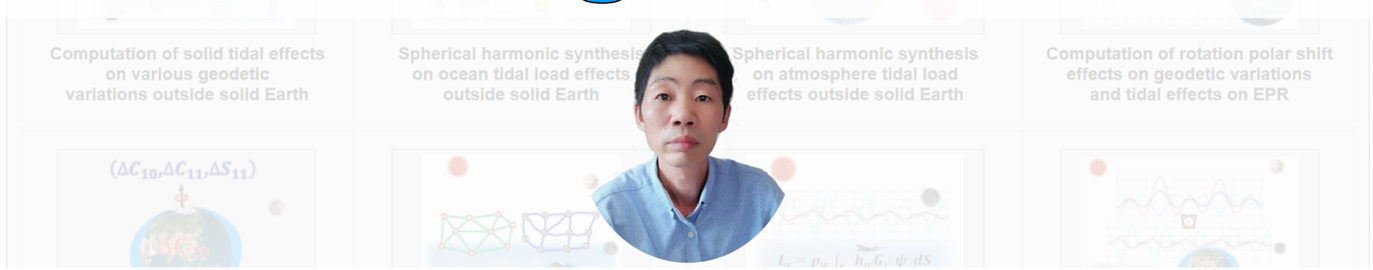
www.zcyphygeodesy.com

Various Earth tidal and polar shift effects on all-element geodetic variations



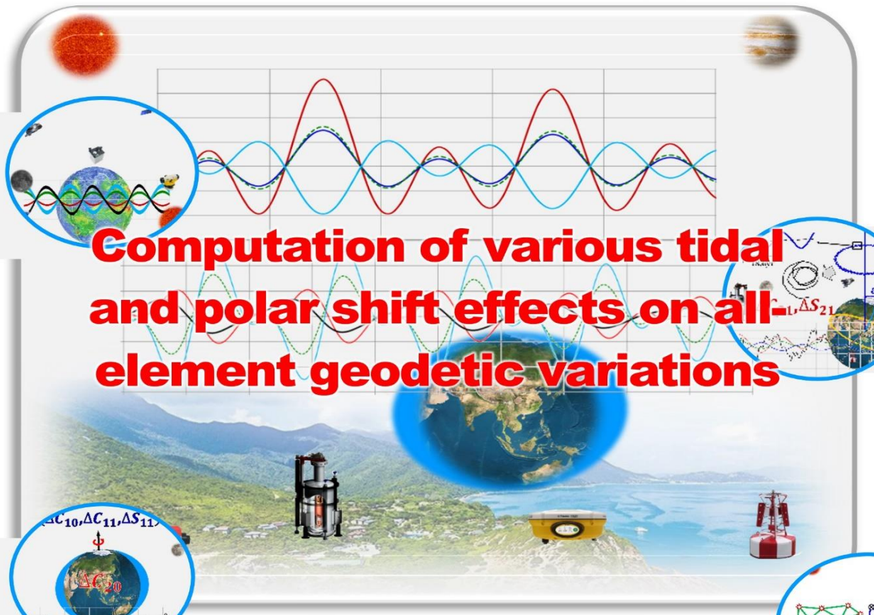
🌎 **Analytically compatible geodetic and geodynamic algorithm package using the numerical standards unified and geophysical models coordinated**

🌎 **Compatible with and improved the IERS conventions, some geodetic concepts clarified, all the algorithms derivated and verificated completely**

🌎 **Uniform computation of solid tidal, load tidal, polar shift and mass centric variation effects on all-element geodetic variations in whole Earth space**

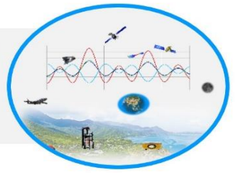
Chuanyin Zhang, zhangchy@casm.ac.cn

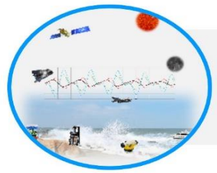
Computation of various tidal and polar shift effects on all-element geodetic variations



- Computation of solid Earth tidal effect time series at a ground site
- Computation of solid Earth tidal effects at ground sites with given time
- Computation of solid Earth tidal effects of Earth satellite or outside solid Earth
- Global forecast of solid tidal effects on various surface geodetic variations

Computation of solid tidal effects on various geodetic variations outside solid Earth





Spherical harmonic synthesis on ocean tidal load effects outside solid Earth

- Computation of ocean tidal load effect time series at a ground site
- Computation of ocean tidal load effects at ground sites with given time
- Computation of ocean tidal load effects of Earth satellite or outside solid Earth
- Global forecast of ocean tidal load effects on various surface geodetic variations

- Computation of surface atmosphere tidal load effect time series at a ground site
- Computation of surface atmosphere tidal load effects at ground sites with given time
- Computation of surface atmosphere tidal load effects of satellite or outside Earth
- Global forecast of surface atmosphere tidal load effects on surface geodetic variations

Spherical harmonic synthesis on atmosphere tidal load effects outside solid Earth

Computation of Earth's rotation polar shift effects on geodetic variations and tidal effects on EPR

- Computation of rotation polar shift or ocean pole tidal effect time series at a ground site
- Computation of rotation polar shift or ocean pole tidal effects at ground sites with given time
- Computation of rotation polar shift or ocean pole tidal effects of satellite or outside solid Earth
- Calculation of rotation polar shift effects on various geodetic variations
- Forecast of the tidal effect time series on Earth's rotation

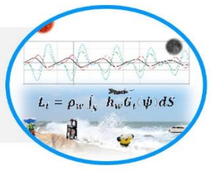
- Computation of permanent tidal effects on various geodetic variations
- Computation of Earth's mass centric variation effects on all-element geodetic variations
- Forecast of ocean tidal load effects on Earth's mass centric variation
- Forecast of atmosphere tidal load effects on Earth's mass centric variation

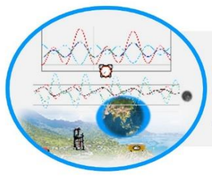
Computation of the permanent tidal and Earth's mass centric variation effects on geodetic variations

Computation of solid Earth and load tidal effects on geodetic networks

- Computation of residual ocean tidal load effects by Green's Integra
- Computation of residual atmosphere tidal load effects by Green's Integral

The regional approach of load tidal effects by load Green's Integral





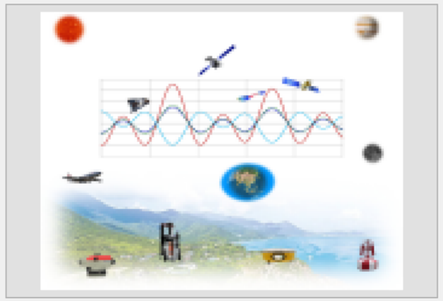
Forecast of various tidal effects on surface all-element geodetic variations

- Numerical forecast of solid Earth tidal effects on various geodetic variations
- Numerical forecast of ocean tidal load effects on various geodetic variations
- Numerical forecast of surface atmosphere tidal load effects on various geodetic variations

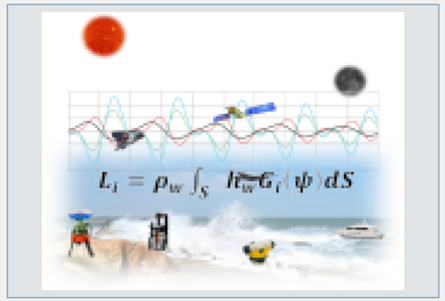
Compatible with and improved all the geodetic algorithms in Chapters 6, 7, and 8 of the IERS conventions (2010).

Computation of various tidal effects on various geodetic variations

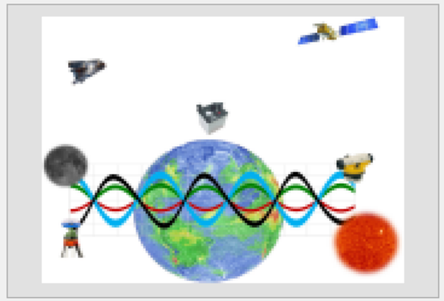
Computation of various tidal and polar shift effects on all-element geodetic variations



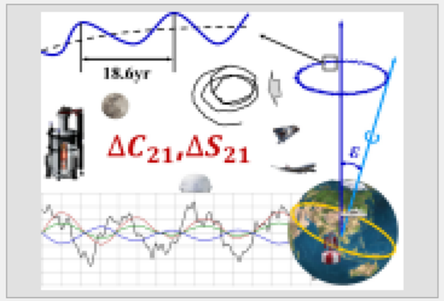
Computation of solid tidal effects on various geodetic variations outside solid Earth



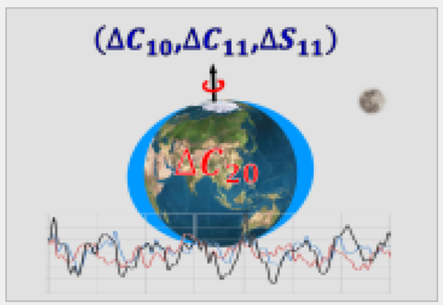
Spherical harmonic synthesis on ocean tidal load effects outside solid Earth



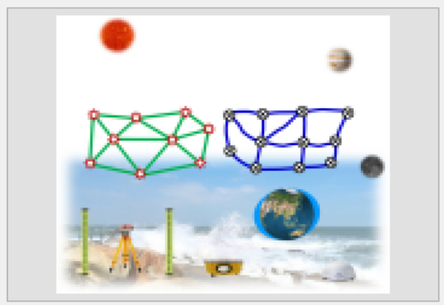
Spherical harmonic synthesis on atmosphere tidal load effects outside solid Earth



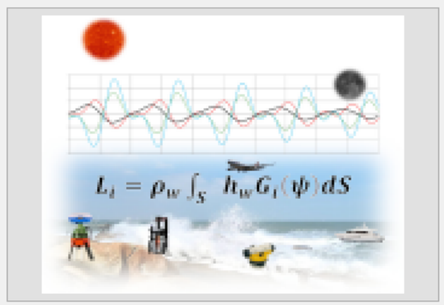
Computation of rotation polar shift effects on geodetic variations and tidal effects on EPR



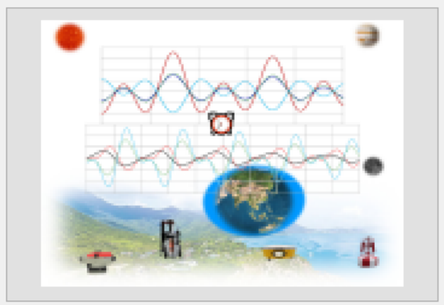
Computation of the permanent tidal and Earth's mass centric variation effects on geodetic variations



Computation of solid Earth and load tidal effects on geodetic networks



The regional approach of load tidal effects by load Green's Integral



Forecast of various tidal effects on surface all-element geodetic variations

- **Analytically compatible geodetic and geodynamic algorithm package using the numerical standards unified and geophysical models coordinated**
- **Compatible with and improved the IERS conventions, some geodetic concepts clarified, all the algorithms derivated and verificated completely**
- **Uniform computation of solid tidal, load tidal, polar shift and mass centric variation effects on all-element geodetic variations in whole Earth space**

Functional architecture of the subsystem

The files format of 5 kinds of geodetic variation time series

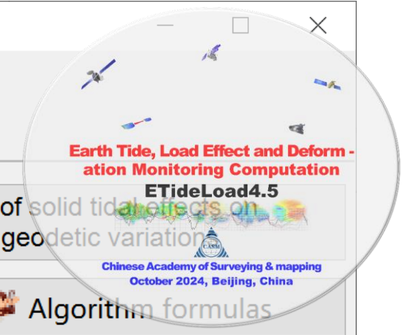
These programs are suitable for various geodetic variations on the ground or outside the solid Earth. A point outside the solid Earth generally refers to the space point that is not fixed to the solid Earth in ocean space, near-Earth space, or satellite altitude. The geodetic variations marked with ⊙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

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, e.g., 2018122412.

Computation of solid tidal effects on various geodetic variations outside solid Earth

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

Open file | Save as | Import parameters | Start computation | Save process | Follow example



Computation of solid Earth tidal effect time series at a ground site | Computation of solid Earth tidal effects at ground sites with given time | Computation of solid Earth tidal effects of Earth satellite or outside solid Earth | Global forecast of solid tidal effects on various surface geodetic variations

Open the geodetic site variation time series file | Save program process as | Algorithm formulas

Set the file parameters

Column ordinal number of ellipsoidal height in the header: 4

Column ordinal number of time in the record: 1

Column ordinal number of starting MJD0 in the header: 5

Select the type of effects

- [x] geoid or height anomaly (mm)
- [x] ground gravity (μGal)
- [x] gravity disturbance (μGal)
- [x] ground tilt (SW, mas)
- [x] vertical deflection (SW, mas)
- [x] horizontal displacement (EN, mm)
- [x] ground radial displacement (mm)
- [x] ground normal or orthometric height (mm)
- [x] radial gravity gradient (10μE)
- [x] horizontal gravity gradient (NW, 10μE)

```
>> [Function] From a geodetic site variation time series file, compute the time series of the solid Earth tidal effects on the geoid or height anomaly (mm), ground gravity (μGal), gravity disturbance (μGal), 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), radial gravity gradient (10μE) or horizontal gravity gradient (NW, to the north and to the west, 10μE).
>> Open the geodetic site variation time series file C:/ETideLoad4.5_win64en/examples/Tideffectsolidearth/Tmseries.txt.
  ** Set the file format parameters according to the text box below, and then select the type of the geodetic variation to be computed. After giving the output file name, click the control button [Import setting parameters]...
>> Save the computed results as C:/ETideLoad4.5_win64en/examples/Tideffectsolidearth/tmsqurst.txt.
  ** Behind the input file record, add one or several columns of the tidal effects as the output file record.
>> Setting parameters have been imported into the program!
  ** Click the control button [Start computation], or the tool button [Start computation]....
>> Computation start time:  2024-10-18 09:33:30
>> Complete the computation of solid earth tide effects!
>> Computation end time:  2024-10-18 09:33:30
```

Columns 2 and 3 of the file header are agreed as the longitude and latitude of the ground site

Save the computed results as | Import setting parameters | Start computation

Display of the input-output file↓ | Save data in the text box as

```
Forcast  121.240000   29.428100    17.830    58456.959028
201812042301   0.000000   -9.1781  -156.8405   -64.8337   -72.7348    6.9147   -9.0453   13.0621   -17
201812042316   0.010417   -9.0405  -126.4444   -52.4062   -58.7014    7.9809   -9.4946   15.0158   -18
201812042331   0.020833   -8.9068   -94.9272   -39.5093   -44.1436    9.0491   -9.7445   16.9727   -18
201812042346   0.031250   -8.7789   -62.9361   -26.4105   -29.3615   10.1045   -9.7926   18.9054   -18
201812050001   0.041667   -8.6586   -31.1203   -13.3786   -14.6566   11.1322   -9.6398   20.7863   -18
201812050016   0.052083   -8.5474    -0.1200    -0.6789    -0.3259   12.1177   -9.2907   22.5888   -17
201812050031   0.062500   -8.4468    29.4450    11.4319    13.3426   13.0468   -8.7535   24.2868   -16
201812050046   0.072917   -8.3580    56.9866    22.7100    26.0757   13.9061   -8.0396   25.8557   -15
201812050101   0.083333   -8.2822    81.9584    32.9291    37.6197   14.6833   -7.1638   27.2729   -13
201812050116   0.093750   -8.2201   103.8654    41.8842    47.7447   15.3671   -6.1436   28.5175   -12
201812050131   0.104167   -8.1724   122.2731    49.3954    56.2491   15.9477   -4.9992   29.5715    -9
201812050146   0.114583   -8.1392   136.8147    55.3112    62.9628   16.4168   -3.7529   30.4194    -7
201812050201   0.125000   -8.1207   147.3217    59.4822    67.6822   16.7655   -2.3948   31.0503    -5
201812050216   0.135417   -8.1169   153.2094    61.9080    70.5139   16.9850   -1.0529   31.4507    -2
201812050231   0.145833   -8.1277   154.7202    62.4451    71.1537   17.0565    0.3480   31.6153     0
201812050246   0.156250   -8.1527   151.6863    61.1178    69.7705   17.0700    1.7487   31.5523     2
```

Improve the algorithm of solid tidal effect on displacement of reference points in the IERS Conventions (2010), and then compute the solid tidal effects uniformly on all-element geodetic variations in the whole Earth space.

The program adopts the same numerical standards and analytical algorithms of the solid Earth tidal effects on geopotential and and geodetic site displacement that are compatible with the IERS Conventions (2010), and compute uniformly the solid Earth tidal effects on all-element geodetic variations considering the latitude and frequency dependence of the Love numbers, so as to maintain rigorously the analytical relationships between the solid Earth tidal effects on various geodetic variations.

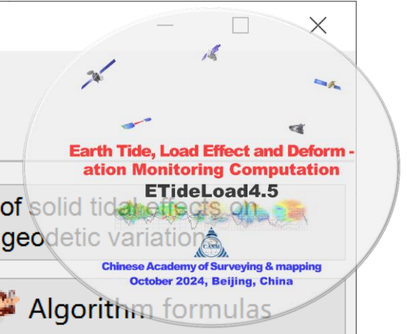
The Earth's tide generating potential (TGP) from the moon is calculated from 2nd to 6th degree, that from the sun from 2nd to 3rd degree, and that from other planets at the 2nd degree.

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.

Computation of solid tidal effects on various geodetic variations outside solid Earth

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

Open file | Save as | Import parameters | Start computation | Save process | Follow example



Computation of solid Earth tidal effect time series at a ground site | **Computation of solid Earth tidal effects at ground sites with given time** | Computation of solid Earth tidal effects of Earth satellite or outside solid Earth | Global forecast of solid tidal effects on various surface geodetic variations

Open the location and time file of the calculation points | Save program process as | Algorithm formulas

Set the file parameters

Column ordinal number of ellipsoidal height in the record: 4

Column ordinal number of time in the record: 1

Column ordinal number of starting MJD0 in the header: 5

Select the type of effects

- [x] geoid or height anomaly (mm)
- [x] ground gravity (μGal)
- [x] gravity disturbance (μGal)
- [x] ground tilt (SW, mas)
- [x] vertical deflection (SW, mas)
- [x] horizontal displacement (EN, mm)
- [x] ground radial displacement (mm)
- [x] ground normal or orthometric height (mm)
- [x] radial gravity gradient (10μE)
- [x] horizontal gravity gradient (NW, 10μE)

```
>> [Function] According to the location and time in the calculation point file, compute the solid Earth tidal effects on the geoid or height anomaly (mm), ground gravity (μGal), gravity disturbance (μGal), 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), radial gravity gradient (10μE) or horizontal gravity gradient (NW, to the north and to the west, 10μE).
>> Open the location and time file of the calculation points C:/ETideLoad4.5_win64en/examples/Tideffectsolidearth/Postiontm.txt.
  ** Set the file format parameters according to the text box below, and then select the type of the geodetic variation to be computed. After giving the output file name, click the control button [Import setting parameters]...
>> Save the computed results as C:/ETideLoad4.5_win64en/examples/Tideffectsolidearth/Postmrst.txt.
  ** Behind the input file record, add one or several columns of the tidal effects as the output file record.
>> Setting parameters have been imported into the program!
  ** Click the control button [Start computation], or the tool button [Start computation]....
>> Computation start time：2024-10-18 09:34:51
>> Complete the computation of solid earth tide effects!
>> Computation end time: 2024-10-18 09:34:52
```

Columns 2 and 3 of the record are agreed as the longitude and latitude of the calculated point

Save the computed results as | Import setting parameters | Start computation

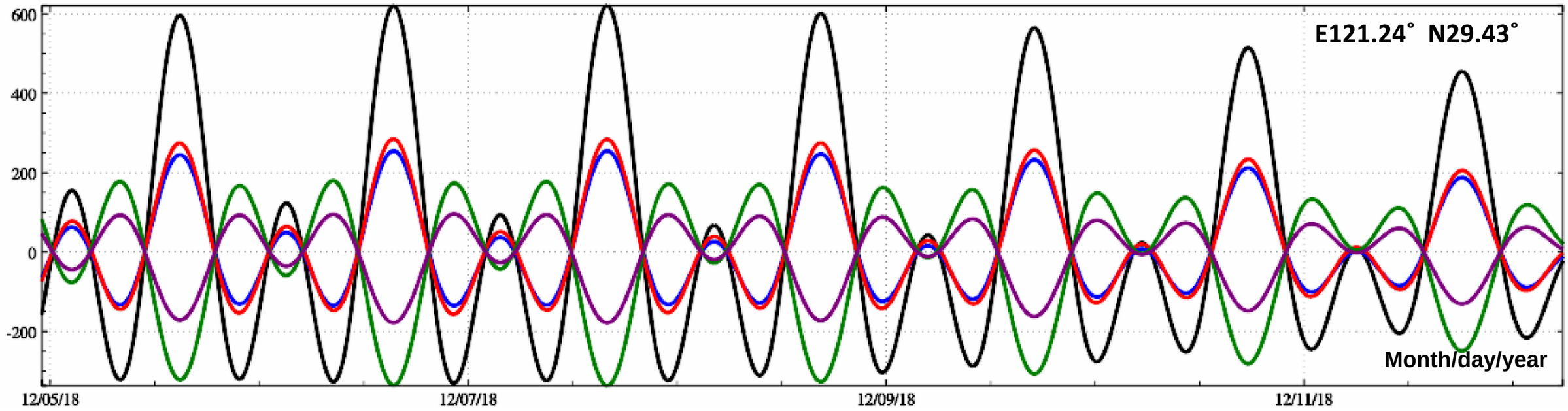
Display of the input-output file↓ | Save data in the text box as

```
101.230000    29.910000    47.218  58484.000000
201901010000  101.230000    29.910000  47.218    4.5400    1.5938    1.8815   10.3967   -5.0328   19.44
201901010100  101.230000    29.910000  47.218   58.3841   23.5680   26.8064   12.8415   -2.9395   23.86
201901010200  101.230000    29.910000  47.218   77.7136   31.2014   35.6850   14.1545    0.3355   26.20
201901010300  101.230000    29.910000  47.218   53.3053   20.7449   24.2861   14.0836    3.7768   25.99
201901010400  101.230000    29.910000  47.218  -10.6764   -5.9421   -5.3630   12.6903    6.3132   23.34
201901010500  101.230000    29.910000  47.218  -97.6404  -41.8707  -45.4873   10.3233    7.1142   18.88
201901010600  101.230000    29.910000  47.218 -182.8869  -76.7981  -84.6356    7.5204    5.8108   13.61
201901010700  101.230000    29.910000  47.218 -240.0672  -99.9398 -110.7040    4.8711    2.5864    8.64
201901010800  101.230000    29.910000  47.218 -248.0760 -102.7831 -114.0960    2.8762   -1.8762    4.92
201901010900  101.230000    29.910000  47.218 -196.6498  -81.3022  -90.2338    1.8393   -6.5659    3.04
201901011000  101.230000    29.910000  47.218  -89.3439  -37.0804  -40.8477    1.8121  -10.3839    3.12
201901011100  101.230000    29.910000  47.218   56.7775   22.8815   26.2172    2.5980  -12.3987    4.76
201901011200  101.230000    29.910000  47.218  214.6442   87.5974   98.6094    3.8130  -12.0601    7.23
201901011300  101.230000    29.910000  47.218  353.0865  144.4495  162.1326    4.9861   -9.3304    9.61
201901011400  101.230000    29.910000  47.218  443.8313  181.9624  203.8886    5.6795   -4.7058   11.07
201901011500  101.230000    29.910000  47.218  468.0165  192.4016  215.2148    5.6022    0.8800   11.03
```

The program adopts the same numerical standards and analytical algorithms of the solid Earth tidal effects on geopotential and and geodetic site displacement that are compatible with the IERS Conventions (2010), and compute uniformly the solid Earth tidal effects on all-element geodetic variations considering the latitude and frequency dependence of the Love numbers, so as to maintain rigorously the analytical relationships between the solid Earth tidal effects on various geodetic variations.

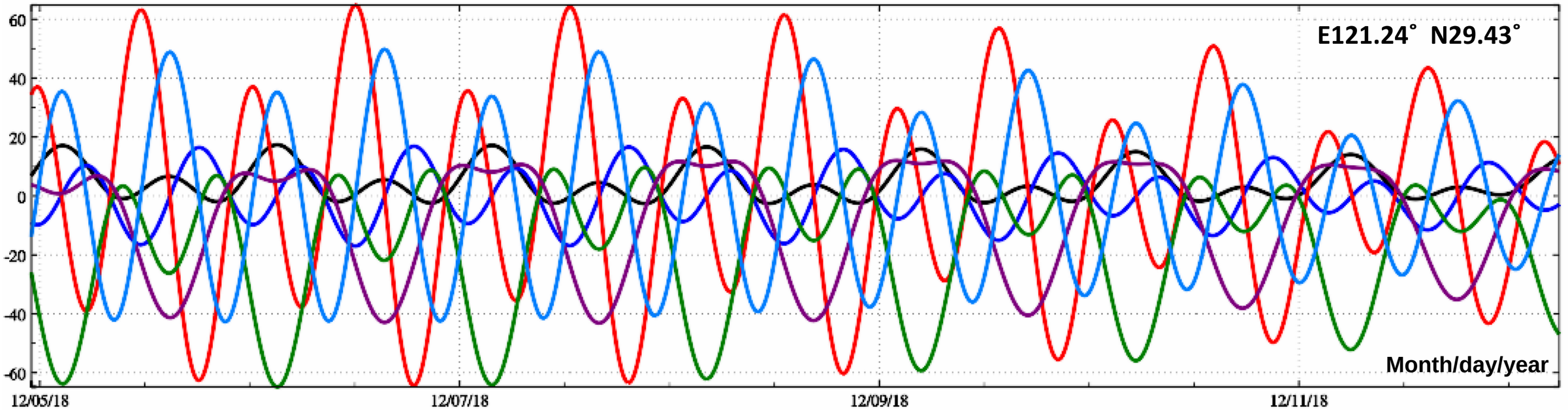
The Earth's tide generating potential (TGP) from the moon is calculated from 2nd to 6th degree, that from the sun from 2nd to 3rd degree, and that from other planets at the 2nd degree.

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.



Solid tidal effects : geoid or height anomaly (mm) ground gravity (μGal) radial displacement (mm) normal or orthometric height (mm) radial gravity gradient (10μE)

The solid tidal effect on normal height (approximately 300mm) is out of phase with that on the ellipsoidal height or geoid (approximately 600mm, namely the sign is opposite).

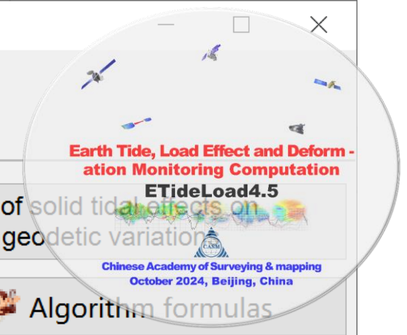


Solid tidal effects : ground tilt (S, mas) tilt (W, mas) horizontal displacement (E, mm) horizontal displacement (N, mm) horizontal gradient (N, 10μE) horizontal gradient (W, 10μE)

Computation of solid tidal effects on various geodetic variations outside solid Earth

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

Open file | Save as | Import parameters | Start computation | Save process | Follow example



Computation of solid Earth tidal effect time series at a ground site | Computation of solid Earth tidal effects at ground sites with given time | Computation of solid Earth tidal effects of Earth satellite or outside solid Earth | Global forecast of solid tidal effects on various surface geodetic variations

Open the location and time file of the external points | Save program process as | Algorithm formulas

Set the file parameters

Column ordinal number of ellipsoidal height in the record: 4

Column ordinal number of time in the record: 1

Column ordinal number of starting MJD0 in the header: 5

Select the type of effects

- [x] geopotential (0.1m²/s²)
- [ ] gravity vector (XYZ, μGal)
- [x] gravity vector (ENU, μGal)
- [ ] gravity gradient (XYZ, 10μE)
- [x] gravity gradient (ENU, 10μE)

```
>> Complete the computation of solid earth tide effects!
>> Computation end time: 2024-10-18 09:34:52
>> [Function] According to the location and time in the external space point file, compute the solid Earth tidal effects on the geopotential (0.1m²/s²), gravity (μGal) or gravity gradient (10μE) outside the solid Earth
>> Open the location and time file of the external points C:/ETideLoad4.5_win64en/examples/Tideffectsolidearth/outerptm.txt.
  ** Set the file format parameters according to the text box below, and then select the type of the geodetic variation to be computed. After giving the output file name, click the control button [Import setting parameters]...
>> Save the computed results as C:/ETideLoad4.5_win64en/examples/Tideffectsolidearth/outerst.txt.
  ** Behind the input file record, add one or several columns of the tidal effects as the output file record.
>> Setting parameters have been imported into the program!
  ** Click the control button [Start computation], or the tool button [Start computation]....
>> Computation start time：2024-10-18 09:36:45
>> Complete the computation of solid earth tide effects!
>> Computation end time: 2024-10-18 09:36:46
```

Columns 2 and 3 of the record are agreed as the longitude and latitude of the satellite

Save the computed results as | Import setting parameters | Start computation

Display of the input-output file↓

GRACE satellite altitude

Save data in the text box as

NY 101.23 29.91 450000.0 58484.000000									
2019010100	101.23	29.91	450000.0	0.3604	-70.1968	35.9074	-1.4347	-5.6569	-0.4118	-0
2019010101	101.23	29.91	450000.0	4.6518	-86.1581	21.8362	-20.3774	-12.8867	0.0283	-11
2019010102	101.23	29.91	450000.0	6.1944	-94.6243	-0.3418	-27.1374	-16.1680	0.7045	-15
2019010103	101.23	29.91	450000.0	4.2516	-93.8995	-23.8846	-18.4910	-14.5544	1.7299	-10
2019010104	101.23	29.91	450000.0	-0.8480	-84.3469	-41.5914	4.0409	-8.4398	2.9803	2
2019010105	101.23	29.91	450000.0	-7.7849	-68.2530	-47.7595	34.5670	0.5710	4.1143	20
2019010106	101.23	29.91	450000.0	-14.5906	-49.2170	-39.7054	64.3857	10.1118	4.6601	37
2019010107	101.23	29.91	450000.0	-19.1615	-31.2465	-18.4674	84.2772	17.6806	4.1459	49
2019010108	101.23	29.91	450000.0	-19.8092	-17.8013	11.4510	86.9118	21.2684	2.2387	50
2019010109	101.23	29.91	450000.0	-15.7095	-11.0186	43.1839	68.7753	19.8363	-1.1440	40
2019010110	101.23	29.91	450000.0	-7.1432	-11.2874	69.1547	31.1672	13.5472	-5.7776	18
2019010111	101.23	29.91	450000.0	4.5274	-17.2502	82.8776	-19.9374	3.7183	-11.1451	-11
2019010112	101.23	29.91	450000.0	17.1380	-26.2132	80.5037	-75.1125	-7.4804	-16.5208	-43
2019010113	101.23	29.91	450000.0	28.1955	-34.8618	61.7745	-123.5198	-17.5134	-21.1048	-72
2019010114	101.23	29.91	450000.0	35.4394	-40.1205	30.1681	-155.3162	-24.0531	-24.1817	-90
2019010115	101.23	29.91	450000.0	37.3634	-39.9606	-7.8095	-163.9024	-25.5231	-25.2664	-95

The program adopts the same numerical standards and analytical algorithms of the solid Earth tidal effects on geopotential and and geodetic site displacement that are compatible with the IERS Conventions (2010), and compute uniformly the solid Earth tidal effects on all-element geodetic variations considering the latitude and frequency dependence of the Love numbers, so as to maintain rigorously the analytical relationships between the solid Earth tidal effects on various geodetic variations.

The Earth's tide generating potential (TGP) from the moon is calculated from 2nd to 6th degree, that from the sun from 2nd to 3rd degree, and that from other planets at the 2nd degree.

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.

Computation of solid tidal effects on various geodetic variations outside solid Earth

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

Open file | Save as | Import parameters | Start computation | Save process | Follow example

Earth Tide, Load Effect and Deformation Monitoring Computation
ETideLoad4.5
Chinese Academy of Surveying & mapping
October 2024, Beijing, China

Computation of solid Earth tidal effect time series at a ground site

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

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

Global forecast of solid tidal effects on various surface geodetic variations

Open the location and time file of the external points

Save program process as

Algorithm formulas

Set the file parameters

Column ordinal number of ellipsoidal height in the record: 4

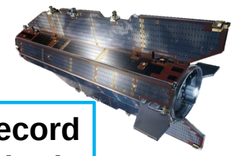
Column ordinal number of time in the record: 1

Column ordinal number of starting MJD0 in the header: 5

Select the type of effects

- [x] geopotential (0.1m²/s²)
- [ ] gravity vector (XYZ, μGal)
- [ ] gravity vector (ENU, μGal)
- [ ] gravity gradient (XYZ, 10μE)
- [x] gravity gradient (ENU, 10μE)

```
>> Complete the computation of solid earth tide effects!
>> Computation end time: 2024-10-18 09:36:46
>> [Function] According to the location and time in the external space point file, compute the solid Earth tidal effects on the geopotential (0.1m²/s²), gravity (μGal) or gravity gradient (10μE) outside the solid Earth
>> Open the location and time file of the external points C:/ETideLoad4.5_win64en/examples/Tideffectsolidearth/satptm.txt.
  ** Set the file format parameters according to the text box below, and then select the type of the geodetic variation to be computed. After giving the output file name, click the control button [Import setting parameters]...
>> Save the computed results as C:/ETideLoad4.5_win64en/examples/Tideffectsolidearth/satprst.txt.
  ** Behind the input file record, add one or several columns of the tidal effects as the output file record.
>> Setting parameters have been imported into the program!
  ** Click the control button [Start computation], or the tool button [Start computation]
>> Computation start time：2024-10-18 09:38:21
>> Complete the computation of solid earth tide effects!
>> Computation end time: 2024-10-18 09:38:22
```



Columns 2 and 3 of the record are agreed as the longitude and latitude of the satellite

Save the computed results as

Import setting parameters

Start computation

Display of the input-output file↓

GOCE satellite altitude

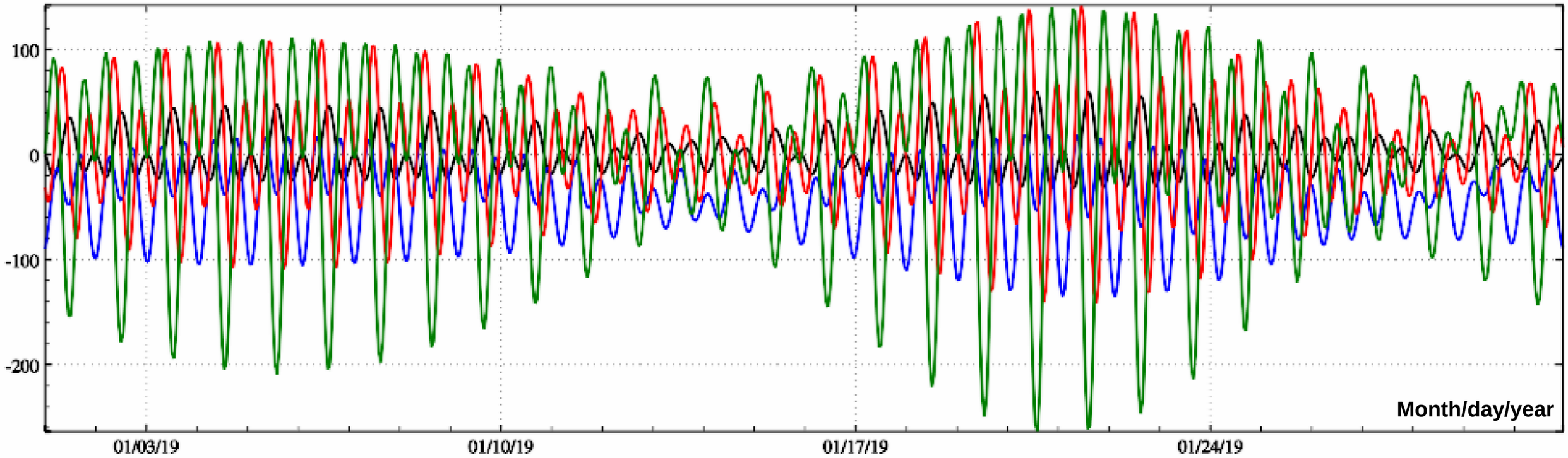
Save data in the text box as

```
NYB 150.24  32.42   250000.0   58119.000000
  201901010000   150.24  32.42  250000.0     0.2777   -14.0775     4.4894    -0.4489
  201901010100   150.24  32.42  250000.0    -5.9123    -5.5368     5.7527    16.6033
  201901010200   150.24  32.42  250000.0   -13.1543     5.2957     6.5691    36.3888
  201901010300   150.24  32.42  250000.0   -19.3259    15.5801     6.4614    53.0735
  201901010400   150.24  32.42  250000.0   -22.3930    22.6134     5.0126    61.1675
  201901010500   150.24  32.42  250000.0   -20.9443    24.4922     1.9985    56.9495
  201901010600   150.24  32.42  250000.0   -14.5749    20.5536    -2.5187    39.4422
  201901010700   150.24  32.42  250000.0    -4.0300    11.5134    -8.1597    10.7348
  201901010800   150.24  32.42  250000.0     8.9232    -0.7050   -14.2705   -24.3961
  201901010900   150.24  32.42  250000.0    21.8654   -13.4028   -20.0322   -59.4712
  201901011000   150.24  32.42  250000.0    32.2542   -23.7069   -24.6126   -87.6891
  201901011100   150.24  32.42  250000.0    37.9959   -29.2208   -27.3295  -103.4147
  201901011200   150.24  32.42  250000.0    37.9288   -28.5910   -27.7875  -103.4592
  201901011300   150.24  32.42  250000.0    32.1058   -21.8628   -25.9573   -87.8569
  201901011400   150.24  32.42  250000.0    21.7992   -10.5274   -22.1787   -59.9358
  201901011500   150.24  32.42  250000.0     9.2180     2.7787   -17.0844   -25.6164
  201901011600   150.24  32.42  250000.0    -3.0075    14.8794   -11.4618     7.9396
```

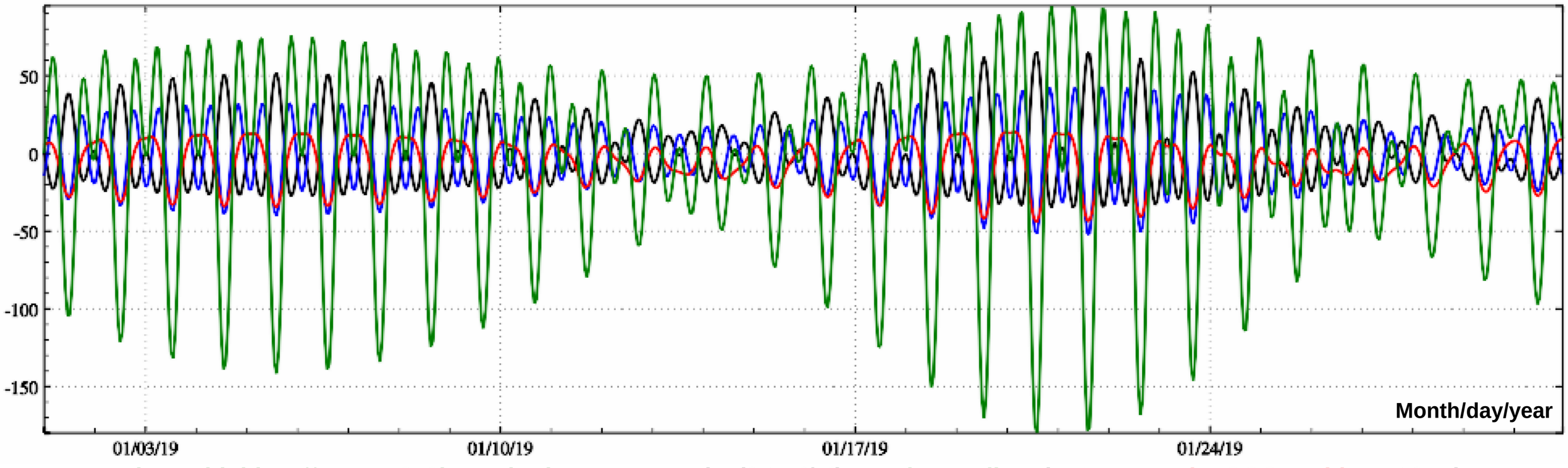
The program adopts the same numerical standards and analytical algorithms of the solid Earth tidal effects on geopotential and and geodetic site displacement that are compatible with the IERS Conventions (2010), and compute uniformly the solid Earth tidal effects on all-element geodetic variations considering the latitude and frequency dependence of the Love numbers, so as to maintain rigorously the analytical relationships between the solid Earth tidal effects on various geodetic variations.

The Earth's tide generating potential (TGP) from the moon is calculated from 2nd to 6th degree, that from the sun from 2nd to 3rd degree, and that from other planets at the 2nd degree.

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.



The solid tidal effects at 450km altitude： geopotential (0.1m²/s²), gravity vector (E, N: along the GRACE orbit/SST-II, U, μGal)



The solid tidal effects at 250km altitude： geopotential (0.1m²/s²), gravity gradient (E, N: along the GOCE orbit, U, 10μE)

Global forcast of solid tidal effects on various surface geodetic variations

Global forecast of solid tidal effects on various surface geodetic variations

Earth Tide, Load Effect and Deformation Monitoring Computation
ETideLoad4.5
Chinese Academy of Surveying & mapping
October 2024, Beijing, China

Location of surface point to be forecast

Longitude 121.240000°
Latitude 29.428100°
Ellipsoidal height 17.830m

Forecast time series parameters

Start time 20160701
End time 20160704
Time interval 10.00 min

Calculate and save as

Tidal effects to be plot

- [x] geoid or height anomaly (mm)
- [x] ground gravity (μGal)
- [ ] gravity disturbance (μGal)
- [ ] ground tilt (SW, mas)
- [ ] vertical deflection (SW, mas)
- [ ] horizontal displacement (EN, mm)
- [x] ground radial displacement (mm)
- [x] normal (orthometric) height (mm)
- [x] radial gravity gradient (10μE)
- [ ] horizontal gravity gradient (NW, 10μE)

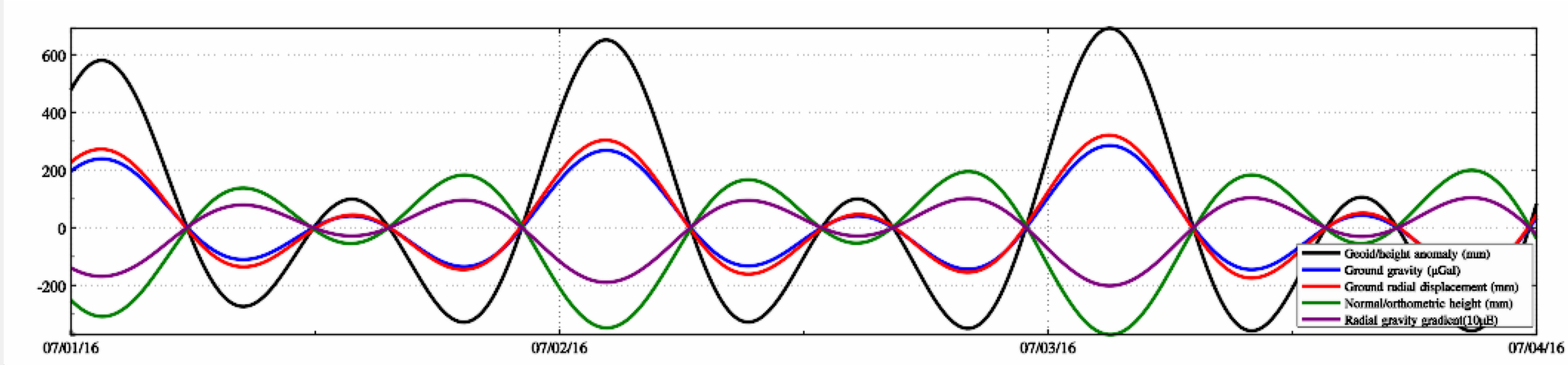
Tidal effect time series on all-element geodetic variations

201607032040	2.861111	-357.1604	-147.1050	-164.6183	0.7322	1.0[illegible]
201607032050	2.868056	-357.9992	-147.5027	-165.0620	0.2210	
2016070321	2.875000	-356.3099	-146.8649	-164.3405	-0.2467	-1.3169
201607032110	2.881944	-352.0355	-145.1672	-162.4264	-0.6691	-2.5490
201607032120	2.888889	-345.1367	-142.3926	-159.3010	-1.0443	-3.7961
201607032130	2.895833	-335.5930	-138.5315	-154.9538	-1.3709	-5.0493
201607032140	2.902778	-323.4025	-133.5821	-149.3833	-1.6478	-6.3000
201607032150	2.909722	-308.5825	-127.5506	-142.5966	-1.8745	-7.5390
2016070322	2.916667	-291.1692	-120.4506	-134.6095	-2.0504	-8.7574
201607032210	2.923611	-271.2180	-112.3039	-125.4469	-2.1757	-9.9465
201607032220	2.930556	-248.8027	-103.1400	-115.1422	-2.2507	-11.0973
201607032230	2.937500	-224.0159	-92.9958	-103.7374	-2.2762	-12.2013
201607032240	2.944444	-196.9676	-81.9159	-91.2827	-2.2534	-13.2502
201607032250	2.951389	-167.7855	-69.9518	-77.8366	-2.1836	-14.2360
2016070323	2.958333	-136.6134	-57.1621	-63.4650	-2.0687	-15.1510
201607032310	2.965278	-103.6110	-43.6116	-48.2413	-1.9108	-15.9881
201607032320	2.972222	-68.9523	-29.3717	-32.2456	-1.7122	-16.7405
201607032330	2.979167	-32.8249	-14.5190	-15.5645	-1.4758	-17.4021
201607032340	2.986111	4.5714	0.8646	1.7098	-1.2045	-17.9673
201607032350	2.993056	43.0259	16.6924	19.4799	-0.9014	-18.4311
2016070400	3.000000	82.3184	32.8740	37.6440	-0.5700	-18.7895

Set line thickness 3
Extract time series to be plot
Plot↓

Tidal effect curve on surface geodetic variations

Save the current plot as



Firstly, calculate the tidal effect time series on all-element geodetic variations, and then select the variations to be plot.

Look at the amplitude of various solid tidal effects, the in-phase or out-of-phase (same or opposite sign) relationship between different types of variations, and the time-varying characteristics of the tidal effect curves.

Global forcast of solid tidal effects on various surface geodetic variations

Global forecast of solid tidal effects on various surface geodetic variations

Earth Tide, Load Effect and Deform - ation Monitoring Computation
ETideLoad4.5
Chinese Academy of Surveying & mapping
October 2024, Beijing, China

Location of surface point to be forecast

Longitude	121.240000°
Latitude	29.428100°
Ellipsoidal height	17.830m

Forecast time series parameters

Start time	20160701
End time	20160704
Time interval	10.00 min

Calculate and save as

Tidal effects to be plot

- ☐ geoid or height anomaly (mm)
- ☐ ground gravity (μGal) ⊙
- ☐ gravity disturbance (μGal)
- ☑ ground tilt (SW, mas) ⊙
- ☐ vertical deflection (SW, mas)
- ☑ horizontal displacement (EN, mm) ⊙
- ☐ ground radial displacement (mm) ⊙
- ☐ normal (orthometric) height (mm) ⊙
- ☐ radial gravity gradient (10μE)
- ☑ horizontal gravity gradient (NW, 10μE)

Tidal effect time series on all-element geodetic variations

201607032040	2.861111	-357.1604	-147.1050	-164.6183	0.7322	1.0405
201607032050	2.868056	-357.9992	-147.5027	-165.0620	0.2210	-0.4785
2016070321	2.875000	-356.3099	-146.8649	-164.3405	-0.2467	-1.3169
201607032110	2.881944	-352.0355	-145.1672	-162.4264	-0.6691	-2.5490
201607032120	2.888889	-345.1367	-142.3926	-159.3010	-1.0443	-3.7961
201607032130	2.895833	-335.5930	-138.5315	-154.9538	-1.3709	-5.0493
201607032140	2.902778	-323.4025	-133.5821	-149.3833	-1.6478	-6.3000
201607032150	2.909722	-308.5825	-127.5506	-142.5966	-1.8745	-7.5390
2016070322	2.916667	-291.1692	-120.4506	-134.6095	-2.0504	-8.7574
201607032210	2.923611	-271.2180	-112.3039	-125.4469	-2.1757	-9.9465
201607032220	2.930556	-248.8027	-103.1400	-115.1422	-2.2507	-11.0973
201607032230	2.937500	-224.0159	-92.9958	-103.7374	-2.2762	-12.2013
201607032240	2.944444	-196.9676	-81.9159	-91.2827	-2.2534	-13.2502
201607032250	2.951389	-167.7855	-69.9518	-77.8366	-2.1836	-14.2360
2016070323	2.958333	-136.6134	-57.1621	-63.4650	-2.0687	-15.1510
201607032310	2.965278	-103.6110	-43.6116	-48.2413	-1.9108	-15.9881
201607032320	2.972222	-68.9523	-29.3717	-32.2456	-1.7122	-16.7405
201607032330	2.979167	-32.8249	-14.5190	-15.5645	-1.4758	-17.4021
201607032340	2.986111	4.5714	0.8646	1.7098	-1.2045	-17.9673
201607032350	2.993056	43.0259	16.6924	19.4799	-0.9014	-18.4311
2016070400	3.000000	82.3184	32.8740	37.6440	-0.5700	-18.7895

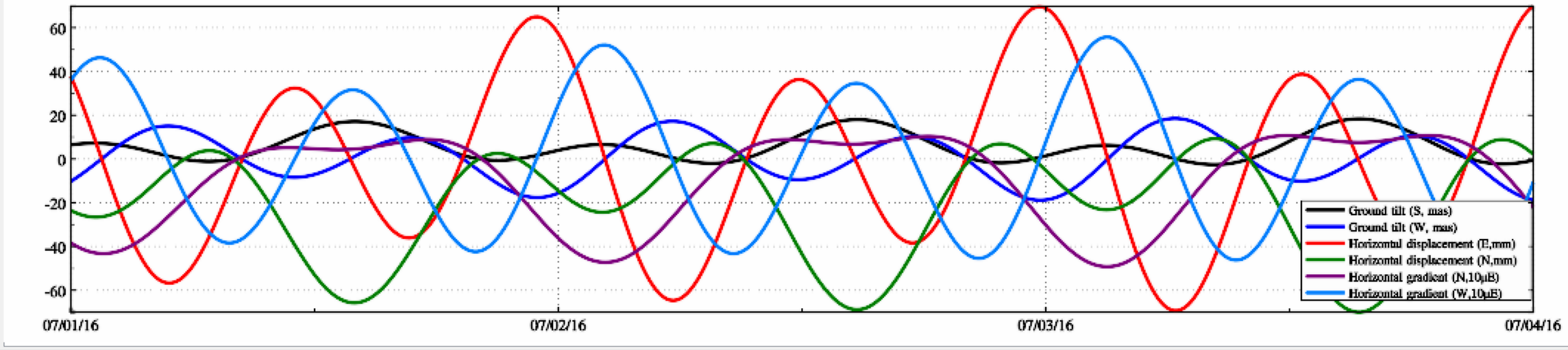
Set line thickness 3

Extract time series to be plot

Plot↓

Tidal effect curve on surface geodetic variations

Save the current plot as



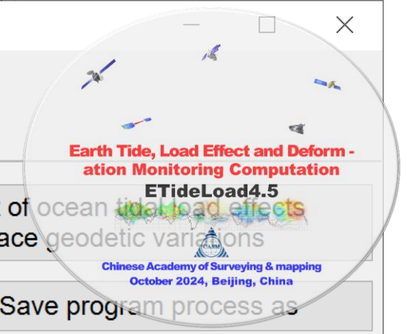
Firstly, calculate the tidal effect time series on all-element geodetic variations, and then select the variations to be plot.

Look at the amplitude of various solid tidal effects, the in-phase or out-of-phase (same or opposite sign) relationship between different types of variations, and the time-varying characteristics of the tidal effect curves.

Spherical harmonic synthesis on ocean tidal load effects outside solid Earth

Computation of ocean tidal load effect time series at a ground site

Open file | Save as | Import parameters | Start computation | Save process | Follow example



Computation of ocean tidal load effect time series at a ground site | Computation of ocean tidal load effects at ground sites with given time | Computation of ocean tidal load effects of Earth satellite or outside solid Earth | Global forecast of ocean tidal load effects on various surface geodetic variations

Open the geodetic site variation time series file

>> Program Process ** Operation Prompts

Save program process as

Set the file parameters

Column ordinal number of normal or orthometric height in the header: 4

Column ordinal number of time in the record: 1

Column ordinal number of starting MJD0 in the header: 5

Select the type of effects

- [x] geoid or height anomaly (mm)
- [x] ground gravity (μGal)
- [x] gravity disturbance (μGal)
- [x] ground tilt (SW, mas)
- [x] vertical deflection (SW, mas)
- [x] horizontal displacement (EN, mm)
- [x] ground radial displacement (mm)
- [x] ground normal or orthometric height (mm)
- [x] radial gravity gradient (10μE)
- [x] horizontal gravity gradient (NW, 10μE)

```
>> [Function] From a geodetic site variation time series file, compute the time series of the ocean tidal load effects on the geoid or height anomaly (mm), ground gravity (μGal), gravity disturbance (μGal), 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), radial gravity gradient (10μE) or horizontal gravity gradient (NW, to the north and to the west, 10μE).
>> Open the geodetic site variations time series file C:/ETideLoad4.5_win64en/examples/OTideloadharmsynth/Tmseries.txt.
  ** Set the file format parameters according to the text box below, and then select the type of the geodetic variation to be calculated. After giving the output file name, click the control button [Import setting parameters]...
>> Save the computed results as C:/ETideLoad4.5_win64en/examples/OTideloadharmsynth/Tmsqurst.txt.
  ** Behind the input file record, add one or several columns of the tidal effects selected as the output file record.
>> Setting parameters have been imported into the program!
  ** Click the control button [Start computation], or the tool button [Start computation]....
  ** The computation process needs to wait... During the computation period, you can open the output file C:/ETideLoad4.5_win64en/examples/OTideloadharmsynth/Tmsqurst.txt, to look at the computation progress!
>> Computation start time:  2024-10-18 10:38:34
>> Complete the computation of the ocean tidal load effects!
>> Computation end time: 2024-10-18 10:43:51
```

Columns 2 and 3 of the file header are agreed as the longitude and latitude of the ground site

Maximum truncated degree of the coefficient model: 120

Save the computed results as | Import setting parameters | Start computation

Display of the input-output file↓

Save data in the text box as

```
NYB  101.230000     29.910000     47.218   58484.000000
 201901010000      0.000000      2.764      1.7717     -0.8065     -0.5333     -0.3260      0.1351      0.0020      0.206
 201901010100      0.041667      2.778      1.1277     -0.3570     -0.2073     -0.3976      0.0118     -0.0177      0.172
 201901010200      0.083333      2.762      0.1811      0.0404     -0.0049     -0.4110     -0.1253     -0.0464      0.096
 201901010300      0.125000      2.724     -0.8863      0.2795      0.0081     -0.2791     -0.2769     -0.0589     -0.016
 201901010400      0.166667      2.675     -1.8226      0.4877      0.0176     -0.1319     -0.4500     -0.0691     -0.156
 201901010500      0.208333      2.626     -2.3880      0.6370      0.0485     -0.0720     -0.5929     -0.0812     -0.289
 201901010600      0.250000      2.582     -2.4797      0.5023     -0.0996      0.0143     -0.6538     -0.0618     -0.384
 201901010700      0.291667      2.546     -2.1169      0.1065     -0.4004      0.2000     -0.6556      0.0044     -0.434
 201901010800      0.333333      2.517     -1.3803     -0.2650     -0.5803      0.3634     -0.6313      0.0881     -0.438
 201901010900      0.375000      2.489     -0.4362     -0.4885     -0.5524      0.4001     -0.5473      0.1586     -0.382
 201901011000      0.416667      2.455      0.4859     -0.6369     -0.4446      0.3657     -0.3595      0.2130     -0.265
 201901011100      0.458333      2.410      1.1845     -0.6862     -0.2841      0.3571     -0.1032      0.2554     -0.110
 201901011200      0.500000      2.354      1.5253     -0.4881      0.0397      0.3524      0.1333      0.2678      0.038
 201901011300      0.541667      2.288      1.4545     -0.0193      0.5286      0.2566      0.3072      0.2244      0.154
 201901011400      0.583333      2.223      1.0144      0.4953      0.9573      0.1114      0.4397      0.1376      0.232
```

Compute the ocean tidal load effects on all-element geodetic variations on the ground or outside solid Earth from the ocean tidal load spherical harmonic coefficient model.

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.

The global ocean tidal load spherical harmonic coefficient model (cm) adopts the FES2004 format, which can be constructed from the global tidal height harmonic constant grid models by the function [Spherical harmonic analysis on ocean tidal constituent harmonic constants].

Spherical harmonic synthesis on ocean tidal load effects outside solid Earth

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

Open file | Save as | Import parameters | Start computation | Save process | Follow example

Earth Tide, Load Effect and Deform - ation Monitoring Computation
ETideLoad4.5
Chinese Academy of Surveying & mapping
October 2024, Beijing, China

Computation of ocean tidal load effect time series at a ground site

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

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

Global forecast of ocean tidal load effects on various surface geodetic variations

Open the location and time file of the calculation points

>> Program Process ** Operation Prompts

Save program process as

Set the file parameters

Column ordinal number of normal or orthometric height in the record: 4

Column ordinal number of time in the record: 1

Column ordinal number of starting MJD0 in the header: 5

Select the type of effects

- [x] geoid or height anomaly (mm)
- [x] ground gravity (μGal)
- [x] gravity disturbance (μGal)
- [x] ground tilt (SW, mas)
- [x] vertical deflection (SW, mas)
- [x] horizontal displacement (EN, mm)
- [x] ground radial displacement (mm)
- [x] ground normal or orthometric height (mm)
- [x] radial gravity gradient (10μE)
- [x] horizontal gravity gradient (NW, 10μE)

```
>> [Function] According to the location and time in the calculation point file, compute the ocean tidal load effects on the geoid or height anomaly (mm), ground gravity (μGal), gravity disturbance (μGal), 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), radial gravity gradient (10μE) or horizontal gravity gradient (NW, to the north and to the west, 10μE).
>> Open the location and time file of the calculation points C:/ETideLoad4.5_win64en/examples/OTideloadharmsynth/Postiontm.txt.
  ** Set the file format parameters according to the text box below, and then select the type of the geodetic variation to be calculated. After giving the output file name, click the control button [Import setting parameters]...
>> Save the computed results as C:/ETideLoad4.5_win64en/examples/OTideloadharmsynth/Postmrst.txt.
  ** Behind the input file record, add one or several columns of the tidal effects selected as the output file record.
>> Setting parameters have been imported into the program!
  ** Click the control button [Start computation], or the tool button [Start computation]....
  ** The computation process needs to wait... During the computation period, you can open the output file C:/ETideLoad4.5_win64en/examples/OTideloadharmsynth/Postmrst.txt, to look at the computation progress!
>> Computation start time：2024-10-18 10:46:37
>> Complete the computation of the ocean tidal load effects!
>> Computation end time: 2024-10-18 10:49:46
```

Columns 2 and 3 of the record are agreed as the longitude and latitude of the calculated point

Maximum truncated degree of the coefficient model: 120

Save the computed results as | Import setting parameters | Start computation

Display of the input-output file↓

Save data in the text box as

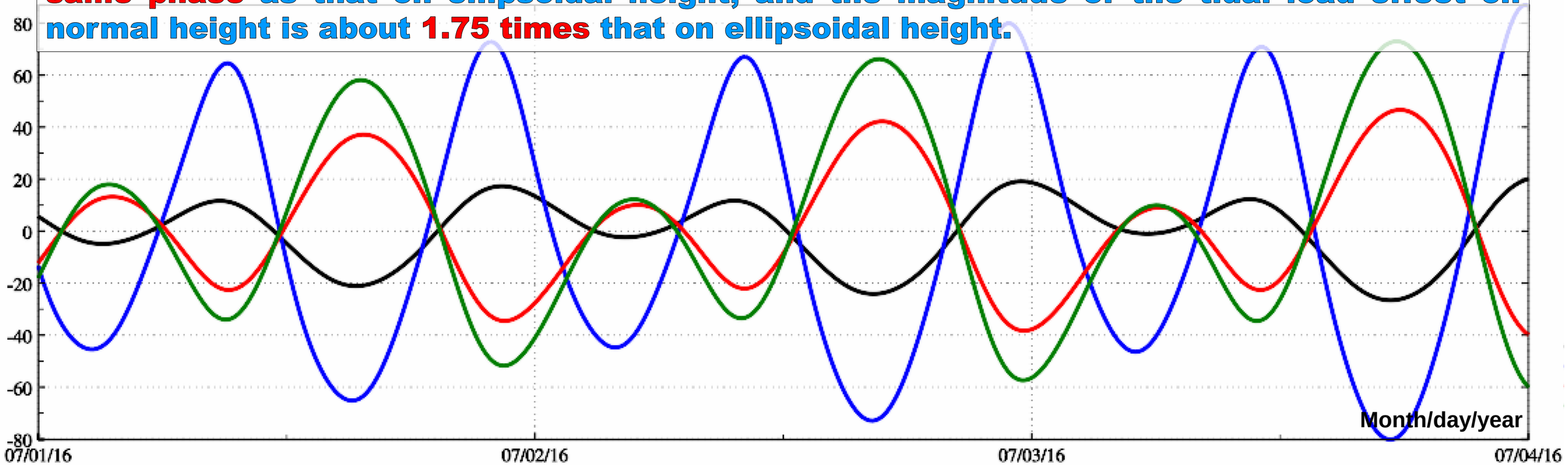
```
NY 151.0901  12.5001   47.218  58484.000000
 2019010100  151.0901  12.5001  2.52    6.8195   2.6525   3.7841   0.0601  -5.2443   0.0716  -2.21
 2019010101  151.0901  12.5001  2.52    9.1418   3.0137   4.4889   0.6043  -4.8543   0.3262  -2.07
 2019010102  151.0901  12.5001  2.52   10.7919   3.3139   5.0467   1.0761  -3.2011   0.5498  -1.38
 2019010103  151.0901  12.5001  2.52   11.3862   3.4869   5.3330   1.3877  -0.7025   0.6975  -0.30
 2019010104  151.0901  12.5001  2.52   10.6640   3.4233   5.1902   1.5095   2.0883   0.7518   0.91
 2019010105  151.0901  12.5001  2.52    8.5686   2.9811   4.4517   1.4505   4.5559   0.7190   1.99
 2019010106  151.0901  12.5001  2.52    5.3233   2.1095   3.0875   1.2049   6.0784   0.6034   2.65
 2019010107  151.0901  12.5001  2.52    1.4544   0.9701   1.3387   0.7815   6.2269   0.4107   2.71
 2019010108  151.0901  12.5001  2.52   -2.3524  -0.1609  -0.4067   0.2781   4.9513   0.1760   2.16
 2019010109  151.0901  12.5001  2.52   -5.5336  -1.1485  -1.9271  -0.1563   2.5616  -0.0412   1.11
 2019010110  151.0901  12.5001  2.52   -7.8127  -2.0656  -3.2601  -0.4290  -0.4074  -0.1956  -0.19
 2019010111  151.0901  12.5001  2.52   -9.1073  -2.9640  -4.4449  -0.5308  -3.3007  -0.2753  -1.47
 2019010112  151.0901  12.5001  2.52   -9.4064  -3.7153  -5.3348  -0.4979  -5.4368  -0.2915  -2.43
 2019010113  151.0901  12.5001  2.52   -8.8148  -4.1478  -5.7517  -0.3925  -6.2859  -0.2671  -2.83
 2019010114  151.0901  12.5001  2.52   -7.6135  -4.2084  -5.6707  -0.2978  -5.6771  -0.2358  -2.60
```

Expand and improve the ocean tidal load effect algorithm in the IERS conventions (2010) to adapt to all-element geodetic variations in the whole Earth space.

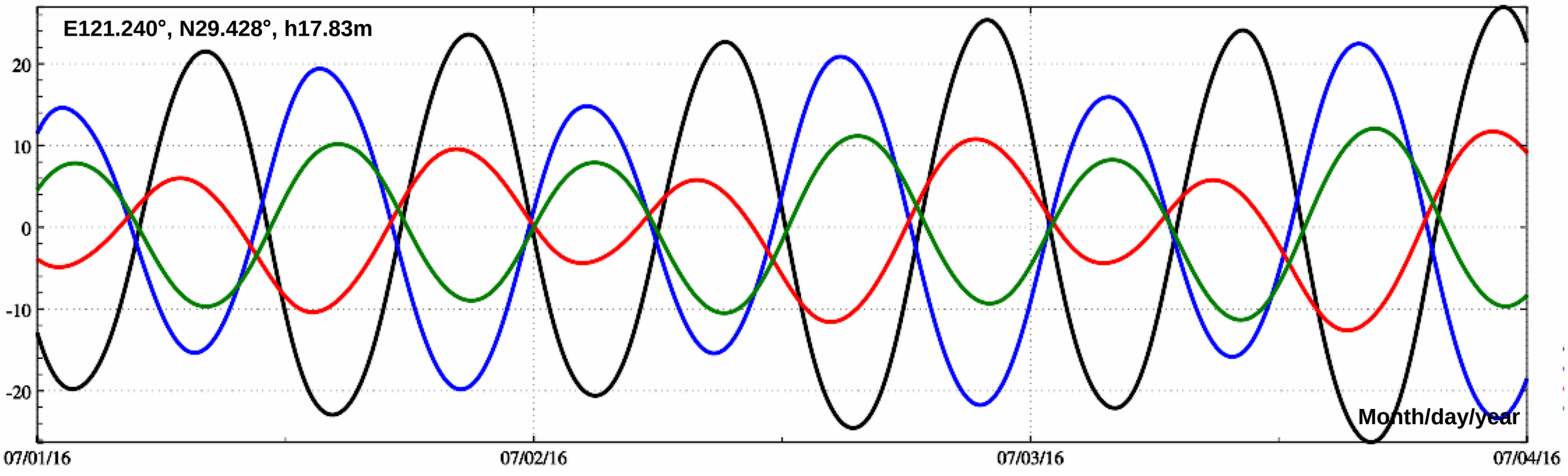
The height of the calculated point is normal or orthometric height relative to the sea surface since the ocean tidal loads are generally considered to be on the sea surface.

The global ocean tidal load spherical harmonic coefficient model (cm) adopts the FES2004 format, which can be constructed from the global tidal height harmonic constant grid models by the function [Spherical harmonic analysis on ocean tidal constituent harmonic constants].

Different from the effect of the solid Earth's tide, the load effect on normal height is in the same phase as that on ellipsoidal height, and the magnitude of the tidal load effect on normal height is about 1.75 times that on ellipsoidal height.



The ocean tidal load effects (360-degree) : height anomaly (mm) ground gravity (μGal) radial displacement (mm) orthometric height (mm)



The ocean tidal load effects (360-degree) : ground tilt (S, mas) tilt (W, mas) horizontal displacement (E, mm) horizontal displacement (N, mm)

Spherical harmonic synthesis on ocean tidal load effects outside solid Earth

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

Open file Save as Import parameters Start computation Save process Follow example

Computation of ocean tidal load effect time series at a ground site | Computation of ocean tidal load effects at ground sites with given time | Computation of ocean tidal load effects of Earth satellite or outside solid Earth | Global forecast of ocean tidal load effects on various surface geodetic variations

Open the location and time file of the external points

>> Program Process ** Operation Prompts

Save program process as

Set the file parameters

Column ordinal number of normal or orthometric height in the record: 4

Column ordinal number of time in the record: 1

Column ordinal number of starting MJD0 in the header: 5

Select the type of effects

- [x] geopotential (0.1m²/s²)
- [ ] gravity vector (XYZ, μGal)
- [x] gravity vector (ENU, μGal)
- [ ] gravity gradient (XYZ, 10μE)
- [ ] gravity gradient (ENU, 10μE)

```
>> Computation end time: 2024-10-18 10:49:46
>> [Function] According to the location and time in the external space point file, compute the ocean tidal load effects on the geopotential (0.1m²/s²), gravity (μGal), or gravity gradient (10μE) outside the solid Earth.
>> Open the location and time file of the external points C:/ETideLoad4.5_win64en/examples/OTideloadharmsynth/outerptm.txt.
  ** Set the file format parameters according to the text box below, and then select the type of the geodetic variation to be calculated. After giving the output file name, click the control button [Import setting parameters]...
>> Save the computed results as C:/ETideLoad4.5_win64en/examples/OTideloadharmsynth/outerptmrst.txt.
  ** Behind the input file record, add one or several columns of the tidal effects selected as the output file record.
>> Setting parameters have been imported into the program!
  ** Click the control button [Start computation], or the tool button [Start computation]....
  ** The computation process needs to wait... During the computation period, you can open the output file C:/ETideLoad4.5_win64en/examples/OTideloadharmsynth/outerptmrst.txt, to look at the computation progress!
>> Computation start time：2024-10-18 10:51:29
>> Complete the computation of the ocean tidal load effects!
>> Computation end time: 2024-10-18 10:56:33
```

Columns 2 and 3 of the record are agreed as the longitude and latitude of the satellite

Maximum truncated degree of the coefficient model: 120

Save the computed results as | Import setting parameters | Start computation

Display of the input-output file↓

GRACE satellite altitude

Save data in the text box as

```
NYB 150.24  32.42   450000.0   58119.000000
 201901010000   150.24   32.42   450000.0    0.7062    1.8994    3.6395   -4.5368
 201901010100   150.24   32.42   450000.0    0.7226    1.2392    2.2724   -4.9812
 201901010200   150.24   32.42   450000.0    0.6455    0.1608    0.1145   -4.7514
 201901010300   150.24   32.42   450000.0    0.4814   -1.1760   -2.3711   -3.8555
 201901010400   150.24   32.42   450000.0    0.2474   -2.5020   -4.6259   -2.3812
 201901010500   150.24   32.42   450000.0   -0.0279   -3.5198   -6.1243   -0.4961
 201901010600   150.24   32.42   450000.0   -0.3059   -4.0274   -6.5031    1.5358
 201901010700   150.24   32.42   450000.0   -0.5459   -3.9739   -5.6522    3.3925
 201901010800   150.24   32.42   450000.0   -0.7143   -3.4097   -3.7274    4.7711
 201901010900   150.24   32.42   450000.0   -0.7902   -2.4276   -1.1052    5.4721
 201901011000   150.24   32.42   450000.0   -0.7698   -1.1688    1.6849    5.4405
 201901011100   150.24   32.42   450000.0   -0.6668    0.1603    4.0655    4.7565
 201901011200   150.24   32.42   450000.0   -0.5092    1.3309    5.5536    3.6224
 201901011300   150.24   32.42   450000.0   -0.3310    2.1604    5.8885    2.3125
 201901011400   150.24   32.42   450000.0   -0.1594    2.5516    5.0887    1.0591
 201901011500   150.24   32.42   450000.0   -0.0108    2.5163    3.4329   -0.0001
 201901011600   150.24   32.42   450000.0    0.1052    2.1898    1.3849   -0.7773
 201901011700   150.24   32.42   450000.0    0.1857    1.7899   -0.5166   -1.2273
 201901011800   150.24   32.42   450000.0    0.2399    1.5064   -1.7959   -1.4002
```

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.

The global ocean tidal load spherical harmonic coefficient model (cm) adopts the FES2004 format, which can be constructed from the global tidal height harmonic constant grid models by the function [Spherical harmonic analysis on ocean tidal constituent harmonic constants].

Spherical harmonic synthesis on ocean tidal load effects outside solid Earth

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

Open file | Save as | Import parameters | Start computation | Save process | Follow example

Computation of ocean tidal load effect time series at a ground site | Computation of ocean tidal load effects at ground sites with given time | Computation of ocean tidal load effects of Earth satellite or outside solid Earth | Global forecast of ocean tidal load effects on various surface geodetic variations

Open the location and time file of the external points

>> Program Process ** Operation Prompts

Save program process as

Set the file parameters

Column ordinal number of normal or orthometric height in the record: 4

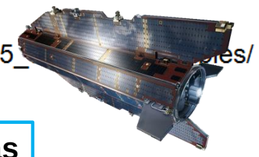
Column ordinal number of time in the record: 1

Column ordinal number of starting MJD0 in the header: 5

Select the type of effects

- [x] geopotential (0.1m²/s²)
- [ ] gravity vector (XYZ, μGal)
- [ ] gravity vector (ENU, μGal)
- [ ] gravity gradient (XYZ, 10μE)
- [x] gravity gradient (ENU, 10μE)

```
>> Computation end time: 2024-10-18 10:56:33
>> [Function] According to the location and time in the external space point file, compute the ocean tidal load effects on the geopotential (0.1m²/s²), gravity (μGal), or gravity gradient (10μE) outside the solid Earth.
>> Open the location and time file of the external points C:/ETideLoad4.5_win64en/examples/OTideloadharmsynth/satptm.txt.
  ** Set the file format parameters according to the text box below, and then select the type of the geodetic variation to be calculated. After giving the output file name, click the control button [Import setting parameters]...
>> Save the computed results as C:/ETideLoad4.5_win64en/examples/OTideloadharmsynth/satprst.txt.
  ** Behind the input file record, add one or several columns of the tidal effects selected as the output file record.
>> Setting parameters have been imported into the program!
  ** Click the control button [Start computation], or the tool button [Start computation]....
  ** The computation process needs to wait... During the computation period, you can open the output file C:/ETideLoad4.5_win64en/examples/OTideloadharmsynth/satprst.txt, to look at the computation progress!
>> Computation start time：2024-10-18 10:57:57
>> Complete the computation of the ocean tidal load effects!
>> Computation end time: 2024-10-18 11:03:22
```



Columns 2 and 3 of the record are agreed as the longitude and latitude of the satellite

Maximum truncated degree of the coefficient model: 120

Save the computed results as | Import setting parameters | Start computation

Display of the input-output file↓

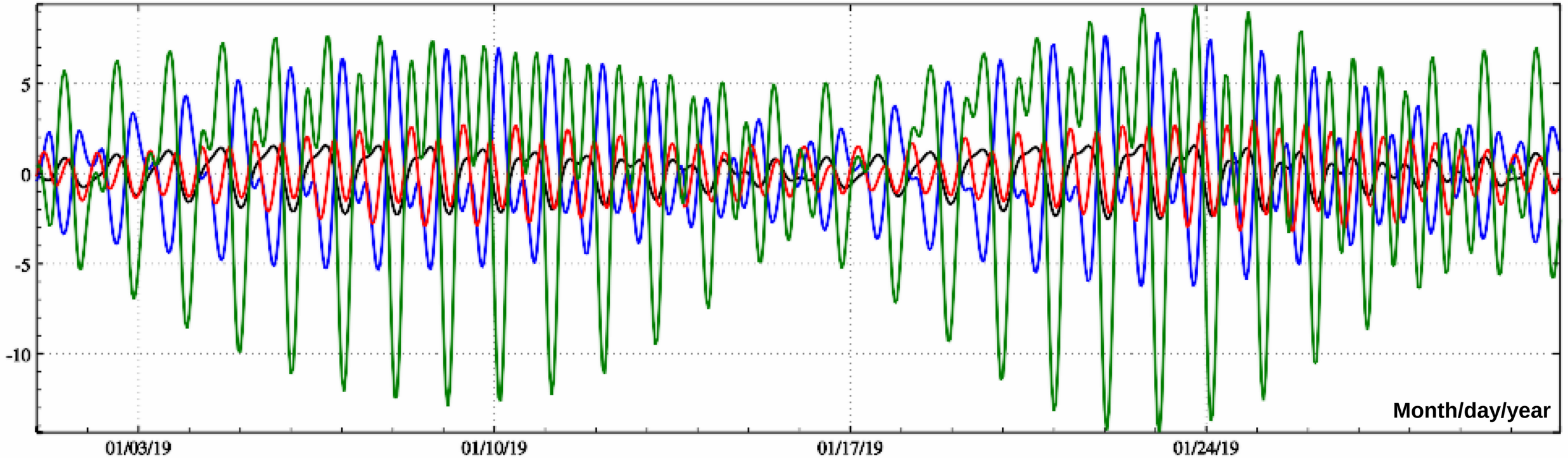
GOCE satellite altitude

Save data in the text box as

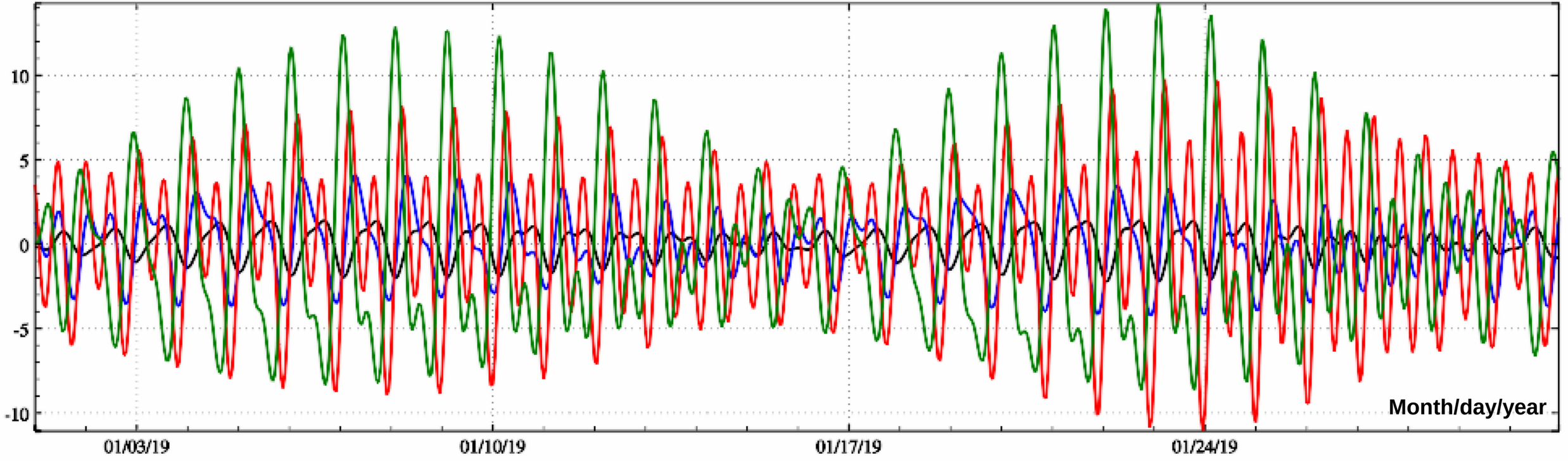
```
NYB 150.24  32.42   250000.0   58119.000000
 201901010000   150.24   32.42   250000.0    0.8053   -3.1881   -0.5733    4.7552
 201901010100   150.24   32.42   250000.0    0.8319   -3.6135   -0.2601    5.4440
 201901010200   150.24   32.42   250000.0    0.7499   -3.4396    0.0527    5.2184
 201901010300   150.24   32.42   250000.0    0.5661   -2.7244    0.3243    4.1564
 201901010400   150.24   32.42   250000.0    0.2997   -1.5932    0.4757    2.3948
 201901010500   150.24   32.42   250000.0   -0.0173   -0.1972    0.4659    0.1546
 201901010600   150.24   32.42   250000.0   -0.3400    1.2391    0.3024   -2.2075
 201901010700   150.24   32.42   250000.0   -0.6210    2.4250    0.0029   -4.2682
 201901010800   150.24   32.42   250000.0   -0.8196    3.1060   -0.3676   -5.6278
 201901010900   150.24   32.42   250000.0   -0.9105    3.2028   -0.6885   -6.0611
 201901011000   150.24   32.42   250000.0   -0.8888    2.8216   -0.8345   -5.5836
 201901011100   150.24   32.42   250000.0   -0.7700    2.1150   -0.7272   -4.3450
 201901011200   150.24   32.42   250000.0   -0.5869    1.2442   -0.3975   -2.6412
 201901011300   150.24   32.42   250000.0   -0.3794    0.4417    0.0376   -0.9329
 201901011400   150.24   32.42   250000.0   -0.1803   -0.0826    0.5006    0.4233
 201901011500   150.24   32.42   250000.0   -0.0087   -0.2765    0.9518    1.3248
 201901011600   150.24   32.42   250000.0    0.1237   -0.1893    1.2933    1.7398
 201901011700   150.24   32.42   250000.0    0.2132    0.1102    1.4158    1.6557
 201901011800   150.24   32.42   250000.0    0.2701    0.4983    1.2777    1.2036
```

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.

The global ocean tidal load spherical harmonic coefficient model (cm) adopts the FES2004 format, which can be constructed from the global tidal height harmonic constant grid models by the function [Spherical harmonic analysis on ocean tidal constituent harmonic constants].



The ocean tidal load effects at 450km altitude： geopotential (0.1m²/s²), gravity vector (E, N: along the GRACE orbit/SST-II, U, μGal)



The ocean tidal load effects at 250km altitude： geopotential (0.1m²/s²), gravity gradient (E, N: along the GOCE orbit, U, 10μE)

Global forcast of ocean tidal load effects on various surface geodetic variations

Global forecast of ocean tidal load effects on various surface geodetic variations

Earth Tide, Load Effect and Deform - ation Monitoring Computation
ETideLoad4.5
Chinese Academy of Surveying & mapping
October 2024, Beijing, China

Location of surface point to be forecast

Longitude	121.240000°
Latitude	29.428100°
Normal or ortho-metric height	17.830m

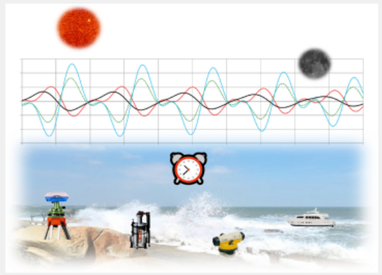
Forecast time series parameters

Start time	20160701
End time	20160704
Time interval	30.00 min

Maximum truncated degree of the coefficients model: 360

Calculate and save as

The program needs some time to calculate the time series of ocean tidal load effects. Please wait until the button [Extract time series to be plot] becomes available.



Tidal effects to be plot

- [x] geoid or height anomaly (mm)
- [x] ground gravity (μGal)
- [ ] gravity disturbance (μGal)
- [ ] ground tilt (SW, mas)
- [ ] vertical deflection (SW, mas)
- [ ] horizontal displacement (EN, mm)
- [x] ground radial displacement (mm)
- [x] normal (orthometric) height (mm)
- [ ] radial gravity gradient (10μE)
- [ ] horizontal gravity gradient (NW, 10μE)
- [x] Sea surface tidal height (cm)

Tidal effect time series on all-element geodetic variations

201607031230	2.520833	19.1056	92.9935	98.9097	94.9732	-62.6457	23.
2016070313	2.541667	19.3684	87.3082	93.3513	73.8155	-50.	
201607031330	2.562500	18.5889	75.2272	81.0302	46.9827	-34.7931	11.
2016070314	2.583333	16.9764	59.0082	64.2757	17.0406	-17.3244	4.
201607031430	2.604167	14.7415	41.0176	45.5290	-12.9246	0.4867	-3.
2016070315	2.625000	12.0734	23.1412	26.7421	-40.1203	17.0683	-9.
201607031530	2.645833	9.1478	6.5005	9.0940	-62.7336	31.2263	-15.
2016070316	2.666667	6.1441	-8.4724	-6.9279	-80.1315	42.2972	-19.
201607031630	2.687500	3.2513	-21.7064	-21.1969	-92.4837	50.0269	-22.
2016070317	2.708333	0.6515	-33.1140	-33.5702	-100.0660	54.3038	-24.
201607031730	2.729167	-1.5063	-42.3641	-43.6670	-102.6922	54.9758	-25.
2016070318	2.750000	-3.1233	-48.9039	-50.8939	-99.6325	51.8924	-24.
201607031830	2.770833	-4.1468	-52.1827	-54.6682	-90.0559	45.1189	-21.
2016070319	2.791667	-4.5510	-51.9099	-54.6744	-73.7051	35.1271	-17.
201607031930	2.812500	-4.3177	-48.1701	-50.9760	-51.3816	22.7912	-12.
2016070320	2.833333	-3.4335	-41.3139	-43.9078	-24.9622	9.1827	-5.
201607032030	2.854167	-1.9043	-31.7056	-33.8271	3.0449	-4.6859	1.
2016070321	2.875000	0.2195	-19.5226	-20.9191	30.1430	-17.9995	8.
201607032130	2.895833	2.8195	-4.7898	-5.2378	54.3698	-30.1088	14.
2016070322	2.916667	5.6968	12.3137	12.9811	74.4909	-40.4162	19.
201607032230	2.937500	8.5742	31.0290	32.8906	89.8553	-48.3088	23.
2016070323	2.958333	11.1175	49.7423	52.7596	100.0555	-53.1880	25.
201607032330	2.979167	12.9800	66.0822	70.0838	104.6045	-54.5511	26.
2016070400	3.000000	13.8632	77.4314	82.1208	102.8130	-52.0484	26.

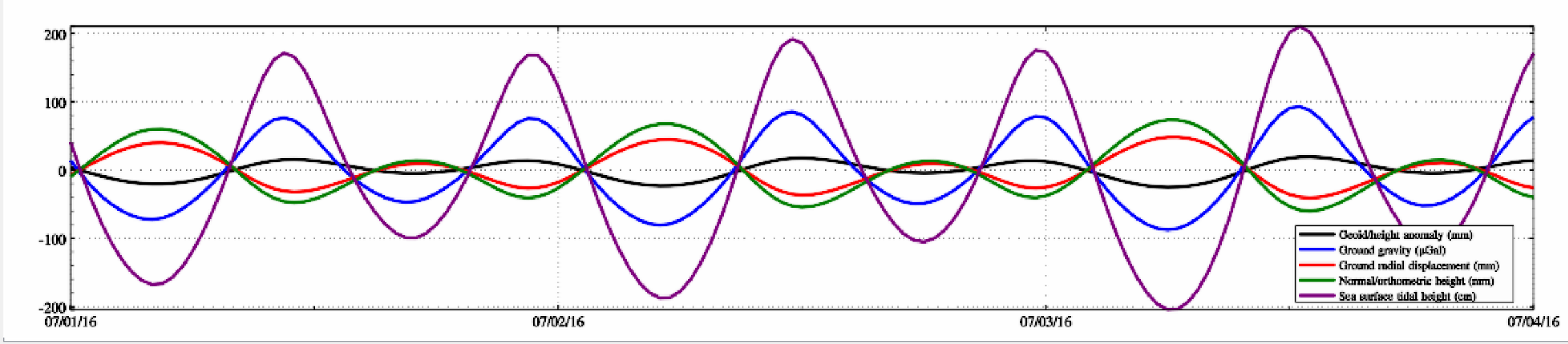
Set line thickness: 3

Extract time series to be plot

Plot↓

Tidal effect curve of surface geodetic variations

Save the current plot as



Firstly, calculate the tidal effect time series on all-element geodetic variations, and then select the variations to be plot.

Look at the amplitude of various ocean tidal load effects, the in-phase or out-of-phase (same or opposite sign) relationship between different types of variations, and the time-varying characteristics of the tidal effect curves.

Global forcast of ocean tidal load effects on various surface geodetic variations

Global forecast of ocean tidal load effects on various surface geodetic variations

Earth Tide, Load Effect and Deform - ation Monitoring Computation
ETideLoad4.5
Chinese Academy of Surveying & mapping
October 2024, Beijing, China

Location of surface point to be forecast

Longitude	121.240000°
Latitude	29.428100°
Normal or ortho-metric height	17.830m

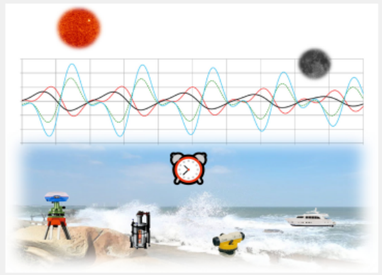
Forecast time series parameters

Start time	20160701
End time	20160704
Time interval	30.00 min

Maximum truncated degree of the coefficients model: 360

Calculate and save as

The program needs some time to calculate the time series of ocean tidal load effects. Please wait until the button [Extract time series to be plot] becomes available.



Tidal effects to be plot

- [ ] geoid or height anomaly (mm)
- [ ] ground gravity (μGal)
- [ ] gravity disturbance (μGal)
- [x] ground tilt (SW, mas)
- [x] vertical deflection (SW, mas)
- [x] horizontal displacement (EN, mm)
- [ ] ground radial displacement (mm)
- [ ] normal (orthometric) height (mm)
- [ ] radial gravity gradient (10μE)
- [ ] horizontal gravity gradient (NW, 10μE)
- [ ] Sea surface tidal height (cm)

Tidal effect time series on all-element geodetic variations

201607031230	2.520833	19.1056	92.9935	98.9097	94.9732	-62.6457	23.
2016070313	2.541667	19.3684	87.3082	93.3513	73.8155	-50.	
201607031330	2.562500	18.5889	75.2272	81.0302	46.9827	-34.7931	11.
2016070314	2.583333	16.9764	59.0082	64.2757	17.0406	-17.3244	4.
201607031430	2.604167	14.7415	41.0176	45.5290	-12.9246	0.4867	-3.
2016070315	2.625000	12.0734	23.1412	26.7421	-40.1203	17.0683	-9.
201607031530	2.645833	9.1478	6.5005	9.0940	-62.7336	31.2263	-15.
2016070316	2.666667	6.1441	-8.4724	-6.9279	-80.1315	42.2972	-19.
201607031630	2.687500	3.2513	-21.7064	-21.1969	-92.4837	50.0269	-22.
2016070317	2.708333	0.6515	-33.1140	-33.5702	-100.0660	54.3038	-24.
201607031730	2.729167	-1.5063	-42.3641	-43.6670	-102.6922	54.9758	-25.
2016070318	2.750000	-3.1233	-48.9039	-50.8939	-99.6325	51.8924	-24.
201607031830	2.770833	-4.1468	-52.1827	-54.6682	-90.0559	45.1189	-21.
2016070319	2.791667	-4.5510	-51.9099	-54.6744	-73.7051	35.1271	-17.
201607031930	2.812500	-4.3177	-48.1701	-50.9760	-51.3816	22.7912	-12.
2016070320	2.833333	-3.4335	-41.3139	-43.9078	-24.9622	9.1827	-5.
201607032030	2.854167	-1.9043	-31.7056	-33.8271	3.0449	-4.6859	1.
2016070321	2.875000	0.2195	-19.5226	-20.9191	30.1430	-17.9995	8.
201607032130	2.895833	2.8195	-4.7898	-5.2378	54.3698	-30.1088	14.
2016070322	2.916667	5.6968	12.3137	12.9811	74.4909	-40.4162	19.
201607032230	2.937500	8.5742	31.0290	32.8906	89.8553	-48.3088	23.
2016070323	2.958333	11.1175	49.7423	52.7596	100.0555	-53.1880	25.
201607032330	2.979167	12.9800	66.0822	70.0838	104.6045	-54.5511	26.
2016070400	3.000000	13.8632	77.4314	82.1208	102.8130	-52.0484	26.

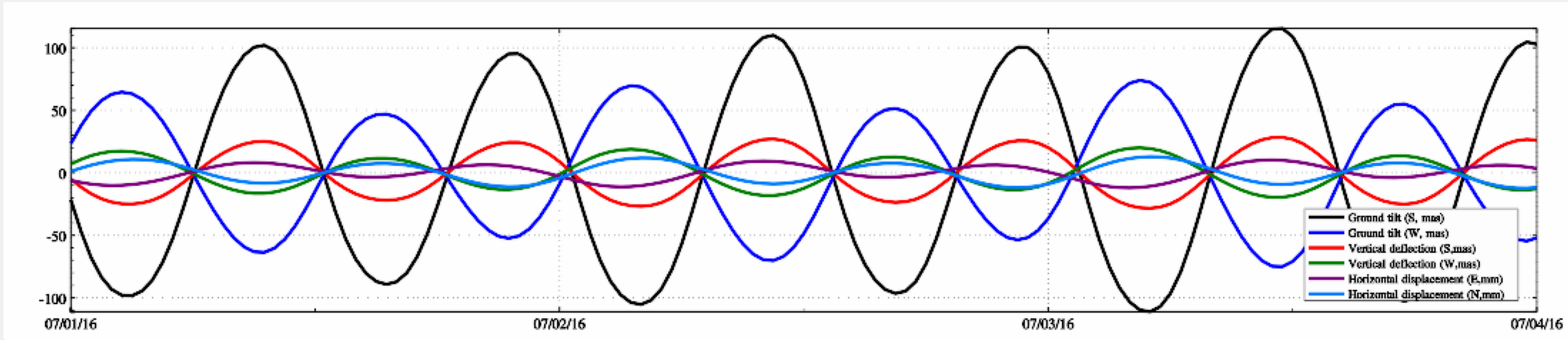
Set line thickness: 3

Extract time series to be plot

Plot↓

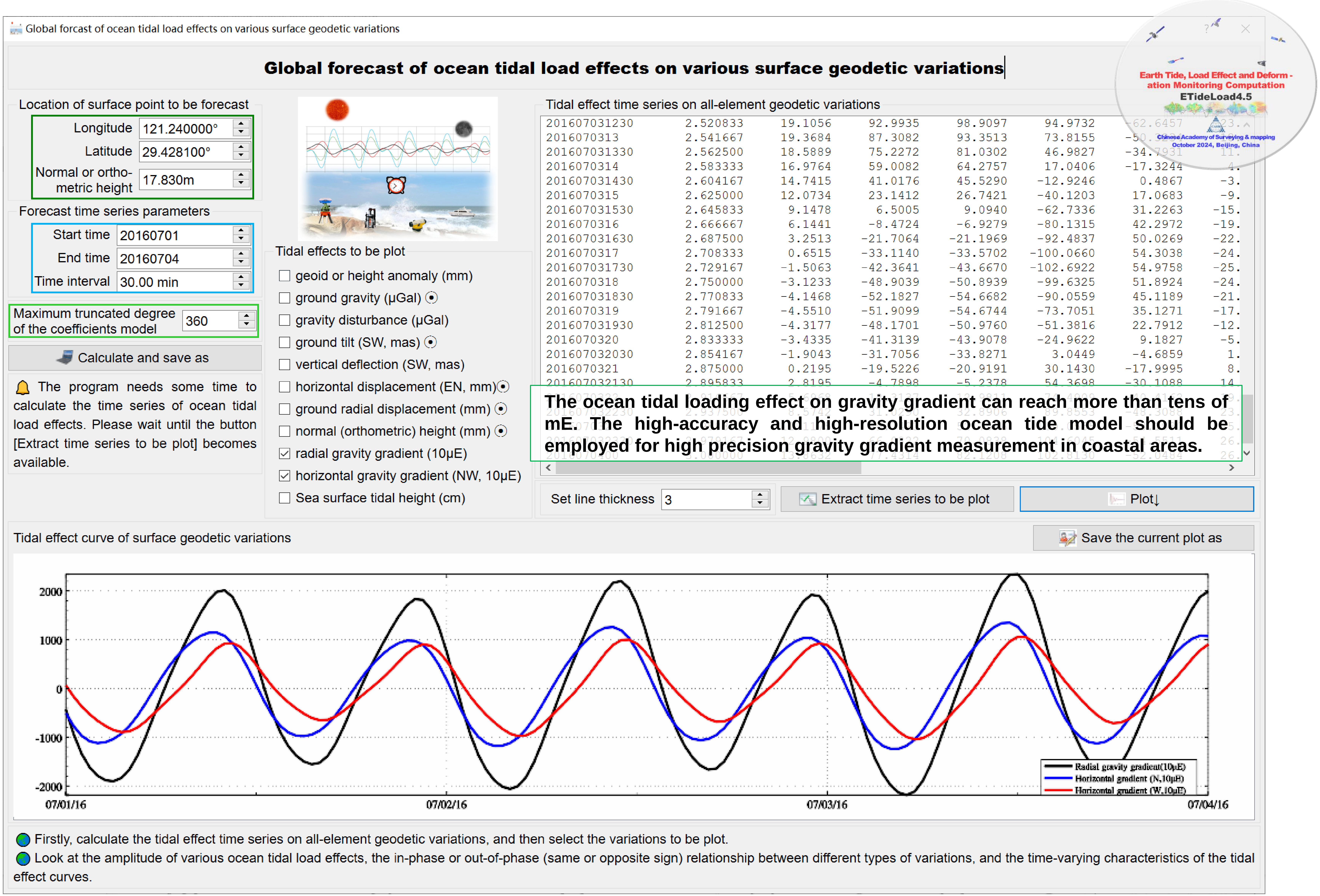
Tidal effect curve of surface geodetic variations

Save the current plot as



Firstly, calculate the tidal effect time series on all-element geodetic variations, and then select the variations to be plot.

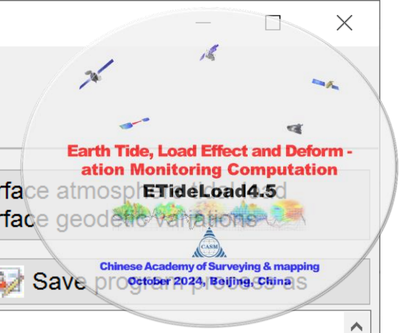
Look at the amplitude of various ocean tidal load effects, the in-phase or out-of-phase (same or opposite sign) relationship between different types of variations, and the time-varying characteristics of the tidal effect curves.


Global forcast of ocean tidal load effects on various surface geodetic variations
Global forecast of ocean tidal load effects on various surface geodetic variations
Earth Tide, Load Effect and Deform - ation Monitoring Computation
ETideLoad4.5
Chinese Academy of Surveying & mapping
October 2024, Beijing, China
Location of surface point to be forecast
Longitude 121.240000°
Latitude 29.428100°
Normal or ortho- metric height 17.830m
Forecast time series parameters
Start time 20160701
End time 20160704
Time interval 30.00 min
Maximum truncated degree of the coefficients model 360
Calculate and save as
The program needs some time to calculate the time series of ocean tidal load effects. Please wait until the button [Extract time series to be plot] becomes available.
Tidal effects to be plot
geoid or height anomaly (mm)
ground gravity (μGal)
gravity disturbance (μGal)
ground tilt (SW, mas)
vertical deflection (SW, mas)
horizontal displacement (EN, mm)
ground radial displacement (mm)
normal (orthometric) height (mm)
radial gravity gradient (10μE)
horizontal gravity gradient (NW, 10μE)
Sea surface tidal height (cm)
Tidal effect time series on all-element geodetic variations
201607031230 2.520833 19.1056 92.9935 98.9097 94.9732
201607031300 2.541667 19.3684 87.3082 93.3513 73.8155
201607031330 2.562500 18.5889 75.2272 81.0302 46.9827 -34.7931 11.
2016070314 2.583333 16.9764 59.0082 64.2757 17.0406 -17.3244 4.
201607031430 2.604167 14.7415 41.0176 45.5290 -12.9246 0.4867 -3.
2016070315 2.625000 12.0734 23.1412 26.7421 -40.1203 17.0683 -9.
201607031530 2.645833 9.1478 6.5005 9.0940 -62.7336 31.2263 -15.
2016070316 2.666667 6.1441 -8.4724 -6.9279 -80.1315 42.2972 -19.
201607031630 2.687500 3.2513 -21.7064 -21.1969 -92.4837 50.0269 -22.
2016070317 2.708333 0.6515 -33.1140 -33.5702 -100.0660 54.3038 -24.
201607031730 2.729167 -1.5063 -42.3641 -43.6670 -102.6922 54.9758 -25.
2016070318 2.750000 -3.1233 -48.9039 -50.8939 -99.6325 51.8924 -24.
201607031830 2.770833 -4.1468 -52.1827 -54.6682 -90.0559 45.1189 -21.
2016070319 2.791667 -4.5510 -51.9099 -54.6744 -73.7051 35.1271 -17.
201607031930 2.812500 -4.3177 -48.1701 -50.9760 -51.3816 22.7912 -12.
2016070320 2.833333 -3.4335 -41.3139 -43.9078 -24.9622 9.1827 -5.
201607032030 2.854167 -1.9043 -31.7056 -33.8271 3.0449 -4.6859 1.
2016070321 2.875000 0.2195 -19.5226 -20.9191 30.1430 -17.9995 8.
The ocean tidal loading effect on gravity gradient can reach more than tens of mE. The high-accuracy and high-resolution ocean tide model should be employed for high precision gravity gradient measurement in coastal areas.
Set line thickness 3
Extract time series to be plot
Plot↓
Tidal effect curve of surface geodetic variations
Save the current plot as
2000
1000
0
-1000
-2000
07/01/16
07/02/16
07/03/16
07/04/16
Radial gravity gradient(10μE)
Horizontal gradient (N,10μE)
Horizontal gradient (W,10μE)
Firstly, calculate the tidal effect time series on all-element geodetic variations, and then select the variations to be plot.
Look at the amplitude of various ocean tidal load effects, the in-phase or out-of-phase (same or opposite sign) relationship between different types of variations, and the time-varying characteristics of the tidal effect curves.

Spherical harmonic synthesis on surface atmosphere tidal load effects outside solid Earth

Computation of surface atmosphere tidal load effect time series at a ground site

Open file | Save as | Import parameters | Start computation | Save process | Follow example



Computation of surface atmosphere tidal load effect time series at a ground site

Computation of surface atmosphere tidal load effects at ground sites with given time

Computation of surface atmosphere tidal load effects of satellite or outside Earth

Global forecast of surface atmospheric tidal load effects on various surface geodetic variations

Open the geodetic site variation time series file

>> Program Process ** Operation Prompts

Save program operations

Set the file parameters

Column ordinal number of height relative to the surface in the header: 4

Column ordinal number of time in the record: 1

Column ordinal number of starting MJD0 in the header: 5

Select the type of effects

- [x] geoid or height anomaly (mm)
- [x] ground gravity (μGal)
- [x] gravity disturbance (μGal)
- [x] ground tilt (SW, mas)
- [x] vertical deflection (SW, mas)
- [x] horizontal displacement (EN, mm)
- [x] ground radial displacement (mm)
- [x] ground normal or orthometric height (mm)
- [x] radial gravity gradient (10μE)
- [x] horizontal gravity gradient (NW, 10μE)

```
>> Select the computation function from the 4 control buttons on the top of the interface...
>> [Function] From a geodetic site variation time series file, compute the time series of the surface atmosphere tidal load effects on the geoid or height anomaly (mm), ground gravity (μGal), gravity disturbance (μGal), 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), radial gravity gradient (10μE) or horizontal gravity gradient (NW, to the north and to the west, 10μE).
>> Open the geodetic site variation time series file C:/ETideLoad4.5_win64en/examples/ATideloadharmsynth/Tmseries.txt.
  ** Set the file format parameters according to the text box below, and then select the type of the geodetic variation to be computed. After giving the output file name, click the control button [Import setting parameters]...
>> Save the computed results as C:/ETideLoad4.5_win64en/examples/ATideloadharmsynth/Tmsqurst.txt.
  ** Behind the input file record, add one or several columns of the tidal effects as the output file record.
>> Setting parameters have been imported into the program!
  ** Click the control button [Start computation], or the tool button [Start computation]....
  ** The computation process needs to wait... During the computation period, you can open the output file C:/ETideLoad4.5_win64en/examples/ATideloadharmsynth/Tmsqurst.txt, to look at the computation progress!
>> Computation start time：2024-10-18 11:31:01
>> Complete the computation of the atmosphere tidal load effects!
>> Computation end time: 2024-10-18 11:33:10
```

Columns 2 and 3 of the file header are agreed as the longitude and latitude of the ground site

Maximum truncated degree of the coefficient model: 120

Save the computed results as | Import setting parameters | Start computation

Display of the input-output file↓

Save data in the text box as

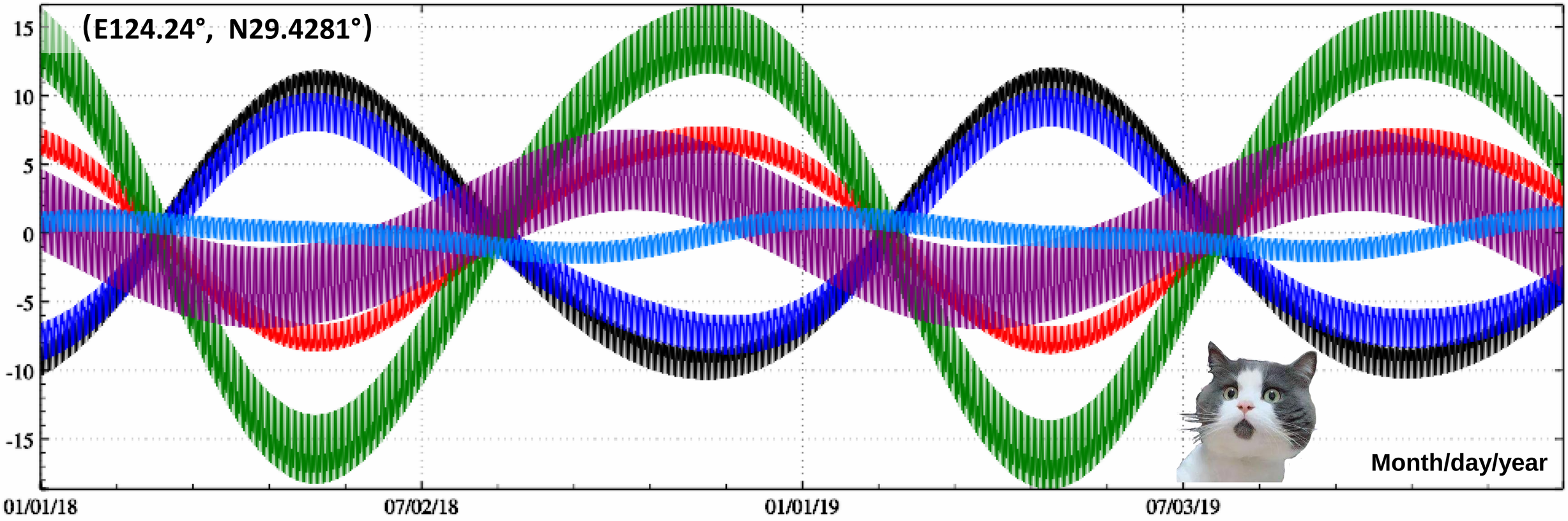
```
Forcast  121.240000   29.428100    0.000   58119.000000
2018010100  0.000000   -8.6691   -7.9206    6.3697    4.9036    0.8431   -0.5672    0.3648   -0.2596    0.4770
2018010103  0.125000   -8.2147   -7.1096    5.8940    4.5588    0.8537   -0.2702    0.3702   -0.1412    0.3252
2018010106  0.250000   -9.1342   -7.3395    6.5245    5.1688    0.7244   -0.1673    0.3216   -0.0971    0.2465
2018010109  0.375000   -9.1453   -7.1337    6.5116    5.1977    0.6881   -0.2389    0.3091   -0.1186    0.2162
2018010112  0.500000   -8.2336   -6.5034    5.7666    4.5417    0.7813   -0.2378    0.3494   -0.1009    0.1314
2018010115  0.625000   -8.6656   -7.1527    6.0979    4.7569    0.7905   -0.2430    0.3563   -0.0885    0.1115
2018010118  0.750000  -10.1846   -8.8031    7.3996    5.7968    0.6932   -0.4551    0.3159   -0.1800    0.2875
2018010121  0.875000  -10.1570   -9.1459    7.5287    5.8738    0.7033   -0.6698    0.3135   -0.2871    0.4855
2018010200  1.000000   -8.5912   -7.8709    6.3132    4.8559    0.8303   -0.5563    0.3596   -0.2550    0.4689
2018010203  1.125000   -8.1364   -7.0595    5.8372    4.5108    0.8409   -0.2593    0.3649   -0.1365    0.3170
2018010206  1.250000   -9.0554   -7.2889    6.4674    5.1205    0.7116   -0.1564    0.3163   -0.0925    0.2383
2018010209  1.375000   -9.0660   -7.0827    6.4542    5.1491    0.6752   -0.2280    0.3039   -0.1139    0.2080
2018010212  1.500000   -8.1539   -6.4520    5.7088    4.4930    0.7683   -0.2269    0.3441   -0.0963    0.1233
2018010215  1.625000   -8.5854   -7.1009    6.0398    4.7078    0.7775   -0.2320    0.3510   -0.0839    0.1034
2018010218  1.750000  -10.1040   -8.7509    7.3411    5.7475    0.6801   -0.4441    0.3106   -0.1753    0.2793
2018010221  1.875000  -10.0760   -9.0933    7.4699    5.8243    0.6902   -0.6588    0.3082   -0.2824    0.4773
2018010300  2.000000   -8.5097   -7.8178    6.2541    4.8063    0.8172   -0.5453    0.3541   -0.2503    0.4607
2018010303  2.125000   -8.0645   -7.0060    5.7778    4.4684    0.8277   -0.2402    0.3594   -0.1319    0.3089
2018010306  2.250000   -8.9733   -7.2351    6.4076    5.0702    0.6985   -0.1440    0.3119   -0.0883    0.2302
```

Compute the atmosphere tidal load effects on all-element geodetic variations on the ground or outside solid Earth from the atmosphere tidal load spherical harmonic coefficient model.

When calculating the indirect influences of surface atmosphere tidal load, the program assumes that the atmosphere loads are concentrated on the Earth's surface, and the height h of the calculation point is the height of the point relative to the surface. When calculating the direct influences of surface atmosphere tidal load to the gravity or gravity gradient, it is assumed that there is a proportional relationship between atmosphere P_h at height h and surface atmosphere P_0, namely $P_h=P_0\,(1-h/44330)^{5225}$.

The annual periodic amplitude of the surface atmosphere tide is more than 10 times the diurnal periodic amplitude. In the land area, the surface atmosphere 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.

Expand and improve surface atmosphere tidal load effect algorithm in the IERS conventions (2010) to adapt to all-element geodetic variations in the whole Earth space.



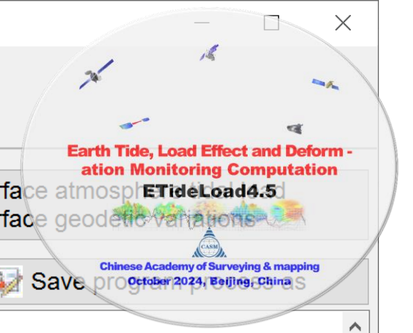
The Surface atmosphere tidal load effects (360-degree) : surface atmosphere(hPa/mbar) height anomaly (mm) ground gravity (μGal) orthometric height (mm) radial gravity gradient (10μE) horizontal displacement (N, 10μE)

The annual periodic amplitude of the surface atmosphere tide is more than 10 times the diurnal periodic amplitude. In the land area, the surface atmosphere 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.

Spherical harmonic synthesis on surface atmosphere tidal load effects outside solid Earth

Computation of surface atmosphere tidal load effects at ground sites with given time

Open file | Save as | Import parameters | Start computation | Save process | Follow example



Computation of surface atmosphere tidal load effect time series at a ground site

Computation of surface atmosphere tidal load effects at ground sites with given time

Computation of surface atmosphere tidal load effects of satellite or outside Earth

Global forecast of surface atmosphere tidal load effects on various surface geodetic variations

Open the location and time file of the calculation points

>> Program Process ** Operation Prompts

Save program process

Set the file parameters

Column ordinal number of height relative to the surface in the record: 4

Column ordinal number of time in the record: 1

Column ordinal number of starting MJD0 in the header: 5

Select the type of effects

- [x] geoid or height anomaly (mm)
- [x] ground gravity (μGal)
- [x] gravity disturbance (μGal)
- [x] ground tilt (SW, mas)
- [x] vertical deflection (SW, mas)
- [x] horizontal displacement (EN, mm)
- [x] ground radial displacement (mm)
- [x] ground normal or orthometric height (mm)
- [x] radial gravity gradient (10μE)
- [x] horizontal gravity gradient (NW, 10μE)

```
>> Computation end time: 2024-10-18 11:33:10
>> [Function] According to the location and time in the calculation point file, compute the surface atmosphere tidal load effects on the geoid or height anomaly (mm), ground gravity (μGal), gravity disturbance (μGal), 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), radial gravity gradient (10μE) or horizontal gravity gradient (NW, to the north and to the west, 10μE)
>> Open the location and time file of the calculation points C:/ETideLoad4.5_win64en/examples/ATideloadharmsynth/Postiontm.txt.
  ** Set the file format parameters according to the text box below, and then select the type of the geodetic variation to be computed. After giving the output file name, click the control button [Import setting parameters]...
>> Save the computed results as C:/ETideLoad4.5_win64en/examples/ATideloadharmsynth/Postmrst.txt.
  ** Behind the input file record, add one or several columns of the tidal effects as the output file record.
>> Setting parameters have been imported into the program!
  ** Click the control button [Start computation], or the tool button [Start computation]....
  ** The computation process needs to wait... During the computation period, you can open the output file C:/ETideLoad4.5_win64en/examples/ATideloadharmsynth/Postmrst.txt, to look at the computation progress!
>> Computation start time:  2024-10-18 11:34:59
>> Complete the computation of the atmosphere tidal load effects!
>> Computation end time: 2024-10-18 11:35:17
```

Columns 2 and 3 of the record are agreed as the longitude and latitude of the calculation point

Maximum truncated degree of the coefficient model: 120

Save the computed results as

Import setting parameters

Start computation

Display of the input-output file↓

Save data in the text box as

```
101.230000    29.910000    0.0   58484.000000
  201901010000   101.230000   29.910000   0.0   -6.1907   2.5717   1.5546   0.3532   -0.2690   0.1689   -0.0595
  201901010100   101.230000   29.910000   0.0   -5.4420   1.6589   0.7758   0.3615   -0.1645   0.1737   -0.0268
  201901010200   101.230000   29.910000   0.0   -4.7521   0.8807   0.1210   0.3615   -0.0105   0.1772    0.0250
  201901010300   101.230000   29.910000   0.0   -4.2262   0.3464   -0.3177  0.3492    0.1680   0.1768    0.0865
  201901010400   101.230000   29.910000   0.0   -3.9154   0.0949   -0.5095  0.3224    0.3442   0.1704    0.1475
  201901010500   101.230000   29.910000   0.0   -3.8085   0.0912   -0.4870  0.2813    0.4953   0.1574    0.1991
  201901010600   101.230000   29.910000   0.0   -3.8423   0.2432   -0.3317  0.2288    0.6068   0.1388    0.2357
  201901010700   101.230000   29.910000   0.0   -3.9239   0.4320   -0.1474  0.1710    0.6745   0.1170    0.2562
  201901010800   101.230000   29.910000   0.0   -3.9617   0.5498   -0.0279  0.1153    0.7041   0.0959    0.2631
  201901010900   101.230000   29.910000   0.0   -3.8947   0.5321   -0.0287  0.0693    0.7078   0.0792    0.2619
  201901011000   101.230000   29.910000   0.0   -3.7117   0.3775   -0.1510  0.0394    0.7000   0.0702    0.2586
  201901011100   101.230000   29.910000   0.0   -3.4571   0.1485   -0.3407  0.0293    0.6920   0.0707    0.2582
  201901011200   101.230000   29.910000   0.0   -3.2184   -0.0471  -0.5050  0.0393    0.6884   0.0804    0.2627
  201901011300   101.230000   29.910000   0.0   -3.1018   -0.0875  -0.5396  0.0665    0.6861   0.0974    0.2705
  201901011400   101.230000   29.910000   0.0   -3.2011   0.1248   -0.3610  0.1056    0.6747   0.1184    0.2770
  201901011500   101.230000   29.910000   0.0   -3.5674   0.6318   0.0660   0.1499    0.6408   0.1395    0.2759
  201901011600   101.230000   29.910000   0.0   -4.1910   1.4011   0.7134   0.1932    0.5720   0.1570    0.2612
  201901011700   101.230000   29.910000   0.0   -4.9973   2.3286   1.4913   0.2311    0.4621   0.1688    0.2292
  201901011800   101.230000   29.910000   0.0   -5.8605   3.2583   2.2667   0.2611    0.3145   0.1742    0.1801
```

When calculating the indirect influences of surface atmosphere tidal load, the program assumes that the atmosphere loads are concentrated on the Earth's surface, and the height h of the calculation point is the height of the point relative to the surface. When calculating the direct influences of surface atmosphere tidal load to the gravity or gravity gradient, it is assumed that there is a proportional relationship between atmosphere P_h at height h and surface atmosphere P_0, namely $P_h=P_0\,(1-h/44330)^{5225}$.

The annual periodic amplitude of the surface atmosphere tide is more than 10 times the diurnal periodic amplitude. In the land area, the surface atmosphere 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.

Spherical harmonic synthesis on surface atmosphere tidal load effects outside solid Earth

Computation of surface atmosphere tidal load effects of satellite or outside Earth

Open file | Save as | Import parameters | Start computation | Save process | Follow example

Computation of surface atmosphere tidal load effect time series at a ground site

Computation of surface atmosphere tidal load effects at ground sites with given time

Computation of surface atmosphere tidal load effects of satellite or outside Earth

Global forecast of surface atmosphere tidal load effects on various surface geodetic variations

Open the location and time file of the external points

>> Program Process ** Operation Prompts

Save program process as

Set the file parameters

Column ordinal number of height relative to the surface in the record: 4

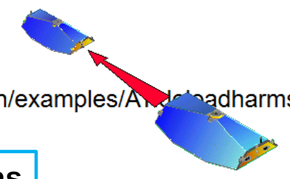
Column ordinal number of time in the record: 1

Column ordinal number of starting MJD0 in the header: 5

Select the type of effects

- [x] geopotential (0.1m²/s²)
- [ ] gravity vector (XYZ, μGal)
- [x] gravity vector (ENU, μGal)
- [ ] gravity gradient (XYZ, 10μE)
- [ ] gravity gradient (ENU, 10μE)

```
>> Computation start time：2024-10-18 11:34:59
>> Complete the computation of the atmosphere tidal load effects!
>> Computation end time: 2024-10-18 11:35:17
>> [Function] According to the location and time in the external space point file, compute the surface atmosphere tidal load effects on the geopotential (0.1m²/s²), gravity(μGal), or gravity gradient (10μE) outside the solid Earth.
>> Open the location and time file of the external points C:/ETideLoad4.5_win64en/examples/ATideloadharmsynth/outerptm.txt.
  ** Set the file format parameters according to the text box below, and then select the type of the geodetic variation to be computed. After giving the output file name, click the control button [Import setting parameters]...
>> Save the computed results as C:/ETideLoad4.5_win64en/examples/ATideloadharmsynth/outerprst.txt.
  ** Behind the input file record, add one or several columns of the tidal effects as the output file record.
>> Setting parameters have been imported into the program!
  ** Click the control button [Start computation], or the tool button [Start computation]....
  ** The computation process needs to wait... During the computation period, you can open the output file C:/ETideLoad4.5_win64en/examples/ATideloadharmsynth/outerprst.txt, to look at the computation progress!
>> Computation start time：2024-10-18 11:36:34
>> Complete the computation of the atmosphere tidal load effects!
>> Computation end time: 2024-10-18 11:38:11
```



Columns 2 and 3 of the record are agreed as the longitude and latitude of the satellite

Maximum truncated degree of the coefficient model: 120

Save the computed results as | Import setting parameters | Start computation

GRACE satellite altitude

Display of the input-output file↓

Save data in the text box as

Forcast	121.2400	29.4281	450000.0	58119.00			
2018010100	121.2400	29.4281	450000.0	-0.6276	-1.1288	0.9385	2.6999
2018010104	121.2400	29.4281	450000.0	-0.5577	-1.1084	0.4650	2.5272
2018010108	121.2400	29.4281	450000.0	-0.5675	-0.9437	0.5120	2.6709
2018010112	121.2400	29.4281	450000.0	-0.5035	-1.1052	0.4518	2.3798
2018010116	121.2400	29.4281	450000.0	-0.6052	-1.1231	0.3106	2.6774
2018010120	121.2400	29.4281	450000.0	-0.7372	-0.9749	0.8376	3.1311
2018010124	121.2400	29.4281	450000.0	-0.6238	-1.1147	0.9249	2.6797
2018010204	121.2400	29.4281	450000.0	-0.5539	-1.0942	0.4514	2.5067
2018010208	121.2400	29.4281	450000.0	-0.5636	-0.9294	0.4984	2.6503
2018010212	121.2400	29.4281	450000.0	-0.4996	-1.0908	0.4382	2.3591
2018010216	121.2400	29.4281	450000.0	-0.6012	-1.1086	0.2970	2.6564
2018010220	121.2400	29.4281	450000.0	-0.7332	-0.9604	0.8239	3.1099
2018010224	121.2400	29.4281	450000.0	-0.6198	-1.1000	0.9112	2.6583
2018010304	121.2400	29.4281	450000.0	-0.5498	-1.0795	0.4376	2.4852
2018010308	121.2400	29.4281	450000.0	-0.5595	-0.9146	0.4846	2.6286
2018010312	121.2400	29.4281	450000.0	-0.4954	-1.0759	0.4244	2.3372
2018010316	121.2400	29.4281	450000.0	-0.5970	-1.0937	0.2832	2.6343
2018010320	121.2400	29.4281	450000.0	-0.7289	-0.9453	0.8100	3.0877
2018010324	121.2400	29.4281	450000.0	-0.6154	-1.0849	0.8973	2.6359
2018010404	121.2400	29.4281	450000.0	-0.5455	-1.0643	0.4237	2.4626

When calculating the indirect influences of surface atmosphere tidal load, the program assumes that the atmosphere loads are concentrated on the Earth's surface, and the height h of the calculation point is the height of the point relative to the surface. When calculating the direct influences of surface atmosphere tidal load to the gravity or gravity gradient, it is assumed that there is a proportional relationship between atmosphere P_h at height h and surface atmosphere P_0, namely $P_h=P_0\ (1-h/44330)^{5225}$.

The annual periodic amplitude of the surface atmosphere tide is more than 10 times the diurnal periodic amplitude. In the land area, the surface atmosphere 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.

Spherical harmonic synthesis on surface atmosphere tidal load effects outside solid Earth

Computation of surface atmosphere tidal load effects of satellite or outside Earth

Open file | Save as | Import parameters | Start computation | Save process | Follow example

Computation of surface atmosphere tidal load effect time series at a ground site

Computation of surface atmosphere tidal load effects at ground sites with given time

Computation of surface atmosphere tidal load effects of satellite or outside Earth

Global forecast of surface atmosphere tidal load effects on various surface geodetic variations

Open the location and time file of the external points

>> Program Process ** Operation Prompts

Save program process as

Set the file parameters

Column ordinal number of height relative to the surface in the record: 4

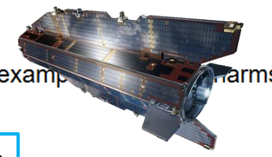
Column ordinal number of time in the record: 1

Column ordinal number of starting MJD0 in the header: 5

Select the type of effects

- [x] geopotential (0.1m²/s²)
- [ ] gravity vector (XYZ, μGal)
- [ ] gravity vector (ENU, μGal)
- [ ] gravity gradient (XYZ, 10μE)
- [x] gravity gradient (ENU, 10μE)

```
>> Computation start time：2024-10-18 11:36:34
>> Complete the computation of the atmosphere tidal load effects!
>> Computation end time: 2024-10-18 11:38:11
>> [Function] According to the location and time in the external space point file, compute the surface atmosphere tidal load effects on the geopotential (0.1m²/s²), gravity(μGal), or gravity gradient (10μE) outside the solid Earth.
>> Open the location and time file of the external points C:/ETideLoad4.5_win64en/examples/ATideloadharmsynth/satptm.txt.
  ** Set the file format parameters according to the text box below, and then select the type of the geodetic variation to be computed. After giving the output file name, click the control button [Import setting parameters]...
>> Save the computed results as C:/ETideLoad4.5_win64en/examples/ATideloadharmsynth/satptmrst.txt.
  ** Behind the input file record, add one or several columns of the tidal effects as the output file record.
>> Setting parameters have been imported into the program!
  ** Click the control button [Start computation], or the tool button [Start computation]....
  ** The computation process needs to wait... During the computation period, you can open the output file C:/ETideLoad4.5_win64en/examp                    harmsynth/satptmrst.txt, to look at the computation progress!
>> Computation start time：2024-10-18 11:40:00
>> Complete the computation of the atmosphere tidal load effects!
>> Computation end time: 2024-10-18 11:41:33
```



Columns 2 and 3 of the record are agreed as the longitude and latitude of the satellite

Maximum truncated degree of the coefficient model: 120

Save the computed results as | Import setting parameters | Start computation

Display of the input-output file↓

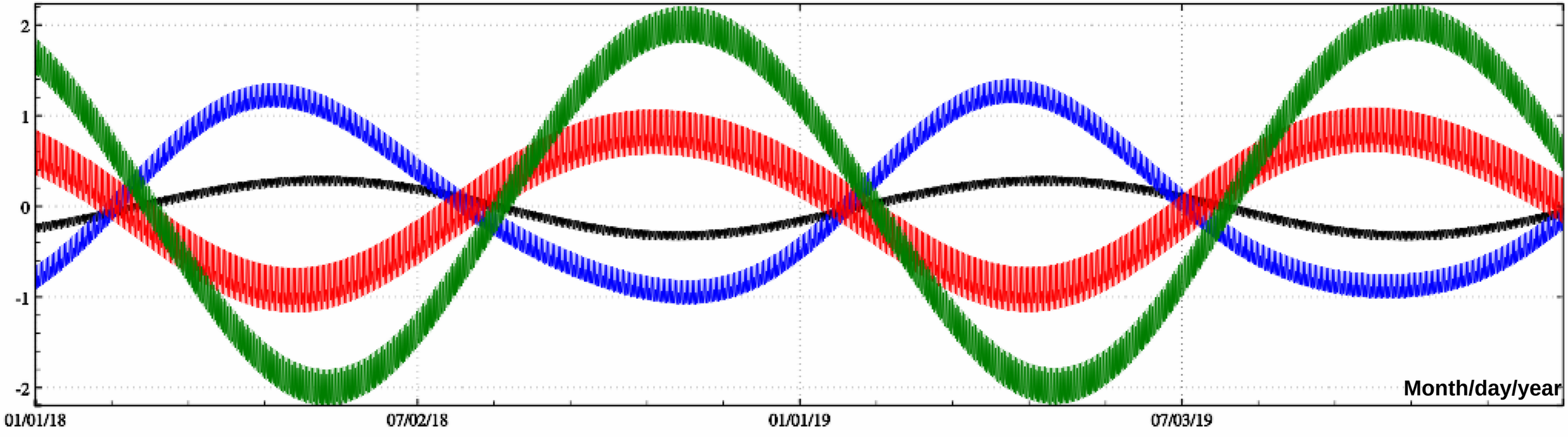
GOCE satellite altitude

Save data in the text box as

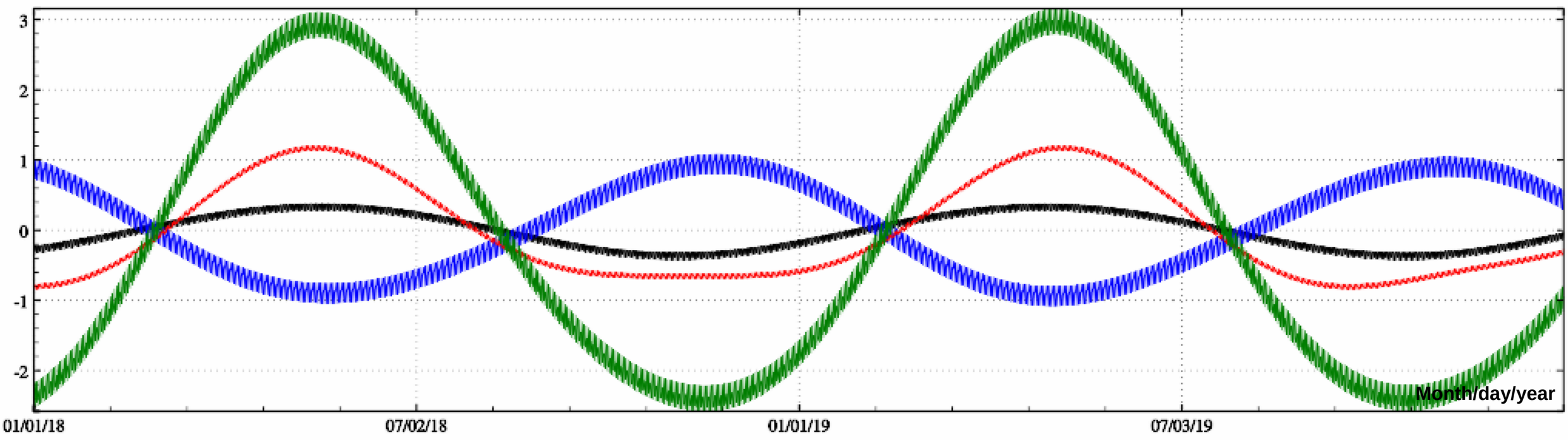
```
 Forcast  121.2400   29.4281  250000.0   58119.00
2018010100 121.2400   29.4281 250000.0    -0.6861     0.8041    -0.9135    -2.7813
2018010104 121.2400   29.4281 250000.0    -0.6128     0.9141    -0.9044    -2.8233
2018010108 121.2400   29.4281 250000.0    -0.6257     1.0474    -0.8697    -2.9583
2018010112 121.2400   29.4281 250000.0    -0.5555     0.9582    -0.8391    -2.7579
2018010116 121.2400   29.4281 250000.0    -0.6634     0.9732    -0.9110    -2.9476
2018010120 121.2400   29.4281 250000.0    -0.8048     0.9478    -0.9501    -3.0964
2018010124 121.2400   29.4281 250000.0    -0.6819     0.7949    -0.9121    -2.7619
2018010204 121.2400   29.4281 250000.0    -0.6086     0.9049    -0.9029    -2.8037
2018010208 121.2400   29.4281 250000.0    -0.6214     1.0381    -0.8681    -2.9385
2018010212 121.2400   29.4281 250000.0    -0.5511     0.9488    -0.8374    -2.7379
2018010216 121.2400   29.4281 250000.0    -0.6590     0.9637    -0.9093    -2.9274
2018010220 121.2400   29.4281 250000.0    -0.8004     0.9383    -0.9484    -3.0760
2018010224 121.2400   29.4281 250000.0    -0.6774     0.7853    -0.9103    -2.7414
2018010304 121.2400   29.4281 250000.0    -0.6040     0.8952    -0.9010    -2.7829
2018010308 121.2400   29.4281 250000.0    -0.6168     1.0284    -0.8662    -2.9176
2018010312 121.2400   29.4281 250000.0    -0.5465     0.9390    -0.8354    -2.7167
2018010316 121.2400   29.4281 250000.0    -0.6543     0.9539    -0.9073    -2.9061
2018010320 121.2400   29.4281 250000.0    -0.7956     0.9284    -0.9463    -3.0545
2018010324 121.2400   29.4281 250000.0    -0.6726     0.7754    -0.9081    -2.7196
2018010404 121.2400   29.4281 250000.0    -0.5992     0.8852    -0.8988    -2.7610
```

When calculating the indirect influences of surface atmosphere tidal load, the program assumes that the atmosphere loads are concentrated on the Earth's surface, and the height h of the calculation point is the height of the point relative to the surface. When calculating the direct influences of surface atmosphere tidal load to the gravity or gravity gradient, it is assumed that there is a proportional relationship between atmosphere P_h at height h and surface atmosphere P_0, namely $P_h=P_0\ (1-h/44330)^{5225}$.

The annual periodic amplitude of the surface atmosphere tide is more than 10 times the diurnal periodic amplitude. In the land area, the surface atmosphere 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.



Surface atmosphere tidal effects at 450km altitude：geopotential (0.1m²/s²), gravity vector (E, N: along the GRACE orbit/SST-ll, U, μGal)



Surface atmosphere tidal effects at 250km altitude：geopotential (0.1m²/s²), gravity gradient (E, N: along the GOCE orbit, U, 10μE)

Global forcast of surface atmosphere tidal load effects on various surface geodetic variations

Global forecast of surface atmosphere tidal load effects on various surface geodetic variations

Earth Tide, Load Effect and Deform - ation Monitoring Computation
ETideLoad4.5
Chinese Academy of Surveying & mapping
October 2024, Beijing, China

Location of surface point to be forecast

Longitude 121.240000°
Latitude 29.428100°

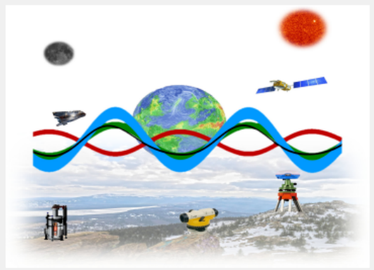
Forecast time series parameters

Start time 20180101
End time 20200101
Time interval 240.00 min

Maximum truncated degree of the coefficients model 180

Calculate and save as

The program needs some time to calculate the time series of surface atmosphere tidal load effects. Please wait until the button [Extract time series to be plot] becomes available.



Tidal effects to be plot

- [ ] geoid or height anomaly (mm)
- [x] ground gravity (μGal)
- [ ] gravity disturbance (μGal)
- [ ] ground tilt (SW, mas)
- [ ] vertical deflection (SW, mas)
- [ ] horizontal displacement (EN, mm)
- [x] ground radial displacement (mm)
- [x] normal (orthometric) height (mm)
- [ ] radial gravity gradient (10μE)
- [ ] horizontal gravity gradient (NW, 10μE)
- [x] surface atmosphere (hPa/mbar)

Tidal effect time series on all-element geodetic variations

Forcast	121.240000	29.428100	0.000	58119.000000			
2018010100	0.000000	-7.9164	6.2615	4.7978	0.8678	-0.5537	0.3612
2018010104	0.166667	-7.1282	5.9730	4.6406	0.8388	-0.1825	0.3074
2018010108	0.333333	-7.3085	6.5907	5.2492	0.6910	-0.1895	0.3509
2018010112	0.500000	-6.5013	5.7109	4.4873	0.7890	-0.2121	0.3451
2018010116	0.666667	-7.6980	6.4871	5.0588	0.7636	-0.2654	0.3081
2018010120	0.833333	-9.2688	7.6269	5.9538	0.6882	-0.6085	0.3652
2018010124	1.000000	-7.8667	6.2045	4.7495	0.8549	-0.5429	0.3560
2018010204	1.166667	-7.0779	5.9156	4.5921	0.8258	-0.1716	0.3022
2018010208	1.333333	-7.2577	6.5328	5.2003	0.6780	-0.1786	0.3456
2018010212	1.500000	-6.4498	5.6527	4.4381	0.7759	-0.2012	0.3397
2018010216	1.666667	-7.6460	6.4284	5.0092	0.7504	-0.2545	0.3028
2018010220	1.833333	-9.2163	7.5678	5.9038	0.6749	-0.5976	0.3598
2018010224	2.000000	-7.8136	6.1450	4.6993	0.8416	-0.5319	0.3505
2018010304	2.166667	-7.0242	5.8556	4.5415	0.8124	-0.1607	0.2967
2018010308	2.333333	-7.2035	6.4724	5.1494	0.6645	-0.1676	0.3401
2018010312	2.500000	-6.3951	5.5918	4.3869	0.7624	-0.1902	0.3342
2018010316	2.666667	-7.5907	6.3671	4.9576	0.7368	-0.2434	0.2972
2018010320	2.833333	-9.1604	7.5060	5.8520	0.6613	-0.5865	0.3542
2018010324	3.000000	-7.7571	6.0828	4.6471	0.8279	-0.5208	0.3449
2018010404	3.166667	-6.9672	5.7931	4.4890	0.7986	-0.1496	0.2911
2018010408	3.333333	-7.1459	6.4094	5.0966	0.6507	-0.1565	0.3345
2018010412	3.500000	-6.3369	5.5284	4.3337	0.7485	-0.1791	0.3285
2018010416	3.666667	-7.5319	6.3032	4.9041	0.7229	-0.2323	

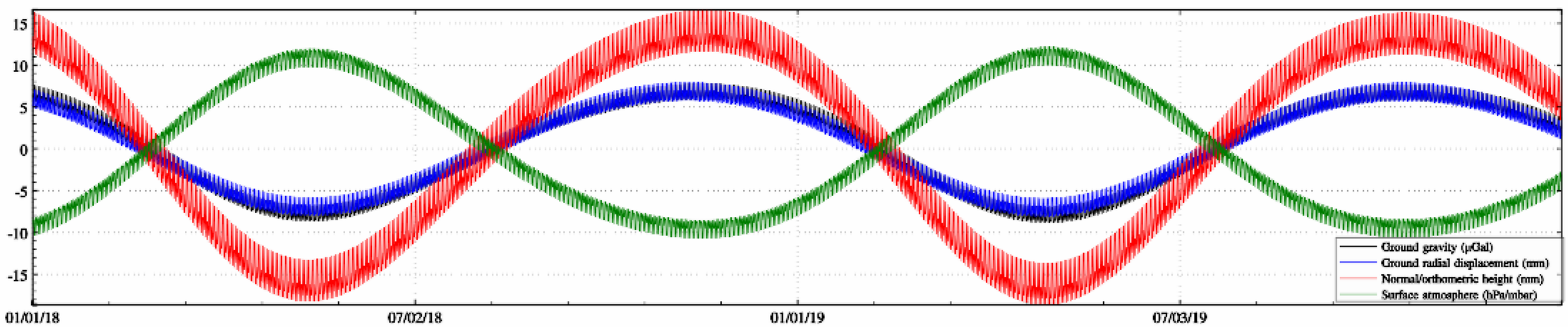
Set line thickness 1

Extract time series to be plot

Plot↓

Tidal effect curve of surface geodetic variations

Save the current plot as

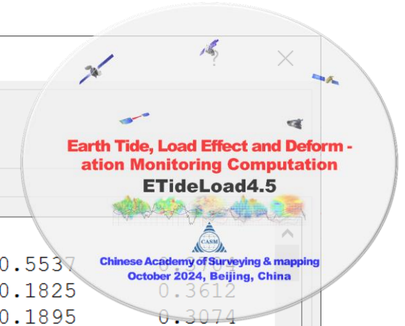


Firstly, calculate the tidal effect time series on all-element geodetic variations, and then select the variations to be plot.

Look at the amplitude of various surface atmosphere tidal load effects, the in-phase or out-of-phase (same or opposite sign) relationship between different types of variations, and the time-varying characteristics of the tidal effect curves.

Global forcast of surface atmosphere tidal load effects on various surface geodetic variations

Global forecast of surface atmosphere tidal load effects on various surface geodetic variations



Location of surface point to be forecast

Longitude 121.240000°

Latitude 29.428100°

Forecast time series parameters

Start time 20180101

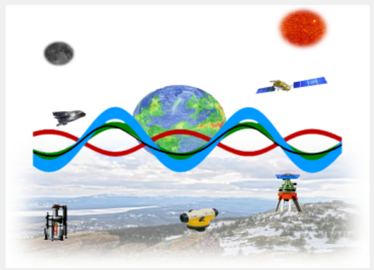
End time 20200101

Time interval 240.00 min

Maximum truncated degree of the coefficients model 180

Calculate and save as

The program needs some time to calculate the time series of surface atmosphere tidal load effects. Please wait until the button [Extract time series to be plot] becomes available.



Tidal effects to be plot

- [ ] geoid or height anomaly (mm)
- [ ] ground gravity (μGal)
- [ ] gravity disturbance (μGal)
- [x] ground tilt (SW, mas)
- [ ] vertical deflection (SW, mas)
- [x] horizontal displacement (EN, mm)
- [ ] ground radial displacement (mm)
- [ ] normal (orthometric) height (mm)
- [ ] radial gravity gradient (10μE)
- [ ] horizontal gravity gradient (NW, 10μE)
- [ ] surface atmosphere (hPa/mbar)

Tidal effect time series on all-element geodetic variations

Forcast	121.240000	29.428100	0.000	58119.000000			
2018010100	0.000000	-7.9164	6.2615	4.7978	0.8678	-0.5537	0.3612
2018010104	0.166667	-7.1282	5.9730	4.6406	0.8388	-0.1825	0.3074
2018010108	0.333333	-7.3085	6.5907	5.2492	0.6910	-0.1895	0.3509
2018010112	0.500000	-6.5013	5.7109	4.4873	0.7890	-0.2121	0.3451
2018010116	0.666667	-7.6980	6.4871	5.0588	0.7636	-0.2654	0.3081
2018010120	0.833333	-9.2688	7.6269	5.9538	0.6882	-0.6085	0.3652
2018010124	1.000000	-7.8667	6.2045	4.7495	0.8549	-0.5429	0.3560
2018010204	1.166667	-7.0779	5.9156	4.5921	0.8258	-0.1716	0.3022
2018010208	1.333333	-7.2577	6.5328	5.2003	0.6780	-0.1786	0.3456
2018010212	1.500000	-6.4498	5.6527	4.4381	0.7759	-0.2012	0.3397
2018010216	1.666667	-7.6460	6.4284	5.0092	0.7504	-0.2545	0.3028
2018010220	1.833333	-9.2163	7.5678	5.9038	0.6749	-0.5976	0.3598
2018010224	2.000000	-7.8136	6.1450	4.6993	0.8416	-0.5319	0.3505
2018010304	2.166667	-7.0242	5.8556	4.5415	0.8124	-0.1607	0.2967
2018010308	2.333333	-7.2035	6.4724	5.1494	0.6645	-0.1676	0.3401
2018010312	2.500000	-6.3951	5.5918	4.3869	0.7624	-0.1902	0.3342
2018010316	2.666667	-7.5907	6.3671	4.9576	0.7368	-0.2434	0.2972
2018010320	2.833333	-9.1604	7.5060	5.8520	0.6613	-0.5865	0.3542
2018010324	3.000000	-7.7571	6.0828	4.6471	0.8279	-0.5208	0.3449
2018010404	3.166667	-6.9672	5.7931	4.4890	0.7986	-0.1496	0.2911
2018010408	3.333333	-7.1459	6.4094	5.0966	0.6507	-0.1565	0.3345
2018010412	3.500000	-6.3369	5.5284	4.3337	0.7485	-0.1791	0.3285
2018010416	3.666667	-7.5319	6.3032	4.9041	0.7229	-0.2323	

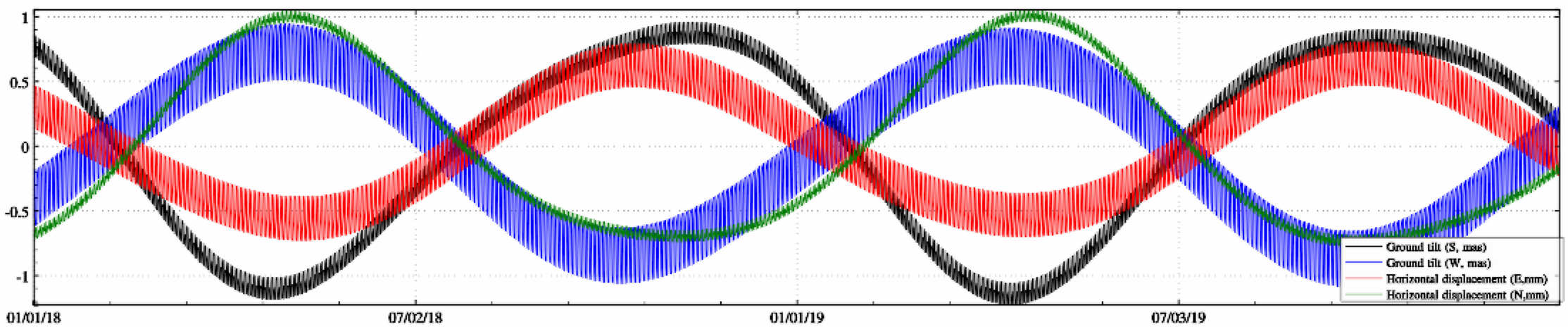
Set line thickness 1

Extract time series to be plot

Plot↓

Tidal effect curve of surface geodetic variations

Save the current plot as

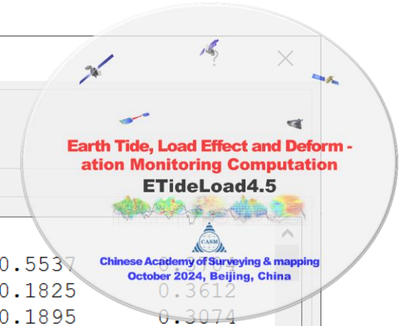


Firstly, calculate the tidal effect time series on all-element geodetic variations, and then select the variations to be plot.

Look at the amplitude of various surface atmosphere tidal load effects, the in-phase or out-of-phase (same or opposite sign) relationship between different types of variations, and the time-varying characteristics of the tidal effect curves.

Global forcast of surface atmosphere tidal load effects on various surface geodetic variations

Global forecast of surface atmosphere tidal load effects on various surface geodetic variations



Location of surface point to be forecast

Longitude 121.240000°

Latitude 29.428100°

Forecast time series parameters

Start time 20180101

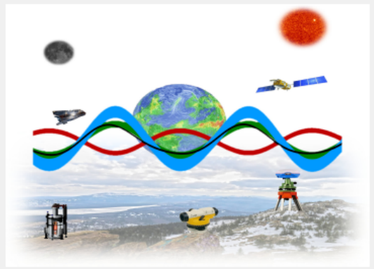
End time 20200101

Time interval 240.00 min

Maximum truncated degree of the coefficients model 180

Calculate and save as

The program needs some time to calculate the time series of surface atmosphere tidal load effects. Please wait until the button [Extract time series to be plot] becomes available.



Tidal effects to be plot

- [ ] geoid or height anomaly (mm)
- [ ] ground gravity (μGal)
- [ ] gravity disturbance (μGal)
- [ ] ground tilt (SW, mas)
- [ ] vertical deflection (SW, mas)
- [ ] horizontal displacement (EN, mm)
- [x] ground radial displacement (mm)
- [ ] normal (orthometric) height (mm)
- [x] radial gravity gradient (10μE)
- [x] horizontal gravity gradient (NW, 10μE)
- [ ] surface atmosphere (hPa/mbar)

Tidal effect time series on all-element geodetic variations

Forcast	121.240000	29.428100	0.000	58119.000000			
2018010100	0.000000	-7.9164	6.2615	4.7978	0.8678	-0.5537	0.3612
2018010104	0.166667	-7.1282	5.9730	4.6406	0.8388	-0.1825	0.3074
2018010108	0.333333	-7.3085	6.5907	5.2492	0.6910	-0.1895	0.3509
2018010112	0.500000	-6.5013	5.7109	4.4873	0.7890	-0.2121	0.3451
2018010116	0.666667	-7.6980	6.4871	5.0588	0.7636	-0.2654	0.3081
2018010120	0.833333	-9.2688	7.6269	5.9538	0.6882	-0.6085	0.3652
2018010124	1.000000	-7.8667	6.2045	4.7495	0.8549	-0.5429	0.3560
2018010204	1.166667	-7.0779	5.9156	4.5921	0.8258	-0.1716	0.3022
2018010208	1.333333	-7.2577	6.5328	5.2003	0.6780	-0.1786	0.3456
2018010212	1.500000	-6.4498	5.6527	4.4381	0.7759	-0.2012	0.3397
2018010216	1.666667	-7.6460	6.4284	5.0092	0.7504	-0.2545	0.3028
2018010220	1.833333	-9.2163	7.5678	5.9038	0.6749	-0.5976	0.3598
2018010224	2.000000	-7.8136	6.1450	4.6993	0.8416	-0.5319	0.3505
2018010304	2.166667	-7.0242	5.8556	4.5415	0.8124	-0.1607	0.2967
2018010308	2.333333	-7.2035	6.4724	5.1494	0.6645	-0.1676	0.3401
2018010312	2.500000	-6.3951	5.5918	4.3869	0.7624	-0.1902	0.3342
2018010316	2.666667	-7.5907	6.3671	4.9576	0.7368	-0.2434	0.2972
2018010320	2.833333	-9.1604	7.5060	5.8520	0.6613	-0.5865	0.3542
2018010324	3.000000	-7.7571	6.0828	4.6471	0.8279	-0.5208	0.3449
2018010404	3.166667	-6.9672	5.7931	4.4890	0.7986	-0.1496	0.2911
2018010408	3.333333	-7.1459	6.4094	5.0966	0.6507	-0.1565	0.3345
2018010412	3.500000	-6.3369	5.5284	4.3337	0.7485	-0.1791	0.3285
2018010416	3.666667	-7.5319	6.3032	4.9041	0.7229	-0.2323	

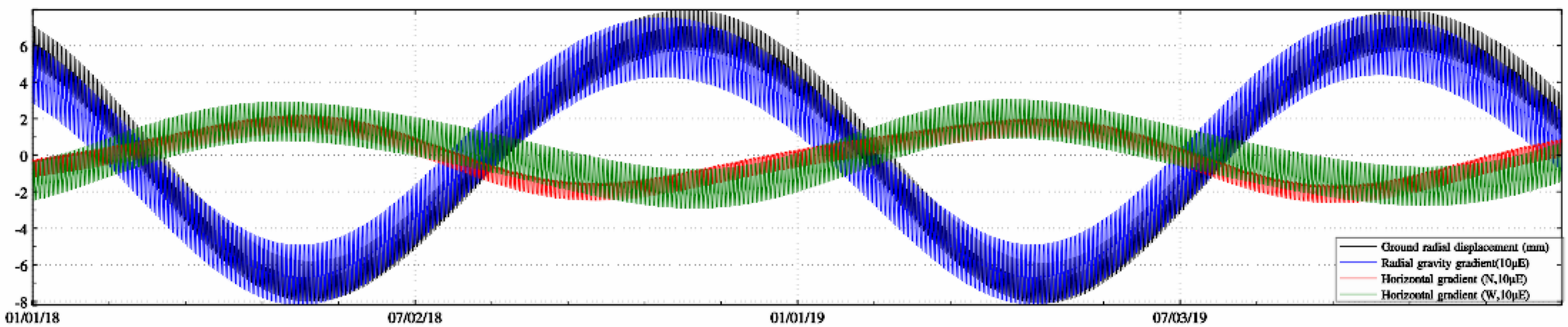
Set line thickness 1

Extract time series to be plot

Plot↓

Tidal effect curve of surface geodetic variations

Save the current plot as



Firstly, calculate the tidal effect time series on all-element geodetic variations, and then select the variations to be plot.

Look at the amplitude of various surface atmosphere tidal load effects, the in-phase or out-of-phase (same or opposite sign) relationship between different types of variations, and the time-varying characteristics of the tidal effect curves.

Computation of Earth's rotation polar shift effects on geodetic variations and tidal effects on EPR

Computation of the rotation polar shift or ocean pole tidal effect time series at a ground site

Earth Tide, Load Effect and Deformation Monitoring Computation
ETideLoad4.5
Chinese Academy of Surveying & mapping
October 2024, Beijing, China

Computation of rotation polar shift or ocean pole tidal effect time series | Computation of rotation polar shift or ocean pole tidal effects at ground sites with given time | Computation of rotation polar shift or ocean pole tidal effects outside solid Earth | Calculation of rotation polar shift effects on various geodetic variations anywhere | Forecast of the tidal effect time series on Earth's rotation

Open the geodetic site variation time series file | Computation of figure polar shift effects from the measured ΔC_{21} and ΔS_{21} | Save program process as | Algorithm formulas

Set the file parameters

Column ordinal number of ellipsoidal height in the header: 4
Column ordinal number of time in the record: 1
Column ordinal number of starting MJD0 in the header: 5

Select the type of effects

- [x] geoid or height anomaly (mm)
- [x] ground gravity (μGal)
- [x] gravity disturbance (μGal)
- [x] ground tilt (SW, mas)
- [x] vertical deflection (SW, mas)
- [x] horizontal displacement (EN, mm)
- [x] ground radial displacement (mm)
- [x] ground normal or orthometric height (mm)
- [x] radial gravity gradient (10μE)
- [x] horizontal gravity gradient (NW, 10μE)

```
>> [Purpose] Using IERS Earth orientation parameters (EOP) product file IERSeopc04.dat, compute the Earth's rotation polar shift and ocean pole tidal effects on various geodetic variations on the ground or outside the solid Earth, or compute the tidal effects on Earth rotation parameters (EPR).
>> Select the computation function from the 6 control buttons on the top of the interface...
>> [Function] From the geodetic site variation time series file, compute the time series of the Earth's rotation polar shift or ocean pole tidal effects on the geoid or height anomaly (mm), ground gravity (μGal), gravity disturbance (μGal), 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), radial gravity gradient (10μE) or horizontal gravity gradient (NW, to the north and to the west, 10μE)
>> Open the geodetic site variation time series file C:/ETideLoad4.5_win64en/examples/Poleshifteffectscalc/Tmseries.txt.
  ** Set the file format parameters according to the text box below, and then select the type of the geodetic variation to be computed. After giving the output file name, click the control button [Import setting parameters]...
>> Save the computed results as C:/ETideLoad4.5_win64en/examples/Poleshifteffectscalc/Tmsqurst.txt.
  ** Behind the input file record, add one or several columns of the tidal effects as the output file record.
>> Setting parameters have been imported into the program!
>> Prepare to compute Earth's rotation polar shift effects ...
  ** Click the control button [Start computation], or the tool button [Start computation]....
>> Computation start time：2024-10-18 12:02:48
>> Complete the computation of Earth's rotation polar shift effects!
>> Computation end time: 2024-10-18 12:02:49
```

Columns 2 and 3 of the file header are agreed as the longitude and latitude of the ground site

Select the effects to be computed: Rotaion polar shift effects | Save the computed results as | Import setting parameters | Start computation

Display of the input-output file↓ | Save data in the text box as

```
ASB   107.230000    29.910000    72.4   56658.000000
 201401010000   0.000000   6.713   -2.1021   -1.1883   0.9926   0.4196   0.4576   -0.0171   0.0908   -0.0329   0.1
 201401011200   0.500000   6.375   -2.1060   -1.1772   0.9694   0.4102   0.4469   -0.0167   0.0908   -0.0321   0.1
 201401020000   1.000000   6.751   -2.1099   -1.1660   0.9462   0.4007   0.4362   -0.0163   0.0908   -0.0313   0.1
 201401021200   1.500000   6.412   -2.1188   -1.1547   0.9199   0.3899   0.4241   -0.0158   0.0910   -0.0305   0.1
 201401030000   2.000000   6.786   -2.1277   -1.1434   0.8935   0.3792   0.4119   -0.0153   0.0912   -0.0296   0.1
 201401031200   2.500000   6.445   -2.1378   -1.1363   0.8743   0.3714   0.4031   -0.0150   0.0915   -0.0290   0.1
 201401040000   3.000000   6.818   -2.1480   -1.1293   0.8551   0.3636   0.3942   -0.0147   0.0918   -0.0283   0.1
 201401041200   3.500000   6.476   -2.1553   -1.1226   0.8382   0.3567   0.3864   -0.0144   0.0920   -0.0278   0.1
 201401050000   4.000000   6.847   -2.1626   -1.1158   0.8214   0.3499   0.3786   -0.0141   0.0922   -0.0272   0.1
 201401051200   4.500000   6.504   -2.1712   -1.1055   0.7970   0.3400   0.3674   -0.0137   0.0924   -0.0264   0.1
 201401060000   5.000000   6.874   -2.1799   -1.0953   0.7727   0.3300   0.3562   -0.0132   0.0926   -0.0256   0.1
 201401061200   5.500000   6.529   -2.1932   -1.0809   0.7381   0.3160   0.3403   -0.0126   0.0929   -0.0244   0.1
 201401070000   6.000000   6.897   -2.2065   -1.0666   0.7035   0.3019   0.3243   -0.0120   0.0932   -0.0233   0.1
 201401071200   6.500000   6.551   -2.2200   -1.0500   0.6645   0.2860   0.3063   -0.0114   0.0935   -0.0220   0.1
 201401080000   7.000000   6.922   -2.2335   -1.0334   0.6255   0.2701   0.2883   -0.0107   0.0939   -0.0207   0.1
 201401081200   7.500000   6.570   -2.2405   -1.0167   0.5900   0.2556   0.2720   -0.0101   0.0939   -0.0195   0.1
 201401090000   8.000000   6.946   -2.2475   -1.0000   0.5545   0.2411   0.2557   -0.0094   0.0939   -0.0182   0.1
 201401091200   8.500000   6.586   -2.2532   -0.9781   0.5102   0.2230   0.2352   -0.0087   0.0939   -0.0169   0.1
 201401100000   9.000000   6.969   -2.2589   -0.9562   0.4659   0.2048   0.2148   -0.0079   0.0939   -0.0154   0.1
```

Improve the rotation polar shift effect algorithm in the IERS conventions (2010) for all-element geodetic variations in whole Earth space. Here the rotation polar shift effect on potential is the sum of the centrifugal force potential and associated geopotential.

The Earth's rotation polar shift and figure polar shift respectively characterize the behavior of the kinematic state and mechanical figure of the Earth system varying over time. Both exist objectively and induce various geodetic elements in the Earth's space to vary over time.

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]. Love numbers in the program are $k_2 = 0.3077 + 0.0036i$, $h_2 = 0.6207$ and $l_2 = 0.0836$.

Computation of Earth's rotation polar shift effects on geodetic variations and tidal effects on EPR

Computation of the rotation polar shift or ocean pole tidal effect time series at a ground site

Earth Tide, Load Effect and Deform - ation Monitoring Computation
ETideLoad4.5
Chinese Academy of Surveying & mapping
October 2024, Beijing, China

Computation of rotation polar shift or ocean pole tidal effect time series | Computation of rotation polar shift or ocean pole tidal effects at ground sites with given time | Computation of rotation polar shift or ocean pole tidal effects outside solid Earth | Calculation of rotation polar shift effects on various geodetic variations anywhere | Forecast of the tidal effect time series on Earth's rotation

Open the geodetic site variation time series file | Computation of figure polar shift effects from the measured ΔC_{21} and ΔS_{21} | Save program process as | Algorithm formulas

Set the file parameters

Column ordinal number of ellipsoidal height in the header: 4
Column ordinal number of time in the record: 1
Column ordinal number of starting MJD0 in the header: 5

Select the type of effects

- [x] geoid or height anomaly (mm)
- [x] ground gravity (μGal)
- [x] gravity disturbance (μGal)
- [x] ground tilt (SW, mas)
- [x] vertical deflection (SW, mas)
- [x] horizontal displacement (EN, mm)
- [x] ground radial displacement (mm)
- [x] ground normal or orthometric height (mm)
- [x] radial gravity gradient (10μE)
- [x] horizontal gravity gradient (NW, 10μE)

```
** Click the control button [Start computation], or the tool button [Start computation]....
>> Computation start time：2024-10-18 12:02:48
>> Complete the computation of Earth's rotation polar shift effects!
>> Computation end time: 2024-10-18 12:02:49
>> [Function] From the geodetic site variation time series file, compute the time series of the Earth's rotation polar shift or ocean pole tidal effects on the geoid or height anomaly (mm), ground gravity (μGal), gravity disturbance (μGal), 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), radial gravity gradient (10μE) or horizontal gravity gradient (NW, to the north and to the west, 10μE)
>> Open the geodetic site variation time series file C:/ETideLoad4.5_win64en/examples/Poleshifteffectscalc/Tmseries.txt.
 ** Set the file format parameters according to the text box below, and then select the type of the geodetic variation to be computed. After giving the output file name, click the control button [Import setting parameters]
>> Save the computed results as C:/ETideLoad4.5_win64en/examples/Poleshifteffectscalc/Tmsquotdrst.txt.
 ** Behind the input file record, add one or several columns of the tidal effects as the output file record.
>> Setting parameters have been imported into the program!
>> Prepare to compute ocean pole tidal effects ...
 ** Click the control button [Start computation], or the tool button [Start computation]....
>> Computation start time：2024-10-18 12:03:33
>> Complete the computation of ocean pole tidal effects!
>> Computation end time: 2024-10-18 12:04:05
```

Columns 2 and 3 of the file header are agreed as the longitude and latitude of the ground site

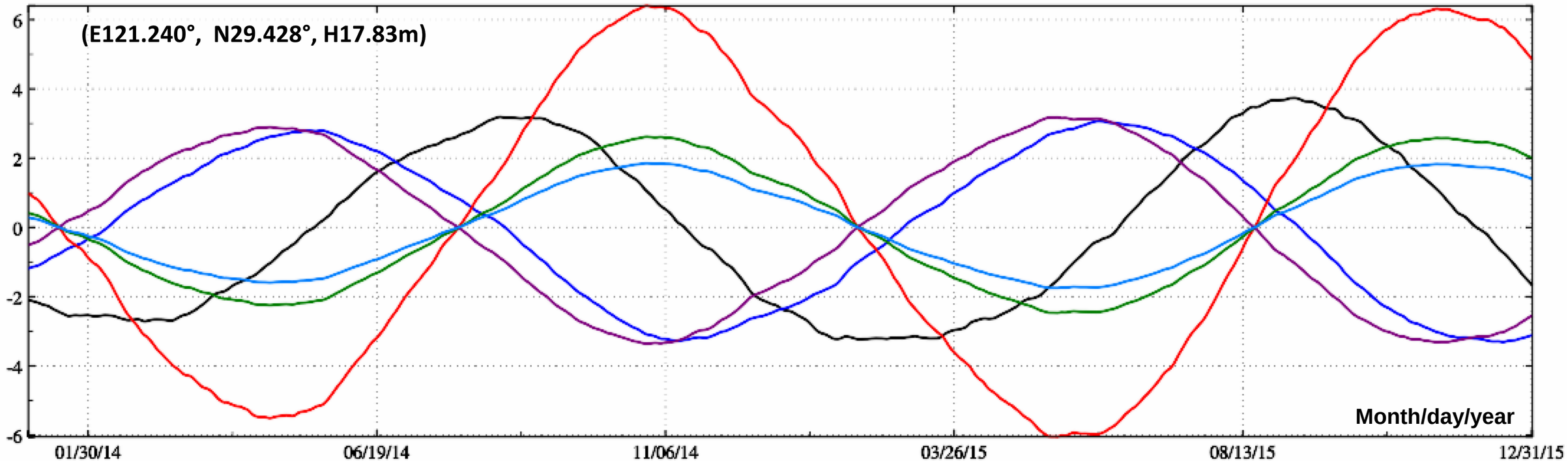
Select the effects to be computed: Ocean pole tidal effects | Save the computed results as | Import setting parameters | Start computation

Display of the input-output file↓ | Save data in the text box as

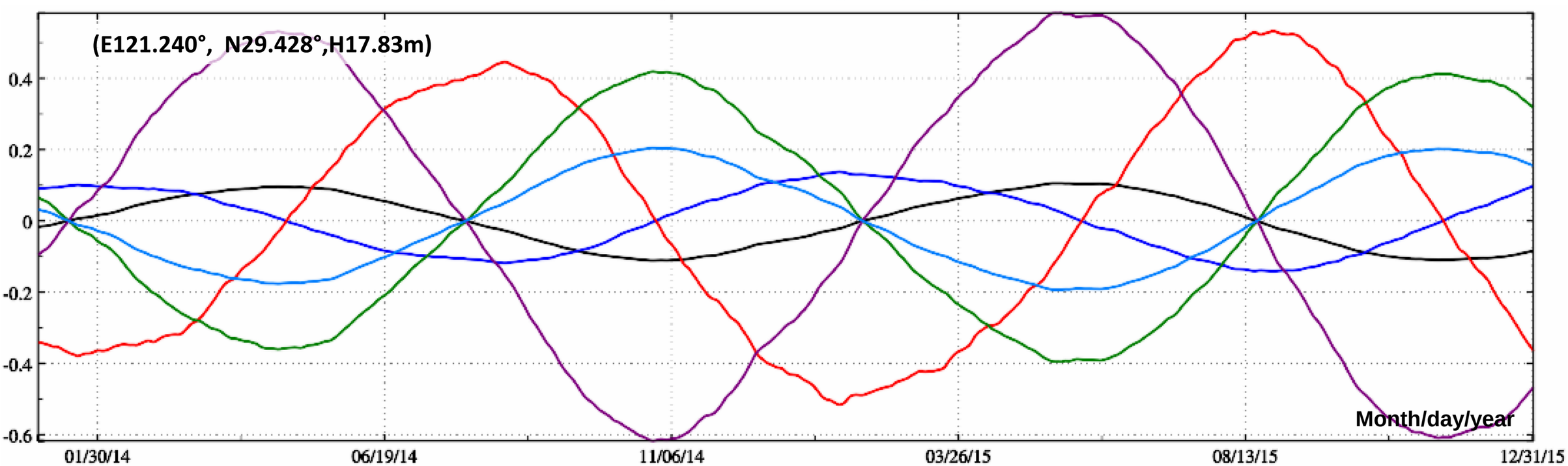
```
ASB   107.230000   29.910000   72.4   56658.000000
201401010000   0.000000   6.713   0.0297   0.0427   0.0535   0.0026   0.0417   0.0004   0.0173   -0.0134   0.(
201401011200   0.500000   6.375   0.0295   0.0427   0.0535   0.0026   0.0417   0.0003   0.0173   -0.0135   0.(
201401020000   1.000000   6.751   0.0294   0.0428   0.0536   0.0026   0.0418   0.0003   0.0173   -0.0135   0.(
201401021200   1.500000   6.412   0.0290   0.0428   0.0536   0.0026   0.0419   0.0003   0.0174   -0.0135   0.(
201401030000   2.000000   6.786   0.0287   0.0428   0.0536   0.0026   0.0419   0.0003   0.0174   -0.0136   0.(
201401031200   2.500000   6.445   0.0284   0.0429   0.0536   0.0026   0.0420   0.0003   0.0174   -0.0136   0.(
201401040000   3.000000   6.818   0.0280   0.0429   0.0536   0.0026   0.0420   0.0003   0.0174   -0.0137   0.(
201401041200   3.500000   6.476   0.0277   0.0429   0.0535   0.0026   0.0421   0.0003   0.0174   -0.0137   0.(
201401050000   4.000000   6.847   0.0275   0.0429   0.0535   0.0026   0.0421   0.0003   0.0175   -0.0138   0.(
201401051200   4.500000   6.504   0.0272   0.0430   0.0535   0.0026   0.0422   0.0003   0.0175   -0.0138   0.(
201401060000   5.000000   6.874   0.0269   0.0430   0.0535   0.0026   0.0422   0.0003   0.0175   -0.0138   0.(
201401061200   5.500000   6.529   0.0264   0.0430   0.0535   0.0026   0.0423   0.0003   0.0176   -0.0139   0.(
201401070000   6.000000   6.897   0.0259   0.0431   0.0535   0.0026   0.0424   0.0003   0.0176   -0.0140   0.(
201401071200   6.500000   6.551   0.0254   0.0431   0.0536   0.0026   0.0425   0.0003   0.0176   -0.0141   0.(
201401080000   7.000000   6.917   0.0250   0.0432   0.0536   0.0026   0.0426   0.0003   0.0177   -0.0141   0.(
201401081200   7.500000   6.570   0.0247   0.0432   0.0536   0.0026   0.0427   0.0003   0.0177   -0.0142   0.(
201401090000   8.000000   6.935   0.0244   0.0433   0.0536   0.0026   0.0428   0.0003   0.0178   -0.0142   0.(
201401091200   8.500000   6.586   0.0242   0.0434   0.0537   0.0026   0.0429   0.0003   0.0178   -0.0143   0.(
201401100000   9.000000   6.950   0.0240   0.0435   0.0538   0.0026   0.0430   0.0003   0.0179   -0.0144   0.(
```

The Earth's rotation polar shift and figure polar shift respectively characterize the behavior of the kinematic state and mechanical figure of the Earth system varying over time. Both exist objectively and induce various geodetic elements in the Earth's space to vary over time.

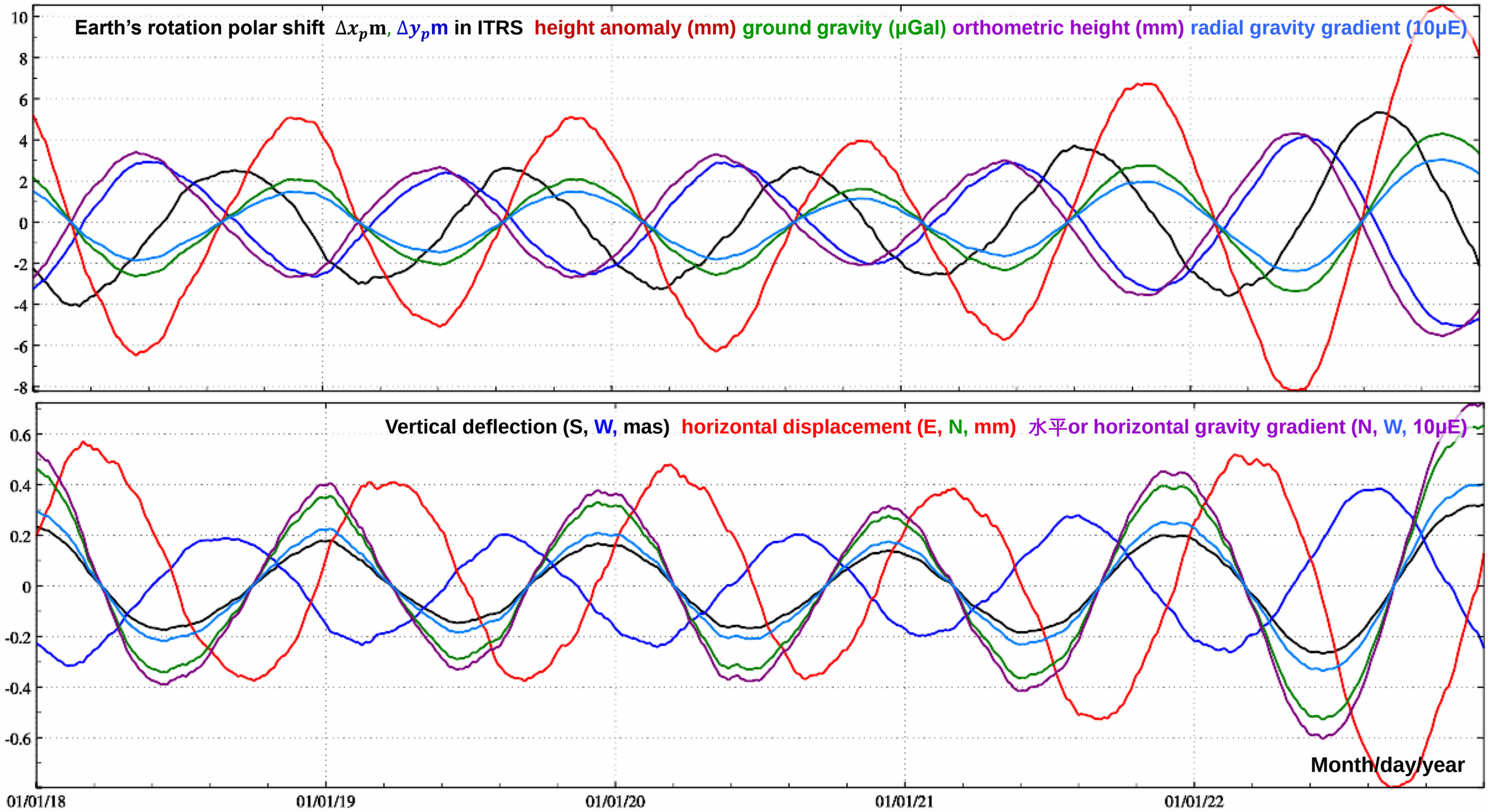
The program adopts the IERS measured or forecast product IERSeopc04.dat (which can be downloaded directly from the IERS website), which can be updated in time by the program [Geophysical models and numerical standards settings]. Love numbers in the program are k_2 = 0.3077 + 0.0036i, h_2 = 0.6207 and l_2 = 0.0836.



Earth's rotation polar shift (Δx_pm, Δy_pm in ITRS) effects: height anomaly (mm) ground gravity (μGal)
orthometric height (mm) radial gravity gradient (10μE)



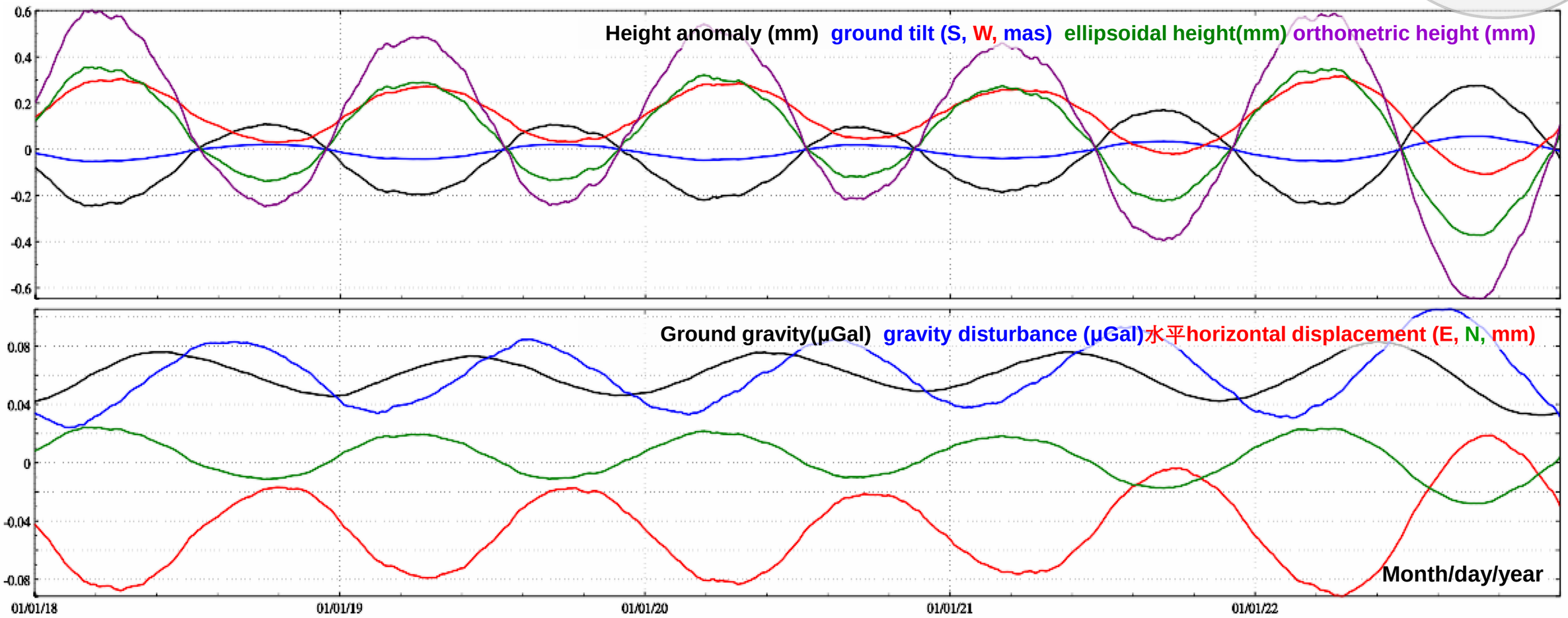
Earth's rotation polar shift effects: ground tilt (S, W, mas) horizontal displacement (E, N, mm) horizontal gravity gradient (N, W, 10μE)



Earth's rotation polar shift effect time series on various geodetic variation

Although the Earth's rotation polar shift itself can reach the meter level, the resulting effect on geoid or ground normal height is only in mm level, that on ground gravity is μGal level, that on radial gravity gradient is 10μE level, that on horizontal geodetic elements are small and can be generally ignored.

Earth Tide, Load Effect and Deform - ation Monitoring Computation
ETideLoad4.5
Chinese Academy of Surveying & mapping
October 2024, Beijing, China



Ocean polar tide effect time series on geodetic variations at the point P in the coastal zone area

The ocean polar tide effects on geodetic variations are small, which can be ignored in general geodetic cases.

Computation of Earth's rotation polar shift effects on geodetic variations and tidal effects on EPR

Computation of the rotation polar shift or ocean pole tidal effects at ground sites with given time

Open file | Save as | Import parameters | Start computation | Save process | Follow example

Computation of rotation polar shift or ocean pole tidal effect time series

Computation of rotation polar shift or ocean pole tidal effects at ground sites with given time

Computation of rotation polar shift or ocean pole tidal effects outside solid Earth

Calculation of rotation polar shift effects on various geodetic variations anywhere

Forecast of the tidal effect time series on Earth's rotation

Open the location and time file of the calculation points

Computation of figure polar shift effects from the measured ΔC_{21} and ΔS_{21}

Save program process as

Algorithm formulas

Set the file parameters

Column ordinal number of ellipsoidal height in the record: 4

Column ordinal number of time in the record: 1

Column ordinal number of starting MJD0 in the header: 5

Select the type of effects

- [x] geoid or height anomaly (mm)
- [x] ground gravity (μGal)
- [x] gravity disturbance (μGal)
- [x] ground tilt (SW, mas)
- [x] vertical deflection (SW, mas)
- [x] horizontal displacement (EN, mm)
- [x] ground radial displacement (mm)
- [x] ground normal or orthometric height (mm)
- [x] radial gravity gradient (10μE)
- [x] horizontal gravity gradient (NW, 10μE)

```
** Click the control button [Start computation], or the tool button [Start computation]....
>> Computation start time: 2024-10-18 21:31:23
>> Complete the computation of ocean pole tidal effects!
>> Computation end time: 2024-10-18 21:31:47
>> [Function] According to the location and time in the calculation point file, compute the Earth's rotation polar shift or ocean pole tidal effects on the geoid or height anomaly (mm), ground gravity (μGal), gravity disturbance (μGal), 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), radial gravity gradient (10μE) or horizontal gravity gradient (NW, to the north and to the west, 10μE).
>> Open the location and time file of the calculation points C:/ETideLoad4.5_win64en/examples/Poleshifteffectscalc/Postiontm.txt.
** Set the file format parameters according to the text box below, and then select the type of the geodetic variation to be computed. After giving the output file name, click the control button [Import setting parameters]
>> Save the computed results as C:/ETideLoad4.5_win64en/examples/Poleshifteffectscalc/Postmrst.txt.
** Behind the input file record, add one or several columns of the tidal effects as the output file record.
>> Setting parameters have been imported into the program!
>> Prepare to compute Earth's rotation polar shift effects ...
** Click the control button [Start computation], or the tool button [Start computation]....
>> Computation start time: 2024-10-18 21:33:05
>> Complete the computation of Earth's rotation polar shift effects!
>> Computation end time: 2024-10-18 21:33:06
```

Columns 2 and 3 of the record are agreed as the longitude and latitude

Select the effects to be computed: Rotaion polar shift effects

Save the computed results as | Import setting parameters | Start computation

Display of the input-output file↓

Save data in the text box as

```
 107.230000    29.910000  72.4  56658.000000
201401010000  107.230000  29.910000  72.4  -17.7068  -7.2595  -8.1628  0.3078  -0.1574  0.5865  -0.2979  0.5848
201401011200  107.230000  29.910000  72.4  -17.7300  -7.2690  -8.1734  0.3082  -0.1574  0.5873  -0.2979  0.5848
201401020000  107.230000  29.910000  72.4  -17.7532  -7.2785  -8.1841  0.3086  -0.1573  0.5880  -0.2979  0.5847
201401021200  107.230000  29.910000  72.4  -17.7795  -7.2892  -8.1963  0.3090  -0.1571  0.5889  -0.2975  0.5840
201401030000  107.230000  29.910000  72.4  -17.8059  -7.3000  -8.2084  0.3095  -0.1570  0.5898  -0.2971  0.5832
201401031200  107.230000  29.910000  72.4  -17.8251  -7.3078  -8.2173  0.3098  -0.1567  0.5904  -0.2966  0.5821
201401040000  107.230000  29.910000  72.4  -17.8443  -7.3156  -8.2261  0.3102  -0.1564  0.5910  -0.2960  0.5810
201401041200  107.230000  29.910000  72.4  -17.8612  -7.3224  -8.2339  0.3105  -0.1562  0.5916  -0.2956  0.5803
201401050000  107.230000  29.910000  72.4  -17.8781  -7.3293  -8.2417  0.3108  -0.1560  0.5922  -0.2953  0.5796
201401051200  107.230000  29.910000  72.4  -17.9024  -7.3392  -8.2529  0.3112  -0.1558  0.5930  -0.2949  0.5788
201401060000  107.230000  29.910000  72.4  -17.9267  -7.3491  -8.2641  0.3116  -0.1556  0.5938  -0.2945  0.5781
201401061200  107.230000  29.910000  72.4  -17.9613  -7.3632  -8.2801  0.3122  -0.1553  0.5949  -0.2939  0.5769
201401070000  107.230000  29.910000  72.4  -17.9959  -7.3773  -8.2960  0.3128  -0.1550  0.5961  -0.2933  0.5757
201401071200  107.230000  29.910000  72.4  -18.0349  -7.3932  -8.3140  0.3135  -0.1547  0.5974  -0.2927  0.5745
201401080000  107.230000  29.910000  72.4  -18.0739  -7.4091  -8.3320  0.3142  -0.1543  0.5986  -0.2921  0.5733
201401081200  107.230000  29.910000  72.4  -18.1095  -7.4236  -8.3484  0.3148  -0.1543  0.5998  -0.2920  0.5731
201401090000  107.230000  29.910000  72.4  -18.1450  -7.4381  -8.3647  0.3154  -0.1542  0.6010  -0.2919  0.5729
201401091200  107.230000  29.910000  72.4  -18.1892  -7.4562  -8.3851  0.3162  -0.1543  0.6025  -0.2920  0.5730
201401100000  107.230000  29.910000  72.4  -18.2334  -7.4742  -8.4055  0.3169  -0.1543  0.6039  -0.2920  0.5731
```

The Earth's rotation polar shift and figure polar shift respectively characterize the behavior of the kinematic state and mechanical figure of the Earth system varying over time. Both exist objectively and induce various geodetic elements in the Earth's space to vary over time.

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]. Love numbers in the program are $k_2 = 0.3077 + 0.0036i$, $h_2 = 0.6207$ and $l_2 = 0.0836$.

Computation of Earth's rotation polar shift effects on geodetic variations and tidal effects on EPR

Computation of the rotation polar shift or ocean pole tidal effects of satellite or outside solid Earth

Open file | Save as | Import parameters | Start computation | Save process | Follow example

Computation of rotation polar shift or ocean pole tidal effect time series

Computation of rotation polar shift or ocean pole tidal effects at ground sites with given time

Computation of rotation polar shift or ocean pole tidal effects outside solid Earth

Calculation of rotation polar shift effects on various geodetic variations anywhere

Forecast of the tidal effect time series on Earth's rotation

Open the location and time file of the external points

Computation of figure polar shift effects from the measured ΔC_{21} and ΔS_{21}

Save program process as

Algorithm formulas

Set the file parameters

Column ordinal number of ellipsoidal height in the record: 4

Column ordinal number of time in the record: 1

Column ordinal number of starting MJD0 in the header: 5

Select the type of effects

- [x] geopotential (0.1m²/s²)
- [ ] gravity vector (XYZ, μGal)
- [x] gravity vector (ENU, μGal)
- [ ] gravity gradient (XYZ, 10μE)
- [ ] gravity gradient (ENU, 10μE)

```
 ** Behind the input file record, add one or several columns of the tidal effects as the output file record.
>> Setting parameters have been imported into the program!
>> Prepare to compute Earth's rotation polar shift effects ...
 ** Click the control button [Start computation], or the tool button [Start computation]....
>> Computation start time：2024-10-18 12:05:42
>> Complete the computation of Earth's rotation polar shift effects!
>> Computation end time: 2024-10-18 12:05:43
>> [Function] According to the location and time in the external sapce point file, compute the Earth's rotation polar shift or ocean pole tidal effects on the geopotential (0.1m²/s²),
gravity(μGal), or gravity gradient(10μE) outside the solid Earth
>> Open the location and time file of the external points C:/ETideLoad4.5_win64en/examples/Poleshifteffectscalc/outerptm.txt.
 ** Set the file format parameters according to the text box below, and then select the type of the geodetic variation to be computed. After giving the output file name, the
control button [Import setting parameters]...
>> Save the computed results as C:/ETideLoad4.5_win64en/examples/Poleshifteffectscalc/outsatrst.txt.
>> Setting parameters have been imported into the program!
>> Prepare to compute Earth's rotation polar shift effects ...
 ** Click the control button [Start computation], or the tool button [Start computation]....
>> Computation start time：2024-10-18 12:08:30
>> Complete the computation of Earth's rotation polar shift effects!
>> Computation end time: 2024-10-18 12:08:31
```

Columns 2 and 3 of the record are agreed as the longitude and latitude

Select the effects to be computed: Rotaion polar shift effects

Save the computed results as | Import setting parameters | Start computation

GRACE satellite altitude

Display of the input-output file↓

Save data in the text box as

```
 Forcast  121.240000   29.428100  450000.000   58119.000000
2018010100 121.240000   29.428100 450000.0   -0.8623   -1.3486    1.4417    3.7916
2018010104 121.240000   29.428100 450000.0   -0.8637   -1.3508    1.4403    3.7978
2018010108 121.240000   29.428100 450000.0   -0.8651   -1.3530    1.4389    3.8039
2018010112 121.240000   29.428100 450000.0   -0.8665   -1.3552    1.4374    3.8101
2018010116 121.240000   29.428100 450000.0   -0.8680   -1.3574    1.4360    3.8163
2018010120 121.240000   29.428100 450000.0   -0.8694   -1.3596    1.4346    3.8225
2018010124 121.240000   29.428100 450000.0   -0.8708   -1.3617    1.4331    3.8286
2018010204 121.240000   29.428100 450000.0   -0.8721   -1.3638    1.4319    3.8345
2018010208 121.240000   29.428100 450000.0   -0.8734   -1.3659    1.4307    3.8404
2018010212 121.240000   29.428100 450000.0   -0.8748   -1.3680    1.4294    3.8462
2018010216 121.240000   29.428100 450000.0   -0.8761   -1.3701    1.4282    3.8521
2018010220 121.240000   29.428100 450000.0   -0.8774   -1.3722    1.4269    3.8579
2018010224 121.240000   29.428100 450000.0   -0.8788   -1.3743    1.4257    3.8638
2018010304 121.240000   29.428100 450000.0   -0.8799   -1.3761    1.4249    3.8690
2018010308 121.240000   29.428100 450000.0   -0.8811   -1.3779    1.4241    3.8742
2018010312 121.240000   29.428100 450000.0   -0.8823   -1.3798    1.4233    3.8793
2018010316 121.240000   29.428100 450000.0   -0.8835   -1.3816    1.4225    3.8845
2018010320 121.240000   29.428100 450000.0   -0.8846   -1.3835    1.4217    3.8897
2018010324 121.240000   29.428100 450000.0   -0.8858   -1.3853    1.4209    3.8949
2018010404 121.240000   29.428100 450000.0   -0.8870   -1.3871    1.4206    3.8999
```

The Earth's rotation polar shift and figure polar shift respectively characterize the behavior of the kinematic state and mechanical figure of the Earth system varying over time. Both exist objectively and induce various geodetic elements in the Earth's space to vary over time.

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]. Love numbers in the program are k_2 = 0.3077 + 0.0036i, h_2 = 0.6207 and l_2 = 0.0836.

Computation of Earth's rotation polar shift effects on geodetic variations and tidal effects on EPR

Computation of the rotation polar shift or ocean pole tidal effects of satellite or outside solid Earth

Open file | Save as | Import parameters | Start computation | Save process | Follow example

Computation of rotation polar shift or ocean pole tidal effect time series | Computation of rotation polar shift or ocean pole tidal effects at ground sites with given time | **Computation of rotation polar shift or ocean pole tidal effects outside solid Earth** | Calculation of rotation polar shift effects on various geodetic variations anywhere | Forecast of the tidal effect time series on Earth's rotation

Open the location and time file of the external points | Computation of figure polar shift effects from the measured ΔC_{21} and ΔS_{21} | Save program process as | Algorithm formulas

Set the file parameters

Column ordinal number of ellipsoidal height in the record: 4

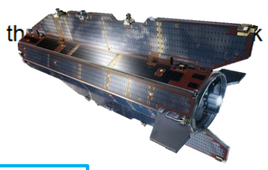
Column ordinal number of time in the record: 1

Column ordinal number of starting MJD0 in the header: 5

Select the type of effects

- [x] geopotential (0.1m²/s²)
- [ ] gravity vector (XYZ, μGal)
- [ ] gravity vector (ENU, μGal)
- [ ] gravity gradient (XYZ, 10μE)
- [x] gravity gradient (ENU, 10μE)

```
>> Save the computed results as C:/ETideLoad4.5_win64en/examples/Poleshifteffectscalc/outsatrst.txt.
>> Setting parameters have been imported into the program!
>> Prepare to compute Earth's rotation polar shift effects ...
  ** Click the control button [Start computation], or the tool button [Start computation]....
>> Computation start time：2024-10-18 12:08:30
>> Complete the computation of Earth's rotation polar shift effects!
>> Computation end time: 2024-10-18 12:08:31
>> [Function] According to the location and time in the external sapce point file, compute the Earth's rotation polar shift or ocean pole tidal effects on the geopotential (0.1m²/s²), gravity(μGal), or gravity gradient(10μE) outside the solid Earth
>> Open the location and time file of the external points C:/ETideLoad4.5_win64en/examples/Poleshifteffectscalc/satptm.txt.
  ** Set the file format parameters according to the text box below, and then select the type of the geodetic variation to be computed. After giving th                k the
control button [Import setting parameters]...
>> Save the computed results as C:/ETideLoad4.5_win64en/examples/Poleshifteffectscalc/satorbrst.txt.
>> Setting parameters have been imported into the program!
>> Prepare to compute Earth's rotation polar shift effects ...
  ** Click the control button [Start computation], or the tool button [Start computation]....
>> Computation start time：2024-10-18 12:09:09
>> Complete the computation of Earth's rotation polar shift effects!
>> Computation end time: 2024-10-18 12:09:10
```



Columns 2 and 3 of the record are agreed as the longitude and latitude

Select the effects to be computed: Rotaion polar shift effects

Save the computed results as | Import setting parameters | Start computation

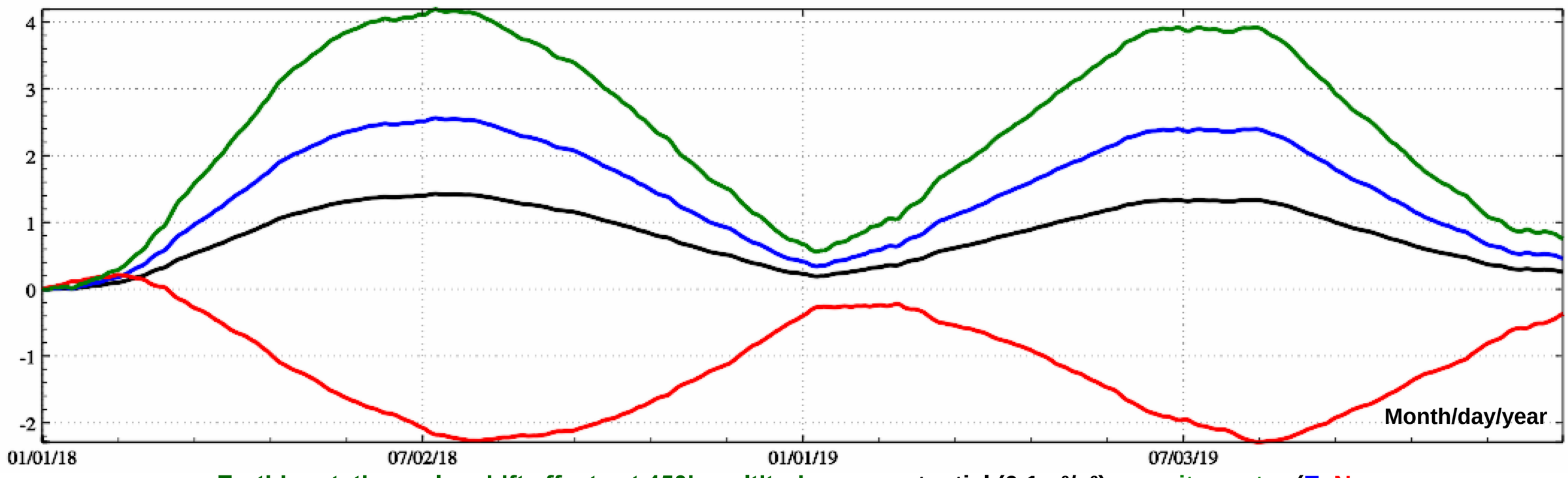
GOCE satellite altitude

Display of the input-output file↓ | Save data in the text box as

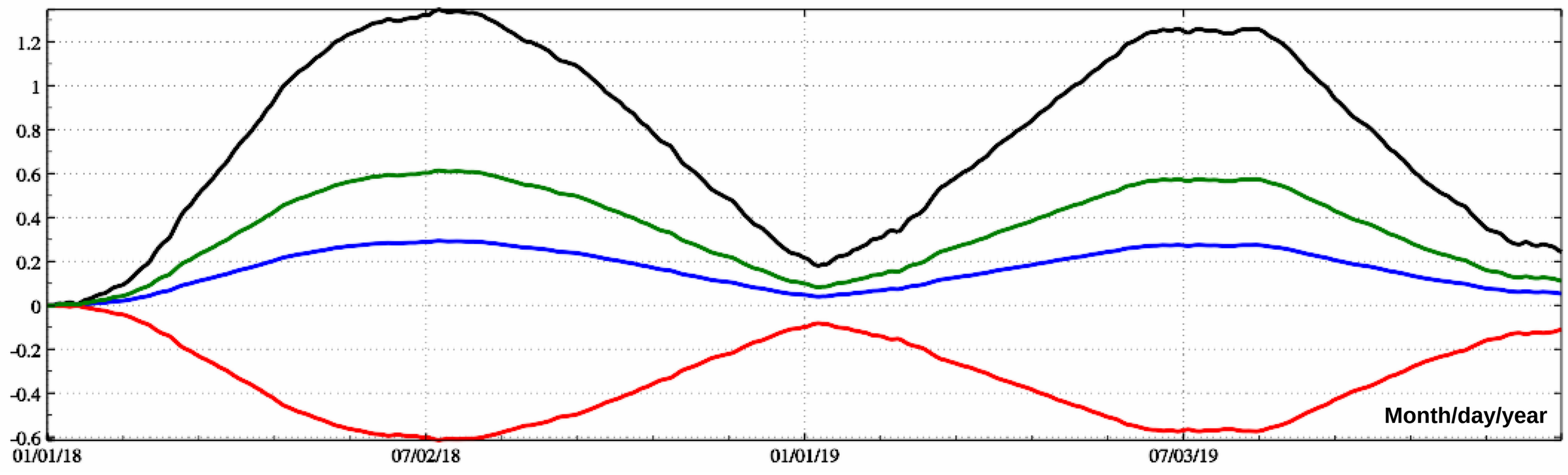
```
 Forcast  121.240000   29.428100  250000.000   58119.000000
2018010100 121.240000  29.428100 250000.0  -0.9427   0.2824   0.8597   -2.5791
2018010104 121.240000  29.428100 250000.0  -0.9443   0.2829   0.8611   -2.5833
2018010108 121.240000  29.428100 250000.0  -0.9458   0.2834   0.8625   -2.5875
2018010112 121.240000  29.428100 250000.0  -0.9474   0.2838   0.8639   -2.5917
2018010116 121.240000  29.428100 250000.0  -0.9489   0.2843   0.8653   -2.5959
2018010120 121.240000  29.428100 250000.0  -0.9504   0.2847   0.8667   -2.6001
2018010124 121.240000  29.428100 250000.0  -0.9520   0.2852   0.8681   -2.6043
2018010204 121.240000  29.428100 250000.0  -0.9534   0.2856   0.8694   -2.6083
2018010208 121.240000  29.428100 250000.0  -0.9549   0.2861   0.8708   -2.6123
2018010212 121.240000  29.428100 250000.0  -0.9563   0.2865   0.8721   -2.6162
2018010216 121.240000  29.428100 250000.0  -0.9578   0.2869   0.8734   -2.6202
2018010220 121.240000  29.428100 250000.0  -0.9592   0.2874   0.8747   -2.6242
2018010224 121.240000  29.428100 250000.0  -0.9607   0.2878   0.8761   -2.6282
2018010304 121.240000  29.428100 250000.0  -0.9620   0.2882   0.8772   -2.6317
2018010308 121.240000  29.428100 250000.0  -0.9633   0.2886   0.8784   -2.6353
2018010312 121.240000  29.428100 250000.0  -0.9646   0.2890   0.8796   -2.6388
2018010316 121.240000  29.428100 250000.0  -0.9659   0.2894   0.8808   -2.6423
2018010320 121.240000  29.428100 250000.0  -0.9671   0.2897   0.8819   -2.6458
2018010324 121.240000  29.428100 250000.0  -0.9684   0.2901   0.8831   -2.6493
2018010404 121.240000  29.428100 250000.0  -0.9697   0.2905   0.8842   -2.6527
```

The Earth's rotation polar shift and figure polar shift respectively characterize the behavior of the kinematic state and mechanical figure of the Earth system varying over time. Both exist objectively and induce various geodetic elements in the Earth's space to vary over time.

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]. Love numbers in the program are k_2 = 0.3077 + 0.0036i, h_2 = 0.6207 and l_2 = 0.0836.



Earth's rotation polar shift effects at 450km altitude： geopotential (0.1m²/s²), gravity vector (E, N: along the GRACE orbit/SST-ll, U, μGal)



Earth's rotation polar shift effects at 250km altitude： geopotential (0.1m²/s²), gravity gradient (E, N: along the GOCE orbit, U, 10μE)

Calculation of Earth's rotation polar shift effects on geodetic variations anywhere

Calculation of Earth's rotation polar shift effects on various surface geodetic variations anywhere

Earth Tide, Load Effect and Deformation Monitoring Computation
ETideLoad4.5
Chinese Academy of Surveying & mapping
October 2024, Beijing, China

Location of surface point to be forecast

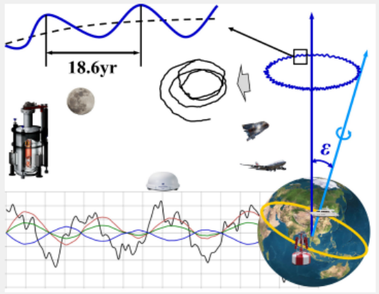
Longitude	121.240000°
Latitude	29.428100°
Ellipsoidal height	17.830m

Time series parameters

Start time	20180101
End time	20200101
Time interval	240.00 min

Calculate and save as

Reference epoch time of the non-tidal pole shift effects: Start time entered.



Effects to be plot

- [x] geoid or height anomaly (mm)
- [x] ground gravity (μGal)
- [ ] gravity disturbance (μGal)
- [ ] ground tilt (SW, mas)
- [ ] vertical deflection (SW, mas)
- [ ] horizontal displacement (EN, mm)
- [x] ground radial displacement (mm)
- [x] normal (orthometric) height (mm)
- [ ] radial gravity gradient (10μE)
- [ ] horizontal gravity gradient (NW, 10μE)

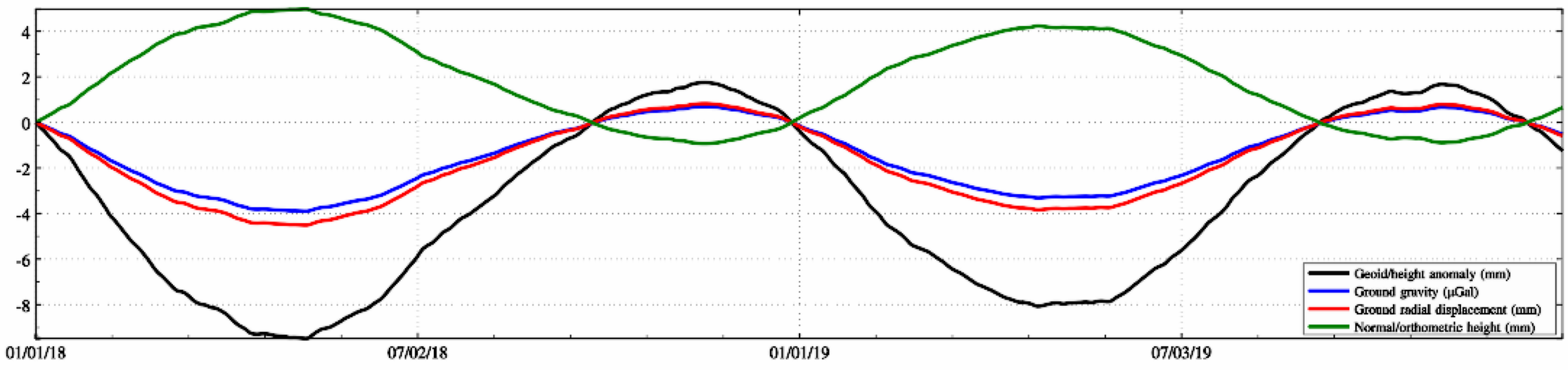
Pole shift effect time series on all-element geodetic variations

Forcast	121.240000	29.428100	17.830	58119.000000			
2018010100	0.000000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2018010104	0.166667	-0.0176	-0.0072	-0.0081	0.0003	0.0002	0.0006
2018010108	0.333333	-0.0352	-0.0143	-0.0162	0.0006	0.0004	0.0012
2018010112	0.500000	-0.0528	-0.0215	-0.0243	0.0010	0.0006	0.0018
2018010116	0.666667	-0.0704	-0.0286	-0.0324	0.0013	0.0008	0.0024
2018010120	0.833333	-0.0880	-0.0358	-0.0405	0.0016	0.0010	0.0030
2018010124	1.000000	-0.1055	-0.0429	-0.0487	0.0019	0.0012	0.0036
2018010204	1.166667	-0.1222	-0.0497	-0.0564	0.0022	0.0014	0.0042
2018010208	1.333333	-0.1389	-0.0565	-0.0640	0.0025	0.0016	0.0048
2018010212	1.500000	-0.1556	-0.0633	-0.0717	0.0028	0.0018	0.0054
2018010216	1.666667	-0.1723	-0.0701	-0.0794	0.0031	0.0020	0.0060
2018010220	1.833333	-0.1890	-0.0769	-0.0871	0.0034	0.0021	0.0065
2018010224	2.000000	-0.2057	-0.0837	-0.0948	0.0037	0.0023	0.0071
2018010304	2.166667	-0.2205	-0.0897	-0.1016	0.0040	0.0024	0.0076
2018010308	2.333333	-0.2353	-0.0957	-0.1084	0.0043	0.0026	0.0081
2018010312	2.500000	-0.2500	-0.1017	-0.1152	0.0045	0.0027	0.0086
2018010316	2.666667	-0.2648	-0.1077	-0.1220	0.0048	0.0028	0.0092
2018010320	2.833333	-0.2795	-0.1138	-0.1288	0.0051	0.0029	0.0097
2018010324	3.000000	-0.2943	-0.1198	-0.1357	0.0054	0.0030	0.0102
2018010404	3.166667	-0.3085	-0.1256	-0.1422	0.0056	0.0031	0.0107

Set line thickness 3 | Extract time series to be plot | Plot↓

Pole shift effect curve of surface geodetic variations

Save the current plot as



Firstly, calculate the Earth's rotation polar shift effect time series on all-element geodetic variations, and then select the variations to be plot.

Look at the amplitude of various rotation polar shift effects, the in-phase or out-of-phase (same or opposite sign) relationship between different types of variations, and the time-varying characteristics of the rotation polar shift effect curves.

Calculation of Earth's rotation polar shift effects on geodetic variations anywhere

Calculation of Earth's rotation polar shift effects on various surface geodetic variations anywhere

Earth Tide, Load Effect and Deform - ation Monitoring Computation
ETideLoad4.5
Chinese Academy of Surveying & mapping
October 2024, Beijing, China

Location of surface point to be forecast

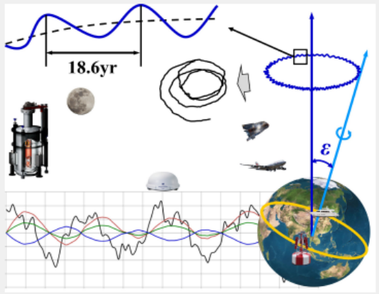
Longitude	121.240000°
Latitude	29.428100°
Ellipsoidal height	17.830m

Time series parameters

Start time	20180101
End time	20200101
Time interval	240.00 min

Calculate and save as

Reference epoch time of the non-tidal pole shift effects: Start time entered.



Effects to be plot

- [ ] geoid or height anomaly (mm)
- [ ] ground gravity (μGal)
- [ ] gravity disturbance (μGal)
- [x] ground tilt (SW, mas)
- [ ] vertical deflection (SW, mas)
- [x] horizontal displacement (EN, mm)
- [ ] ground radial displacement (mm)
- [ ] normal (orthometric) height (mm)
- [ ] radial gravity gradient (10μE)
- [ ] horizontal gravity gradient (NW, 10μE)

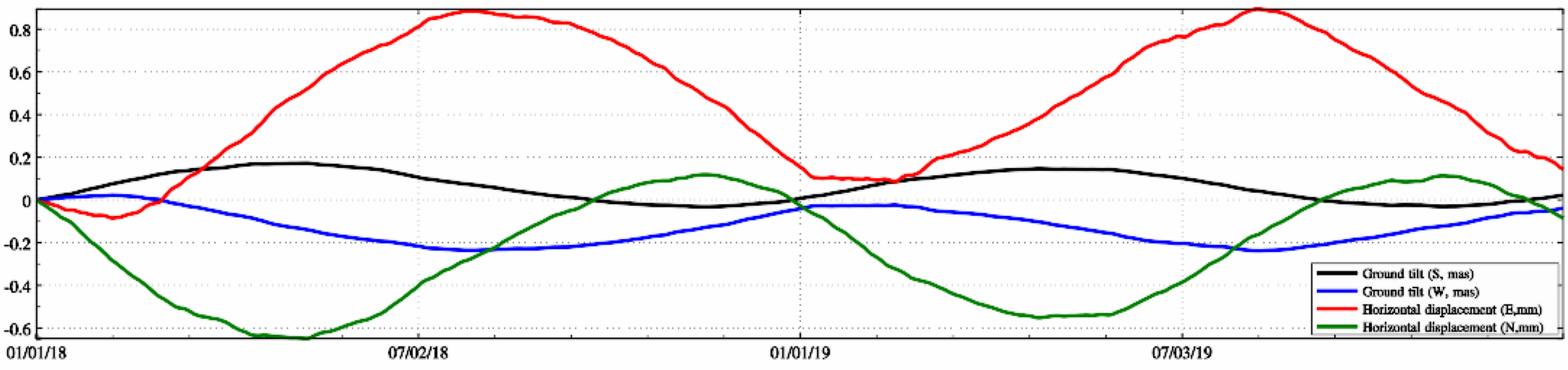
Pole shift effect time series on all-element geodetic variations

Forcast	121.240000	29.428100	17.830	58119.000000			
2018010100	0.000000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2018010104	0.166667	-0.0176	-0.0072	-0.0081	0.0003	0.0002	0.0006
2018010108	0.333333	-0.0352	-0.0143	-0.0162	0.0006	0.0004	0.0012
2018010112	0.500000	-0.0528	-0.0215	-0.0243	0.0010	0.0006	0.0018
2018010116	0.666667	-0.0704	-0.0286	-0.0324	0.0013	0.0008	0.0024
2018010120	0.833333	-0.0880	-0.0358	-0.0405	0.0016	0.0010	0.0030
2018010124	1.000000	-0.1055	-0.0429	-0.0487	0.0019	0.0012	0.0036
2018010204	1.166667	-0.1222	-0.0497	-0.0564	0.0022	0.0014	0.0042
2018010208	1.333333	-0.1389	-0.0565	-0.0640	0.0025	0.0016	0.0048
2018010212	1.500000	-0.1556	-0.0633	-0.0717	0.0028	0.0018	0.0054
2018010216	1.666667	-0.1723	-0.0701	-0.0794	0.0031	0.0020	0.0060
2018010220	1.833333	-0.1890	-0.0769	-0.0871	0.0034	0.0021	0.0065
2018010224	2.000000	-0.2057	-0.0837	-0.0948	0.0037	0.0023	0.0071
2018010304	2.166667	-0.2205	-0.0897	-0.1016	0.0040	0.0024	0.0076
2018010308	2.333333	-0.2353	-0.0957	-0.1084	0.0043	0.0026	0.0081
2018010312	2.500000	-0.2500	-0.1017	-0.1152	0.0045	0.0027	0.0086
2018010316	2.666667	-0.2648	-0.1077	-0.1220	0.0048	0.0028	0.0092
2018010320	2.833333	-0.2795	-0.1138	-0.1288	0.0051	0.0029	0.0097
2018010324	3.000000	-0.2943	-0.1198	-0.1357	0.0054	0.0030	0.0102
2018010404	3.166667	-0.3085	-0.1256	-0.1422	0.0056	0.0031	0.0107

Set line thickness 3 | Extract time series to be plot | Plot↓

Pole shift effect curve of surface geodetic variations

Save the current plot as

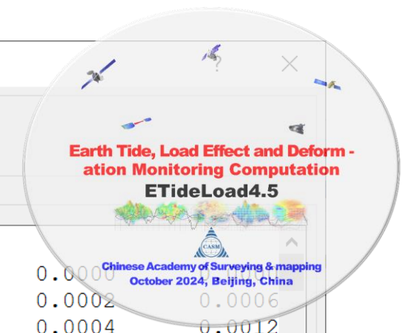


Firstly, calculate the Earth's rotation polar shift effect time series on all-element geodetic variations, and then select the variations to be plot.

Look at the amplitude of various rotation polar shift effects, the in-phase or out-of-phase (same or opposite sign) relationship between different types of variations, and the time-varying characteristics of the rotation polar shift effect curves.

Calculation of Earth's rotation polar shift effects on geodetic variations anywhere

Calculation of Earth's rotation polar shift effects on various surface geodetic variations anywhere



Location of surface point to be forecast

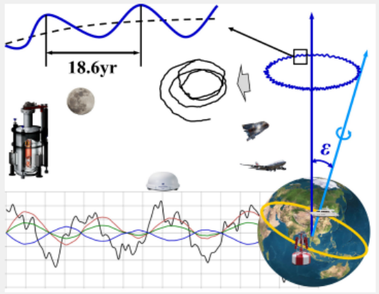
Longitude	121.240000°
Latitude	29.428100°
Ellipsoidal height	17.830m

Time series parameters

Start time	20180101
End time	20200101
Time interval	240.00 min

Calculate and save as

Reference epoch time of the non-tidal pole shift effects：Start time entered.



Effects to be plot

- ☐ geoid or height anomaly (mm)
- ☐ ground gravity (μGal) ⊙
- ☐ gravity disturbance (μGal)
- ☐ ground tilt (SW, mas) ⊙
- ☐ vertical deflection (SW, mas)
- ☐ horizontal displacement (EN, mm) ⊙
- ☐ ground radial displacement (mm) ⊙
- ☐ normal (orthometric) height (mm) ⊙
- ☑ radial gravity gradient (10μE)
- ☑ horizontal gravity gradient (NW, 10μE)

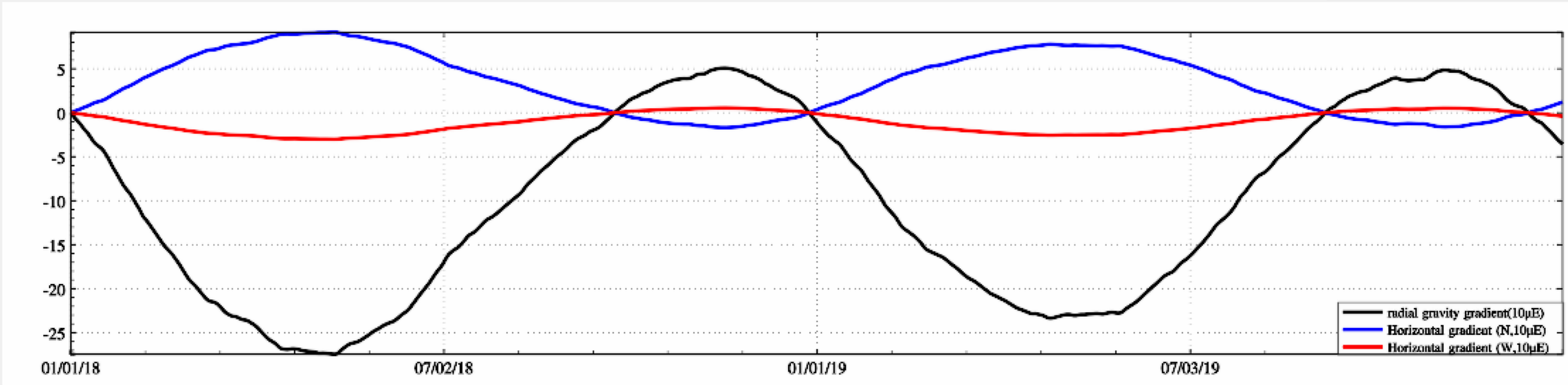
Pole shift effect time series on all-element geodetic variations

Forcast	121.240000	29.428100	17.830	58119.000000			
2018010100	0.000000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2018010104	0.166667	-0.0176	-0.0072	-0.0081	0.0003	0.0002	0.0006
2018010108	0.333333	-0.0352	-0.0143	-0.0162	0.0006	0.0004	0.0012
2018010112	0.500000	-0.0528	-0.0215	-0.0243	0.0010	0.0006	0.0018
2018010116	0.666667	-0.0704	-0.0286	-0.0324	0.0013	0.0008	0.0024
2018010120	0.833333	-0.0880	-0.0358	-0.0405	0.0016	0.0010	0.0030
2018010124	1.000000	-0.1055	-0.0429	-0.0487	0.0019	0.0012	0.0036
2018010204	1.166667	-0.1222	-0.0497	-0.0564	0.0022	0.0014	0.0042
2018010208	1.333333	-0.1389	-0.0565	-0.0640	0.0025	0.0016	0.0048
2018010212	1.500000	-0.1556	-0.0633	-0.0717	0.0028	0.0018	0.0054
2018010216	1.666667	-0.1723	-0.0701	-0.0794	0.0031	0.0020	0.0060
2018010220	1.833333	-0.1890	-0.0769	-0.0871	0.0034	0.0021	0.0065
2018010224	2.000000	-0.2057	-0.0837	-0.0948	0.0037	0.0023	0.0071
2018010304	2.166667	-0.2205	-0.0897	-0.1016	0.0040	0.0024	0.0076
2018010308	2.333333	-0.2353	-0.0957	-0.1084	0.0043	0.0026	0.0081
2018010312	2.500000	-0.2500	-0.1017	-0.1152	0.0045	0.0027	0.0086
2018010316	2.666667	-0.2648	-0.1077	-0.1220	0.0048	0.0028	0.0092
2018010320	2.833333	-0.2795	-0.1138	-0.1288	0.0051	0.0029	0.0097
2018010324	3.000000	-0.2943	-0.1198	-0.1357	0.0054	0.0030	0.0102
2018010404	3.166667	-0.3085	-0.1256	-0.1422	0.0056	0.0031	0.0107

Set line thickness 3 | Extract time series to be plot | Plot↓

Pole shift effect curve of surface geodetic variations

Save the current plot as

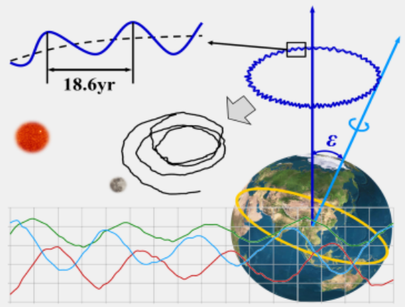


Firstly, calculate the Earth's rotation polar shift effect time series on all-element geodetic variations, and then select the variations to be plot.

Look at the amplitude of various rotation polar shift effects, the in-phase or out-of-phase (same or opposite sign) relationship between different types of variations, and the time-varying characteristics of the rotation polar shift effect curves.

The 1mas polar shift corresponds to the surface displacement of 3cm.

Forecast of the tidal effect time series on Earth's rotation (EPR)



Forecast time series parameters

Start time 20180101

End time 20200101

Time interval 240.00 min

select the type of tidal effect: Long period tidal effect

Calculate and save as

The tidal effect time series on Earth's rotation (EPR)

date	day	m1	m2(uas)	dLOD(us/day)	dUT1(ms)	dX1(mas)	dX2(mas)	dw(e-14rad/s)			
2018010100			0.000000	176.3364	-80.0140	-16.4154	-109.4040	-0.8817	-0.5187	1.3851	
2018010104			0.166667	178.0185	-77.2652	-28.0124	-109.4003	-1.0389	-0.7073	2.3639	
2018010108			0.333333	180.1408	-74.1469	-37.8732	-109.3948	-1.1843	-0.8874	3.1961	
2018010112			0.500000	182.6795	-70.6880	-45.8797	-109.3878	-1.3166	-1.0572	3.8719	
2018010116			0.666667	185.6071	-66.9207	-51.9376	-109.3796	-1.4347	-1.2152	4.3832	
2018010120			0.833333	188.8922	-62.8798	-55.9783	-109.3706	-1.5373	-1.3598	4.7242	
2018010124			1.000000	192.5001	-58.6028	-57.9595	-109.3611	-1.6237	-1.4898	4.8915	
2018010204			1.166667	196.3932	-54.1291	-57.8657	-109.3514	-1.6930	-1.6038	4.8836	
2018010208			1.333333	200.5310	-49.5001	-55.7085	-109.3419	-1.7446	-1.7007	4.7015	
2018010212			1.500000	204.8709	-44.7585	-51.5258	-109.3330	-1.7781	-1.7798	4.3485	
2018010216			1.666667	209.3681	-39.9480	-45.3814	-109.3249	-1.7931	-1.8402	3.8300	
2018010220			1.833333	213.9766	-35.1127	-37.3636	-109.3179	-1.7897	-1.8813	3.1533	
2018010224			2.000000	218.6491	-30.2972	-27.5838	-109.3125	-1.7677	-1.9027	2.3279	
2018010304			2.166667	223.3377	-25.5457	-16.1743	-109.3088	-1.7275	-1.9043	1.3650	
2018010308			2.333333	227.9944	-20.9017	-3.2863	-109.3072	-1.6695	-1.8860	0.2773	
2018010312			2.500000	232.5713	-16.4077	10.9126	-109.3078	-1.5942	-1.8479	-0.9211	
2018010316			2.666667	237.0211	-12.1049	26.2411	-109.3109	-1.5022	-1.7903	-2.2148	
2018010320			2.833333	241.2979	-8.0327	42.5072	-109.3166	-1.3945	-1.7137	-3.5876	
2018010324			3.000000	245.3568	-4.2284	59.5107	-109.3251	-1.2720	-1.6188	-5.0227	

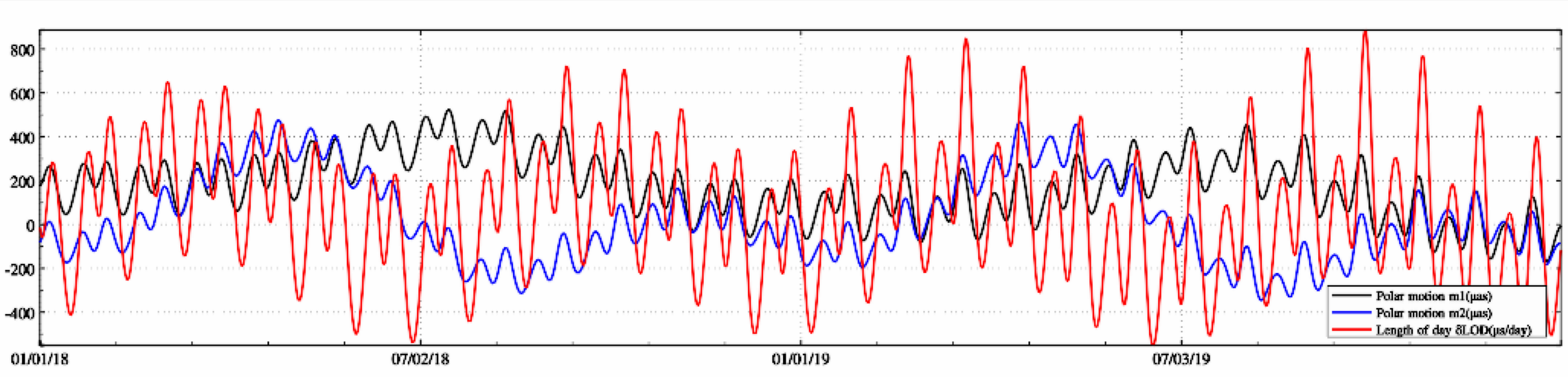
Set line thickness 2

Extract time series to be plot

Plot↓

The tidal effect time series curves on Earth's rotation (EPR)

Save the current plot as



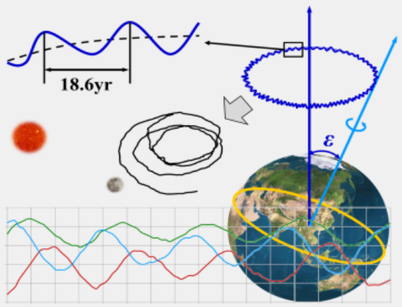
Firstly, set the time series parameters and select the type of tidal effects, then calculate and plot the tidal effect time series on Earth's rotation.

The calculation function for the zonal tidal effects calls the routine RG_ZONT2.F, while that for the short period tidal effects calls the routine ORTHO_EOP.F. The two routines are available from the IERS Conventions (2010) website.

Earth Tide, Load Effect and Deformation Monitoring Computation
ETideLoad4.5
Chinese Academy of Surveying & mapping
October 2024, Beijing, China

Forecast of the tidal effect time series on Earth's rotation

Forecast of the tidal effect time series on Earth's rotation (EPR)



Forecast time series parameters

Start time 20180301

End time 20180501

Time interval 15.00 min

select the type of tidal effect: Short peroid tidal effect

Calculate and save as

The tidal effect time series on Earth's rotation (EPR)

date	day	m1	m2(uas)	dLOD(us/day)	dUT1(us)		
2018030100		0.000000		-23.1557	75.6890	204.1958	9.9047
201803010015		0.010417		-99.7346	76.5366	190.3564	7.8459
201803010030		0.020833		-174.2225	73.2414	172.3248	5.9535
201803010045		0.031250		-245.5903	65.8178	150.5021	4.2690
2018030101		0.041667		-312.8575	54.3589	125.3551	2.8296
201803010115		0.052083		-375.1085	39.0358	97.4075	1.6672
201803010130		0.062500		-431.5059	20.0944	67.2315	0.8080
201803010145		0.072917		-481.3044	-2.1483	35.4381	0.2721
2018030102		0.083333		-523.8619	-27.3092	2.6667	0.0731
201803010215		0.093750		-558.6499	-54.9455	-30.4258	0.2177
201803010230		0.104167		-585.2612	-84.5620	-63.1759	0.7058
201803010245		0.114583		-603.4166	-115.6193	-94.9249	1.5304
2018030103		0.125000		-613.9687	-147.5426	-125.0301	2.6777
201803010315		0.135417		-616.4	-180.4	-154.2	4.1
201803010330		0.145833		-606.3445	-211.5707	-177.8827	5.8527
201803010345		0.156250		-[illegible]	-[illegible]	-[illegible]	[illegible]
2018030104		0.166667		-566.8756	-271.7203	-217.3138	9.9961
201803010415		0.177083		-[illegible]	-[illegible]	-[illegible]	[illegible]
201803010430		0.187500		-498.0722	-323.1527	-239.7994	14.7895

The excitation effect of short-period ocean tides on the rotation polar shift will be greatly attenuated, and the effect is less than 1% of the rotation polar shift.

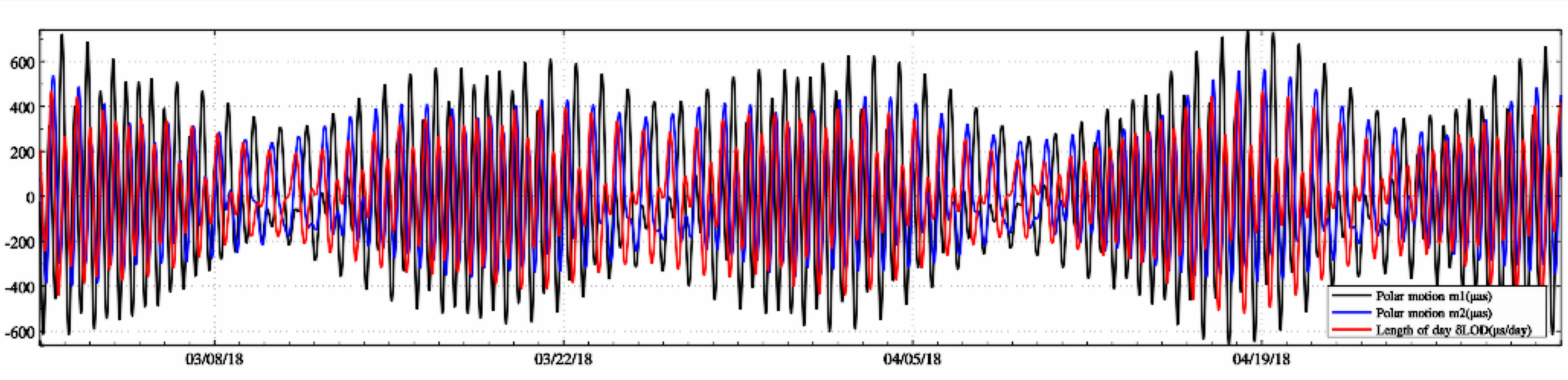
Set line thickness 2

Extract time series to be plot

Plot↓

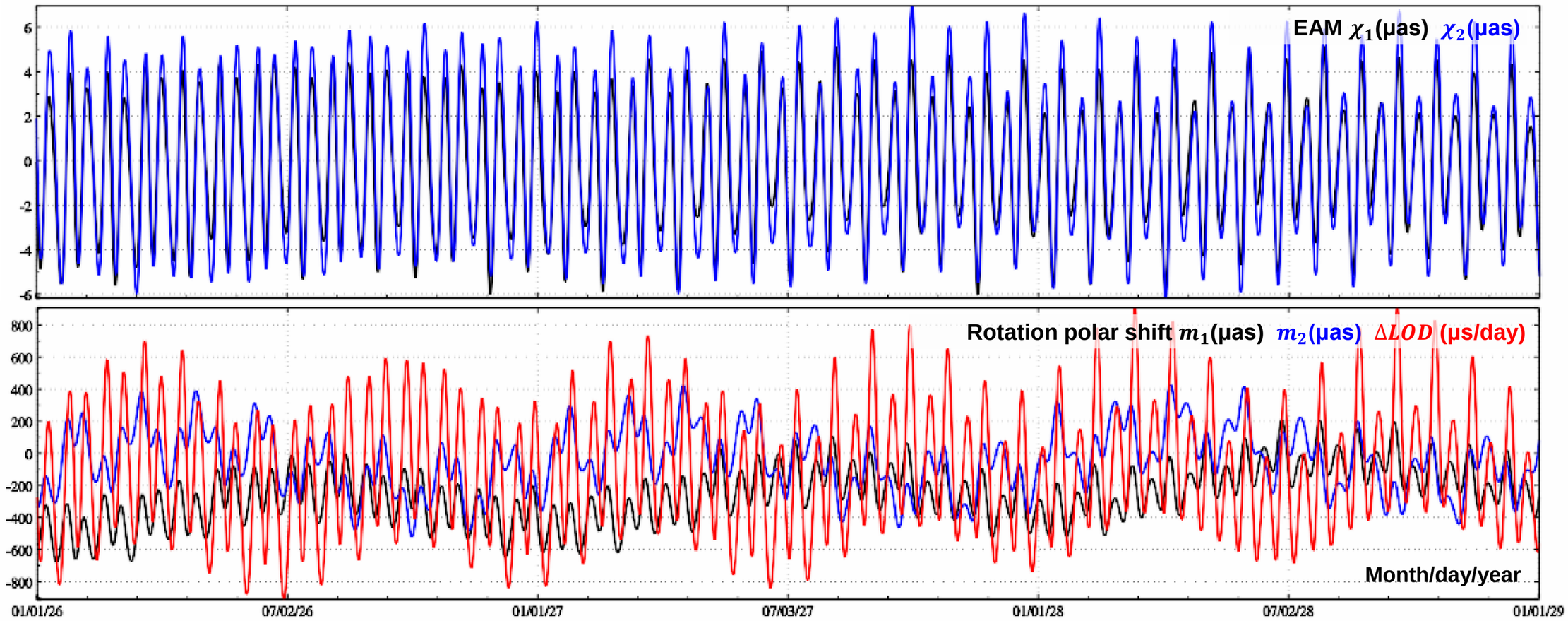
The tidal effect time series curves on Earth's rotation (EPR)

Save the current plot as

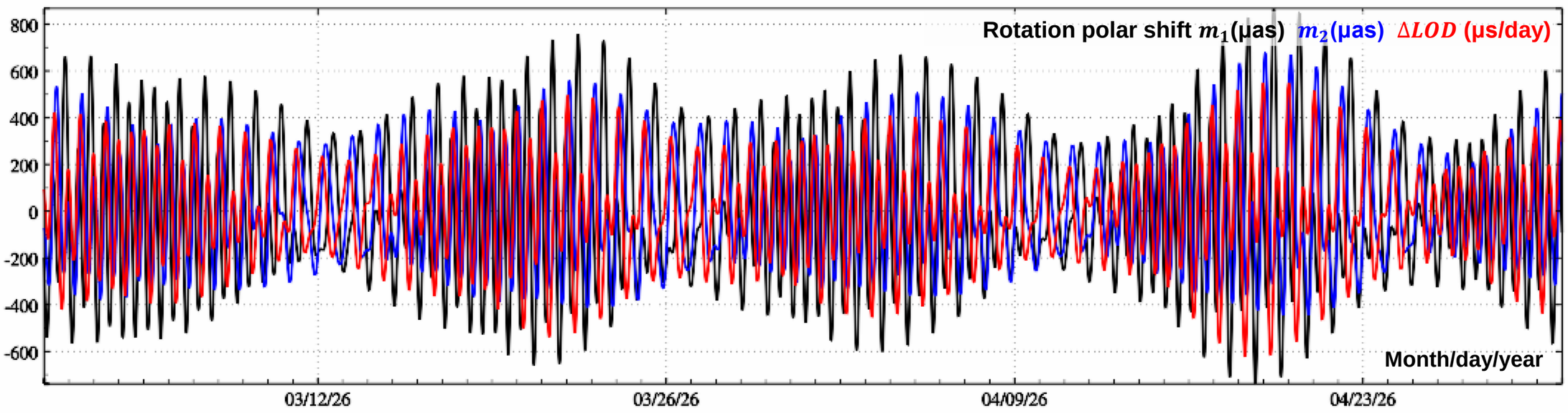


Firstly, set the time series parameters and select the type of tidal effects, then calculate and plot the tidal effect time series on Earth's rotation.

The calculation function for the zonal tidal effects calls the routine RG_ZONT2.F, while that for the short period tidal effects calls the routine ORTHO_EOP.F. The two routines are available from the IERS Conventions (2010) website.



Long-period tidal effect time series for the Earth's rotation motion



The time series of diurnal and semi-diurnal tidal effects on ERP

Computation of Earth's rotation polar shift effects on geodetic variations and tidal effects on EPR

Computation of Earth's figure polar shift effects on geodetic variations from the measured ΔC_{21} and ΔS_{21}

Open file | Save as | Import parameters | Start computation | Save process | Follow example

Computation of rotation polar shift or ocean pole tidal effect time series

Computation of rotation polar shift or ocean pole tidal effects at ground sites with given time

Computation of rotation polar shift or ocean pole tidal effects outside solid Earth

Calculation of rotation polar shift effects on various geodetic variations anywhere

Forecast of the tidal effect time series on Earth's rotation

Computation of figure polar shift effects from the measured ΔC_{21} and ΔS_{21}

Save program process as

Algorithm formulas

(μGal), gravity disturbance (μGal), 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), radial gravity gradient (10μE) or horizontal gravity gradient (NW, to the north and to the west, 10μE).
>> Complete calculation of Earth's rotation polar shift effects on various surface geodetic variations !
>> [Function] Set the time series parameters, calculate and display the long period or short peroid tidal effects on Earth's rotation. Here, the long period tidal effects include the zonal tidal effects and long period ocean tidal effects on Earth's rotation. The calculation function for the zonal tidal effects calls the routine RG_ZONT2.F, while that for the short period tidal effects calls the routine ORTHO_EOP.F. The two routines are available from the IERS Conventions (2010) website.
>> Complete calculation!
>> [Function] Input the site time series file and the UT/CSR RL-06 ΔC_{21} and ΔS_{21} monthly time series file C21_S21_RL06.txt in the directory C:/ETideLoad4.5_win64en/iers (the first 15 rows in the file ignored by the program) to compute the Earth's figure polar shift effects on the geoid or height anomaly (mm), ground gravity (μGal), gravity disturbance (μGal), 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), radial gravity gradient (10μE) or horizontal gravity gradient (NW, to the north and to the west, 10μE).
>> Save the computed results as C:/ETideLoad4.5_win64en/examples/Poleshifteffectscalc/fgrpolareffect.txt.
>> Open the UT/CSR RL-06 ΔC_{21} and ΔS_{21} monthly time series file C:/ETideLoad4.5_win64en/iers/C21_S21_RL06.txt。
>> Setting parameters have been imported into the program!
>> Prepare to compute Earth's figure polar shift effects...
** Click the control button [Start computation], or the tool button [Start computation]....
>> Computation start time：2024-10-18 14:21:24
>> Complete the computation of Earth's figure polar shift effects!
>> Computation end time: 2024-10-18 14:21:25

Save the computed results as

Import setting parameters

Start computation

Display of the input-output file↓

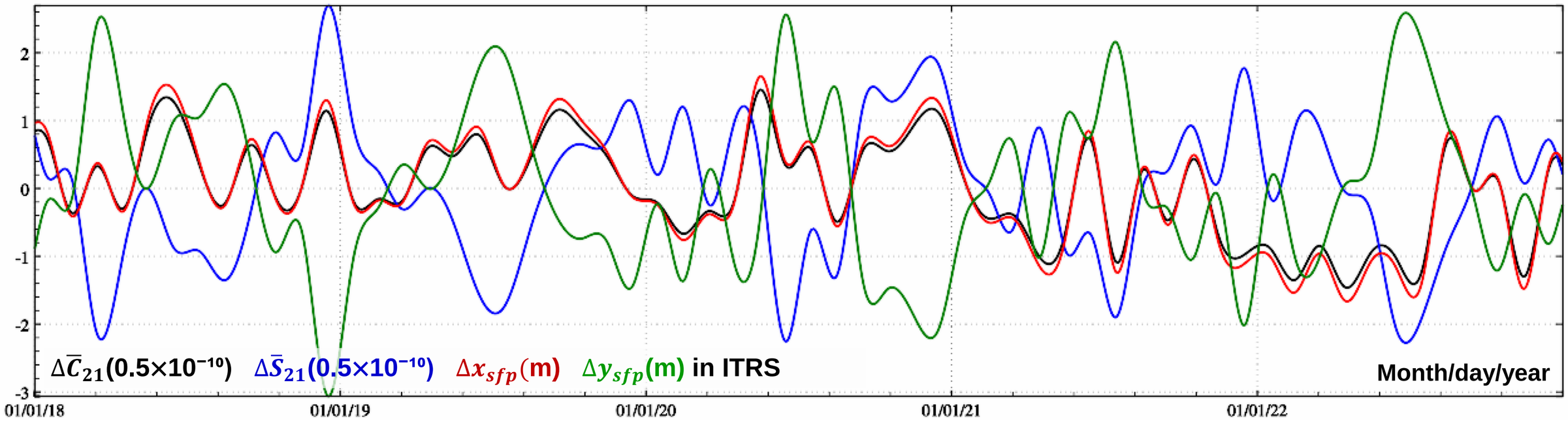
Save data in the text box as

```
 Forcast  12
2018010100  121.240000   29.428100  250000.0      0.4899      0.9034      0.5570     -1.0272      0.2636      0.0724      0.1082      0.0392     -0.0213      0.0161     -0.0088     -0.0098
2018010104  121.240000   29.428100  250000.0      0.4909      0.8947      0.5581     -1.0173      0.2596      0.0713      0.1066      0.0390     -0.0210      0.0160     -0.0086     -0.0096
2018010108  121.240000   29.428100  250000.0      0.4919      0.8860      0.5593     -1.0074      0.2555      0.0701      0.1049      0.0389     -0.0207      0.0160     -0.0085     -0.0095
2018010112  121.240000   29.428100  250000.0      0.4928      0.8773      0.5604     -0.9975      0.2515      0.0690      0.1033      0.0387     -0.0203      0.0159     -0.0084     -0.0093
2018010116  121.240000   29.428100  250000.0      0.4938      0.8686      0.5614     -0.9876      0.2475      0.0679      0.1016      0.0385     -0.0200      0.0158     -0.0082     -0.0092
2018010120  121.240000   29.428100  250000.0      0.4946      0.8599      0.5624     -0.9777      0.2434      0.0668      0.1000      0.0384     -0.0197      0.0158     -0.0081     -0.0090
2018010124  121.240000   29.428100  250000.0      0.4955      0.8512      0.5634     -0.9678      0.2394      0.0657      0.0983      0.0382     -0.0194      0.0157     -0.0080     -0.0089
2018010204  121.240000   29.428100  250000.0      0.4963      0.8425      0.5643     -0.9579      0.2354      0.0646      0.0967      0.0380     -0.0190      0.0156     -0.0078     -0.0087
2018010208  121.240000   29.428100  250000.0      0.4971      0.8338      0.5652     -0.9480      0.2315      0.0635      0.0950      0.0379     -0.0187      0.0156     -0.0077     -0.0086
2018010212  121.240000   29.428100  250000.0      0.4978      0.8251      0.5660     -0.9382      0.2275      0.0624      0.0934      0.0377     -0.0184      0.0155     -0.0076     -0.0084
2018010216  121.240000   29.428100  250000.0      0.4985      0.8165      0.5668     -0.9283      0.2235      0.0614      0.0918      0.0375     -0.0181      0.0154     -0.0074     -0.0083
2018010220  121.240000   29.428100  250000.0      0.4992      0.8078      0.5676     -0.9185      0.2196      0.0603      0.0902      0.0374     -0.0178      0.0154     -0.0073     -0.0081
2018010224  121.240000   29.428100  250000.0      0.4998      0.7992      0.5683     -0.9087      0.2157      0.0592      0.0886      0.0372     -0.0174      0.0153     -0.0072     -0.0080
2018010304  121.240000   29.428100  250000.0      0.5004      0.7905      0.5689     -0.8989      0.2118      0.0581      0.0870      0.0370     -0.0171      0.0152     -0.0070     -0.0078
2018010308  121.240000   29.428100  250000.0      0.5009      0.7819      0.5695     -0.8891      0.2079      0.0571      0.0854      0.0368     -0.0168      0.0151     -0.0069     -0.0077
2018010312  121.240000   29.428100  250000.0      0.5014      0.7733      0.5701     -0.8793      0.2040      0.0560      0.0838      0.0367     -0.0165      0.0151     -0.0068     -0.0076
2018010316  121.240000   29.428100  250000.0      0.5019      0.7648      0.5706     -0.8696      0.2002      0.0549      0.0822      0.0365     -0.0162      0.0150     -0.0067     -0.0074
2018010320  121.240000   29.428100  250000.0      0.5023      0.7562      0.5711     -0.8598      0.1964      0.0539      0.0806      0.0363     -0.0159      0.0149     -0.0065     -0.0073
2018010324  121.240000   29.428100  250000.0      0.5026      0.7477      0.5715     -0.8501      0.1926      0.0529      0.0791      0.0361     -0.0156      0.0148     -0.0064     -0.0071
```

The Earth's rotation polar shift and figure polar shift respectively characterize the behavior of the kinematic state and mechanical figure of the Earth system varying over time. Both exist objectively and induce various geodetic elements in the Earth's space to vary over time.

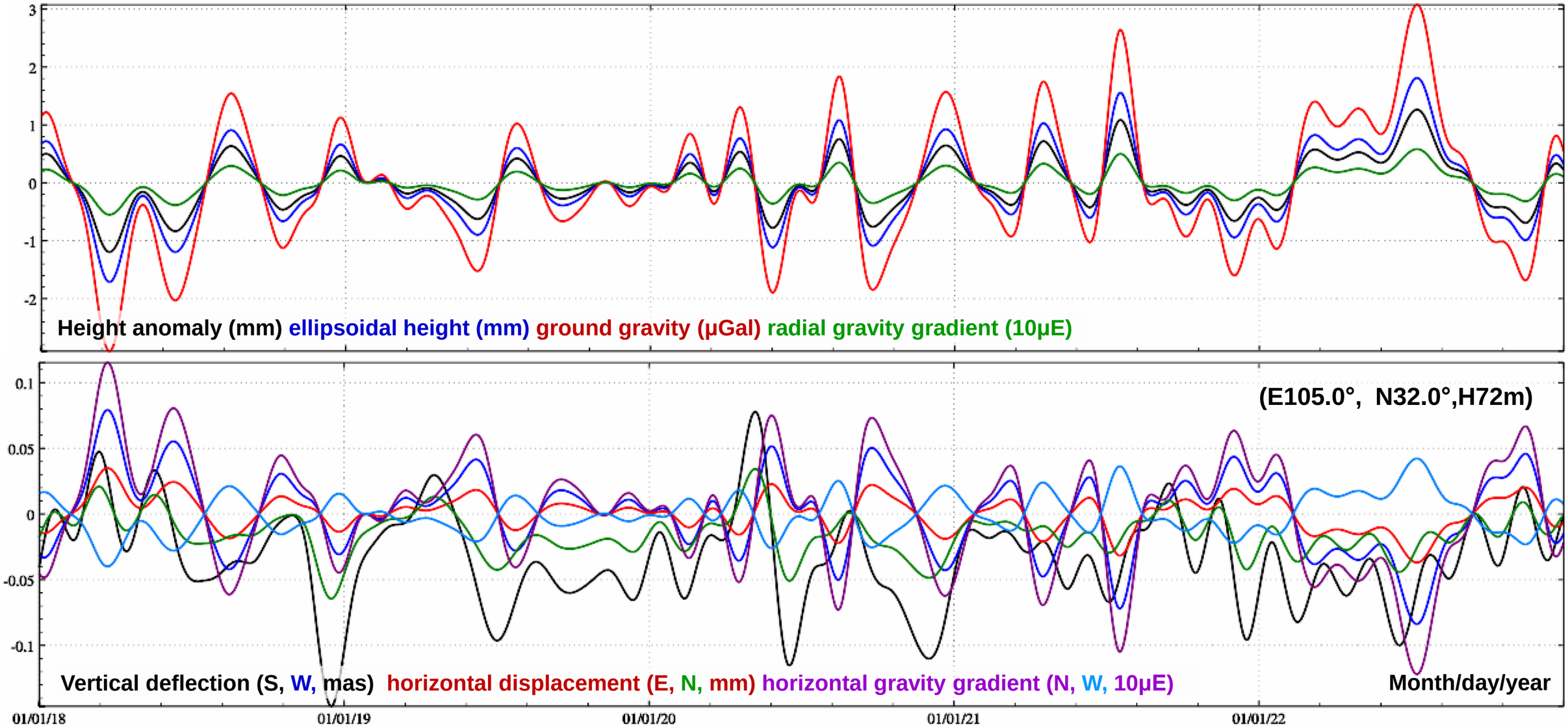
The program adopts the IERS measured or forecast product IERSeopc04.dat (which can be downloaded directly from the IERS website), which can be updated in time by the program [Geophysical models and numerical standards settings]. Love numbers in the program are $k_2 = 0.3077 + 0.0036i$, $h_2 = 0.6207$ and $l_2 = 0.0836$.

In the Earth-fixed coordinate system with arbitrary positioning and orientation, the mechanical figure polar coordinates of the deforming Earth can be uniquely determined by the degree-2 tesseral harmonic geopotential coefficients $(\overline{C}_{21}, \overline{S}_{21})$. Therefore, the various tidal and non-tidal effects on figure pole can be accurately obtained in geodesy.



Degree-2 tesseral sector harmonic geopotential coefficient and Earth's figure polar shift time series measured by SLR from UT/CSR

Although the Earth's figure polar shift itself can reach the meter level, the resulting effect on geoid is not greater than 2mm. The Earth's figure polar shift effects on horizontal geodetic elements such as ground horizontal displacement, vertical deviation or horizontal gravity gradient are small and can be generally ignored.



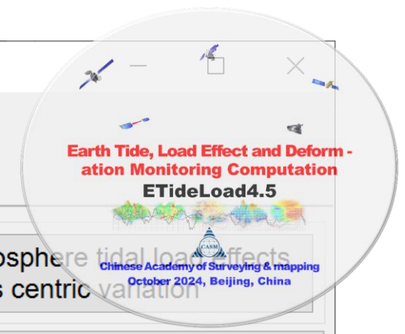
Earth's figure polar shift effect time series on geodetic variations

The Earth's rotation polar shift and Earth's figure polar shift respectively represent the kinematic state of the whole Earth system and the characteristics of Earth's mechanical shape changing with time, which are both natural objective behaviors. Both of them will cause various geodetic elements in Earth's space to change with time.

Computation of permanent tidal and Earth's mass centric variation effects on geodetic variations

Computation of permanent tidal effects on various geodetic variations

Open file Save as Impor parameters Start computation Save process Follow example



Computation of permanent tidal effects on various geodetic variations | Computation of Earth's mass centric variation effects on all-element geodetic variations | Forecast of ocean tidal load effects on Earth's mass centric variation | Forecast of atmosphere tidal load effects on Earth's mass centric variation

Open the geodetic point record file | Save program process as | Effects of the Earth's mass centric variations and figure polar shifts

Set the file parameters

The number of rows of the file header: 0

Column ordinal number of ellipsoidal height in the record: 4

Select the type of variations

- [x] geoid or height anomaly (mm)
- [x] ground gravity (μGal)
- [x] gravity disturbance (μGal)
- [x] ground tilt (SW, mas)
- [x] vertical deflection (SW, mas)
- [x] horizontal displacement (EN, mm)
- [x] ground radial displacement (mm)
- [x] ground normal or orthometric height (mm)
- [x] disturbing gravity gradient (radial, 10μE)
- [x] horizontal gravity gradient (NE, 10μE)

```
>> [Function] According to the location in the point record file, compute the permanent tidal effects on the geoid or height anomaly (mm), ground gravity (μGal), gravity disturbance (μGal), 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), radial gravity gradient (10μE) or horizontal gravity gradient (NW, to the north and to the west, 10μE).
>> Open the geodetic point record file C:/ETideLoad4.5_win64en/examples/Permanentdgeocenter/GNSSlksirent.txt.
  ** Enter the file format parameters according to the text box below. After giving the output file name, click the control button [Import setting parameters]...
>> Save the computed results as C:/ETideLoad4.5_win64en/examples/Permanentdgeocenter/permrst.txt.
  ** Behind the input file record, add several columns of the computed results as the output file record.
>> Setting parameters have been imported into the program!
  ** Click the control button [Start computation], or the tool button [Start computation]...
>> Computation start time：2024-10-18 14:37:47
>> Complete the computation of the permanent tidal effects!
```

Columns 2 and 3 of the record are agreed as the longitude and latitude of the calculated point.

Type of permanent tidal effects: Total effects | Save the computed results as | Import setting parameters | Start computation

Display of the input-output file↓ | Save the data in the text box as

2	102.546777	24.458002	1659.0410	-0.1046	63.3095	26.1954	12.5279	4.9793	0.0000
4	102.725921	24.460578	2111.3872	-0.0612	63.2920	26.1863	12.5236	4.9790	0.0000
6	102.528697	24.562786	1936.4260	-0.0491	62.7782	25.9745	12.4223	4.9949	0.0000
9	102.832641	24.575505	1977.4949	-0.1223	62.7136	25.9476	12.4094	4.9968	0.0000
10	102.345532	24.668953	1919.7825	-0.0782	62.2412	25.7525	12.3161	5.0111	0.0000
11	102.423972	24.652933	1959.3369	-0.0548	62.3220	25.7857	12.3320	5.0086	0.0000
13	102.631063	24.657055	1906.3415	-0.1185	62.3016	25.7775	12.3281	5.0093	0.0000
14	102.742718	24.652871	1935.7882	-0.0767	62.3226	25.7860	12.3322	5.0086	0.0000
15	102.843573	24.642787	1880.7707	-0.1319	62.3742	25.8076	12.3425	5.0072	0.0000
16	103.137778	24.658224	1838.4387	-0.0730	62.2964	25.7756	12.3272	5.0096	0.0000
17	102.426305	24.743284	1929.0475	-0.0771	61.8640	25.5964	12.2415	5.0223	0.0000
20	102.729945	24.734909	1856.2213	-0.1356	61.9073	25.6146	12.2502	5.0212	0.0000
21	102.840819	24.752018	2117.8582	-0.0459	61.8178	25.5765	12.2320	5.0233	0.0000

The permanent tide does not change with time. It is the zero-frequency tide ΔC_{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. The Love numbers in the program are k_{20}=0.29525, h_{20}=0.6078 and l_{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.

The variation of the Earth's center of mass is equal to the first-degree term of Earth's loading deformation, which excites the variations of all the geometric and physical geodetic elements in the Earth's space with time, rather than can be simply expressed as the ground site displacement of pure geometric quantity.

Computation of permanent tidal and Earth's mass centric variation effects on geodetic variations

Computation of Earth's mass centric variation effects on all-element geodetic variations

Open file Save as Impor parameters Start computation Save process Follow example

Computation of permanent tidal effects on various geodetic variations | Computation of Earth's mass centric variation effects on all-element geodetic variations | Forecast of ocean tidal load effects on Earth's mass centric variation | Forecast of atmosphere tidal load effects on Earth's mass centric variation

Open the location and time file of calculation points | Save program process as | Effects of the Earth's mass centric variations and figure polar shifts

Set the file parameters

Column ordinal number of time in the record: 1

Column ordinal number of ellipsoidal height in the record: 4

Column ordinal number of starting MJD0 in the header: 5

Select the type of variations

- [x] geoid or height anomaly (mm)
- [x] ground gravity (μGal)
- [x] gravity disturbance (μGal)
- [x] ground tilt (SW, mas)
- [x] vertical deflection (SW, mas)
- [x] horizontal displacement (EN, mm)
- [x] ground radial displacement (mm)
- [x] ground normal or orthometric height (mm)
- [x] disturbing gravity gradient (radial, 10μE)
- [x] horizontal gravity gradient (NE, 10μE)

>> [Function] Input the calculation point coordinate file with the epoch time on the ground or outside the earth, using the Earth's mass centric variation time series from the measured SLR, and compute the Earth's mass centric variation effects on the geoid or height anomaly (mm), ground gravity (μGal), gravity disturbance (μGal), 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), radial gravity gradient (10μE) or horizontal gravity gradient (NW, to the north and to the west, 10μE).

>> Open the location and time file of calculation points C:/ETideLoad4.5_win64en/examples/Permanentdgeocenter/Postiontm.txt.

** Enter the file format parameters according to the text box below. After giving the output file name, click the control button [Import setting parameters]...

>> Save the computed results as C:/ETideLoad4.5_win64en/examples/Permanentdgeocenter/geocenterst.txt.

** Behind the input file record, add 3 columns of Earth's mass centric variations interpolated and one or several columns of Earth's mass centric variation effects selected as the output file record..

>> Setting parameters have been imported into the program!

** Click the control button [Start computation], or the tool button [St...

Columns 2 and 3 of the record are agreed as the longitude and latitude of the calculation point

Save the computed results as | Import setting parameters | Start computation

Display of the input-output file↓ | Save the data in the text box as

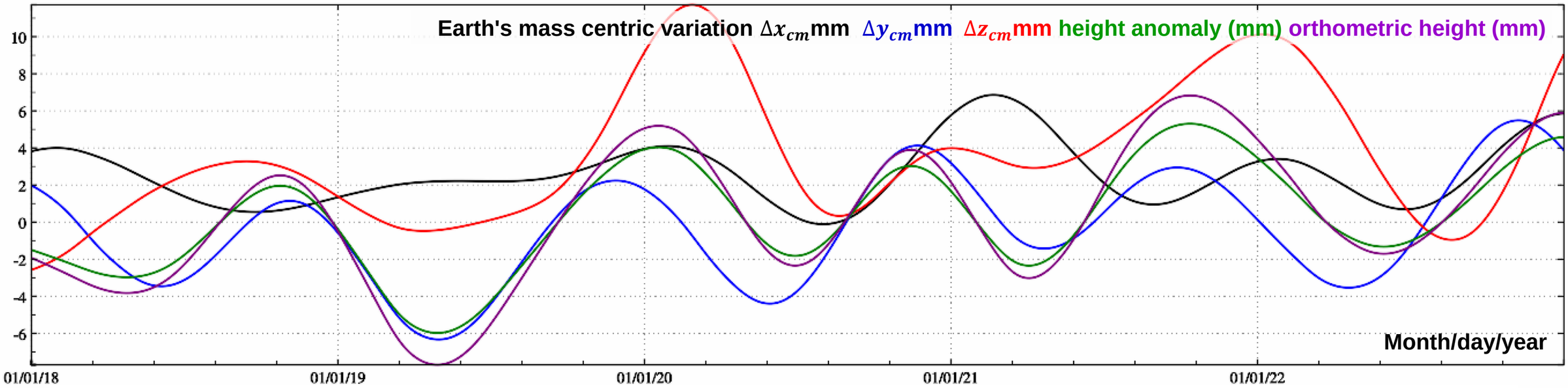
```
 107.230000    29.910000  72.4  56658.000000
201401010000  107.230000  29.910000  72.4   0.9547   0.1535   4.5946   2.1684   0.2837
201401011200  107.230000  29.910000  72.4   0.9543   0.1384   4.6096   2.1634   0.2831
201401020000  107.230000  29.910000  72.4   0.9539   0.1232   4.6244   2.1582   0.2824
201401021200  107.230000  29.910000  72.4   0.9534   0.1080   4.6389   2.1529   0.2817
201401030000  107.230000  29.910000  72.4   0.9528   0.0927   4.6533   2.1475   0.2810
201401031200  107.230000  29.910000  72.4   0.9522   0.0773   4.6675   2.1419   0.2803
201401040000  107.230000  29.910000  72.4   0.9515   0.0618   4.6814   2.1362   0.2795
201401041200  107.230000  29.910000  72.4   0.9507   0.0463   4.6952   2.1303   0.2788
201401050000  107.230000  29.910000  72.4   0.9499   0.0307   4.7088   2.1243   0.2780
201401051200  107.230000  29.910000  72.4   0.9490   0.0151   4.7222   2.1182   0.2772
```

Improve the algorithm of Earth's mass centric variation effects in the IERS Conventions (2010) and then compute the tidal and non-tidal load effects on all-element geodetic variations in the whole Earth space.

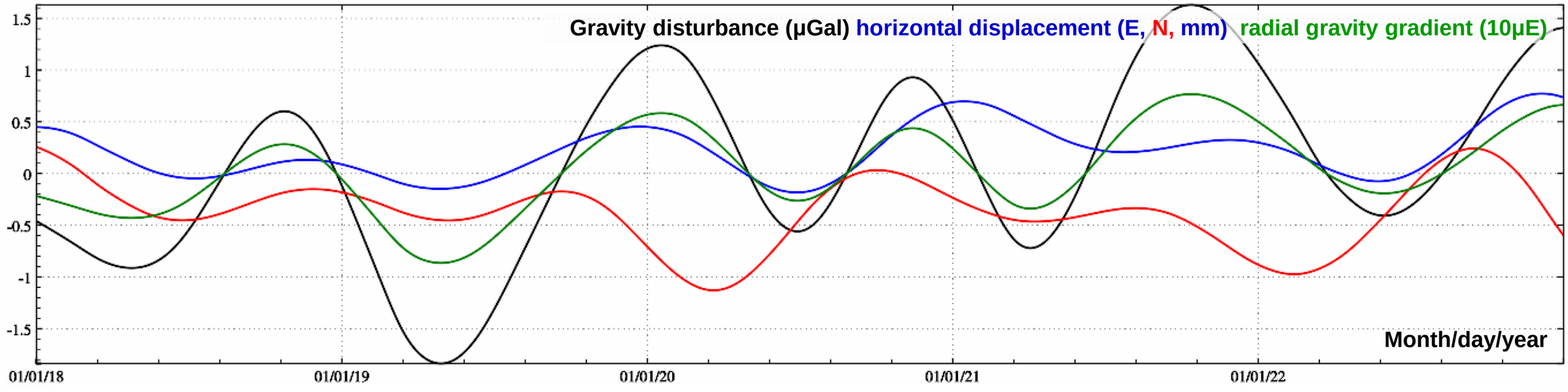
The permanent tide does not change with time. It is the zero-frequency tide ΔC_{20} in the long-period solid tide. The permanent tide produces a permanent additional oblateness that varies with latitude to the Earth, and its effects on the geodetic quantities have nothing to do with the longitude of its location. The Love numbers in the program are k_{20}=0.29525, h_{20}=0.6078 and l_{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.

The variation of the Earth's center of mass is equal to the first-degree term of Earth's loading deformation, which excites the variations of all the geometric and physical geodetic elements in the Earth's space with time, rather than can be simply expressed as the ground site displacement of pure geometric quantity.



Earth's mass centric variation and their effects on the height anomaly geoid and orthometric height



Earth's mass centric variation effect time series on various geodetic variations

The variations of the Earth's center of mass measured by the SLR generally represent the deformation of whole Earth system excited by the non-tidal load variations, thus affecting various geometric and physical geodetic elements in the Earth space, rather than simply showing the ground site displacement of pure geometric elements.

Computation of permanent tidal and Earth's mass centric variation effects on geodetic variations

Forecast of ocean tidal load effects on Earth's mass centric variation

Open file Save as Impor parameters Start computation Save process Follow example

Computation of permanent tidal effects on various geodetic variations | Computation of Earth's mass centric variation effects on all-element geodetic variations | Forecast of ocean tidal load effects on Earth's mass centric variation | Forecast of atmosphere tidal load effects on Earth's mass centric variation

Forecast time series parameters

Start time	20160701
End time	20160715
Time interval	60.00 min

Save program process as

Effects of the Earth's mass centric variations and figure polar shifts

```
>> Computation end time: 2024-10-18 14:40:01
>> [Function] Input time series parameters, and forecast the ocean tidal load effect time series on Earth's mass centric variation (Xcm, Ycm, Zcm, in unit of mm) from the first-degree ocean tidal load spherical harmonic coefficient file OtideOne.dat output by the function [Spherical harmonic analysis on ocean tidal constituent harmonic constants].
>> Save the computed results as C:/ETideLoad4.5_win64en/examples/Permanentdgeocenter/otdgeocntrst.txt.
  ** The output file record includes the sampling epoch time, 3 columns of the ocean tidal load effects on Earth's mass centric variation (Xcm, Ycm, Zcm, in unit mm).
>> Setting parameters have been imported into the program!
  ** Click the control button [Start computation], or the tool button [Start computation]....
>> Computation start time：2024-10-18 14:41:56
>> Complete the computation of ocean tidal load effects on Earth's mass centric variation!
>> Computation end time: 2024-10-18 14:41:56
```

Save the computed results as | Import setting parameters | Start computation

Display of the input-output file↓

Save the data in the text box as

```
 Otidegeocenter     0.00     0.00     0.00    57570.000000
2016070100          0.000000    1.8250     4.1299    -1.8888
2016070101          0.041667    0.5041     4.1937    -3.5160
2016070102          0.083333   -0.8168     3.6263    -5.0214
2016070103          0.125000   -1.9306     2.4942    -6.0838
2016070104          0.166667   -2.6848     0.9966    -6.4140
2016070105          0.208333   -3.0220    -0.5533    -5.9776
2016070106          0.250000   -2.9774    -1.8460    -4.9099
2016070107          0.291667   -2.6381    -2.7016    -3.3494
2016070108          0.333333   -2.1152    -3.0653    -1.4945
2016070109          0.375000   -1.5704    -2.9291     0.3139
```

Improve the algorithm of Earth's mass centric variation effects in the IERS Conventions (2010) and then compute the tidal and non-tidal load effects on all-element geodetic variations in the whole Earth space.

The permanent tide does not change with time. It is the zero-frequency tide ΔC_{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. The Love numbers in the program are k_{20}=0.29525, h_{20}=0.6078 and l_{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.

The variation of the Earth's center of mass is equal to the first-degree term of Earth's loading deformation, which excites the variations of all the geometric and physical geodetic elements in the Earth's space with time, rather than can be simply expressed as the ground site displacement of pure geometric quantity.

Computation of permanent tidal and Earth's mass centric variation effects on geodetic variations

Forecast of atmosphere tidal load effects on Earth's mass centric variation

Open file | Save as | Impor parameters | Start computation | Save process | Follow example

Computation of permanent tidal effects on various geodetic variations | Computation of Earth's mass centric variation effects on all-element geodetic variations | Forecast of ocean tidal load effects on Earth's mass centric variation | Forecast of atmosphere tidal load effects on Earth's mass centric variation

Forecast time series parameters

Start time 20160701

End time 20160715

Time interval 60.00 min

Save program process as

Effects of the Earth's mass centric variations and figure polar shifts

```
>> Computation end time: 2024-10-18 14:41:56
>> [Function] Input time series parameters, and forecast the atmosphere tidal load effect time series on Earth's mass centric variation (Xcm, Ycm, Zcm, in unit of mm) from the first-degree atmosphere tidal load spherical harmonic coefficient file AtideOne.dat output by the function [Spherical harmonic analysis on atmosphere tidal constituent harmonic constants]
>> Save the computed results as C:/ETideLoad4.5_win64en/examples/Permanentdgeocenter/atdgeocntrst.txt.
  ** The output file record includes the sampling epoch time, 3 columns of the atmosphere tidal load effects on Earth's mass centric variation (Xcm, Ycm, Zcm, in unit mm).
>> Setting parameters have been imported into the program!
  ** Click the control button [Start computation], or the tool button [Start computation]....
>> Computation start time：2024-10-18 14:42:36
>> Complete the computation of atmosphere tidal load effects on Earth's mass centric variation!
>> Computation end time: 2024-10-18 14:42:36
```

Save the computed results as | Import setting parameters | Start computation

Display of the input-output file↓

Save the data in the text box as

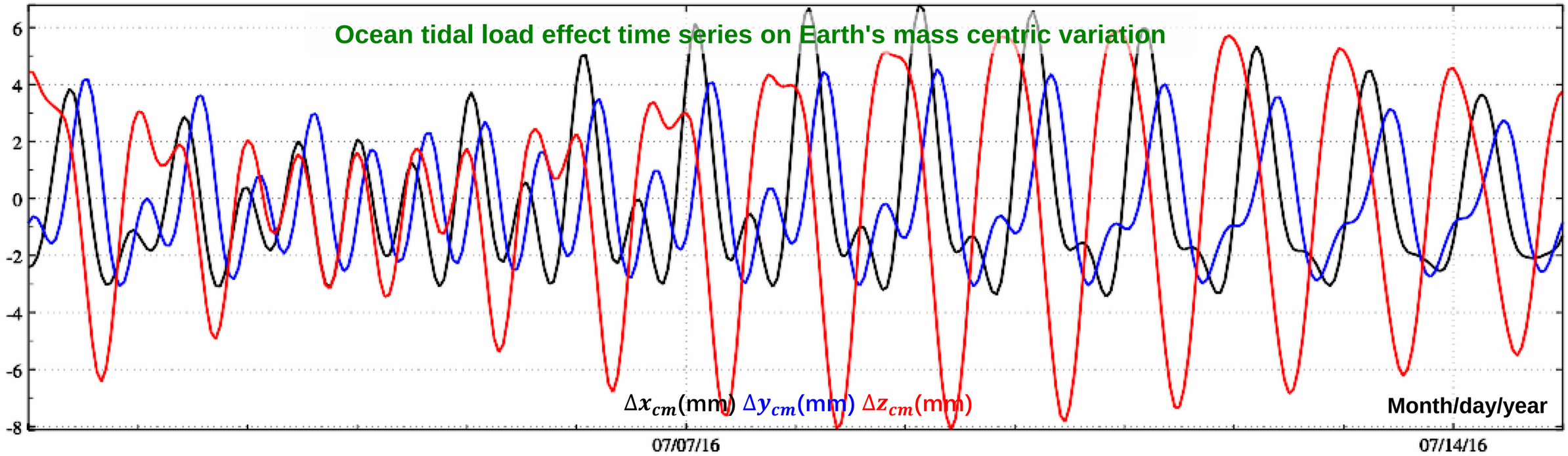
```
 Atidegeocenter     0.00     0.00     0.00    57570.000000
2016070100          0.000000       1.5728       2.0072       3.0910
2016070101          0.041667       1.5070       1.7158       3.0921
2016070102          0.083333       1.3772       1.4450       3.0968
2016070103          0.125000       1.1846       1.2199       3.1016
2016070104          0.166667       0.9395       1.0633       3.1041
2016070105          0.208333       0.6616       0.9921       3.1033
2016070106          0.250000       0.3779       1.0148       3.1005
2016070107          0.291667       0.1185       1.1292       3.0981
2016070108          0.333333      -0.0884       1.3234       3.0993
2016070109          0.375000      -0.2208       1.5775       3.1070
```

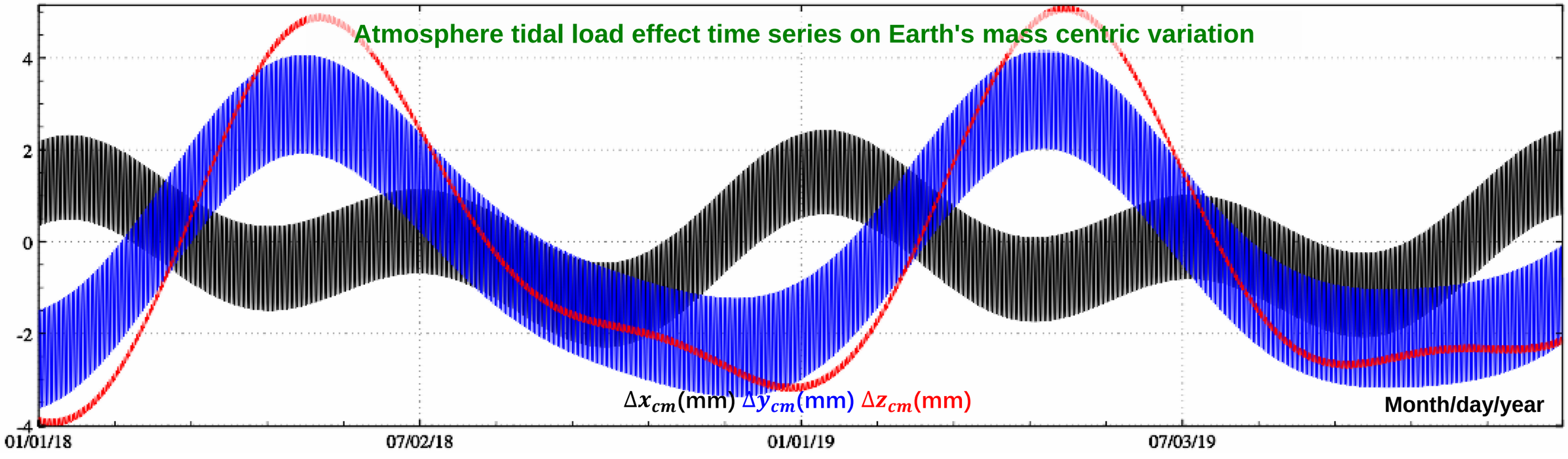
Improve the algorithm of Earth's mass centric variation effects in the IERS Conventions (2010) and then compute the tidal and non-tidal load effects on all-element geodetic variations in the whole Earth space.

The permanent tide does not change with time. It is the zero-frequency tide ΔC_{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. The Love numbers in the program are k_{20}=0.29525, h_{20}=0.6078 and l_{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.

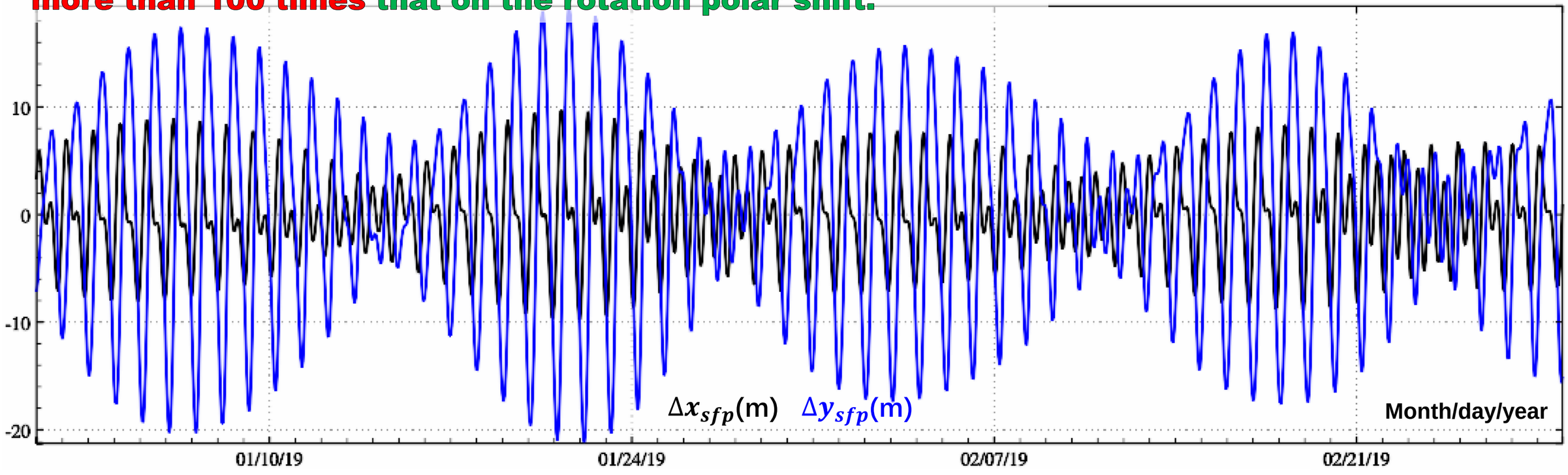
The variation of the Earth's center of mass is equal to the first-degree term of Earth's loading deformation, which excites the variations of all the geometric and physical geodetic elements in the Earth's space with time, rather than can be simply expressed as the ground site displacement of pure geometric quantity.



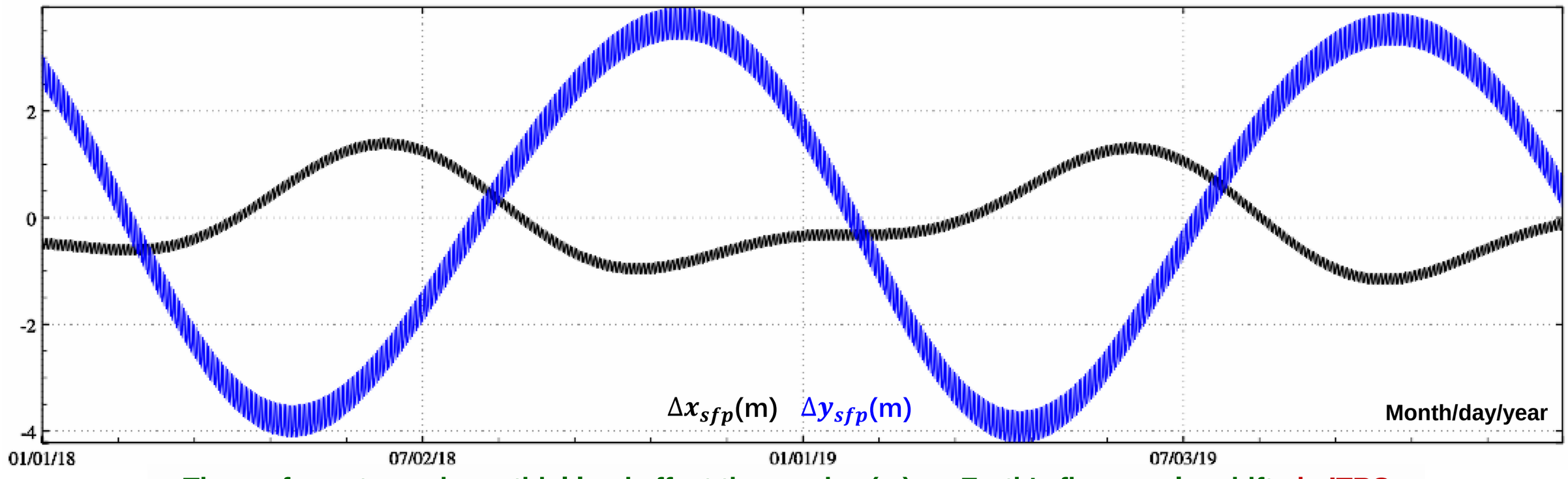


The Earth's tidal force from the celestial body at the Earth's center of mass is always equal to zero, so geodesy does not specifically study the solid tidal effect on the Earth's center of mass. Ocean tides and surface atmosphere tides lead to the redistribution of surface mass, causing periodic variations of Earth's center of mass.

The ocean tidal load effect on the Earth's figure polar shift is more than 100 times that on the rotation polar shift.



The ocean tidal load effect time series (m) on Earth's figure polar shifts in ITRS

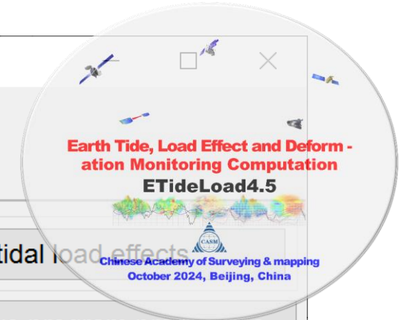


The surface atmosphere tidal load effect time series (m) on Earth's figure polar shifts in ITRS

Computation of solid Earth and load tidal effects on geodetic networks

Computation of solid Earth tidal effects on geodetic networks

Open file | Save as | Import parameters | Start computation | Save process | Follow example



Computation of solid Earth tidal effects | Computation of ocean tidal load effects | Computation of atmosphere tidal load effects

Select the type of control network: GNSS baseline network

Open the GNSS baseline network file including time attribute

Set the file parameters

Column ordinal number of starting MJD0 in the header: 3

Column ordinal number of time in the record: 10

>> Program Process ** Operation Prompts

Save program process as

```
>> [Function] Compute the solid Earth, ocean tidal load or surface atmosphere tidal load effects on the GNSS baseline or level height difference according to the location and observation time in the input geodetic control network record file.
  ** The input file adopts ETideLoad's own format. The file header occupies a row. Record format: the GNSS baseline or leveling route name, starting point longitude, latitude, height, ending point longitude, latitude, height, …, observation time, …. The GNSS baseline network  file and the level route network file are the same in ETideLoad format.
>> Select the type of the control network firstly, and select the computation function from the 3 control buttons on the top of the interface...
>> Compute the solid Earth tidal effects (mm)...
>> Compute the tidal effects on 3-D GNSS baseline vectors...
>> Open the GNSS baseline network file including time attribute C:/ETideLoad4.5_win64en/examples/Controlnetworktidef/GNSSbaseline_levelingroutine.txt.
  ** Enter the file format parameters according to the text box below. After giving the output file name, click the control button [Import setting parameters]...
>> Save the computed results as C:/ETideLoad4.5_win64en/examples/Controlnetworktidef/GNSSbaselsolidtide.txt.
  ** Behind the input file record, add the tidal effects as the output file record.
>> Setting parameters have been imported into the program!
  ** Click the control button [Start computation], or the tool button [Start computation]....
>> Computation start time：2024-10-18 15:28:48
```

Display of the input-output file↓

Save the computed results as | Import setting parameters | Start computation

```
 9  4  57022
 CANN_DONT  120.424700  27.522580  21.8  121.150270  27.834630  28.6   79493.9  1.5  2016072412  1.2202    0.9021    0.1274   -2.7422
 CANN_FDIQ  120.424700  27.522580  21.8  120.207320  27.335310  32.5   29876.4  1.5  2016072412  1.2721   -0.2673   -0.0267    1.0012
 CANN_JHYW  120.424700  27.522580  21.8  120.078380  29.272690  32.5  196899.1  1.5  2016072412  1.3927   -0.4186   -0.2735   -1.9788
 CANN_JINH  120.424700  27.522580  21.8  119.642580  29.217830  32.5  202930.8  1.5  2016072412  1.6668   -0.9439   -0.3836   -0.5259
 CANN_JINX  120.424700  27.522580  21.8  119.379220  29.070950  32.5  199897.1  1.5  2016072412  1.3931   -0.9635   -0.2428    1.6815
 CANN_JNJZ  120.424700  27.522580  21.8  119.637540  27.976350  32.5   92473.9  1.5  2016072412  1.2143   -0.9635   -0.2428    1.6815
 CANN_JSAN  120.424700  27.522580  21.8  118.608360  28.717950  32.5  222881.6  2.5  2016072512  1.2766   -0.9303   -1.0173    2.8778
 CANN_LHAI  120.424700  27.522580  21.8  121.184760  28.985510  32.5  170695.1  2.5  2016072512  1.3588    0.7499    0.6886   -6.9378
 CANN_LISH  120.424700  27.522580  21.8  119.929490  28.461260  32.5  114864.2  2.5  2016072512  1.6040   -0.1649   -0.3840   -1.1000
 CANN_LONQ  120.424700  27.522580  21.8  119.133090  28.080720  32.5  141509.7  2.5  2016072512  1.3241   -0.7295   -0.9609    2.9925
 CANN_LUOY  120.424700  27.522580  21.8  119.705090  27.552460  32.5   71164.3  2.5  2016072512  1.1005   -0.4621   -0.3085    2.5352
 CANN_PANA  120.424700  27.522580  21.8  120.436660  29.054190  32.5  169743.8  2.5  2016072512  1.8985    0.2692   -0.2575   -4.7458
 CANN_PCHQ  120.424700  27.522580  21.8  118.542210  27.923210  32.5  190867.4  2.5  2016072512  1.4645   -1.1110   -0.8864    5.6815
 CANN_PCJM  120.424700  27.522580  21.8  118.445440  28.167970  32.5  207660.5  2.5  2016072512  1.7441   -1.1253   -0.9801    5.2647
```

Longitude, latitude, and ellipsoidal height of Starting-ending stations

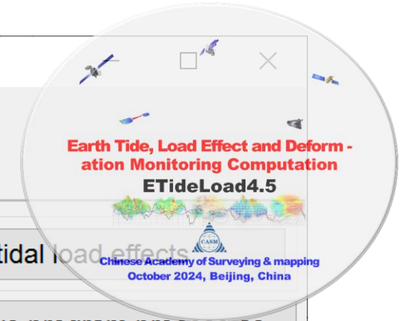
The solid tidal effects on GNSS baseline displacement (ENU, mm)

- The GNSS baseline network file and the level route network file are the same in ETideLoad format.
- 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, and the height relative to the surface (set as zero in the program) when calculating the atmosphere tidal load effects.

Computation of solid Earth and load tidal effects on geodetic networks

Computation of solid Earth tidal effects on geodetic networks

Open file | Save as | Import parameters | Start computation | Save process | Follow example



Computation of solid Earth tidal effects | Computation of ocean tidal load effects | Computation of atmosphere tidal load effects

Select the type of control network: Levelling control network

Open the levelling network routes file including time attribute

Set the file parameters

Column ordinal number of starting MJD0 in the header: 3

Column ordinal number of time in the record: 10

>> Program Process ** Operation Prompts

Save program process as

```
>> Computation start time：2024-10-18 15:28:48
>> Complete the computation of the tidal effects!
>> Computation end time: 2024-10-18 15:28:49
>> Compute the solid Earth tidal effects (mm)...
>> Compute the tidal effects on levelling height differences...
>> Open the levelling network routes file including time attribute C:/ETideLoad4.5_win64en/examples/Controlnetworktidef/
GNSSbaseline_levelingroutine.txt.
  ** Enter the file format parameters according to the text box below. After giving the output file name, click the control button [Import setting
parameters]...
>> Save the computed results as C:/ETideLoad4.5_win64en/examples/Controlnetworktidef/levelroutinesolidtide.txt.
  ** Behind the input file record, add the tidal effects as the output file record.
>> Setting parameters have been imported into the program!
  ** Click the control button [Start computation], or the tool button [Start computation]....
>> Computation start time：2024-10-18 15:30:03
>> Computation end time: 2024-10-18 15:30:04
```

The solid tidal effect on orthometric height difference is always numerical opposite sign to that on ellipsoidal height difference.

Display of the input-output file↓

Save the computed results as | Import setting parameters | Start computation

```
 9   4   57022
 CANN_DONT  120.424700  27.522580  21.8  121.150270  27.834630  28.6   79493.9  1.5  2016072412  1.2202    3.2574
 CANN_FDIQ  120.424700  27.522580  21.8  120.207320  27.335310  32.5   29876.4  1.5  2016072412  1.2721   -1.1628
 CANN_JHYW  120.424700  27.522580  21.8  120.078380  29.272690  32.5  196899.1  1.5  2016072412  1.3927    1.8728
 CANN_JINH  120.424700  27.522580  21.8  119.642580  29.217830  32.5  202930.8  1.5  2016072412  1.6668    0.1125
 CANN_JINX  120.424700  27.522580  21.8  119.379220  29.070950  32.5  199897.1  1.5  2016072412  1.3931   -1.1770
 CANN_JNJZ  120.424700  27.522580  21.8  119.637540  27.976350  32.5   92473.9  1.5  2016072412  1.2143   -2.1936
 CANN_JSAN  120.424700  27.522580  21.8  118.606560  28.717950  32.5  222881.6  2.5  2016072512  1.2766   -3.8987
 CANN_LHAI  120.424700  27.522580  21.8  121.184470  28.955410  32.5  170695.1  2.5  2016072512  1.3588    7.8461
 CANN_LISH  120.424700  27.522580  21.8  119.929490  28.461260  32.5  114864.2  2.5  2016072512  1.6040    0.9773
 CANN_LONQ  120.424700  27.522580  21.8  119.133090  28.080720  32.5  141509.7  2.5  2016072512  1.3241   -3.7956
 CANN_LUOY  120.424700  27.522580  21.8  119.705090  27.552460  32.5   71164.3  2.5  2016072512  1.1005   -3.0525
 CANN_PANA  120.424700  27.522580  21.8  120.436660  29.054190  32.5  169743.8  2.5  2016072512  1.8985    5.1476
 CANN_PCHQ  120.424700  27.522580  21.8  118.542210  27.923210  32.5  190867.4  2.5  2016072512  1.4645   -6.9589
 CANN_PCJM  120.424700  27.522580  21.8  118.445440  28.167970  32.5  207660.5  2.5  2016072512  1.7441   -6.5510
```

Longitude, latitude, and ellipsoidal height of Starting-ending stations

The solid tidal effects on height difference of the levelling routine

- The GNSS baseline network file and the level route network file are the same in ETideLoad format.
- 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, and the height relative to the surface (set as zero in the program) when calculating the atmosphere tidal load effects.

Computation of solid Earth and load tidal effects on geodetic networks

Computation of ocean tidal load effects on geodetic networks

Open file | Save as | Import parameters | Start computation | Save process | Follow example

Computation of solid Earth tidal effects | Computation of ocean tidal load effects | Computation of atmosphere tidal load effects

Select the type of control network: GNSS baseline network

Open the GNSS baseline network file including time attribute

Set the file parameters

Column ordinal number of starting MJD0 in the header: 3

Column ordinal number of time in the record: 10

Maximum truncated degree of the coefficients model: 120

>> Program Process ** Operation Prompts

Save program process as

```
>> Computation start time：2024-10-18 15:30:03
>> Complete the computation of the tidal effects!
>> Computation end time: 2024-10-18 15:30:04
>> Compute the ocean tidal load effects (mm)....
>> Compute the tidal effects on 3-D GNSS baseline vectors...
>> Open the GNSS baseline network file including time attribute C:/ETideLoad4.5_win64en/examples/Controlnetworktidef/
GNSSbaseline_levelingroutine.txt.
  ** Enter the file format parameters according to the text box below. After giving the output file name, click the control button [Import setting
parameters]...
>> Save the computed results as C:/ETideLoad4.5_win64en/examples/Controlnetworktidef/GNSSbaselotideload.txt.
  ** Behind the input file record, add the tidal effects as the output file record.
>> Setting parameters have been imported into the program!
  ** Click the control button [Start computation], or the tool button [Start computation]....
>> Computation start time：2024-10-18 15:31:11
>> Complete the computation of the tidal effects!
>> Computation end time: 2024-10-18 15:32:13
```

Display of the input-output file↓

Save the computed results as | Import setting parameters | Start computation

```
 9   4   57022
CANN_DONT  120.424700  27.522580  21.8  121.150270  27.834630  28.6   79493.9  1.5  2016072412  1.2202    2.9653   -1.5855   -5.9971
CANN_FDIQ  120.424700  27.522580  21.8  120.207320  27.335310  32.5   29876.4  1.5  2016072412  1.2721   -0.8555    0.2769    1.8802
CANN_JHYW  120.424700  27.522580  21.8  120.078380  29.272690  32.5  196899.1  1.5  2016072412  1.3927   -4.4438   -0.6162  -16.3385
CANN_JINH  120.424700  27.522580  21.8  119.642580  29.217830  32.5  202930.8  1.5  2016072412  1.6668   -5.4186   -0.4014  -21.1547
CANN_JINX  120.424700  27.522580  21.8  119.379220  29.070950  32.5  199897.1  1.5  2016072412  1.3931   -5.7[illegible]
CANN_JNJZ  120.424700  27.522580  21.8  119.637540  27.976350  32.5   92473.9  1.5  2016072412  1.2143   -4.8333    1.2520  -11.1695
CANN_JSAN  120.424700  27.522580  21.8  118.608560  28.727950  32.5  222881.6  2.5  2016072512  1.2766   -4.1075    0.7879  -36.4190
CANN_LHAI  120.424700  27.522580  21.8  119.188470  28.085510  32.5  170695.1  2.5  2016072512  1.3588    0.[illegible]
CANN_LISH  120.424700  27.522580  21.8  119.929490  28.461260  32.5  114864.2  2.5  2016072512  1.6040   -3.5675    2.0229  -16.0621
CANN_LONQ  120.424700  27.522580  21.8  119.133090  28.080720  32.5  141509.7  2.5  2016072512  1.3241   -5.2100    1.[illegible]  -23.4411
CANN_LUOY  120.424700  27.522580  21.8  119.705090  27.552460  32.5   71164.3  2.5  2016072512  1.1005   -3.7635    1.1878   -7.1760
CANN_PANA  120.424700  27.522580  21.8  120.436660  29.054190  32.5  169743.8  2.5  2016072512  1.8985   -2.2732    1.8436  -17.6809
CANN_PCHQ  120.424700  27.522580  21.8  118.542210  27.923210  32.5  190867.4  2.5  2016072512  1.4645   -5.1840    1.1543  -30.9806
CANN_PCJM  120.424700  27.522580  21.8  118.445440  28.167970  32.5  207660.5  2.5  2016072512  1.7441   -4.6945    0.9737  -34.2959
```

Longitude, latitude, and orthometric height of Starting-ending stations

The ocean tidal load effects on GNSS baseline displacement (ENU, mm)

- The GNSS baseline network file and the level route network file are the same in ETideLoad format.
- 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, and the height relative to the surface (set as zero in the program) when calculating the atmosphere tidal load effects.

Computation of solid Earth and load tidal effects on geodetic networks

Computation of ocean tidal load effects on geodetic networks

Open file | Save as | Import parameters | Start computation | Save process | Follow example

Computation of solid Earth tidal effects | Computation of ocean tidal load effects | Computation of atmosphere tidal load effects

Select the type of control network: Levelling control network

Open the levelling network routes file including time attribute

Set the file parameters

Column ordinal number of starting MJD0 in the header: 3

Column ordinal number of time in the record: 10

Maximum truncated degree of the coefficients model: 120

>> Program Process ** Operation Prompts

Save program process as

```
>> Computation start time：2024-10-18 15:31:11
>> Complete the computation of the tidal effects!
>> Computation end time: 2024-10-18 15:32:13
>> Compute the ocean tidal load effects (mm)....
>> Compute the tidal effects on levelling height differences...
>> Open the levelling network routes file including time attribute C:/ETideLoad4.5_win64en/examples/Controlnetworktidef/
GNSSbaseline_levelingroutine.txt.
  ** Enter the file format parameters according to the text box below. After giving the output file name, click the control button [Import setting
parameters]...
>> Save the computed results as C:/ETideLoad4.5_win64en/examples/Controlnetworktidef/levelroutineotideload.txt.
  ** Behind the input file record, add the tidal effects as the output file record.
>> Setting parameters have been imported into the program!
  ** Click the control button [Start computation], or the tool button [Start computation]....
>> Computation start time：2024-10-18 15:33:19
>> Complete the computation of the tidal effects!
>> Computation end time: 2024-10-18 15:34:19
```

The load effect on orthometric height difference is about 1.75 times of that on ellipsoidal height difference.

Display of the input-output file↓

Save the computed results as | Import setting parameters | Start computation

```
 9   4   57022
CANN_DONT  120.424700  27.522580  21.8  121.150270  27.834630  28.6   79493.9  1.5  2016072412  1.2202   -8.5306
CANN_FDIQ  120.424700  27.522580  21.8  120.207320  27.335310  32.5   29876.4  1.5  2016072412  1.2721    2.6530
CANN_JHYW  120.424700  27.522580  21.8  120.078380  29.272690  32.5  196899.1  1.5  2016072412  1.3927  -22.2233
CANN_JINH  120.424700  27.522580  21.8  119.642580  29.217830  32.5  202930.8  1.5  2016072412  1.6668  -28.6171
CANN_JINX  120.424700  27.522580  21.8  119.379220  29.070950  32.5  199897.1  1.5  2016072412  1.3931  -32.2487
CANN_JNJZ  120.424700  27.522580  21.8  119.637540  27.876350  32.5   92473.9  1.5  2016072412  1.2143  -14.7665
CANN_JSAN  120.424700  27.522580  21.8  118.608560  28.727950  32.5  222881.6  2.5  2016072512  1.2766  -49.4794
CANN_LHAI  120.424700  27.522580  21.8  121.180470  28.905210  32.5  170695.1  2.5  2016072512  1.3588  -16.2967
CANN_LISH  120.424700  27.522580  21.8  119.929490  28.461260  32.5  114864.2  2.5  2016072512  1.6040  -21.7500
CANN_LONQ  120.424700  27.522580  21.8  119.133090  28.080720  32.5  141509.7  2.5  2016072512  1.3241  -31.6039
CANN_LUOY  120.424700  27.522580  21.8  119.705090  27.552460  32.5   71164.3  2.5  2016072512  1.1005   -9.5573
CANN_PANA  120.424700  27.522580  21.8  120.436660  29.054190  32.5  169743.8  2.5  2016072512  1.8985  -24.1759
CANN_PCHQ  120.424700  27.522580  21.8  118.542210  27.923210  32.5  190867.4  2.5  2016072512  1.4645  -41.8315
CANN_PCJM  120.424700  27.522580  21.8  118.445440  28.167970  32.5  207660.5  2.5  2016072512  1.7441  -46.4215
```

Longitude, latitude, and orthometric height of Starting-ending stations

The ocean tidal load effects on height difference of the levelling routine

- The GNSS baseline network file and the level route network file are the same in ETideLoad format.
- 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, and the height relative to the surface (set as zero in the program) when calculating the atmosphere tidal load effects.

Computation of solid Earth and load tidal effects on geodetic networks

Computation of atmosphere tidal load effects on geodetic networks

Open file Save as Import parameters Start computation Save process Follow example

Computation of solid Earth tidal effects | Computation of ocean tidal load effects | Computation of atmosphere tidal load effects

Select the type of control network: GNSS baseline network

Open the GNSS baseline network file including time attribute

Set the file parameters

Column ordinal number of starting MJD0 in the header: 3

Column ordinal number of time in the record: 10

Maximum truncated degree of the coefficients model: 120

>> Program Process ** Operation Prompts

Save program process as

```
>> Computation start time：2024-10-18 15:33:19
>> Complete the computation of the tidal effects!
>> Computation end time: 2024-10-18 15:34:19
>> Compute the atmosphere tidal load effects (mm)....
>> Compute the tidal effects on 3-D GNSS baseline vectors...
>> Open the GNSS baseline network file including time attribute C:/ETideLoad4.5_win64en/examples/Controlnetworktidef/
GNSSbaseline_levelingroutine.txt.
  ** Enter the file format parameters according to the text box below. After giving the output file name, click the control button [Import setting
parameters]...
>> Save the computed results as C:/ETideLoad4.5_win64en/examples/Controlnetworktidef/GNSSbaselatideload.txt.
  ** Behind the input file record, add the tidal effects as the output file record.
>> Setting parameters have been imported into the program!
  ** Click the control button [Start computation], or the tool button [Start computation]....
>> Computation start time：2024-10-18 15:36:16
>> Complete the computation of the tidal effects!
>> Computation end time: 2024-10-18 15:36:19
```

Display of the input-output file↓

Save the computed results as | Import setting parameters | Start computation

```
 9   4   57022
 CANN_DONT  120.424700  27.522580  21.8  121.150270  27.834630  28.6   79493.9  1.5  2016072412  1.2202   -0.0310   -0.0199    0.0046
 CANN_FDIQ  120.424700  27.522580  21.8  120.207320  27.335310  32.5   29876.4  1.5  2016072412  1.2721    0.0101    0.0082    0.0158
 CANN_JHYW  120.424700  27.522580  21.8  120.078380  29.272690  32.5  196899.1  1.5  2016072412  1.3927   -0.0253   -0.0468   -0.3490
 CANN_JINH  120.424700  27.522580  21.8  119.642580  29.217830  32.5  202930.8  1.5  2016072412  1.6668   -0.0092   -0.0386   -0.3743
 CANN_JINX  120.424700  27.522580  21.8  119.379220  29.070950  32.5  199897.1  1.5  2016072412  1.3931    0.0[illegible]
 CANN_JNJZ  120.424700  27.522580  21.8  119.637540  27.976250  32.5   92473.9  1.5  2016072412  1.2143    0.0120    0.0009   -0.1325
 CANN_JSAN  120.424700  27.522580  21.8  118.608960  28.727950  32.5  222881.6  2.5  2016072512  1.2766    0.0251   -0.0117   -0.3621
 CANN_LHAI  120.424700  27.522580  21.8  119.184470  28.085510  32.5  170695.1  2.5  2016072512  1.3588   -0.0[illegible]
 CANN_LISH  120.424700  27.522580  21.8  119.929490  28.461260  32.5  114864.2  2.5  2016072512  1.6040   -0.0044   -0.0161   -0.1988
 CANN_LONQ  120.424700  27.522580  21.8  119.133090  28.080720  32.5  141509.7  2.5  2016072512  1.3241    0.0209    0.0049   -0.1898
 CANN_LUOY  120.424700  27.522580  21.8  119.705090  27.552460  32.5   71164.3  2.5  2016072512  1.1005    0.0186    0.0104   -0.0494
 CANN_PANA  120.424700  27.522580  21.8  120.436660  29.054190  32.5  169743.8  2.5  2016072512  1.8985   -0.0333   -0.0434   -0.2715
 CANN_PCHQ  120.424700  27.522580  21.8  118.542210  27.923210  32.5  190867.4  2.5  2016072512  1.4645    0.0348    0.0161   -0.2217
 CANN_PCJM  120.424700  27.522580  21.8  118.445440  28.167970  32.5  207660.5  2.5  2016072512  1.7441    0.0339    0.0087   -0.2787
```

Longitude, latitude, and surface height of Starting-ending stations

The atmosphere tidal load effects on GNSS baseline displacement (ENU, mm)

- The GNSS baseline network file and the level route network file are the same in ETideLoad format.
- 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, and the height relative to the surface (set as zero in the program) when calculating the atmosphere tidal load effects.

Computation of solid Earth and load tidal effects on geodetic networks

Computation of atmosphere tidal load effects on geodetic networks

Open file | Save as | Import parameters | Start computation | Save process | Follow example

Computation of solid Earth tidal effects | Computation of ocean tidal load effects | Computation of atmosphere tidal load effects

Select the type of control network: Levelling control network

Open the levelling network routes file including time attribute

Set the file parameters

Column ordinal number of starting MJD0 in the header: 3

Column ordinal number of time in the record: 10

Maximum truncated degree of the coefficients model: 120

>> Program Process ** Operation Prompts

Save program process as

```
>> Computation start time：2024-10-18 15:36:16
>> Complete the computation of the tidal effects!
>> Computation end time: 2024-10-18 15:36:19
>> Compute the atmosphere tidal load effects (mm)....
>> Compute the tidal effects on levelling height differences...
>> Open the levelling network routes file including time attribute C:/ETideLoad4.5_win64en/examples/Controlnetworktidef/
GNSSbaseline_levelingroutine.txt.
  ** Enter the file format parameters according to the text box below. After giving the output file name, click the control button [Import setting
parameters]...
>> Save the computed results as C:/ETideLoad4.5_win64en/examples/Controlnetworktidef/levelroutineatideload.txt.
  ** Behind the input file record, add the tidal effects as the output file record.
>> Setting parameters have been imported into the program!
  ** Click the control button [Start computation], or the tool button [Start computation]....
>> Computation start time：2024-10-18 15:37:01
>> Complete the computation of the tidal effects!
>> Computation end time: 2024-10-18 15:37:04
```

The load effect on orthometric height difference is about 1.75 times of that on ellipsoidal height difference.

Display of the input-output file↓ | Save the computed results as | Import setting parameters | Start computation

```
 9   4   57022
CANN_DONT  120.424700  27.522580  21.8  121.150270  27.834630  28.6   79493.9  1.5  2016072412  1.2202    0.0128
CANN_FDIQ  120.424700  27.522580  21.8  120.207320  27.335310  32.5   29876.4  1.5  2016072412  1.2721    0.0263
CANN_JHYW  120.424700  27.522580  21.8  120.078380  29.272690  32.5  196899.1  1.5  2016072412  1.3927   -0.5863
CANN_JINH  120.424700  27.522580  21.8  119.642580  29.217830  32.5  202930.8  1.5  2016072412  1.6668   -0.6324
CANN_JINX  120.424700  27.522580  21.8  119.379220  29.070950  32.5  199897.1  1.5  2016072412  1.3931   -0.6227
CANN_JNJZ  120.424700  27.522580  21.8  119.637540  27.976250  32.5   92473.9  1.5  2016072412  1.2143   -0.2327
CANN_JSAN  120.424700  27.522580  21.8  118.608960  28.727950  32.5  222881.6  2.5  2016072512  1.2766   -0.6146
CANN_LHAI  120.424700  27.522580  21.8  121.180470  28.985210  32.5  170695.1  2.5  2016072512  1.3588   -0.2838
CANN_LISH  120.424700  27.522580  21.8  119.929490  28.461260  32.5  114864.2  2.5  2016072512  1.6040   -0.3408
CANN_LONQ  120.424700  27.522580  21.8  119.133090  28.080720  32.5  141509.7  2.5  2016072512  1.3241   -0.3294
CANN_LUOY  120.424700  27.522580  21.8  119.705090  27.552460  32.5   71164.3  2.5  2016072512  1.1005   -0.0908
CANN_PANA  120.424700  27.522580  21.8  120.436660  29.054190  32.5  169743.8  2.5  2016072512  1.8985   -0.4549
CANN_PCHQ  120.424700  27.522580  21.8  118.542210  27.923210  32.5  190867.4  2.5  2016072512  1.4645   -0.3771
CANN_PCJM  120.424700  27.522580  21.8  118.445440  28.167970  32.5  207660.5  2.5  2016072512  1.7441   -0.4717
```

Longitude, latitude, and surface height of Starting-ending stations

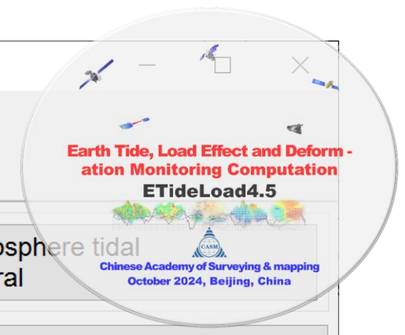
The atmosphere tidal load effects on height difference of the levelling routine

- The GNSS baseline network file and the level route network file are the same in ETideLoad format.
- 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, and the height relative to the surface (set as zero in the program) when calculating the atmosphere tidal load effects.

The regional approach of load tidal effects by load Green's Integral

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

Open file | Save as | Import parameters | Start computation | Save process | Follow example



Open any residual ocean tidal harmonic constant grid file

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

Computation of residual atmosphere tidal load effects by Green's Integral

Open the location and time file of near-Earth points

>> Program Process ** Operation Prompts

Save program process as

Set the format of input file

Column ordinal number of starting MJD0 in the header: 4

Column ordinal number of time in the record: 1

Column ordinal number of the normal or orthometric height in record: 4

Select the type of effects

- [x] geoid or height anomaly (mm)
- [x] ground gravity (μGal)
- [ ] gravity disturbance (μGal)
- [ ] ground tilt (SW, mas)
- [ ] vertical deflection (SW, mas)
- [ ] horizontal displacement (EN, mm)
- [x] ground radial displacement (mm)
- [ ] ground normal or orthometric height (mm)
- [x] radial gravity gradient (mE)
- [ ] horizontal gravity gradient (NW, mE)

Green's integral radius: 400 km

>> Select the computation function from the two control buttons on the upper right of the interface...
>> [Function] From the regional residual ocean tide harmonic constant grids, compute the residual ocean tidal load effects on the geoid or height anomaly (mm), ground gravity (μGal), gravity disturbance (μGal), 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), radial gravity gradient (mE) or horizontal gravity gradient (NE, to the north and to the east, mE) by Green's function integral.
** The valid files of the residual ocean tidal harmonic constants:

C:/ETideLoad4.5_win64en/residOTide/K1got4.8_FES2004.dat
C:/ETideLoad4.5_win64en/residOTide/K2got4.8_FES2004.dat
C:/ETideLoad4.5_win64en/residOTide/M2got4.8_FES2004.dat
C:/ETideLoad4.5_win64en/residOTide/N2got4.8_FES2004.dat
C:/ETideLoad4.5_win64en/residOTide/O1got4.8_FES2004.dat
C:/ETideLoad4.5_win64en/residOTide/P1got4.8_FES2004.dat
C:/ETideLoad4.5_win64en/residOTide/Q1got4.8_FES2004.dat
C:/ETideLoad4.5_win64en/residOTide/S2got4.8_FES2004.dat

8 residual ocean tidal constituent harmonic constants from difference between GOT4.8 and FES2004

Save the computed results as | Import setting parameters | Start computation

Display of the input-output file↓

Save data in the text box as

```
 100.000000  140.000000    0.000000   50.000000  0.50000000  0.50000000  165555
     0.000       0.000       0.000       0.000       0.000       0.000       0.000      14.520       8.360       7.
    -4.420       0.100       9.510       0.000       0.000       0.000       0.000       0.000       0.000       0.
     0.000       0.000       0.000       0.000       0.000     -12.330      -7.470      -3.630      -1.710      -1.
    -6.130      -6.230      -6.310      -5.800      -4.690      -3.260      -2.210      -1.950      -2.380      -3.
     0.950       1.000      -0.610      -1.700      -2.500      -1.900      -0.800      -0.020       0.440       0.
    -0.220      -0.410      -0.490      -0.430      -0.250
     0.000       0.000       0.000       0.000       0.000       0.000      18.180       0.000       0.000       0.
    -3.190       0.410       6.660       0.000       0.000       0.000       0.000       0.000       0.000       0.
     0.000       0.000       0.000       0.000       0.000       0.000      -9.290      -4.210      -1.530      -1.
     0.000       0.000       0.000       0.000      -3.860      -2.070      -1.050      -1.130      -2.230      -3.
    -0.290      -1.750      -2.980      -3.580      -3.450      -2.570      -1.360      -0.330       0.250       0.
    -0.370      -0.270      -0.220      -0.160      -0.090
     0.000       0.000       0.000       0.000       0.000      11.150      12.820       0.000      10.160       2.
    -3.120      -0.560       2.900       0.000       0.000       0.000       0.000       0.000       0.000       0.
     0.000       0.000       0.000       0.000       0.000       0.000       0.000      -2.760      -1.520      -1.
```

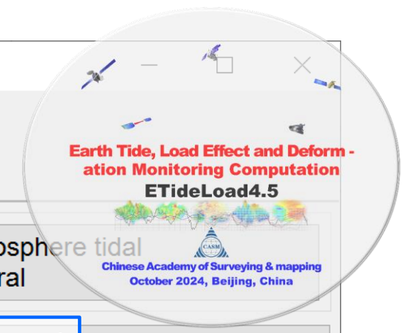
The seventh attribute of the file header is the Doodson constant

- The residual harmonic constants are equal to the regional harmonic constants minus the model value of harmonic constannts calculated by global tidal load spherical harmonic coefficients model.
- The program requires that residual harmonic constant grid files of all tidal constituents are stored in a folder. The file is saved in the form of a vector grid, and the seventh attribute of the file header is the Doodson constant.
- The height of the ground site is orthometric (normal) height when calculating the ocean tidal load effects, and the height relative to the surface when calculating the surface atmosphere tidal load effects.

The regional approach of load tidal effects by load Green's Integral

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

Open file Save as Import parameters Start computation Save process Follow example



Open any residual ocean tidal harmonic constant grid file

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

Computation of residual atmosphere tidal load effects by Green's Integral

Open the location and time file of near-Earth points

>> Program Process ** Operation Prompts

Save program process as

Set the format of input file

Column ordinal number of starting MJD0 in the header: 4

Column ordinal number of time in the record: 1

Column ordinal number of the normal or orthometric height in record: 4

Select the type of effects

- [x] geoid or height anomaly (mm)
- [x] ground gravity (μGal)
- [x] gravity disturbance (μGal)
- [x] ground tilt (SW, mas)
- [x] vertical deflection (SW, mas)
- [x] horizontal displacement (EN, mm)
- [x] ground radial displacement (mm)
- [x] ground normal or orthometric height (mm)
- [x] radial gravity gradient (mE)
- [x] horizontal gravity gradient (NW, mE)

Green's integral radius: 400 km

```
C:/ETideLoad4.5_win64en/residOTide/P1got4.8_FES2004.dat
C:/ETideLoad4.5_win64en/residOTide/Q1got4.8_FES2004.dat
C:/ETideLoad4.5_win64en/residOTide/S2got4.8_FES2004.dat
>> Open the location and time file of near-Earth points C:/ETideLoad4.5_win64en/examples/Tdloadgreenintegral/Postiontm.txt.
  ** Enter the file format parameters according to the text box below, and then enter the Green's integral radius. After giving the output file name,
click the control button [Import setting parameters]...
>> Save the computed results as C:/ETideLoad4.5_win64en/examples/Tdloadgreenintegral/otdloadchdais.txt.
  ** Behind the input file record, add several columns of the load tidal effects as the output file record.
>> Setting parameters have been imported into the program!
>> Prepare to compute the residual ocean tidal load effects...
  ** Click the control button [Start computation], or the tool button [Start computation]....
>> Computation start time：2024-10-18 15:48:40
>> Complete the Green's integral for residual ocean tidal load effects
  ** There are 8 residual tidal constituent harmonic constants grid models involved in the computation.
>> Computation end time: 2024-10-18 15:48:41
```

8 residual ocean tidal constituent harmonic constants from difference between GOT4.8 and FES2004

Columns 2 and 3 of the record are agreed as the longitude and latitude

Save the computed results as

Import setting parameters

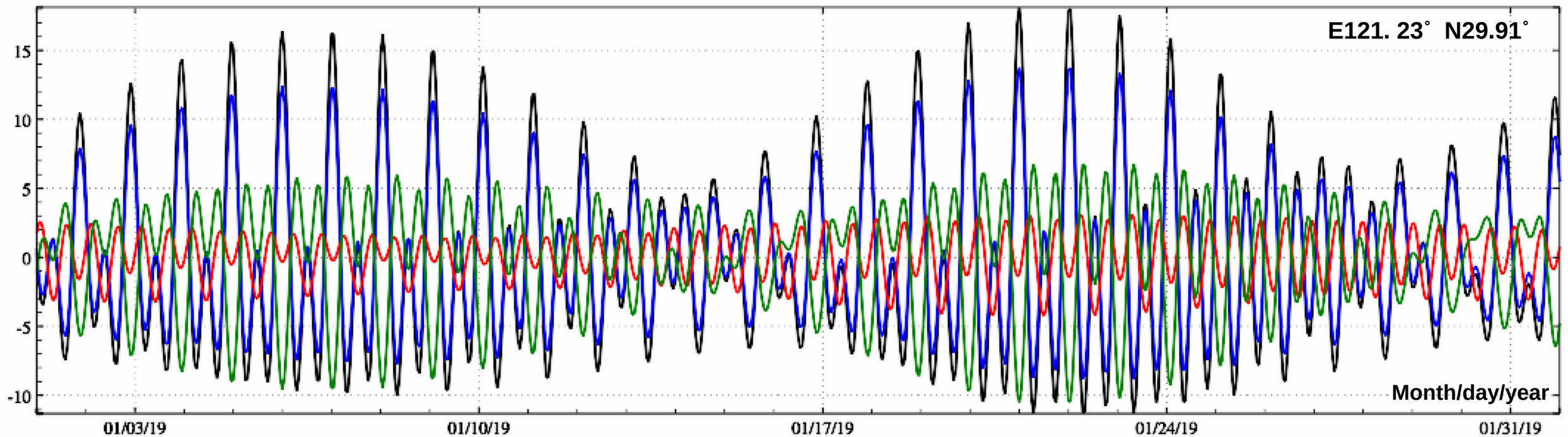
Start computation

Display of the input-output file↓

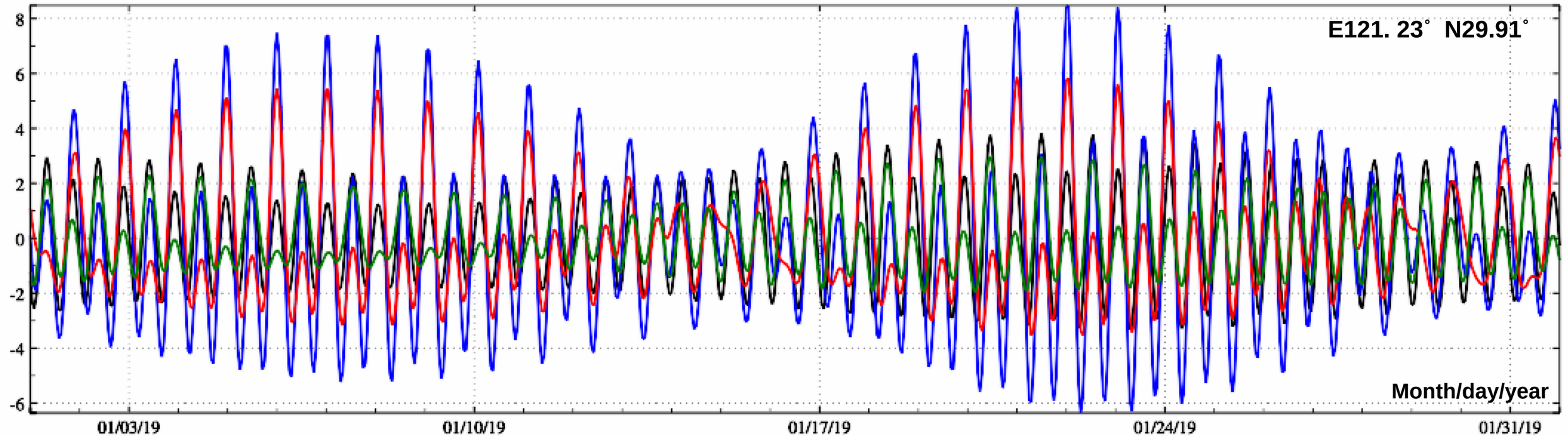
Save data in the text box as

```
121.230000    29.910000    47.218   58484.000000
 201901010000  121.230000   29.910000  2.218    1.0864    0.8426    0.2789   -0.9590    0.9069    0.93
 201901010100  121.230000   29.910000  2.218   -1.2644   -1.0431   -0.3716   -1.9073   -0.5875    1.72
 201901010200  121.230000   29.910000  2.218   -3.0046   -2.4359   -0.8496   -2.3699   -1.7401    2.09
 201901010300  121.230000   29.910000  2.218   -3.7807   -3.0520   -1.0574   -2.2214   -2.3151    1.92
 201901010400  121.230000   29.910000  2.218   -3.4908   -2.8097   -0.9679   -1.4900   -2.2277    1.24
 201901010500  121.230000   29.910000  2.218   -2.3067   -1.8476   -0.6301   -0.3505   -1.5640    0.22
 201901010600  121.230000   29.910000  2.218   -0.6276   -0.4875   -0.1563    0.9193   -0.5567   -0.90
 201901010700  121.230000   29.910000  2.218    1.0228    0.8491    0.3073    2.0076    0.4746   -1.86
 201901010800  121.230000   29.910000  2.218    2.1328    1.7497    0.6179    2.6458    1.2069   -2.42
 201901010900  121.230000   29.910000  2.218    2.3361    1.9195    0.6740    2.6751    1.3981   -2.44
 201901011000  121.230000   29.910000  2.218    1.5110    1.2600    0.4424    2.0860    0.9530   -1.92
 201901011100  121.230000   29.910000  2.218   -0.1807   -0.0992   -0.0311    1.0200   -0.0480   -0.99
 201901011200  121.230000   29.910000  2.218   -2.3281   -1.8278   -0.6316   -0.2658   -1.3641    0.13
 201901011300  121.230000   29.910000  2.218   -4.3682   -3.4733   -1.2019   -1.4624   -2.6509    1.18
 201901011400  121.230000   29.910000  2.218   -5.7260   -4.5735   -1.5823   -2.2855   -3.5458    1.91
```

- The residual harmonic constants are equal to the regional harmonic constants minus the model value of harmonic constannts calculated by global tidal load spherical harmonic coefficients model.
- The program requires that residual harmonic constant grid files of all tidal constituents are stored in a folder. The file is saved in the form of a vector grid, and the seventh attribute of the file header is the Doodson constant.
- The height of the ground site is orthometric (normal) height when calculating the ocean tidal load effects, and the height relative to the surface when calculating the surface atmosphere tidal load effects.



The residual ocean tidal load effects (GOT4.8-FES2004): height anomaly (mm), ground gravity (μGal), radial displacement (mm), orthometric height (mm)



The residual ocean tidal load effects (GOT4.8-FES2004): ground tilt (S, mas), (W, mas), horizontal displacement (E, mm)), (N, mm)

Numerical forecast of various tidal effects on surface geodetic variations

Solid Earth tide | Ocean tidal load | Atmosphere tidal load | Import parameters | Forcast | Follow example

Earth Tide, Load Effect and Deformation Monitoring Computation
ETideLoad4.5
Chinese Academy of Surveying & mapping
October 2024, Beijing, China

Global forecast of tidal effects on surface all-element geodetic variations

Numerical forecast of solid Earth tidal effects | Numerical forecast of ocean tidal load effects | Numerical forecast of surface atmosphere tidal load effects

Location of surface point to be forecast

Longitude 121.240000°
Latitude 29.428100°
Height 17.830m

Date or time is agreed as the long integer format agreed by ETideLoad. E.g, 20181224122642 represents 12:26:42 on December 24, 2018.

The spherical harmonic coefficient model of the ocean tidal load or surface atmosphere tidal load can be updated with the program [System Configs for the geophysical models and numerical standards].

Input the forecast time 201607010930

Import setting parameters | Start to forcast...

Forecast with the given location and time

geoid or height anomaly (mm)	-237.159	ground gravity (μGal)	-95.705	gravity disturbance (μGal)	-108.813
horizontal displacement (E, mm)	20.079	ground tilt (S, mas)	4.222	vertical deflection (S, mas)	8.493
horizontal displacement (N, mm)	-16.345	ground tilt (W, mas)	-5.333	vertical deflection (W, mas)	-10.091
ground radial displacement (mm)	-119.083	radial gravity gradient (10μE)	67.971		
normal or orthometric height (mm)	117.948	horizontal gravity gradient (N, 10μE)	4.203	horizontal gravity gradient (W, 10μE)	-25.594

The height of the site is the ellipsoidal height when forecasting the solid tidal effect, the normal or orthometric height when forecasting the ocean tidal load effects, and the height relative to the surface (set as zero in the program) when forecasting the atmosphere tidal load effects.

Numerical forecast of various tidal effects on surface geodetic variations

Solid Earth tide | Ocean tidal load | Atmosphere tidal load | Import parameters | Forcast | Follow example

Global forecast of tidal effects on surface all-element geodetic variations

Numerical forecast of solid Earth tidal effects | **Numerical forecast of ocean tidal load effects** | Numerical forecast of surface atmosphere tidal load effects

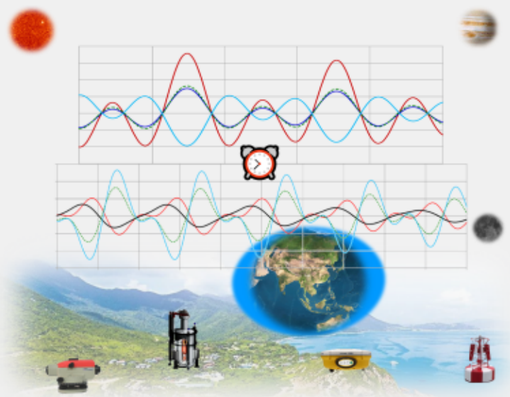
Location of surface point to be forecast

Longitude 121.240000°

Latitude 29.428100°

Height 17.830m

Maximum truncated degree of model 360



Date or time is agreed as the long integer format agreed by ETideLoad. E.g, 20181224122642 represents 12:26:42 on December 24, 2018.

The spherical harmonic coefficient model of the ocean tidal load or surface atmosphere tidal load can be updated with the program [System Configs for the geophysical models and numerical standards].

Sea surface tidal height (cm) -77.433

Input the forecast time 201607010130

Import setting parameters | Start to forcast...

Forecast with the given location and time

geoid or height anomaly (mm)	-12.547	ground gravity (μGal)	-38.621	gravity disturbance (μGal)	-40.790
horizontal displacement (E, mm)	-10.338	ground tilt (S, mas)	-83.500	vertical deflection (S, mas)	-20.769
horizontal displacement (N, mm)	7.780	ground tilt (W, mas)	58.130	vertical deflection (W, mas)	16.004
ground radial displacement (mm)	17.526	radial gravity gradient (10μE)	-1622.769		
normal or orthometric height (mm)	30.073	horizontal gravity gradient (N, 10μE)	-1084.238	horizontal gravity gradient (W, 10μE)	-533.235

The height of the site is the ellipsoidal height when forecasting the solid tidal effect, the normal or orthometric height when forecasting the ocean tidal load effects, and the height relative to the surface (set as zero in the program) when forecasting the atmosphere tidal load effects.

Numerical forecast of various tidal effects on surface geodetic variations

Solid Earth tide | Ocean tidal load | Atmosphere tidal load | Import parameters | Forcast | Follow example

Earth Tide, Load Effect and Deformation Monitoring Computation
ETideLoad4.5
Chinese Academy of Surveying & mapping
October 2024, Beijing, China

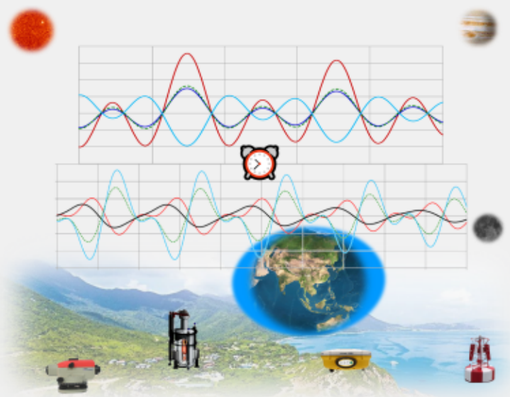
Global forecast of tidal effects on surface all-element geodetic variations

Numerical forecast of solid Earth tidal effects | Numerical forecast of ocean tidal load effects | Numerical forecast of surface atmosphere tidal load effects

Location of surface point to be forecast

Longitude 121.240000°
Latitude 29.428100°
Height 17.830m

Maximum truncated degree of model 360



Date or time is agreed as the long integer format agreed by ETideLoad. E.g, 20181224122642 represents 12:26:42 on December 24, 2018.

The spherical harmonic coefficient model of the ocean tidal load or surface atmosphere tidal load can be updated with the program [System Configs for the geophysical models and numerical standards].

Surface atmosphere (hPa/mbar) 10.055

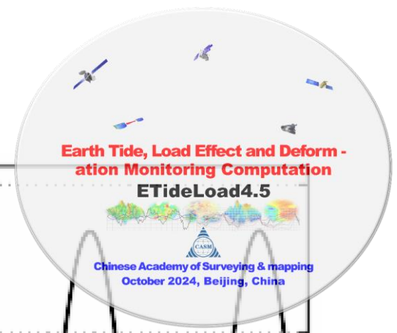
Input the forecast time 20160701115

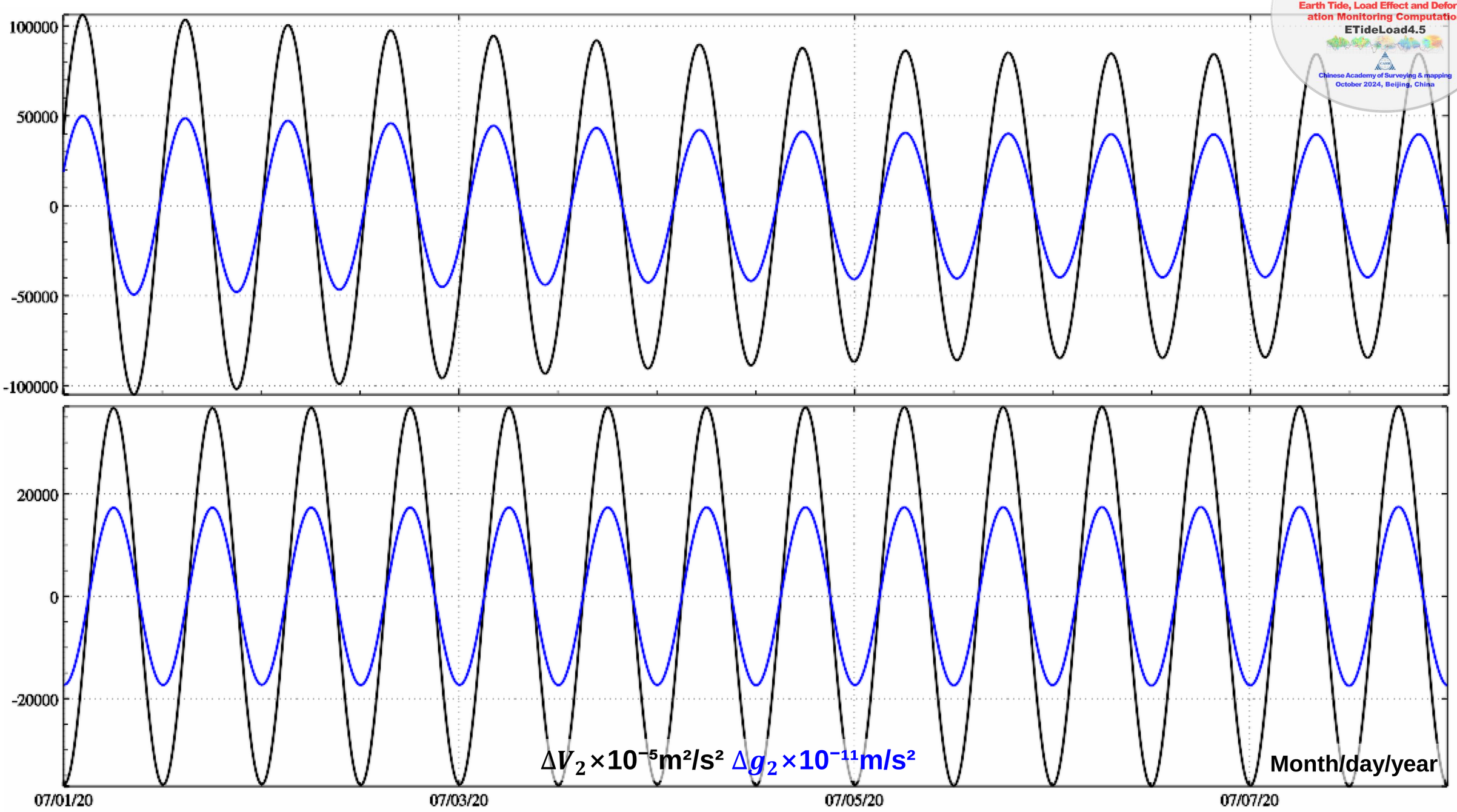
Import setting parameters | Start to forcast...

Forecast with the given location and time

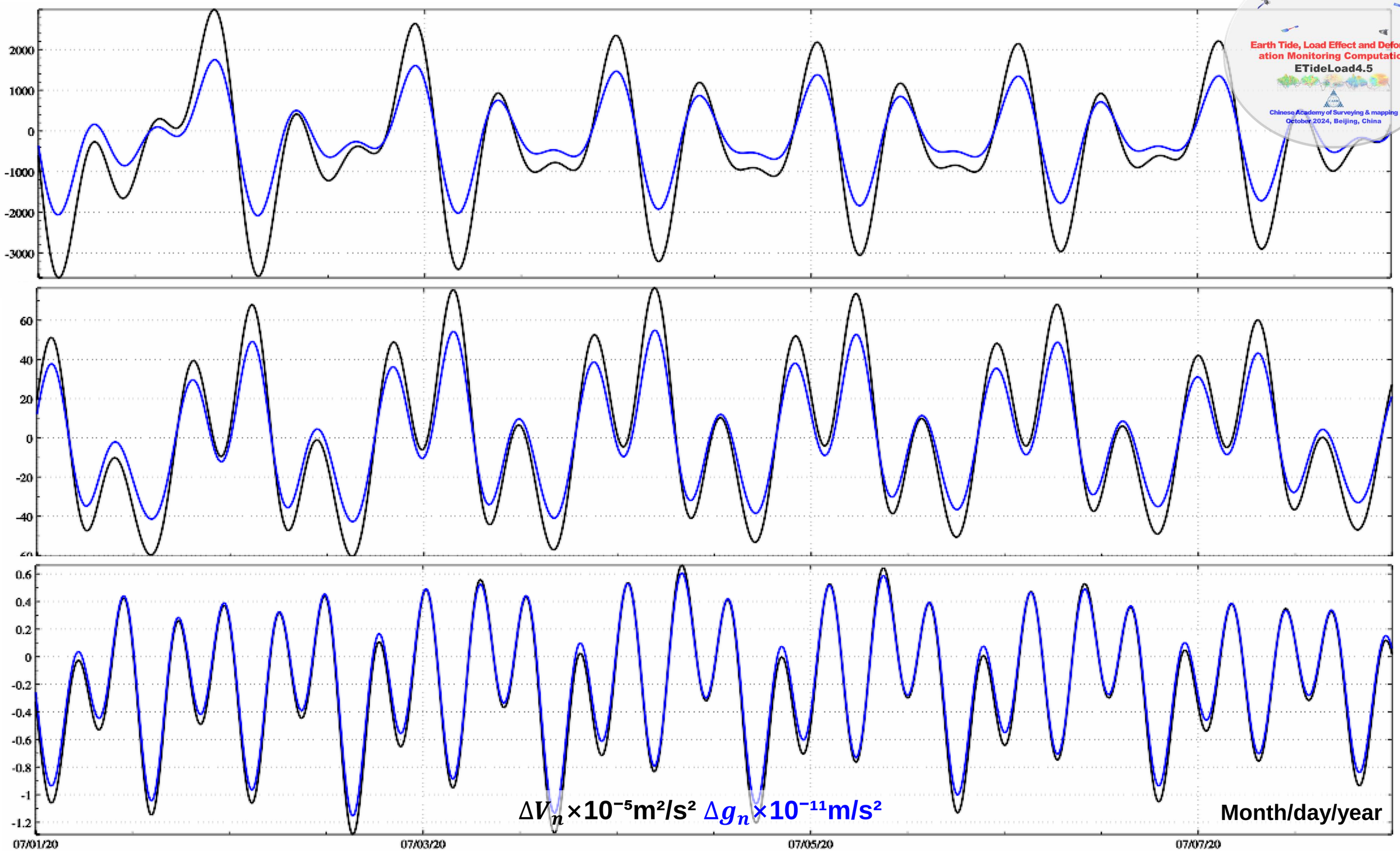
geoid or height anomaly (mm)	4.406	ground gravity (μGal)	-5.437	gravity disturbance (μGal)	-4.602
horizontal displacement (E, mm)	-0.434	ground tilt (S, mas)	-0.673	vertical deflection (S, mas)	-0.284
horizontal displacement (N, mm)	0.518	ground tilt (W, mas)	0.665	vertical deflection (W, mas)	0.268
ground radial displacement (mm)	-5.949	radial gravity gradient (10μE)	-3.601		
normal or orthometric height (mm)	-10.356	horizontal gravity gradient (N, 10μE)	0.655	horizontal gravity gradient (W, 10μE)	0.594

The height of the site is the ellipsoidal height when forecasting the solid tidal effect, the normal or orthometric height when forecasting the ocean tidal load effects, and the height relative to the surface (set as zero in the program) when forecasting the atmosphere tidal load effects.

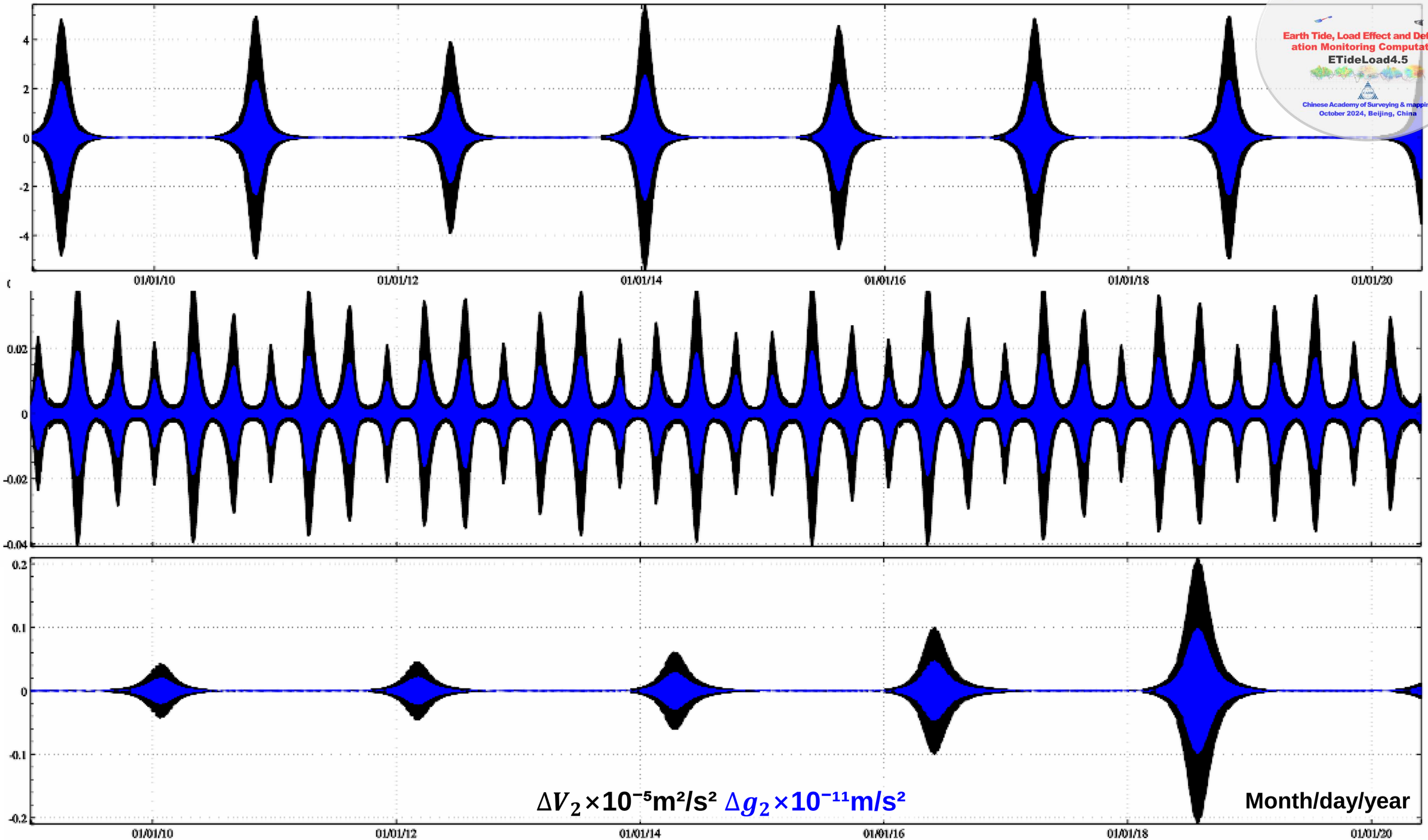




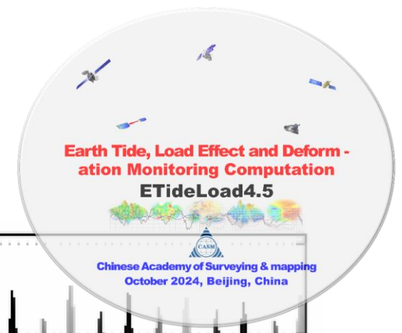
Degree-2 Earth's tidal potential (force) time series from Moon and Sun (7 days)

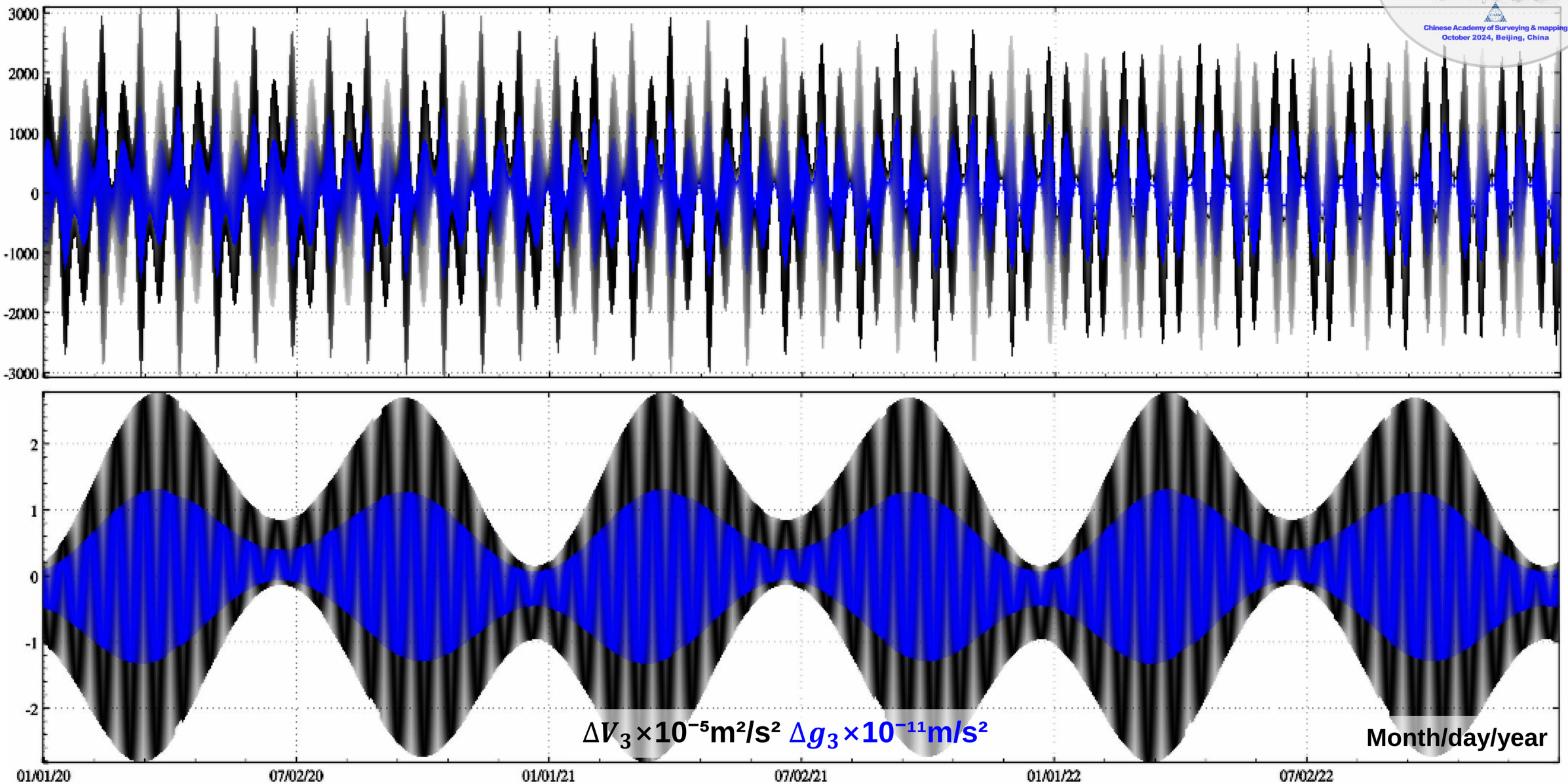


Degree 3, 4 and 5 Earth's tidal potential (force) time series from Moon (7 days)

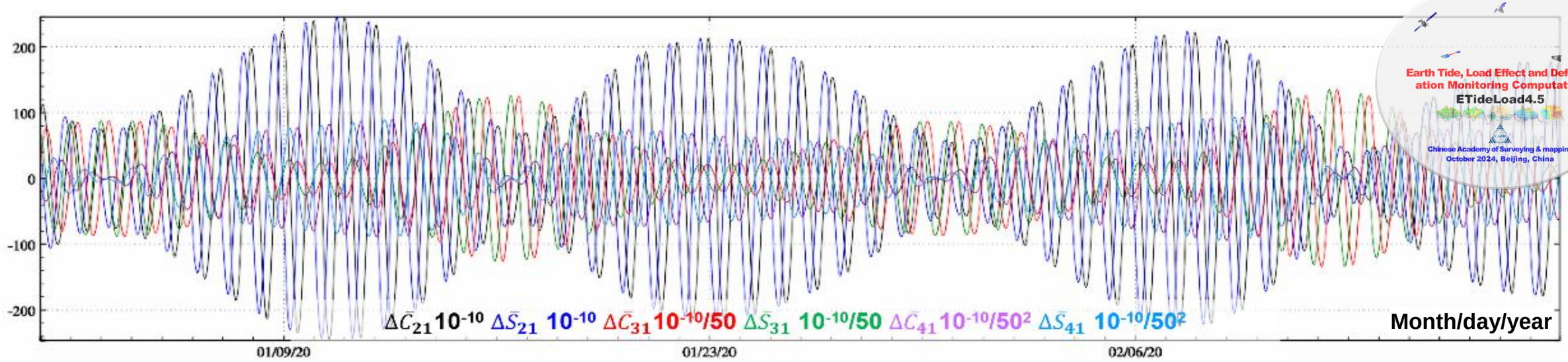


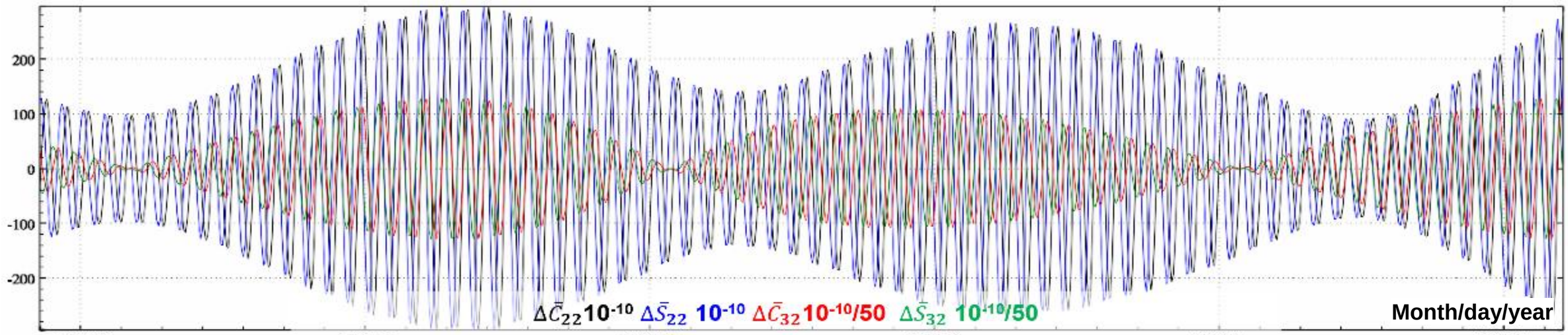
Degree-2 Earth's tidal potential (force) time series from Venus, Jupiter and Mars (12 years)

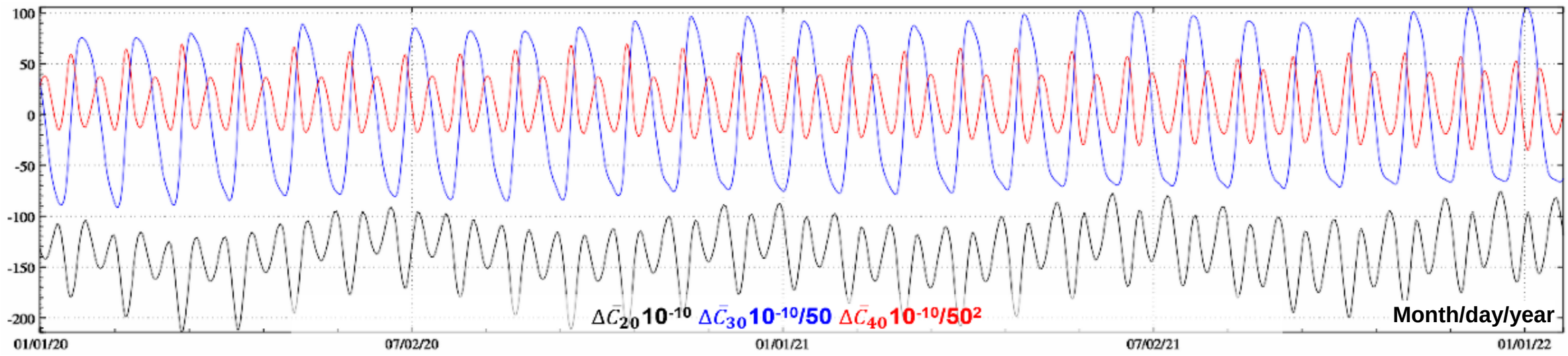




Degree 3 Earth's tidal potential (force) time series from Moon and Sun (2 years)







Earth Tide, Load Effect and Deform - ation Monitoring Computation

ETideLoad4.5

Chinese Academy of Surveying & mapping

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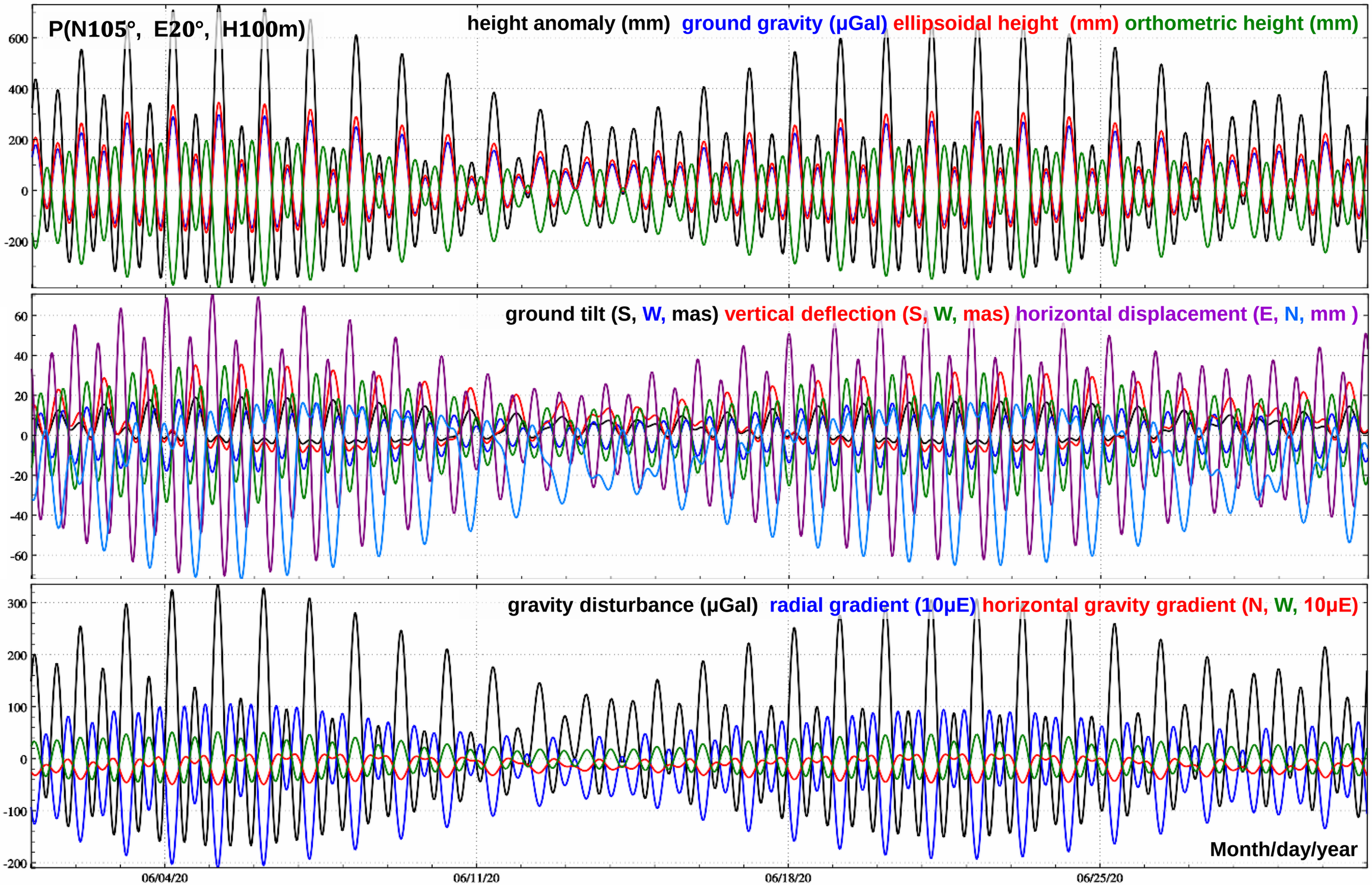
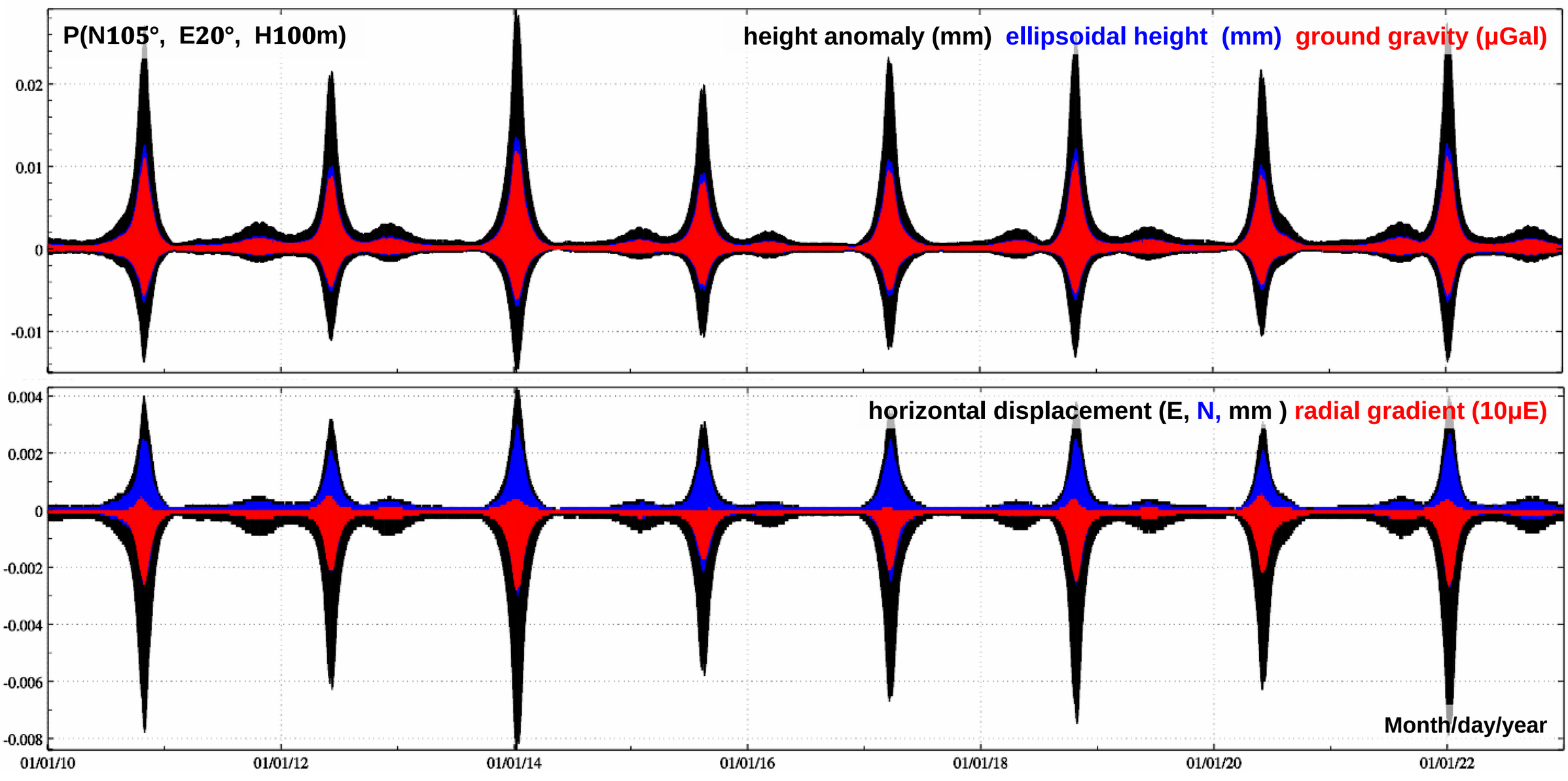
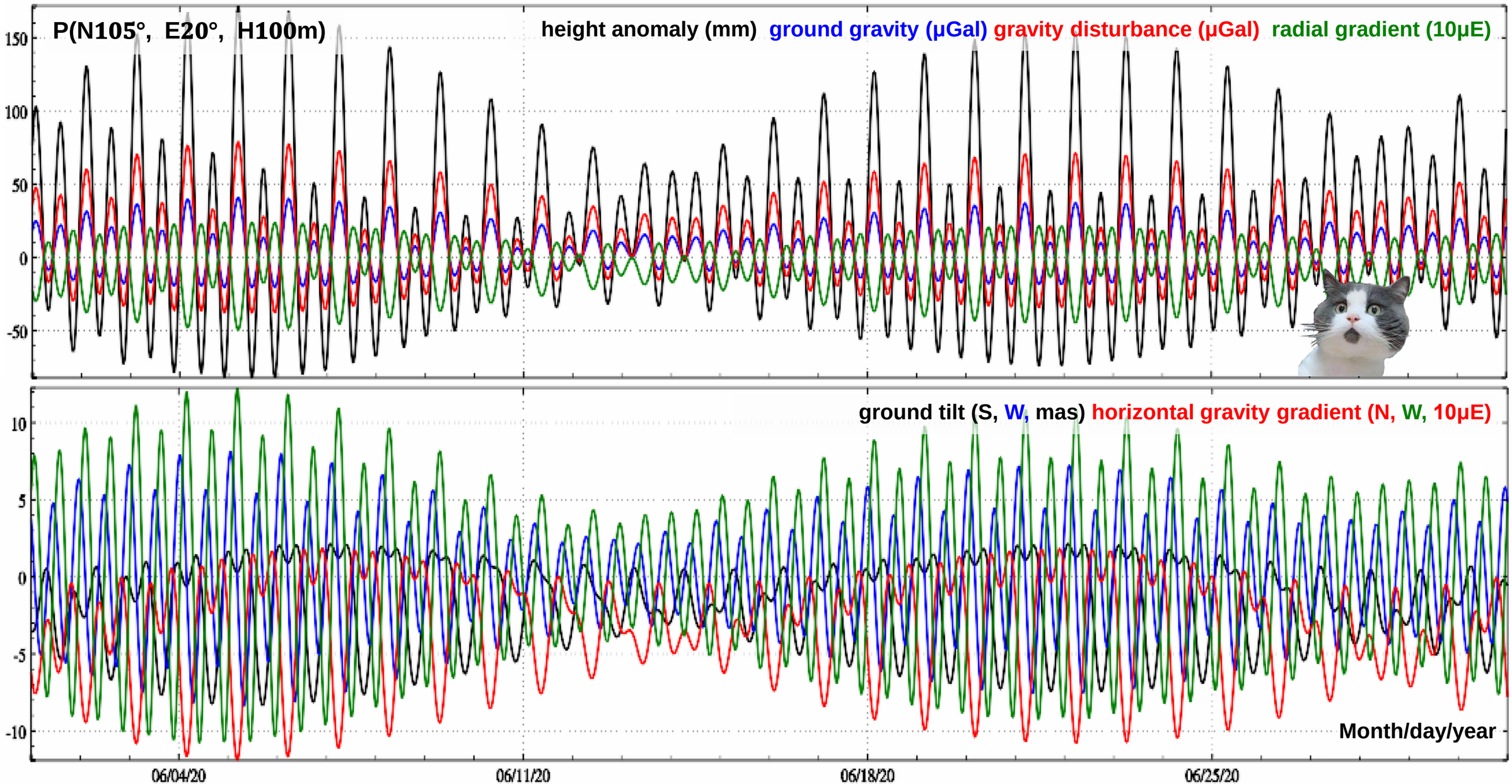


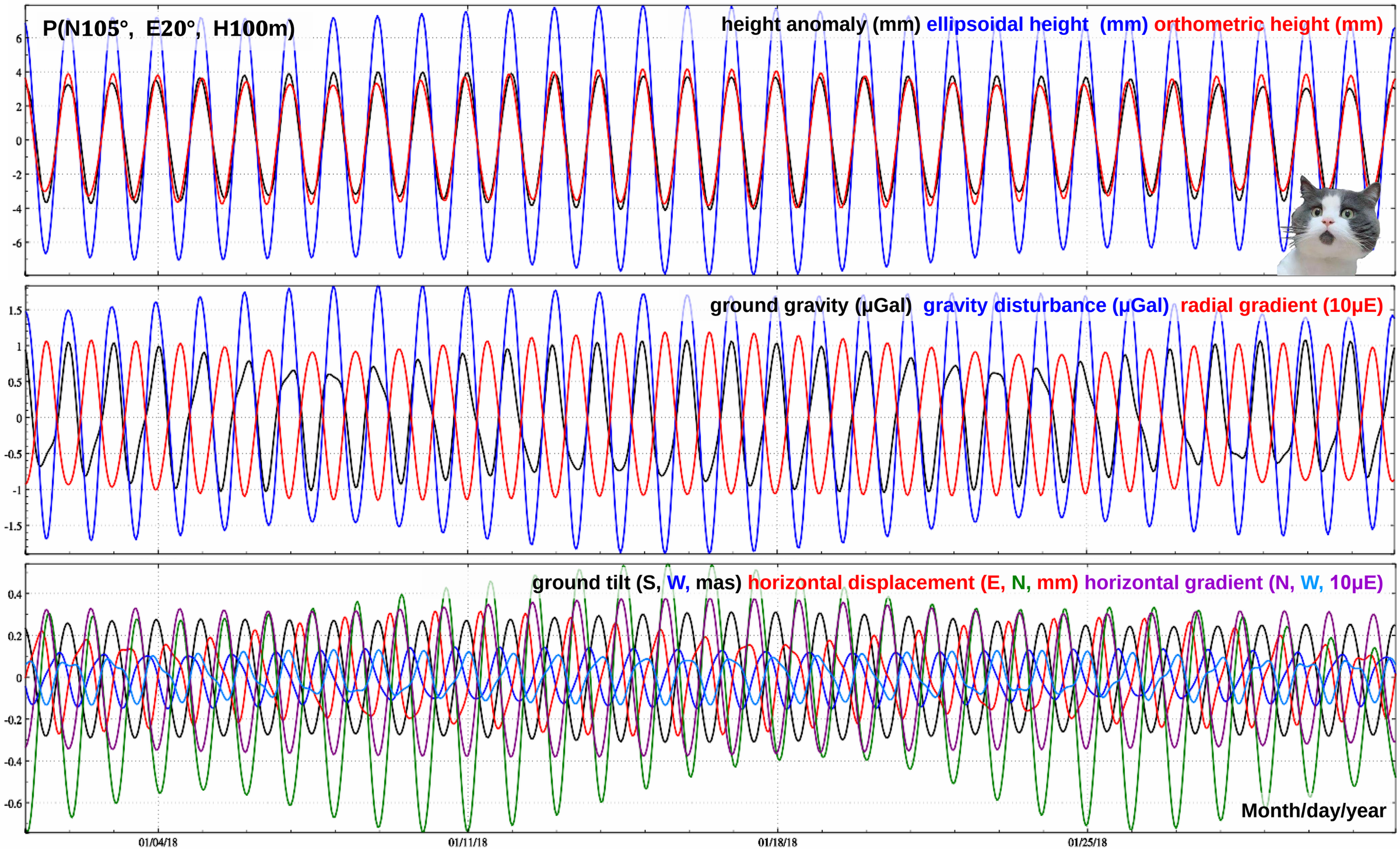
Solid Earth tidal effect time series on all-element geodetic variations



Solid tidal effect time series from the planets outside Earth



The indirect influence time series of tidal potential to geodetic variations



Contributions of potential Love number frequency dependent corrections

airptideS1_cs.dat | proS1_.ini | Airtdloadcs.dat | 0tideloadcs.dat

```
Ocean tidal height load normalized spherical harmonic coefficient model in cm.
Created by ETideLoad, ZHANG Chuanyin, Chinese Academy of Surveying and Mapping.
 Doodson name    n    m          Csin+          Ccos+          Csin-          Ccos-          C+        eps+          C-        eps-
 247.455  2N2    1    0     0.00458562     0.00231038     0.00458562     0.00231038   0.005135    63.2596   0.005135    63.2596
 247.455  2N2    1    1    -0.00773380     0.00473565     0.01063946    -0.00152991   0.009069   301.4805   0.010749    98.1828
 247.455  2N2    2    0     0.01415077    -0.00470716     0.01415077    -0.00470716   0.014913   108.3994   0.014913   108.3994
 247.455  2N2    2    1    -0.01749377     0.01964053    -0.02057617     0.01244109   0.026302   318.3086   0.024045   301.1587
 247.455  2N2    2    2    -0.05076973     0.15409810     0.03408330    -0.00708020   0.162246   341.7648   0.034811   101.7353
 247.455  2N2    3    0    -0.00345932    -0.05402235    -0.00345932    -0.05402235   0.054133   183.6639   0.054133   183.6639
 247.455  2N2    3    1     0.00459468     0.02860553     0.08674509     0.04125120   0.028972     9.1250   0.096054    64.5668
 247.455  2N2    3    2    -0.01359111    -0.04803085     0.00043095     0.01917460   0.049917   195.7997   0.019179     1.2875
 247.455  2N2    3    3     0.11576000     0.04745531     0.10043379    -0.03897379   0.125109    67.7090   0.107731   111.2090
 247.455  2N2    4    0    -0.04607076     0.02579335    -0.04607076     0.02579335   0.052800   299.2429   0.052800   299.2429
 247.455  2N2    4    1     0.03322584     0.01467790     0.01394749     0.02945707   0.036324    66.1660   0.032592    25.3369
 247.455  2N2    4    2     0.06616682    -0.16308472     0.08023800     0.03608357   0.175996   157.9166   0.087978    65.7862
 247.455  2N2    4    3    -0.04323293    -0.08712246    -0.08031745     0.08908738   0.097259   206.3921   0.119948   317.9635
 247.455  2N2    4    4    -0.07108370     0.11911427    -0.03283587     0.04029420   0.138712   329.1726   0.051979   320.8233
 247.455  2N2    5    0     0.00423674     0.05025371     0.00423674     0.05025371   0.050432     4.8190   0.050432     4.8190
```

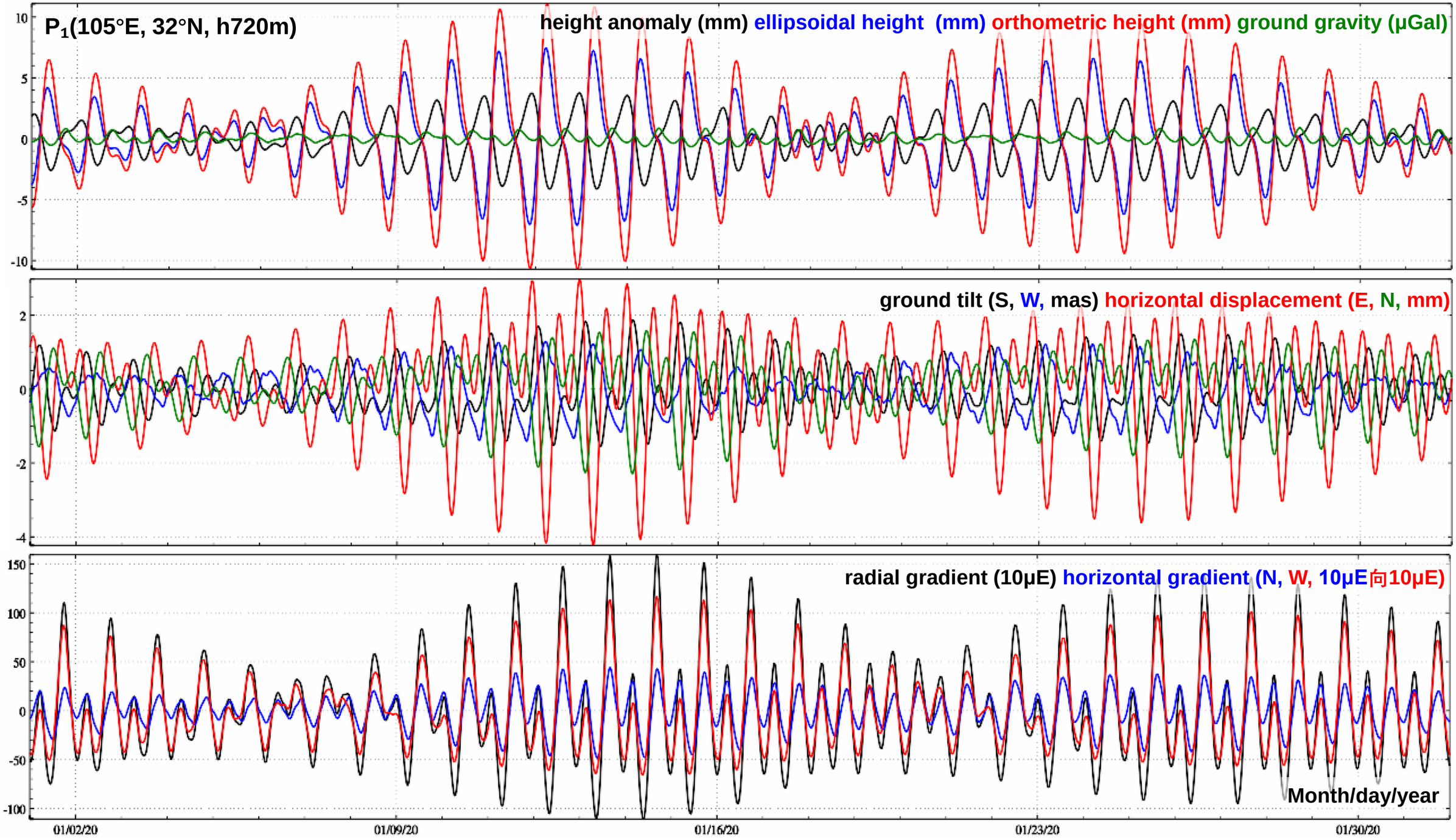
Ocean tidal load spherical harmonic coefficient model FES2014b720cs.dat

ECMWF2006.dat

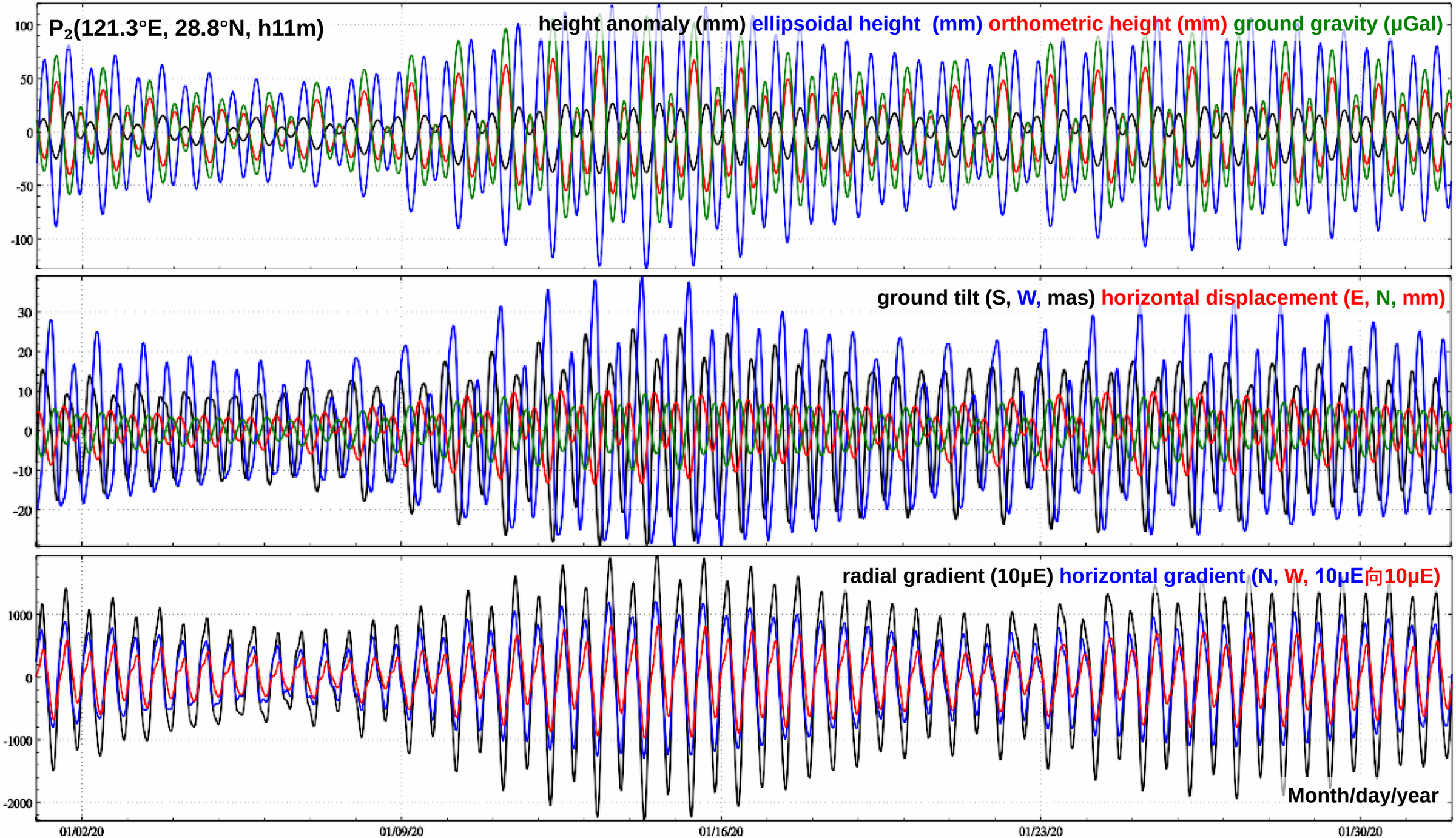
```
Atmospheric tide normalized spherical harmonic coefficients model in hPa.
Created by ETideLoad4.0, ZHANG Chuanyin, Chinese academy of surveying and mapping.
 Doodson name    n    m          Csin+          Ccos+          Csin-          Ccos-          C+        eps+          C-        eps-
 164.556   S1    1    0    -0.01044031     0.00562801    -0.01044031     0.00562801   0.011861   298.3276   0.011861   298.3276
 164.556   S1    1    1    -0.02015273    -0.30983977    -0.02700767     0.03081953   0.310494   183.7214   0.040979   318.7714
 164.556   S1    2    0    -0.00879779     0.02710081    -0.00879779     0.02710081   0.028493   342.0149   0.028493   342.0149
 164.556   S1    2    1    -0.00268684    -0.06100327    -0.02133604     0.03900132   0.061062   182.5219   0.044456   331.3187
 164.556   S1    2    2     0.04746907    -0.07026009    -0.05105739    -0.01871012   0.084793   145.9563   0.054378   249.8745
 164.556   S1    3    0     0.02425656     0.01222288     0.02425656     0.01222288   0.027162    63.2565   0.027162    63.2565
 164.556   S1    3    1    -0.00066157     0.08663528     0.01518488     0.03226590   0.086638   359.5625   0.035660    25.2025
 164.556   S1    3    2     0.05673625    -0.01538495     0.00624773    -0.04261815   0.058785   105.1718   0.043074   171.6600
 164.556   S1    3    3     0.01548229     0.03548483    -0.06617883     0.00859431   0.038715    23.5720   0.066735   277.3993
 164.556   S1    4    0     0.01955708    -0.01828613     0.01955708    -0.01828613   0.026774   133.0765   0.026774   133.0765
 164.556   S1    4    1    -0.01459852     0.00147989     0.03554801    -0.00397062   0.014673   275.7885   0.035769    96.3734
 164.556   S1    4    2     0.01936298     0.02790702     0.01483771    -0.01816466   0.033967    34.7544   0.023454   140.7565
 164.556   S1    4    3     0.05871492     0.05584845     0.02091051    -0.06383148   0.081034    46.4333   0.067169   161.8618
 164.556   S1    4    4     0.05072226    -0.00992714    -0.02941680     0.00989714   0.051685   101.0737   0.031037   288.5953
 164.556   S1    5    0     0.00534727    -0.01557997     0.00534727    -0.01557997   0.016472   161.0570   0.016472   161.0570
```

Atmosphere tidal load spherical harmonic coefficient model ECMF2006cs360.dat

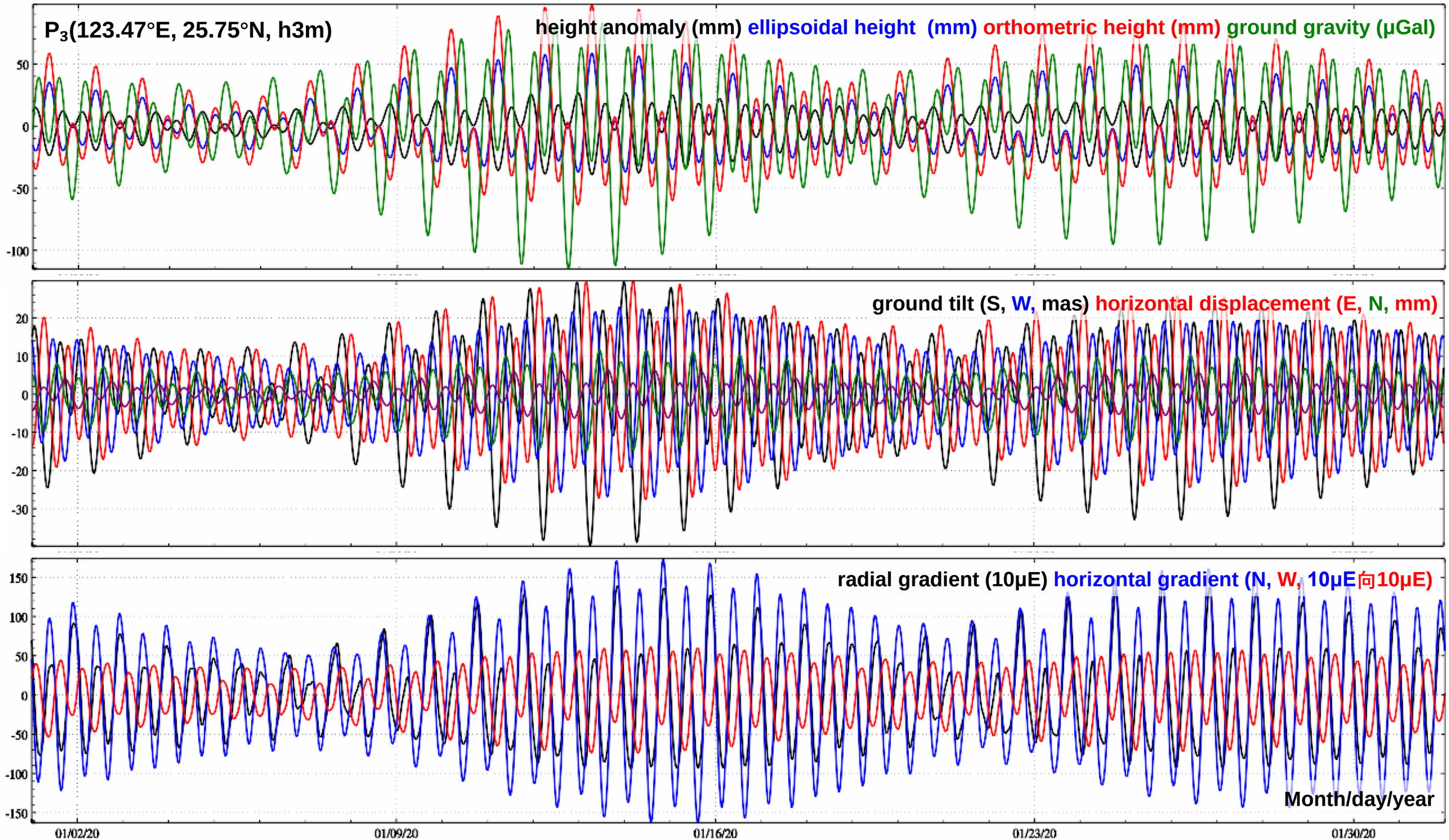
The ocean tidal load effects should be taken into account for the centimeter-level precision geodesy in inland areas.



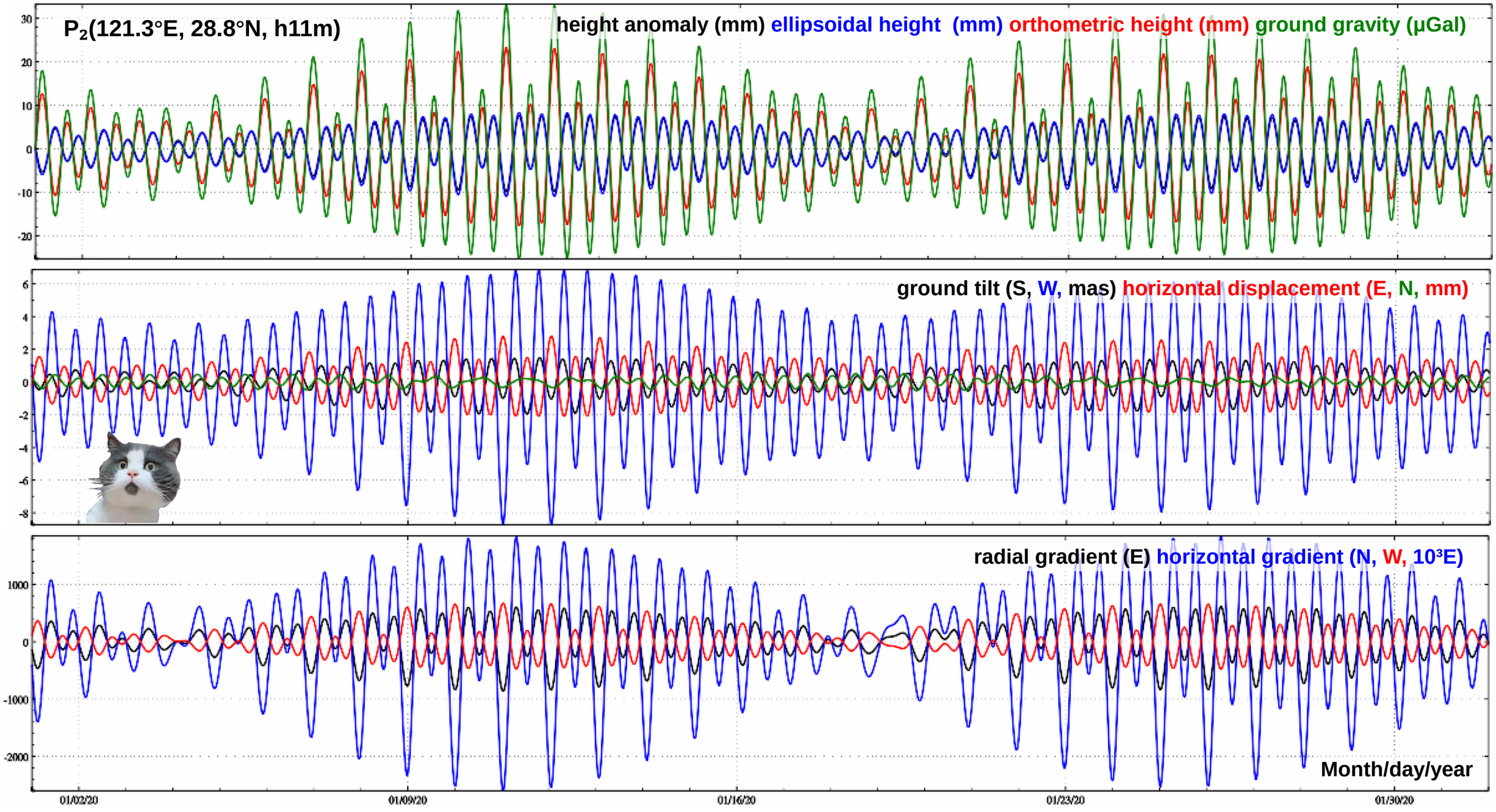
The ocean tidal load effect time series on geodetic variations at P_1 point in the inland area 400km away from the coastline



The ocean tidal load effect time series on geodetic variations at P_2 point on the coastal zone



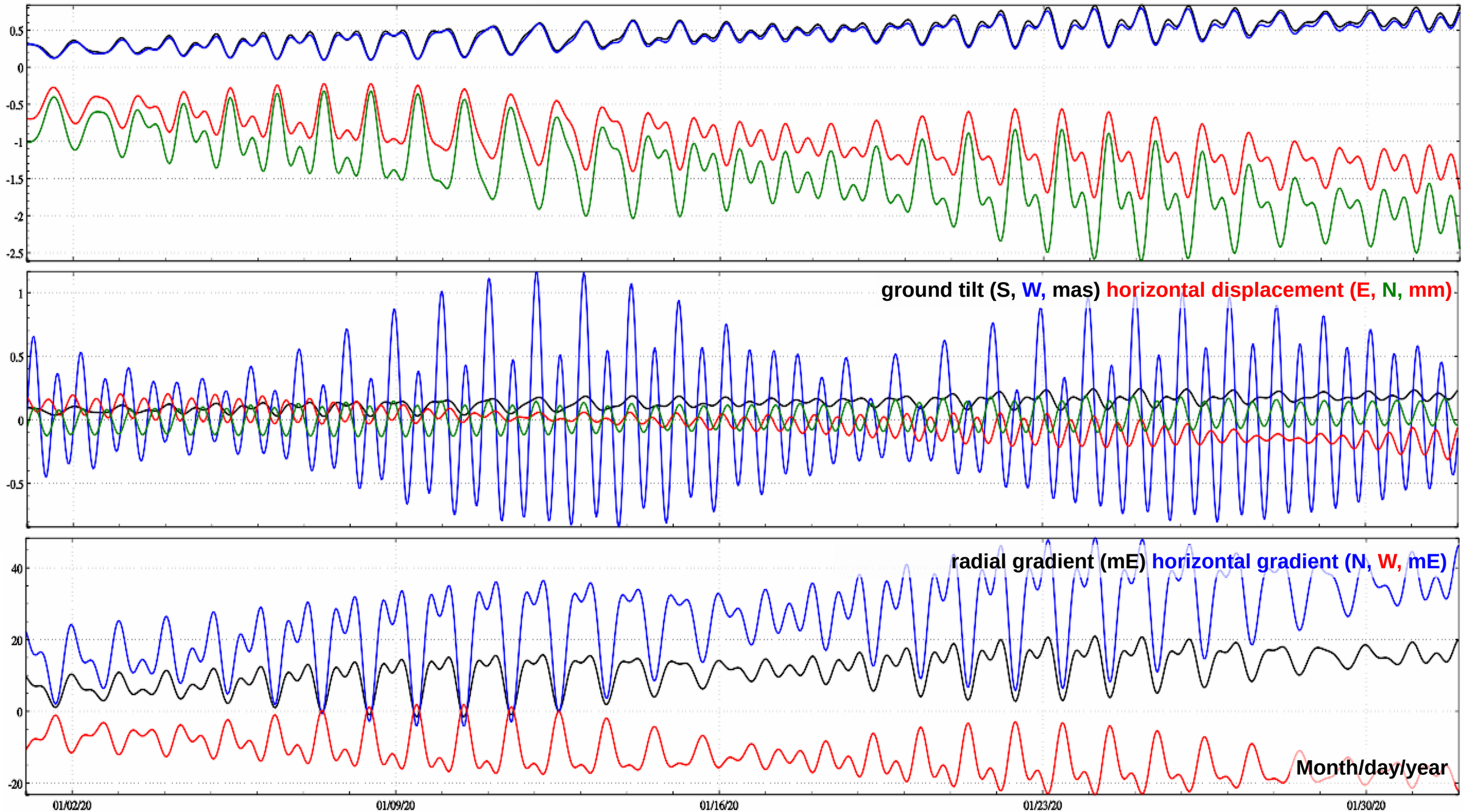
The ocean tidal load effect time series on geodetic variations at P_3 point on offshore island 200km away from the coastline



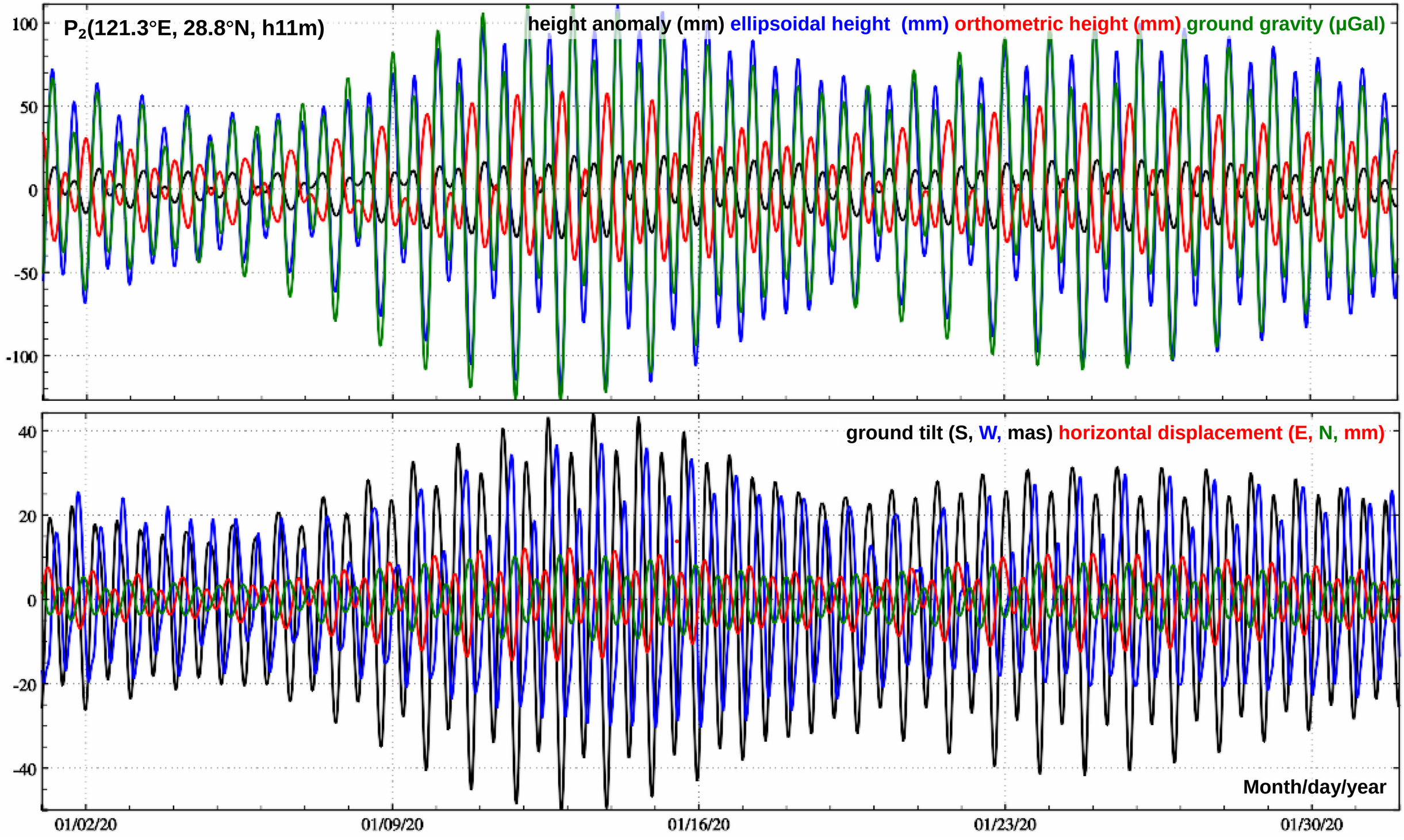
The residual time series of ocean tidal load effects (FES2014b720cs) on geodetic variations at the P_2 in the coastal zone

The ocean tidal load effects on gravity gradient are dominant in the ultrashort wave parts, and the high-degree ocean tidal load spherical harmonic coefficient model FES2014b720cs cannot contain these ultrashort wave signals in coastal areas. The calculation results of the residual load effects on gravity gradient are divergent and not available using load Green's function integral.

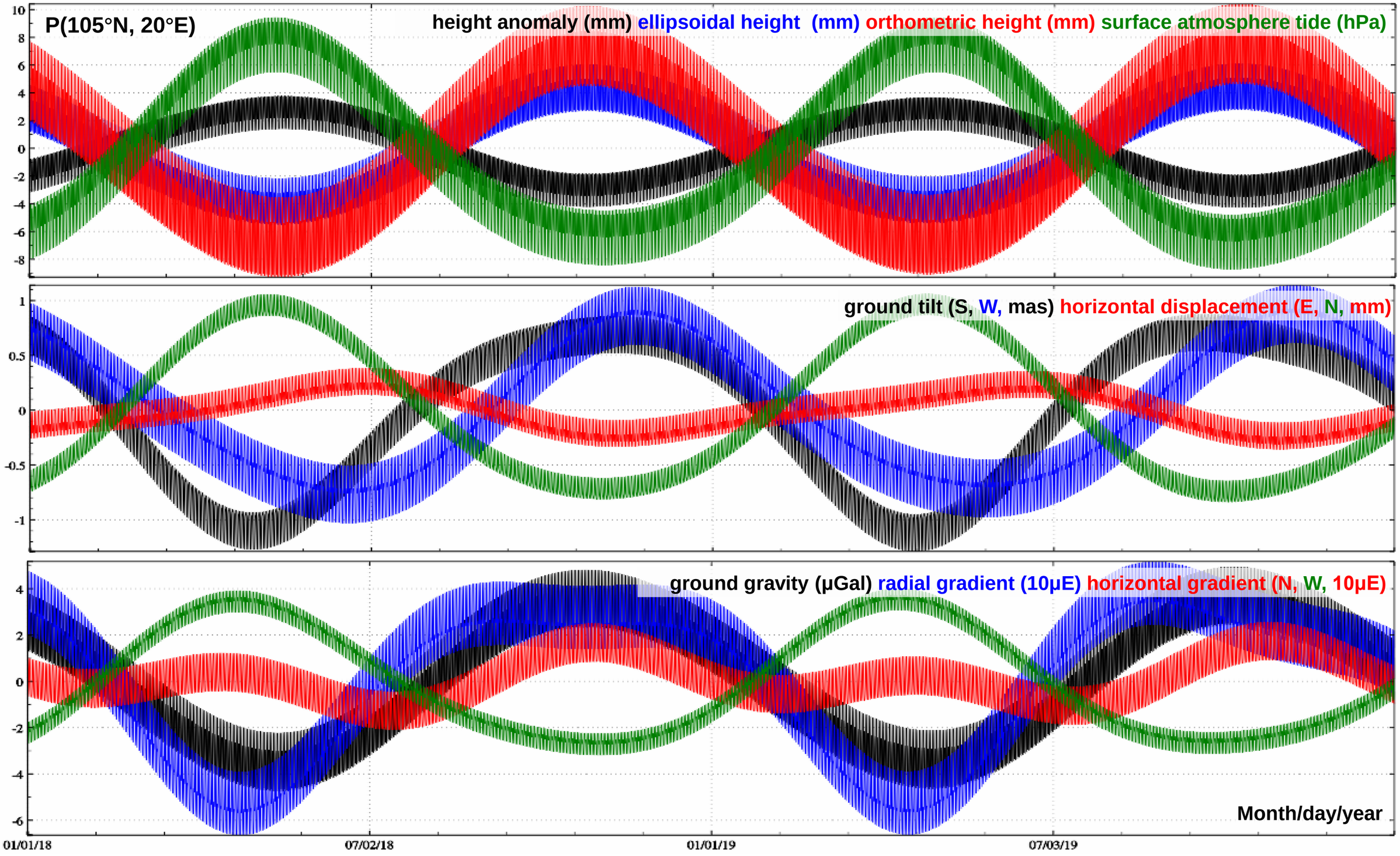
P_3(123.47°E, 25.75°N, h3m)



The residual time series of ocean tidal load effects (FES2014b720cs) on geodetic variations at the P_3 on the sea island 200km away from the coastline



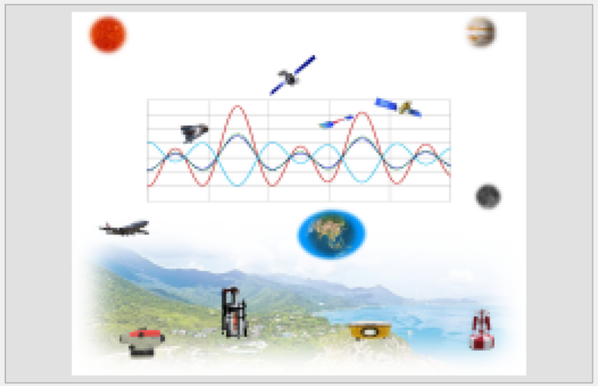
The refine value time series of ocean tidal load effects on geodetic variations at the P_2 in the coastal zone (FES2014b720cs model + load Green's integral of residual)



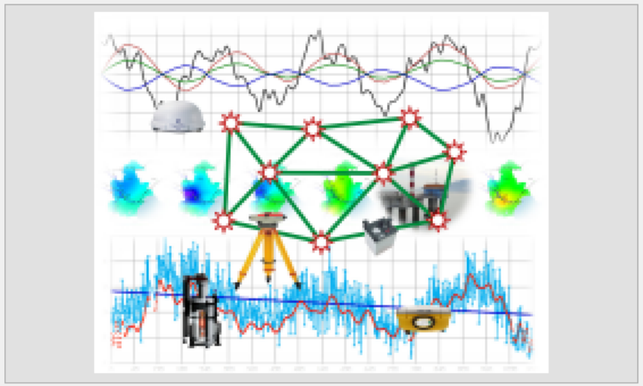
The surface atmosphere tidal load effect time series on geodetic variations

Earth Tide, Load Effects and Deformation Monitoring Computation 4.5

Summary, parameter settings and visualization for ETideLoad4.5



Computation of various tidal effects on all-element geodetic variations



Processing and analysis on non-tidal geodetic variation time series

- Analytically compatible geodetic and geodynamic algorithm package using the numerical standards unified and geophysical models coordinated
- Compatible with and improving of IERS conversations, relevant geodetic concepts clarified, algorithm formulas derivated and verificated completely
- Uniform computation of solid tidal, load tidal, polar shift and mass centric variation effects on all-element geodetic variations in whole Earth space
- Analytical computation of surface load effects on all-element geodetic variations and collaborative monitoring of time-varying Earth gravity field
- Geodetic monitoring of the surface hydrological environment and ground stability variations and prediction of their spatio-temporal evolution

www.zcyphygeodesy.com/en/

ETideLoad4.5 organization structure

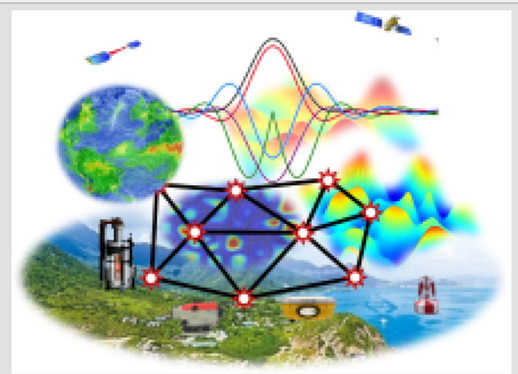
☆ Includes the basic principles, main formulas and important methods of geodesy on the deforming Earth to improve higher education environment.

☆ Can be employed to construct scientifically the technology environment for the deep fusion of multi-source heterogeneous earth data and collaborative monitoring of multiply heterogeneous geodetic system.

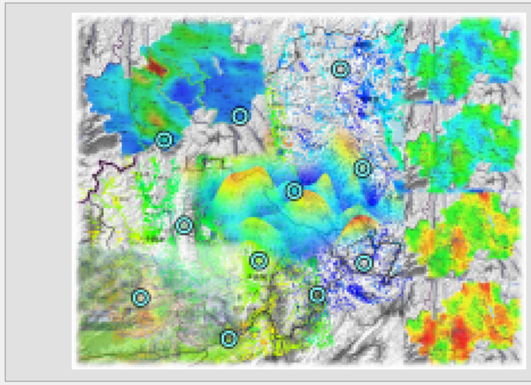
☆ There are the example files saved in the folder C:\ETideLoad4.5_win64en\examples\ for each Win64 program. It will take about 7 working days to complete all the example exercises. Thereafter, you can use ETideLoad4.5 alone.

Models and numerical standards

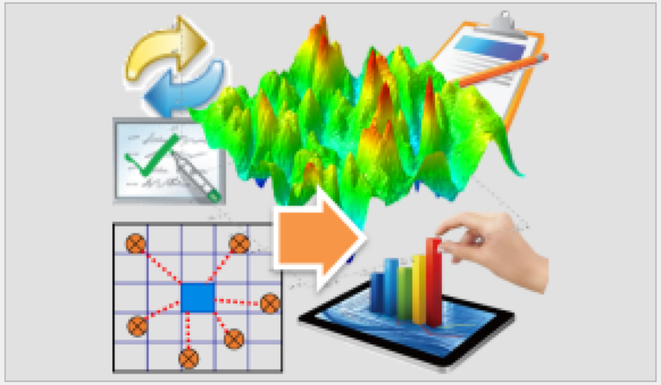
Geodetic variations in ETideLoad



Load deformation field approach and monitoring from heterogeneous variations



CORS/InSAR collaborative monitoring and ground stability estimation



Editing and calculation tools for geodetic data files

Classroom Teaching, Self-Exercise, Science Research and Engineer Computing