Ss_a$ , Sa).

#### 8.5.2 Ocean tidal load effects on geopotential coefficients

According to Farrell's (1972) theory, the external geopotential of ocean tidal load  $V^{ot}$  can be be expressed by Green's function integral

$$V^{ot}(\varphi,\lambda,t) = G\rho_w \iint_{S} H(\varphi',\lambda',t)G^V(\psi)dS,$$
(13)

where *H* is the ocean tidal height, S means the whole sea,  $\psi$  is the spherical angular between the calculation point ( $\varphi$ ,  $\lambda$ ) and the sea surface moving point ( $\varphi'$ ,  $\lambda'$ ),  $G^{V}(\psi)$  is the load Green's function of the external geopotential.

The load Green's function  $G^{V}(\psi)$  can be expressed in the form of a spherical harmonic series with the load love numbers  $k'_{n}$ :

$$G^{V}(\psi) = \sum_{n=1}^{\infty} (1 + k'_{n}) P_{n}(\cos\psi).$$
(14)

Substituting (14) into (13), the integral relationship between the global ocean tidal height *H* and the variations of the geopotential coefficient  $(\Delta \bar{C}_{nm}, \Delta \bar{S}_{nm})$  can be obtained:

$$\begin{bmatrix} \Delta \bar{C}_{nm} \\ \Delta \bar{S}_{nm} \end{bmatrix} = \frac{G\rho_{w}(1+k'_{n})}{g_{0}(2n+1)} \int_{0}^{2\pi} \int_{0}^{\pi} H \bar{P}_{nm}(\sin\varphi) \begin{bmatrix} \cos m\lambda \\ \sin m\lambda \end{bmatrix} \cos \varphi d\varphi d\lambda,$$
(15)

here  $g_0 = \frac{GM}{a^2}$  is the average gravity of the sea surface.

Given an ocean tidal height model expressed by the harmonic constants (amplitudes and phases) grids of all the tidal constituent (angular frequency  $\sigma$ ), on the sea surface( $\varphi$ ,  $\lambda$ ) at epoch time *t*, the instantaneous ocean tidal height:

$$H(t,\varphi,\lambda) = H_t(\varphi,\lambda) = \sum_{\sigma} H_{\sigma}(\varphi,\lambda) \cos[\theta_{\sigma}(t,\varphi,\lambda) - g_{\sigma}],$$
(16)

here  $H_{\sigma}$  is the amplitude of the tidal constituent  $\sigma$ ,  $\theta_{\sigma}(\varphi, \lambda, t)$  is the astronomical argument of the tidal constituent  $\sigma$  on the sea surface( $\varphi, \lambda$ ) at epoch time t,  $g_{\sigma}$  is the phase at Greenwich of the tidal constituent  $\sigma$ .

The in-phase amplitude  $H_{\sigma} cos g_{\sigma}$  and the cross-phase amplitude  $H_{\sigma} sin g_{\sigma}$  are

represent by spherical harmonic series, and they are brought into formula (16) to obtain

$$H_t(\varphi,\lambda) = \sum_{\sigma} \sum_{n=1}^N \sum_{m=0}^n \bar{P}_{nm}(\cos\varphi) \sum_{+}^{-} H_{\sigma,nm}^{\pm}(\lambda,t)$$
(17)

$$H^{\pm}_{\sigma,nm}(t,\lambda) = \bar{C}^{\pm}_{\sigma,nm} \cos(g_{\sigma} + \varepsilon_{\sigma} \pm m\lambda) + \bar{S}^{\pm}_{\sigma,nm} \sin(g_{\sigma} + \varepsilon_{\sigma} \pm m\lambda)$$
(18)

Here  $(\bar{C}_{\sigma,nm}^{\pm}, \bar{S}_{\sigma,nm}^{\pm})$  are called as the prograde and retrograde normalized spherical harmonic coefficients of the tidal constituent  $\sigma$  with degree n and order m, which can be expressed in terms of harmonic amplitude  $\hat{C}_{\sigma,nm}^{\pm}$  and phase  $\varepsilon_{\sigma,nm}^{\pm}$  as:

$$\bar{C}^{\pm}_{\sigma,nm} = \hat{C}^{\pm}_{\sigma,nm} sin \varepsilon^{\pm}_{\sigma,nm}, \quad \bar{S}^{\pm}_{\sigma,nm} = \hat{C}^{\pm}_{\sigma,nm} cos \varepsilon^{\pm}_{\sigma,nm}$$
(19)

In formula (18),  $\varepsilon_{\sigma}$  is called as the phase bias of the tidal constituent  $\sigma$ , which can be defined according to the sign of  $H_{\sigma}$  (Cartwright & Eden, 1973) as Table 1.

Table 1 Values of the phase bias  $\varepsilon_{\sigma}$  according to the sign of  $H_{\sigma}$ 

The pha	ase bias $\varepsilon_{\sigma}$	$H_{\sigma} > 0$	$H_{\sigma} < 0$
m = 0	long period	π	0
m = 1	diurnal	π/2	$-\pi/2$
<i>m</i> = 2	semi-diurnal	0	π

Substituting (17) into (15), taking into account (18) and (19), the external geopotential coefficient variations can be expressed as:

$$\Delta \bar{C}_{nm} - i\Delta \bar{S}_{nm} = \sum_{\sigma} \left( C^{\pm}_{\sigma,nm}, \mp i S^{\pm}_{\sigma,nm} \right) e^{\pm i\theta_{\sigma}}$$
<sup>(20)</sup>

Comparing equations (20) and (16), we have:

$$C_{\sigma,nm}^{\pm} = \frac{4\pi G \rho_w (1+k_n')}{g_0(2n+1)} \hat{C}_{\sigma,nm}^{\pm} \sin\left(\varepsilon_{\sigma,nm}^{\pm} + \varepsilon_{\sigma}\right)$$
(21)

$$S_{\sigma,nm}^{\pm} = \frac{4\pi G \rho_w (1+k_n')}{g_0(2n+1)} \hat{C}_{\sigma,nm}^{\pm} \cos\left(\varepsilon_{\sigma,nm}^{\pm} + \varepsilon_{\sigma}\right)$$
(22)

Using formulas (21) and (22), the ocean tide harmonic constants grid model represented can be converted into the harmonic amplitude, and then the geopotential coefficient variations can be calculated according to the formula (20).

# 8.6 Fast recursion algorithm for $P_{mn}(t)$ and their derivatives to $\theta$

Let 
$$t = \cos\theta$$
,  $u = \sin\theta$ .

8.6.1 Standard forward column recursion algorithm for  $\overline{P}_{nm}(t)$  (n < 1900)

$$\begin{cases} \bar{P}_{nm}(t) = a_{nm} t \bar{P}_{n-1,m}(t) - b_{nm} \bar{P}_{n-2,m}(t) & \forall n > 1, m < n \\ \bar{P}_{nn}(t) = \sqrt{\frac{2n+1}{2n}} \bar{P}_{n-1,n-1} \end{cases}$$
(2)

(1)

$$a_{nm} = \sqrt{\frac{(2n-1)(2n+1)}{(n+m)(n-m)}}, \quad b_{nm} = \sqrt{\frac{(2n+1)(n+m+1)(n-m-1)}{(2n-3)(n+m)(n-m)}}$$
  
$$\bar{P}_{00}(t) = 1, \quad \bar{P}_{10}(t) = \sqrt{3}t, \quad \bar{P}_{11}(t) = \sqrt{3}u$$
(3)

# 8.6.2 Improved Belikov recursion algorithm for $\overline{P}_{nm}(t)$ (n < 64800)

When n=0,1, use formula (3) to calculate  $\bar{P}_{nm}(t)$ . When  $n \ge 2$ :

$$\bar{P}_{n0}(t) = a_n t \bar{P}_{n-1,0}(t) - b_n \frac{u}{2} \bar{P}_{n-1,1}(t), \quad m = 0$$
(4)

$$\bar{P}_{nm}(t) = c_{nm}t\bar{P}_{n-1,m}(t) - d_{nm}u\bar{P}_{n-1,m+1}(t) + e_{nm}u\bar{P}_{n-1,m-1}(t), \ m > 0$$
(5)

$$a_n = \sqrt{\frac{2n+1}{2n-1}}, \quad b_n = \sqrt{\frac{2(n-1)(2n+1)}{n(2n-1)}}$$
(6)

$$c_{nm} = \frac{1}{n} \sqrt{\frac{(n+m)(n-m)(2n+1)}{2n-1}}, \quad d_{nm} = \frac{1}{2n} \sqrt{\frac{(n-m)(n-m-1)(2n+1)}{2n-1}}$$
(7)

When m > 0:

$$e_{nm} = \frac{1}{2n} \sqrt{\frac{2}{2 - \delta_0^{m-1}}} \sqrt{\frac{(n+m)(n+m-1)(2n+1)}{2n-1}}$$
(8)

ETideLoad4.0 adopts mainly the improved Belikov recursion algorithm to calculate the normalized associated Legendre functions  $\bar{P}_{nm}(t)_{\circ}$ 

# 8.6.3 Cross-degree recursive algorithm for $\overline{P}_{nm}(t)$ (n < 20000)

When n=0,1, use formula (3) to calculate  $\bar{P}_{nm}(t)$ . When  $n \ge 2$ :

$$\bar{P}_{nm}(t) = \alpha_{nm}\bar{P}_{n-2,m}(t) + \beta_{nm}\bar{P}_{n-2,m-2}(t) - \gamma_{nm}\bar{P}_{n,m-2}(t)$$

$$\alpha_{nm} = \sqrt{\frac{(2n+1)(n-m)(n-m-1)}{(2n-3)(n+m)(n+m-1)}}$$
(9)

$$\beta_{nm} = \sqrt{1 + \delta_0^{m-2}} \sqrt{\frac{(2n+1)(n+m-2)(n+m-3)}{(2n-3)(n+m)(n+m-1)}}$$

$$\gamma_{nm} = \sqrt{1 + \delta_0^{m-2}} \sqrt{\frac{(n-m+1)(n+m-3)}{(n+m)(n+m-1)}}$$
(10)

# 8.6.4 Non-singular recursive algorithm for $\frac{\partial}{\partial \theta} \overline{P}_{nm}(\cos \theta)$

$$\frac{\partial}{\partial \theta} \bar{P}_{nm}(\cos \theta) = -\sin \theta \frac{\partial}{\partial t} \bar{P}_{nm}(t)$$
(11)

$$\begin{cases} \frac{\partial}{\partial \theta} \bar{P}_{n0} = -\sqrt{\frac{n(n+1)}{2}} \bar{P}_{n1}, & \frac{\partial}{\partial \theta} \bar{P}_{n1} = \sqrt{\frac{n(n+1)}{2}} \bar{P}_{n0} - \frac{\sqrt{(n-1)(n+2)}}{2} \bar{P}_{n2} \end{cases}$$
(12)

$$\begin{pmatrix}
\frac{\partial}{\partial \theta}\bar{P}_{nm} = \frac{\sqrt{(n+m)(n-m+1)}}{2}\bar{P}_{n,m-1} - \frac{\sqrt{(n-m)(n+m+1)}}{2}\bar{P}_{n,m+1}, \quad m > 2 \\
\frac{\partial}{\partial \theta}\bar{P}_{00}(t) = 0, \quad \frac{\partial}{\partial a}\bar{P}_{10}(t) = -\sqrt{3}u, \quad \frac{\partial}{\partial a}\bar{P}_{11}(t) = \sqrt{3}t$$
(13)

# $\frac{\partial}{\partial \theta} P_{00}(t) = 0, \quad \frac{\partial}{\partial \theta} P_{10}(t) = -\sqrt{3}u, \quad \frac{\partial}{\partial \theta} F_{11}(t) - \sqrt{3}u$ 8.6.5 Non-singular recursive algorithm for $\frac{\partial^2}{\partial \theta^2} \overline{P}_{nm}$

$$\begin{cases} \frac{\partial^2}{\partial \theta^2} \bar{P}_{n0} = -\frac{n(n+1)}{2} \bar{P}_{n0} + \sqrt{\frac{n(n-1)(n+1)(n+2)}{8}} \bar{P}_{n2} \\ \frac{\partial^2}{\partial \theta^2} \bar{P}_{n4} = -\frac{2n(n+1)+(n-1)(n+2)}{2} \bar{P}_{n4} + \frac{\sqrt{(n-2)(n-1)(n+2)(n+3)}}{2} \bar{P}_{n2} \end{cases}$$
(14)

$$\frac{\partial^{2}}{\partial\theta^{2}}\bar{P}_{nm} = \frac{\sqrt{(n-m+1)(n-m+2)(n+m-1)(n+m)}}{4}\bar{P}_{n,m-2} - \frac{(n+m)(n-m+1)+(n-m)(n+m+1)}{4}\bar{P}_{nm} - \frac{(n+m)(n-m+1)+(n-m)(n+m+1)}{4}\bar{P}_{nm} + \frac{\sqrt{(n-m-1)(n-m)(n+m+1)(n+m+2)}}{4}\bar{P}_{n,m+2}, \quad m > 2$$
(15)

$$\frac{\partial^2}{\partial\theta^2}\bar{P}_{00}(t) = 0, \quad \frac{\partial^2}{\partial\theta^2}\bar{P}_{10}(t) = -\sqrt{3}t, \quad \frac{\partial^2}{\partial\theta^2}\bar{P}_{11}(t) = -\sqrt{3}u \tag{16}$$

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# Names table of the sample directories and executable files

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1	Computation of solid tidal effects on various geodetic quantities outside solid Earth	Tideffectsolidearth
2	Spherical harmonic synthesis on ocean tidal load effects outside solid Earth	OTideloadharmsynth
3	Spherical harmonic synthesis on air pressure tidal load effects outside solid Earth	ATideloadharmsynth
4	Computation of Earth pole shift and ocean pole tide effects outside solid Earth	Poleshifteffectscalc
5	Computation of permanent tidal effects and correction of Earth's mass center	Permanentdgeocenter
6	Computation of solid Earth tide and loading tide effects on geodetic networks	Controlnetworktidef
7	The regional approaching of tidal load effects by load Green's Integral	Tdloadgreenintegral
8	Global forecast of various tidal effects on various surface geodetic quantities	SolidLoadtidecalctl
9	Separation and processing of gross errors in geodetic variations time series	TmsrsErrorseppreproc
10	Low-pass filtering and signal reconstructing for irregular time series	Tmsrslowpfltrconstr
11	Weighted operation, difference, integral and interpolation on time series	TmsrsAddifferinterp
12	Normalized extraction from batch time series of geodetic monitoring network	Tmsrsbatchnormalize
13	Processing and analysis on batch time series of geodetic monitoring network	Tmsrsnetwkanalyspro
14	Construction and analysis on records time series from geodetic network	Tmrecordanalysproc
15	Processing and analysis on variation (vector) grids time series	Tmgridanalysisproc
16	Multi-form spatiotemporal interpolation from grids time series	Tmgrdinterpolation
17	Spherical harmonic analysis on global surface load time series	Loadspharmonanalys
18	Spherical analysis on tide parameters and construction of tidal load model	Loadtidespharmsynth
19	Computation of the model value by spherical harmonic synthesis	Loadspharmsynthesis
20	Computation of load-deformation field by spherical harmonic synthesis	Loadeformharmsynth
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