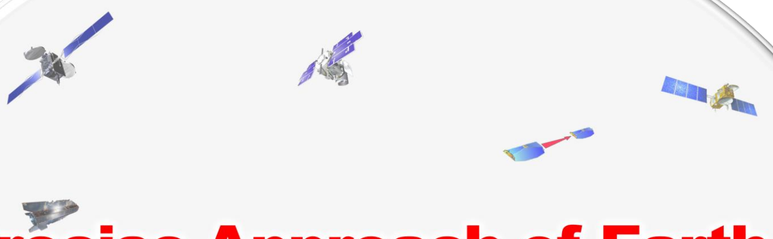
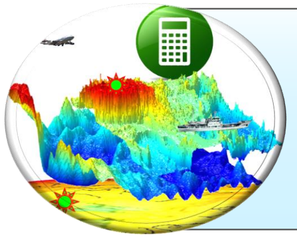


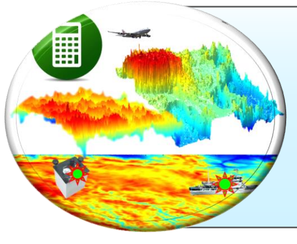
Precise Approach of Earth Gravity Field and Geoid

PAGravf4.5

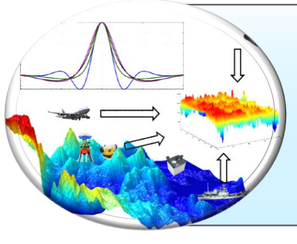
Computation demo for terrain effect and gravity prospecting model



Computation demo of land-sea Bouguer / equilibrium anomaly from geopotential model



Computation process demo of complete Bouguer anomaly on terrain equiheight surface



Scheme of gravity prospecting modeling by analytic fusion of heterogeneous observations

Precise Approach of Earth Gravity Field and Geoid

PAGravf4.5

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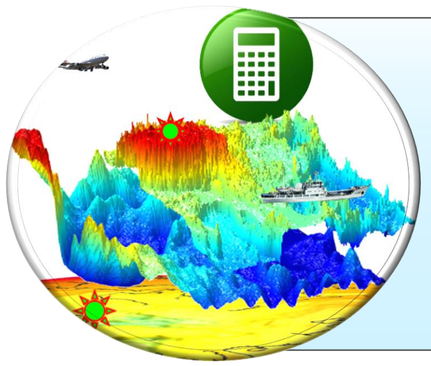
March 2023, Beijing, China

Only four steps universal in global land-sea area. Everyone will !



Computation demo of land-sea Bouguer / equilibrium anomaly from geopotential model

The computation processes for Bouguer (isostatic) gravity anomaly (disturbance) are all exactly the same !

zcyphygeodesy.com/en/

2~180th degree model geoidal height grid

Calculate model geoidal height grid in target area

2′ zero-value grid in target area

ultra-high degree geopotential coefficient model

Calculate the gravity disturbance and gravity anomaly on geoid by spherical harmonic synthesis

2~1800th model gravity disturbance and gravity anomaly grid on geoid

2′ ellipsoidal height grid of land-sea surface

2′ land-sea terrain model

Calculate the land-sea unified classical Bouguer / equilibrium effects

2′ total Bouguer effect grid and total equilibrium effect grid

Weighted operation on two geodetic grid files

2′ land-sea unified Bouguer gravity anomaly grid

2′ land-sea unified isostatic gravity anomaly grid

2′ land-sea unified Bouguer gravity disturbance grid

2′ land-sea unified isostatic gravity disturbance grid

Computation process demo of land-sea Bouguer/equilibrium anomaly from geopotential model

(1) Calculate the 2~180th degree model geoidal height grid as the gravity reduction surface grid in target area.

Calculation of global geopotential model and its spectral character analysis

Follow example

Calculation of gravity field elements from global geopotential model | Calculation of model value for residual terrain (complete Bouguer) effects | Global geopotential coefficient model Calculator | Calculation a character of

Open global geopotential coefficient model file

Select calculation file format

Ellipsoidal height grid file

Open ellipsoidal height grid file of calculation surface

Select elements to be calculated

- [x] height anomaly (m)
- [ ] gravity anomaly (mGal)
- [ ] gravity disturbance (mGal)
- [ ] vertical deflection (", SW)
- [ ] disturbing gravity gradient (E, radial)
- [ ] tangential gravity gradient (E, NW)
- [ ] Laplace operator (E)

Minimum degree 2

Maximum degree 180

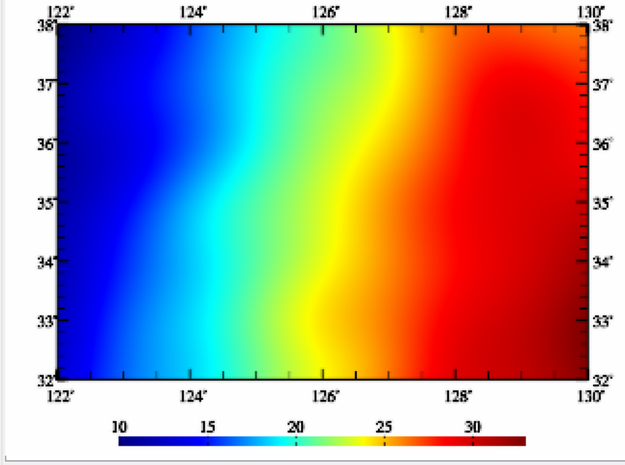
Save computation process as

```
>> [Function] From global geopotential coefficient model, calculate the model value of the (residual) height anomaly (m), gravity
gravity disturbance (mGal), vertical deflection vector (", south, west), disturbing gravity gradient (E, radial), tangential gravity gradi
north, west), or Laplace operator (E).
  ** Click the [Open global geopotential coefficient model file] control button, or the [Open geopotential model] tool button...
>> Open global geopotential coefficient model file C:/PAGravf4.5_win64en/data/EGM2008.gfc.
  ** The window below only shows the geopotential coefficients data with no more than 2000 rows in it.
>> Open ellipsoidal height grid file of calculation surface C:/PAGravf4.5_win64en/examples/Terraininflexercise/GMBougEquilibrium/zero2m.dat.
>> Save the results as C:/PAGravf4.5_win64en/examples/Terraininflexercise/GMBougEquilibrium/GMgeoidh2m_180.txt.
  ** The record format: point no/name, longitude, latitude, ellipsoidal height, several columns of the model values of anomalous field elements.
  ** The program also outputs (residual) height anomaly (*.ksi), gravity anomaly (*.gra), gravity disturbance (*.rga), vertical deflection vector (*.dft),
disturbing gravity gradient (*. grr), tangential gravity gradient vector (*.hgd) or Laplace operator (*.lps) model value grid file into the current directory.
Where * is the output file name entered in the interface, and the program outputs the corresponding (residual) model value grid file according to the
selected gravity field element type.
>> The parameter settings have been entered into the system!
```

Save the results as | Import setting parameters | Start Computation

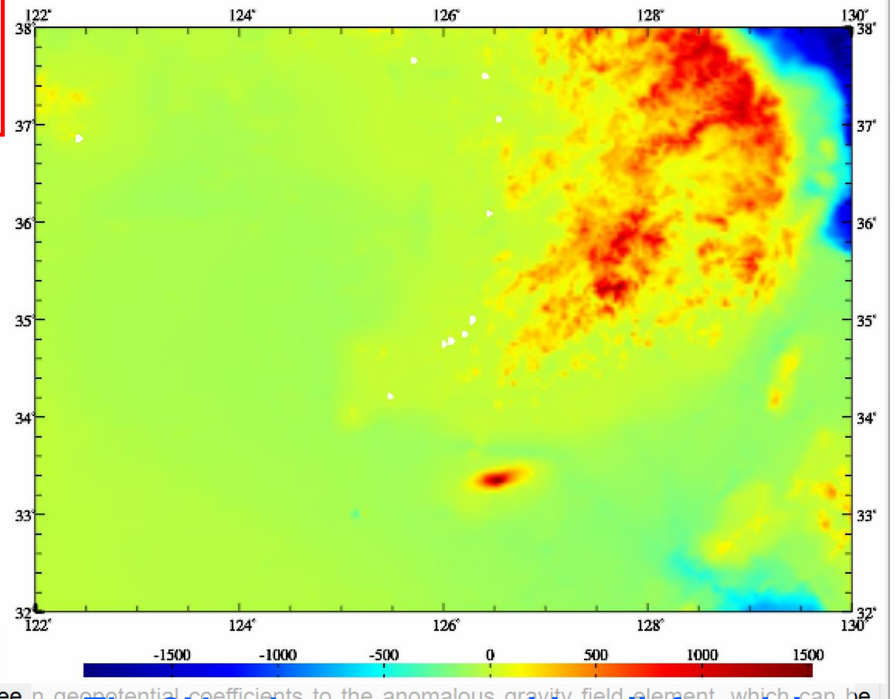
1	122.01667	32.01667	0.000	13.0311
2	122.05000	32.01667	0.000	13.1534
3	122.08333	32.01667	0.000	13.2760
4	122.11667	32.01667	0.000	13.3989
5	122.15000	32.01667	0.000	13.5220
6	122.18333	32.01667	0.000	13.6452
7	122.21667	32.01667	0.000	13.7683
8	122.25000	32.01667	0.000	13.8914
9	122.28333	32.01667	0.000	14.0142
10	122.31667	32.01667	0.000	14.1366

Extract elements to be plot | Plot↓



height anomaly (m)

The 2~180th degree model geoidal height grid as the gravity reduction surface grid in target area



gravity anomaly (mGal)

The 2′ land-sea topographic relief model

When the minimum and maximum degree n to be set is equal, the program calculates the contribution of the degree n geopotential coefficients to the anomalous gravity field element, which can be employed to analyze and evaluate the spectral and space properties of the geopotential coefficient model.

Precise Approach of Earth Gravity Field and Geoid

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Calculation of global geopotential model and its spectral character analysis

(2) Calculate the gravity anomaly and gravity disturbance on geoid from the geopotential coefficient model.

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Calculation of gravity field elements from global geopotential model | Calculation of model value for residual terrain (complete Bouguer) effects | Global geopotential coefficient model Calculator | Calculation a... character of E...

Follow example

Open global geopotential coefficient model file

Select calculation file format

Ellipsoidal height grid file

Open ellipsoidal height grid file of calculation surface

Select elements to be calculated

- [ ] height anomaly (m)
- [x] gravity anomaly (mGal)
- [x] gravity disturbance (mGal)
- [ ] vertical deflection (", SW)
- [ ] disturbing gravity gradient (E, radial)
- [ ] tangential gravity gradient (E, NW)
- [ ] Laplace operator (E)

Minimum degree 2

Maximum degree 1800

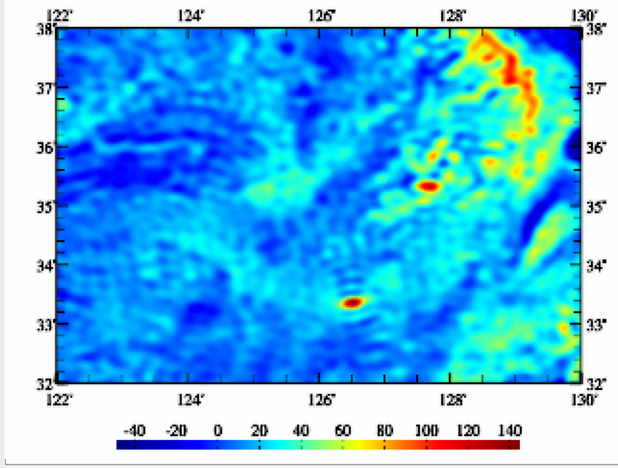
Extract elements to be plot | Plot↓

Save computation process as

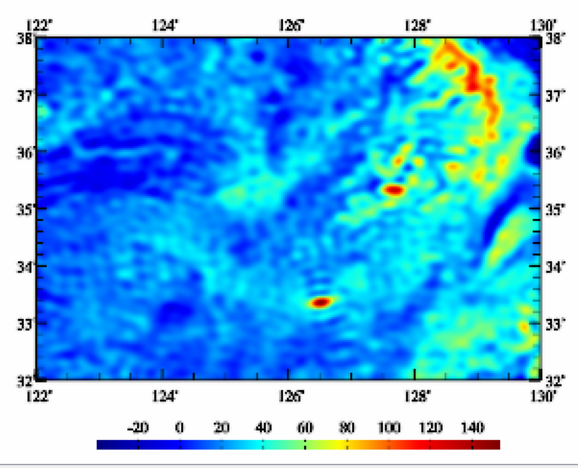
```
>> Open global geopotential coefficient model file C:/PAGravf4.5_win64en/data/EGM2008.gfc.
  ** The window below only shows the geopotential coefficients data with no more than 2000 rows in it.
>> Open ellipsoidal height grid file of calculation surface C:/PAGravf4.5_win64en/examples/Terraininflexercise/GMBougEquilibrium/
GMgeoidh2m_180.ksi.
>> Save the results as C:/PAGravf4.5_win64en/examples/Terraininflexercise/GMBougEquilibrium/EGM2008_2m_1800.txt.
  ** The record format: point no/name, longitude, latitude, ellipsoidal height, several columns of the model values of anomalous field elements.
  ** The program also outputs (residual) height anomaly (*.ksi), gravity anomaly (*.gra), gravity disturbance (*.rga), vertical deflection vector (*.dft),
disturbing gravity gradient (*. grr), tangential gravity gradient vector (*.hgd) or Laplace operator (*.lps) model value grid file into the current
directory. Where * is the output file name entered in the interface, and the program outputs the corresponding (residual) model value grid file
according to the selected gravity field element type.
>> The parameter settings have been entered into the system!
  ** Click the [Start Computation] control button, or the [Start Computation] tool button...
  ** The calculation process need wait, during which you can open the output file to look at the calculation progress...
>> Computation start time：2023-03-19 00:07:22
```

Save the results as | Import setting parameters | Start Computation

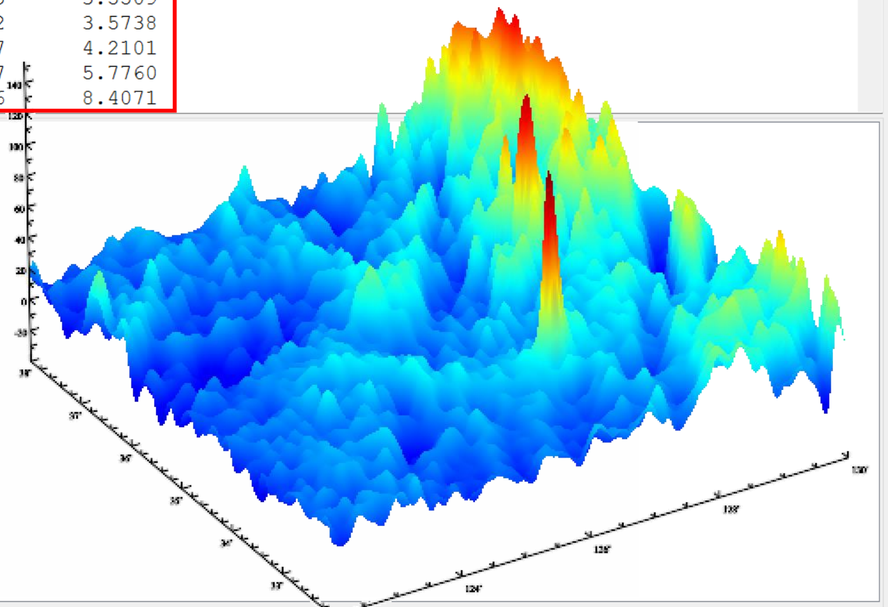
1	122.01667	32.01667	13.031	4.2037	8.2077
2	122.05000	32.01667	13.153	2.6153	6.6517
3	122.08333	32.01667	13.276	1.3041	5.3727
4	122.11667	32.01667	13.399	0.3653	4.4667
5	122.15000	32.01667	13.522	-0.2572	3.8777
6	122.18333	32.01667	13.645	-0.6185	3.5509
7	122.21667	32.01667	13.768	-0.6312	3.5738
8	122.25000	32.01667	13.891	-0.0317	4.2101
9	122.28333	32.01667	14.014	1.4957	5.7760
10	122.31667	32.01667	14.137	4.0866	8.4071



gravity anomaly (mGal)



gravity disturbance (mGal)



vertical deflection (", S

When the minimum and maximum degree n to be set is equal, the program calculates the contribution of the ... gravity ... model ... gravity ... be employed to analyze and evaluate the spectral and space properties of the geopotential coefficient model.

The 2~1800th model gravity disturbance on geoid

Computation of land-sea unified classical gravity Bouguer / equilibrium effect

(3) Calculate the total Bouguer effects and total equilibrium effects on gravity.

Save as | Start Computation | Save process | Follow example

Integral of land-sea unified classical gravity Bouguer / equilibrium effect

Calculator of land-sea unified classical gravity Bouguer / equilibrium effect

Algorithms land-sea unifi… Bouguer and equilibrium

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Open the land-sea terrain model file

Open the ellipsoidal height grid file of land-sea surface

Select calculation points file format

ellipsoidal height grid file

Open the ellipsoidal height grid file on land-sea calculation surface

Integral radius for local terrain effect: 90 km

Integral radius for seawater Bouguer / equilibrium effect: 300 km

Equilibrium compensation depth: 30 km

>> Computation Process ** Operation Prompts

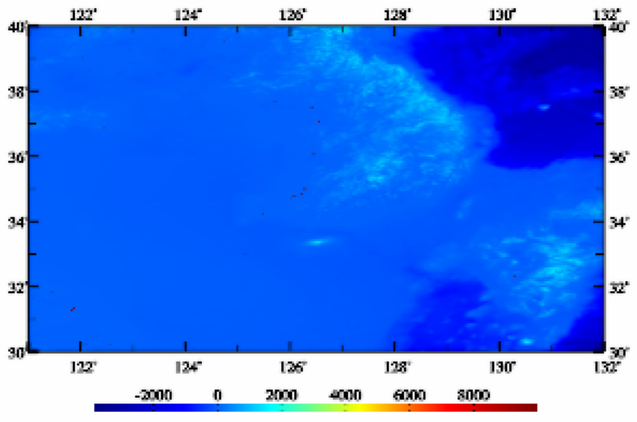
Save con…

```
>> Open the land-sea terrain model file C:/PAGravf4.5_win64en/examples/Terraininflexercise/GMBougEquilibrium/
extlandseadtm2m.dat.
>> Open the ellipsoidal height grid file of land-sea surface C:/PAGravf4.5_win64en/examples/Terraininflexercise/
GMBougEquilibrium/extlandseahgt2m.dat.
>> Open the ellipsoidal height grid file on land-sea calculation surface C:/PAGravf4.5_win64en/examples/Terraininflexercise/
GMBougEquilibrium/extlandseahgt2m.dat.
>> Save the results as C:/PAGravf4.5_win64en/examples/Terraininflexercise/GMBougEquilibrium/BougEquinfl2m.txt0
 ** Record format: Point no, longitude, latitude, ellipsoidal height, terrain height/sea depth, local terrain effect, plane layer effect,
seawater Bouguer effect, land equilibrium effect, ocean equilibrium effect, total Bouguer effect and total equilibrium effect.
 ** At the same time, the program also outputs the land-sea total Bouguer effect (*.bgr) and land-sea total equilibrium effect (*.ist)
grid file into the current directory, where * is the output file name entered from the interface.
```

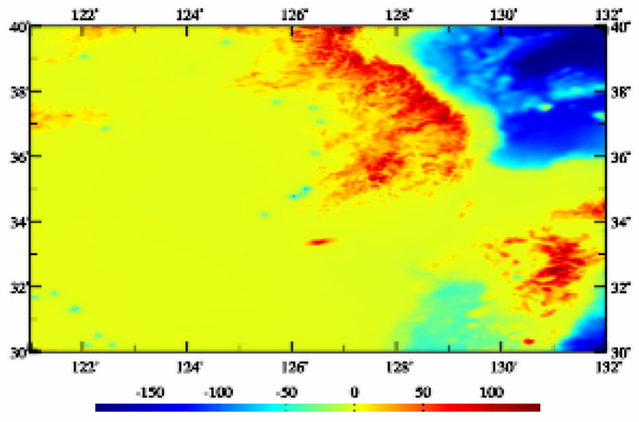
Save the results as | Import setting parameters | Start Computation

no	lon(deg/decimal)	lat	height/depth	local terrian,	plane layer,	seawater Bouguer effect,	...	
1	121.01667	30.01667	43.360	-0.0930	4.8550	-0.0052	-0.5258	0.0729
2	121.05000	30.01667	20.550	-0.0329	2.3010	-0.0053	-0.5820	0.0774
3	121.08333	30.01667	45.640	-0.1658	5.1102	-0.0056	-0.6299	0.0821
4	121.11667	30.01667	7.880	-0.0164	0.8823	-0.0057	-0.6957	0.0870
5	121.15000	30.01667	6.400	-0.0072	0.7166	-0.0058	-0.7545	0.0922
6	121.18333	30.01667	5.000	-0.0311	0.5598	-0.0060	-0.8137	0.0977

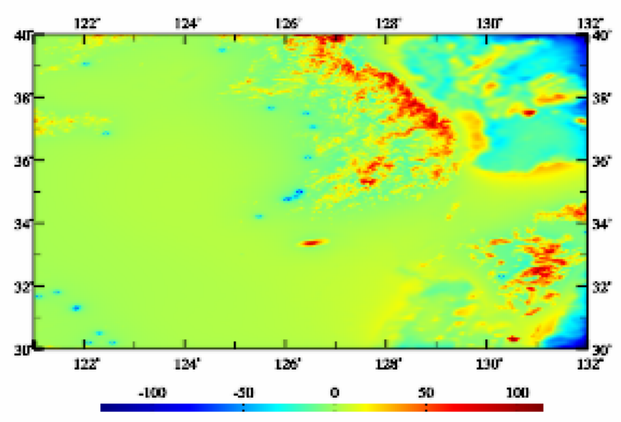
Extract effects | Plot↓



land-sea terrain model (m)



total Bouguer effect (mGal)



total equilibrium effect (mGal)

Classic Bouguer gravity anomaly on geoid = gravity anomaly at the measurement point – total Bouguer effect – analytical continuation of gravity anomaly from the measurement point to the geoid. Classic Bouguer gravity disturbance on geoid = gravity disturbance at the measurement point – total Bouguer effect – analytical continuation of gravity disturbance from the measurement point to the geoid.

Classic equilibrium gravity anomaly on geoid = gravity anomaly at the measurement point – total equilibrium effect – analytical continuation of gravity anomaly from the measurement point to the geoid. Classic equilibrium gravity disturbance on geoid = gravity disturbance at the measurement point – total equilibrium effect – analytical continuation of gravity disturbance from the measurement point to the geoid.

Simple and direct calculation on geodetic data files

(4) Generate the 2′×2′ land-sea unified classical Bouguer / isostatic anomaly grid model.

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Weighted operation on two specified attributes in record file | Weighted operation on two geodetic grid files | Weighted operation on two vector grid files | Weight harmor

Open geodetic grid file 1
Open geodetic grid file 2

Select operation mode: Plus +

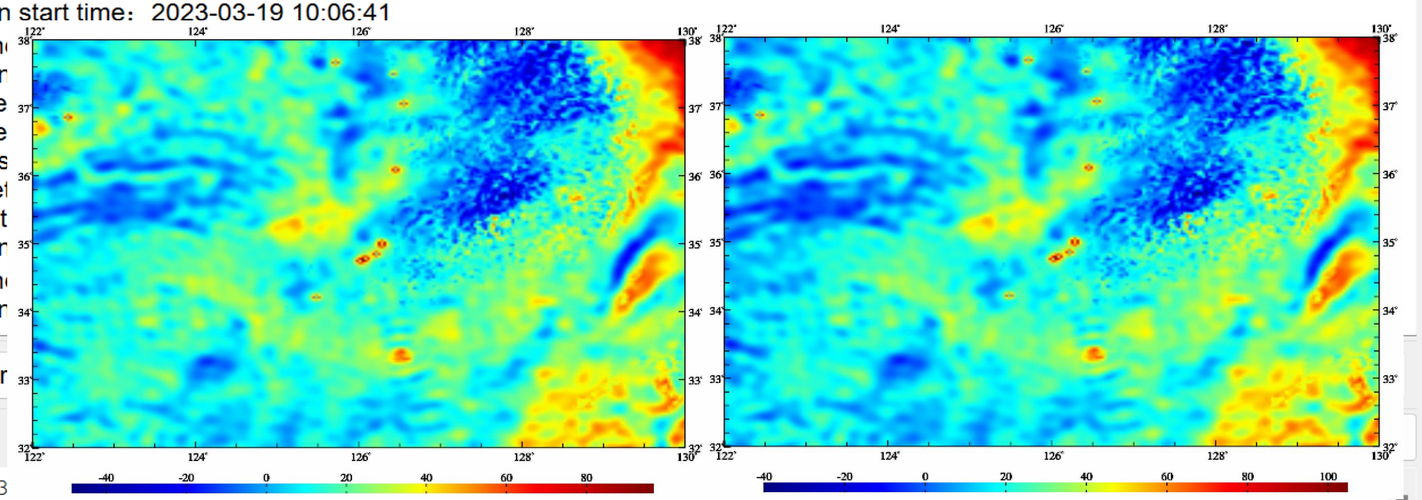
Set weight
The first weight 1.00
The second weight 1.00

Vector grid operation

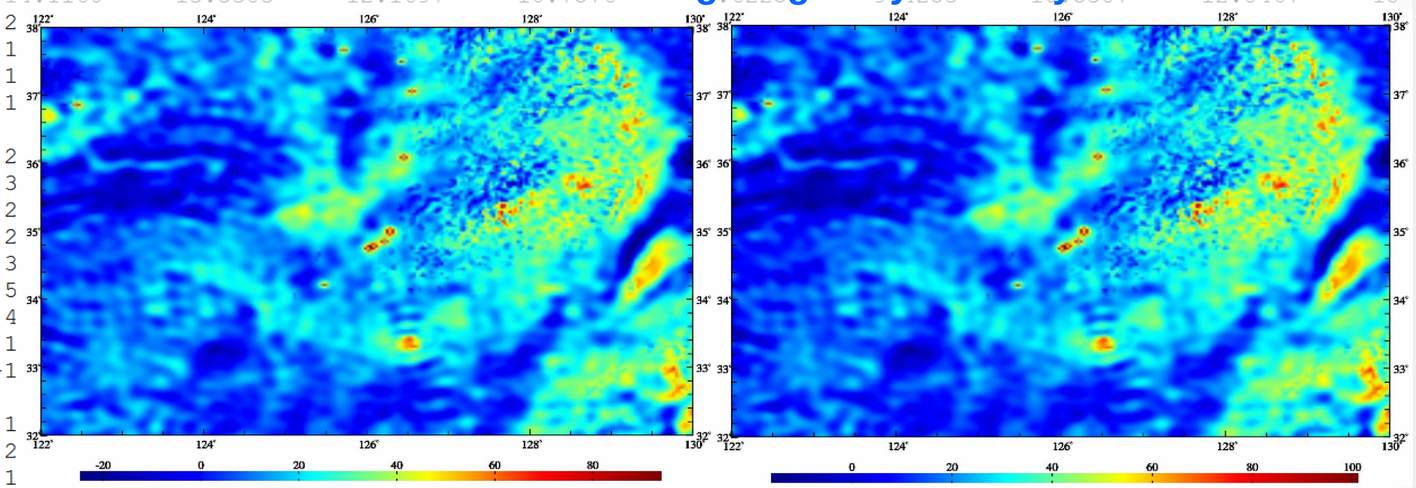
>> Program Process ** Operation Prompts

```
>> Select the function module from the four control buttons at the top of the interface...
>> [Function] Perform weighted plus, minus, or multiply operation on grid elements in two (vector) grid files with the same
>> Open geodetic grid file 1 C:/PAGravf4.5_win64en/examples/Terrainflexercise/GMBougEquilibrium/EGM2008_2m_1800.gra.
>> Open geodetic grid file 2 C:/PAGravf4.5_win64en/examples/Terrainflexercise/GMBougEquilibrium/BougEquinfl2m0.bgr.
>> Save the results as C:/PAGravf4.5_win64en/examples/Terrainflexercise/GMBougEquilibrium/Istbggravanom2m.dat.
>> The parameter settings have been entered into the system!
 ** Click the [Start Computation] control button, or the [Start Computation] tool button...
>> Computation start time：2023-03-19 10:06:41
>> Complete th
>> Computatior
>> Open geode
>> Open geode
>> Save the res
>> The paramet
 ** Click the [St
>> Computatior
>> Complete th
>> Computatior
```

Save the r



The 2′ land-sea unified classical Bouguer gravity anomaly and disturbance



The 2′ land-sea unified classical isostatic gravity anomaly and disturbance

Display of the input-output file↓

122.000000	130.000000	32.000000	38.000000	0.03
8.3775	6.8966	5.6899	4.8540	
19.2133	17.4019	15.8291	14.7983	
24.3218	26.4713	28.0518	28.6086	2
12.9158	10.3765	10.0539	11.7974	1
15.3356	13.0657	11.4755	11.0485	1
22.3411	22.1708	21.4036	20.3436	1
12.8327	12.3341	11.1957	10.0041	
22.0979	22.6739	23.1295	23.1236	2
23.9972	26.5997	28.6183	30.3440	3
27.7904	27.6035	26.8185	26.0919	2
36.7723	32.2543	27.9404	25.2177	2
23.0243	24.8093	26.4821	28.4630	3
60.4889	61.1129	60.1925	58.4199	5
52.1456	47.6924	45.4768	45.1435	4
9.4949	11.3991	12.7729	13.7259	1
0.4051	-4.5601	-10.9319	-16.3954	-1
14.7698	13.3947	11.4517	9.3666	
22.1548	20.7063	19.4075	18.5611	1
22.9153	25.1115	26.7739	27.3524	2
16.1274	12.9445	12.2021	13.7358	1
16.1741	13.6392	11.3091	9.8888	

Precise Approach of Earth Gravity Field and Geoid

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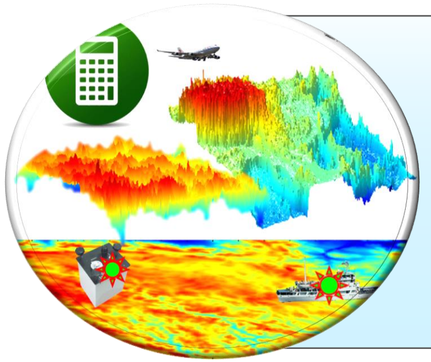
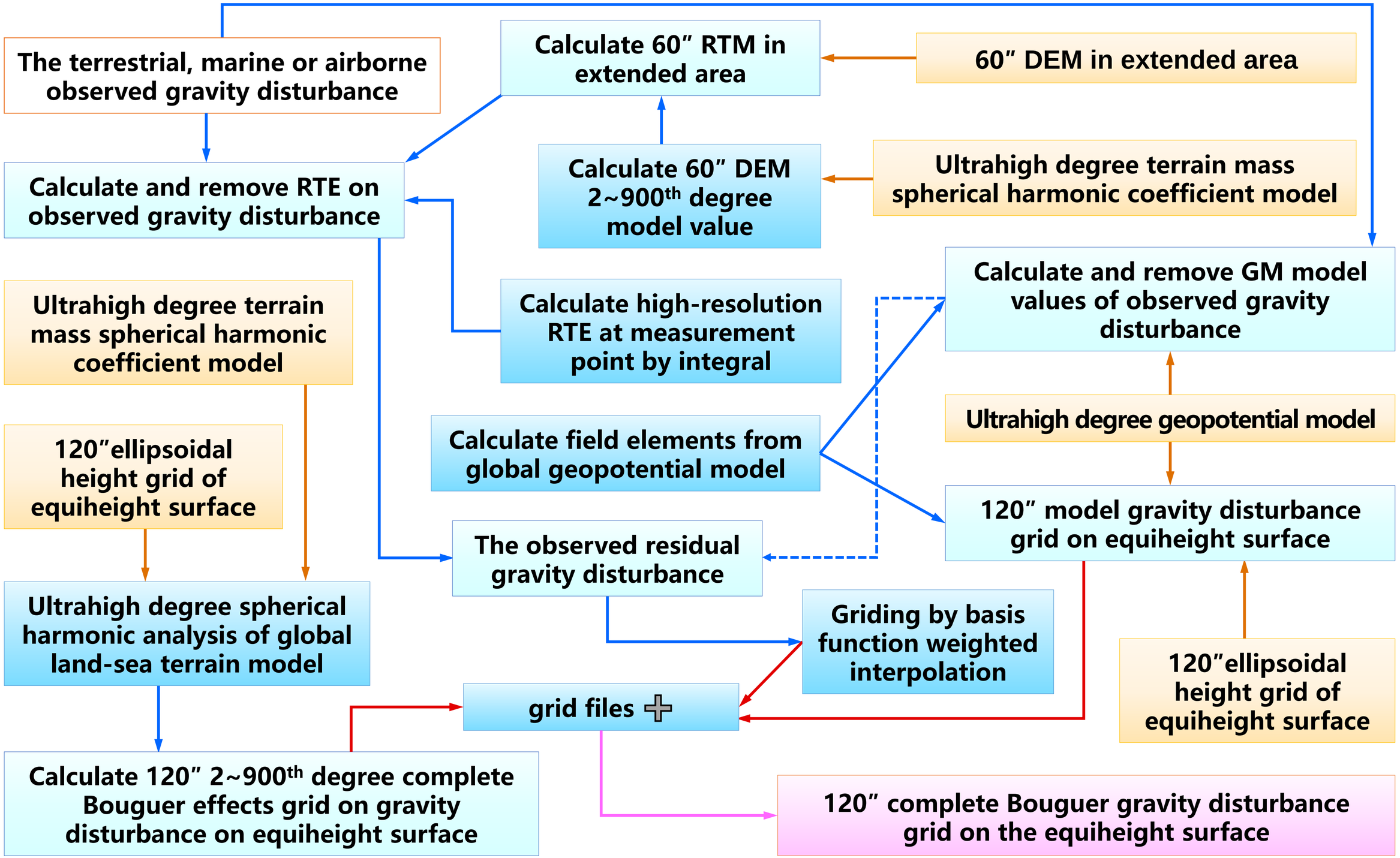
Seven steps of computation, global land-sea universal!

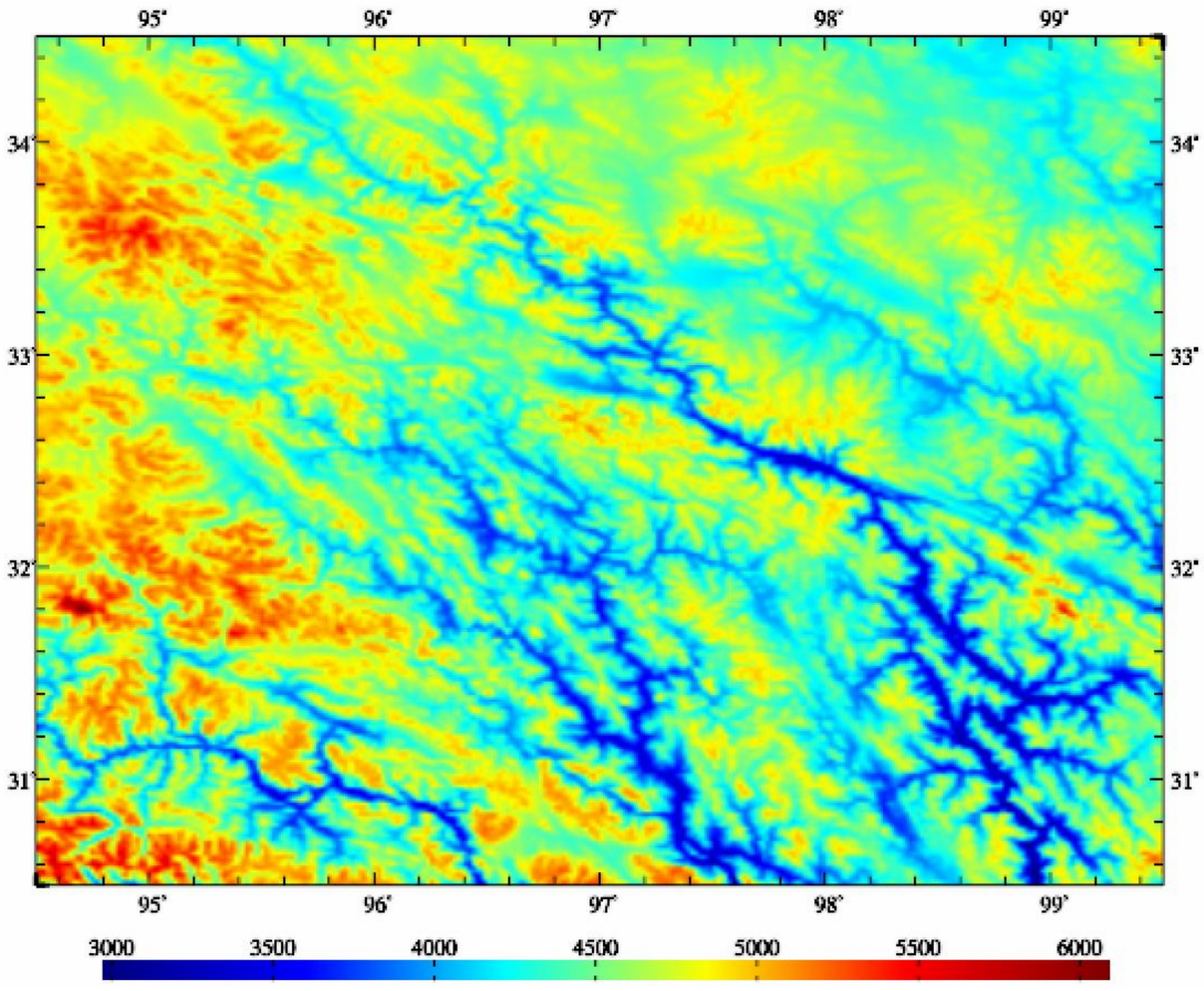


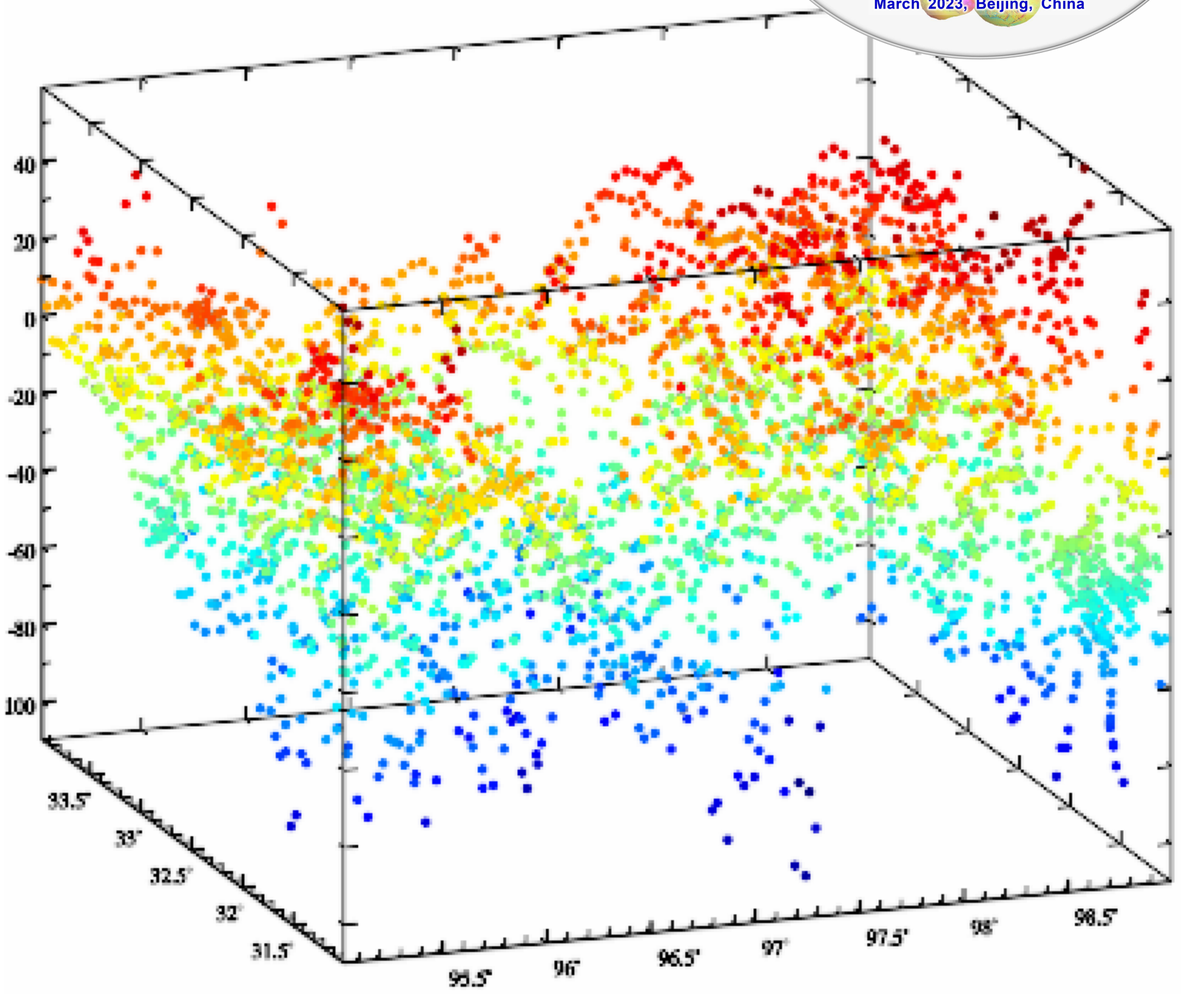
Computation process demo of complete Bouguer anomaly on terrain equiheight surface

- The remove - restore scheme combining with global terrain mass spherical harmonic coefficient model and residual terrain effect.
- The computation processes for compete Bouguer gravity anomaly **(disturbance, and gradient) and vertical deflection are** all exactly **the same !**



Computation process demo of complete Bouguer anomaly on terrain equiheight surface





Ground digital elevation model (m) and gravity measurement point distribution

Precise Approach of Earth Gravity Field and Geoid

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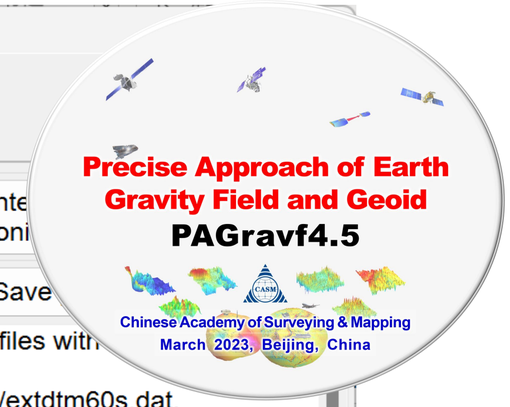
zcyphygeodesy.com/en/

Simple and direct calculation on geodetic data files

● Construct the ground ellipsoidal height grid and ellipsoidal height grid of the terrain equiheight surface.



Weighted operation on two specified attributes in record file | Weighted operation on two geodetic grid files | Weighted operation on two vector grid files | Weighte harmoni

Open geodetic grid file 1

Open geodetic grid file 2

Select operation mode

Plus +

Set weight

The first weight 1.00

The second weight 1.00

Vector grid operation

>> Program Process ** Operation Prompts

Save

```
>> [Function] Perform weighted plus, minus, or multiply operation on grid elements in two (vector) grid files with
specifications.
>> Open geodetic grid file 1 C:/PAGravf4.5_win64en/examples/Terraininflexercise/TerComplbgprocess/extdtm60s.dat.
>> Open geodetic grid file 2 C:/PAGravf4.5_win64en/examples/Terraininflexercise/TerComplbgprocess/EGM180ksi60s.dat.
>> Save the results as C:/PAGravf4.5_win64en/examples/Terraininflexercise/TerComplbgprocess/surfhgt60s.dat.
>> The parameter settings have been entered into the system!
  ** Click the [Start Computation] control button, or the [Start Computation] tool button...
>> Computation start time：2023-03-18 12:37:44
>> Complete the computation!
>> Computation end time: 2023-03-18 12:37:44
>> Open geodetic grid file 1 C:/PAGravf4.5_win64en/examples/Terraininflexercise/TerComplbgprocess/const339.5.dat.
>> Open geodetic grid file 2 C:/PAGravf4.5_win64en/examples/Terraininflexercise/TerComplbgprocess/EGM180ksi120s.dat.
>> Save the results as C:/PAGravf4.5_win64en/examples/Terraininflexercise/TerComplbgprocess/equihgt120s.dat.
>> The parameter settings have been entered into the system!
>> Click the [Start Computation] control button, or the [Start Computation] tool button...
>> Computation start time：2023-03-18 12:44:42
>> Complete the computation!
>> Computation end time: 2023-03-18 12:44:42
```

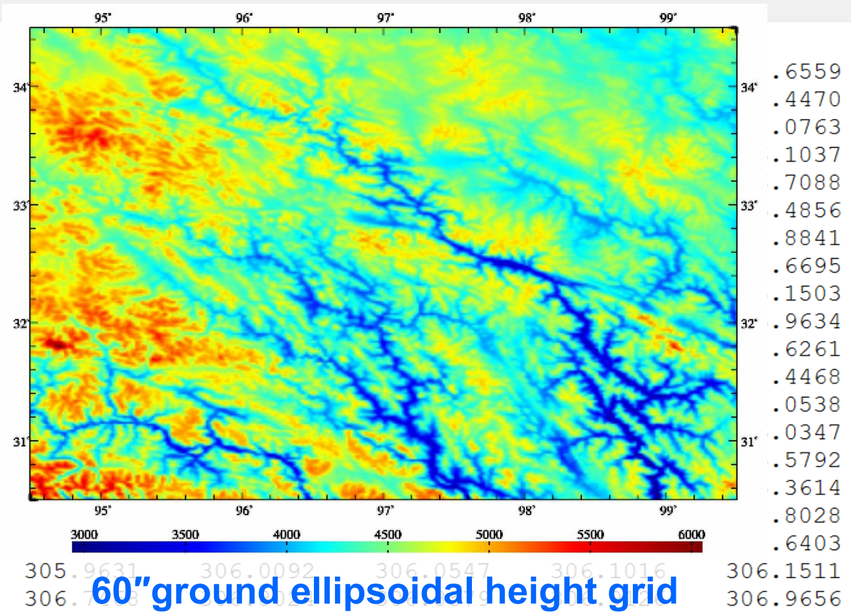
The ground ellipsoidal height grid is employed to give the space location of the terrain surface for the integral operation.

Save the results as | Import setting parameters | Start computation

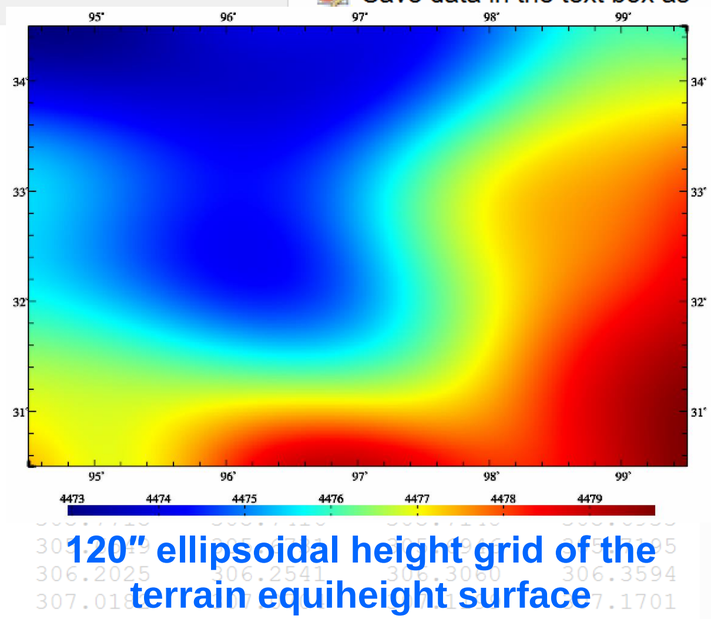
Display of the input-output file↓

Save data in the text box as

```
  94.500000   99.500000   30.500000
   304.9759    304.9250    304.8757
   304.4461    304.4353    304.4261
   304.6877    304.7340    304.7837
   305.6230    305.6941    305.7651
   306.5466    306.5795    306.6058
   306.6824    306.6657    306.6451
   306.1619    306.1215    306.0821
   305.6821    305.6697    305.6585
   305.8508    305.8859    305.9240
   306.5752    306.6304    306.6856
   304.9252    304.8780    304.8321
   304.4372    304.4266    304.4191
   304.6815    304.7264    304.7740
   305.5747    305.6442    305.7135
   306.4293    306.4679    306.4925
   306.5528    306.5377    306.5189
   306.0610    306.0205    305.9836
   305.6288    305.6193    305.6156
   305.8399    305.8782    305.9189
   306.5802    306.6355    306.6912
```



60″ground ellipsoidal height grid



120″ ellipsoidal height grid of the terrain equiheight surface

Spherical harmonic synthesis of complete Bouguer or residual terrain effects

(1) Calculate and remove the model terrain height value, and then construct 60″ residual terrain model (RTM) grids.

Follow example

Calculation of model value for complete Bouguer or residual terrain effects

Calculator of global land-sea terrain effects model

Calculation and analysi of global terrain effects

Open global land-sea terrain mass spherical harmonic coefficient model file

Select calculation file format

Ellipsoidal height grid file

Open ellipsoidal height grid file of calculation surface

Select elements to be calculated

- [x] terrain height/sea depth (m)
- [ ] height anomaly (m)
- [ ] gravity anomaly/disturbance (mGal)
- [ ] vertical deflection (", SW)
- [ ] disturbing gradient (E, radial)
- [ ] tangential gradient (E, NW)
- [ ] disturbing potential/geopotential (m²/s²)

Minimum degree 1

Maximum degree 900

Extract effects

Plot↓

>> Computation Process ** Operation Prompts

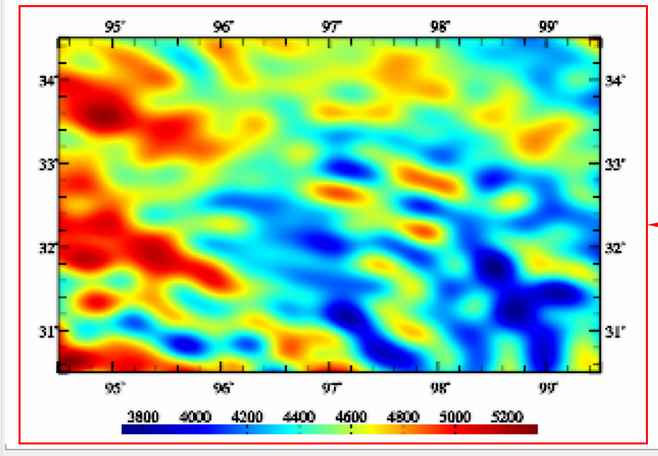
>> [Function] From global land-sea terrain mass spherical harmonic coefficient model (kg/m²), calculate the model value of
as well as the land-sea unified complete Bouguer or residual terrain effects on the height anomaly (m), gravity anomaly (mGal)
(mGal), vertical deflection vector (", south, west), disturbing gravity gradient (E, radial), tangential gravity gradient vector (E, north,
geopotential (m²/s²) on the geoid or in its outer space.
** Click the [Open global land-sea terrain mass spherical harmonic coefficient model file] control button, or the [Open terrain model] tool button...
>> Open global land-sea terrain mass spherical harmonic coefficient model file C:/PAGravf4.5_win64en/data/ETOPOcs1800.dat.
** The window below only shows the geopotential coefficients data with no more than 2000 rows in it.
>> Open ellipsoidal height grid file of calculation surface C:/PAGravf4.5_win64en/examples/Terraininflexercise/TerComplbgprocess/surfhgt60s.dat.
>> Save the results as C:/PAGravf4.5_win64en/examples/Terraininflexercise/TerComplbgprocess/mdldtm60s.txt.
** The record format: point no/name, longitude, latitude, ellipsoidal height, several columns of the model values of complete Bouguer or residual terrain effects.
** The program also outputs the model values grid file for the terrain height/sea depth (*.dtm) complete Bouguer or residual terrain effects on height anomaly (*.ksi), gravity anomaly (*.gra), gravity disturbance (*.rga), vertical deflection vector (*.dft), disturbing gravity gradient (*. grr), tangential gravity gradient vector (*.hgd) or disturbing geopotential (*.get) into the current directory, where * is the output file name entered from the interface.
>> The parameter settings have been entered into the system!
** Click the [Start Computation] control button, or the [Start Computation] tool button.

Save the results as

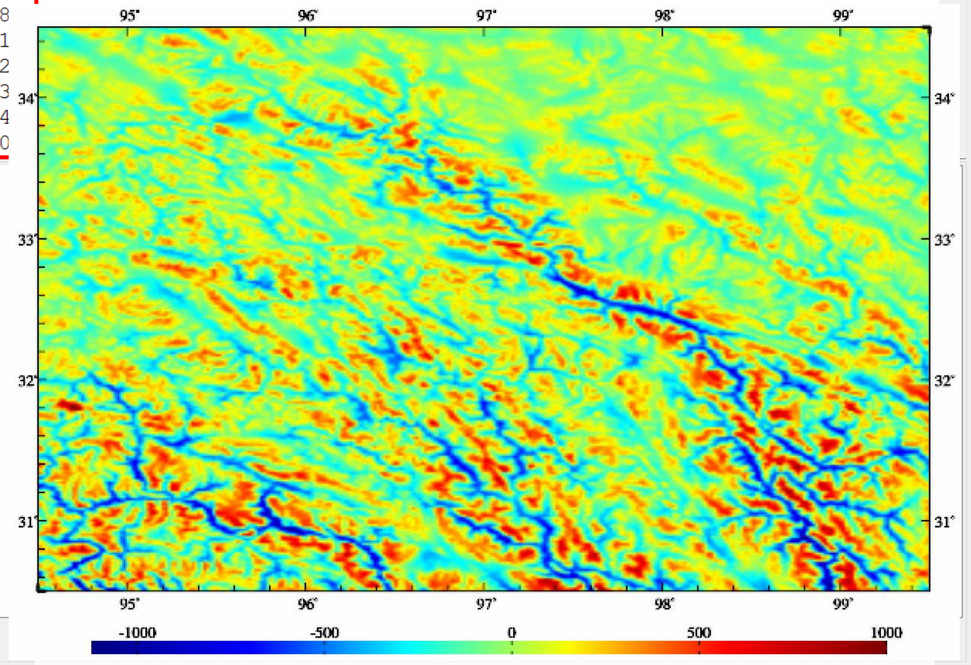
Import setting parameters

Start Computation

1	94.50833	30.50833	4370.696	4853.86
2	94.52500	30.50833	4510.612	4874.82
3	94.54167	30.50833	4743.215	4891.56
4	94.55833	30.50833	4685.708	4903.66
5	94.57500	30.50833	4496.684	4910.88
6	94.59167	30.50833	4619.551	4913.11
7	94.60833	30.50833	5004.403	4910.42
8	94.62500	30.50833	5464.643	4903.03
9	94.64167	30.50833	5530.371	4891.54
10	94.65833	30.50833	5336.237	4876.10



terrain height/sea depth (m)



gravity effect (mGal)

60″ residual terrain model (RTM) resdtm60s.dat

The program is suitable for the unified computation of the complete Bouguer and residual terrain effects on various g... point may be on the geoid and its outer Earth space.

Precise Approach of Earth Gravity Field and Geoid

PAGravf4.5

Chinese Academy of Surveying & Mapping

March 2023, Beijing, China

Calculation of global geopotential model and its spectral character analysis

(2) Calculate and remove the ultrahigh-degree model gravity disturbance at the observed points.

Save as | Start Computation | Follow example

Precise Approach of Earth Gravity Field and Geoid
PAGravf4.5
Chinese Academy of Surveying & Mapping
March 2023, Beijing, China

Calculation of gravity field elements from global geopotential model | Calculation of model value for residual terrain (complete Bouguer) effects | Global geopotential coefficient model Calculator | Calculation ar… character of E…

Open global geopotential coefficient model file

Select calculation file format

Discrete calculation point file

Open space calculation point location file

Set input point file format

Number of rows of file header: 1

Column ordinal number of ellipsoidal height in the record: 4

Select elements to be calculated

- [ ] height anomaly (m)
- [ ] gravity anomaly (mGal)
- [x] gravity disturbance (mGal)
- [ ] vertical deflection (", SW)
- [ ] disturbing gravity gradient (E, radial)
- [ ] tangential gravity gradient (E, NW)
- [ ] Laplace operator (E)

Minimum degree: 2

Maximum degree: 720

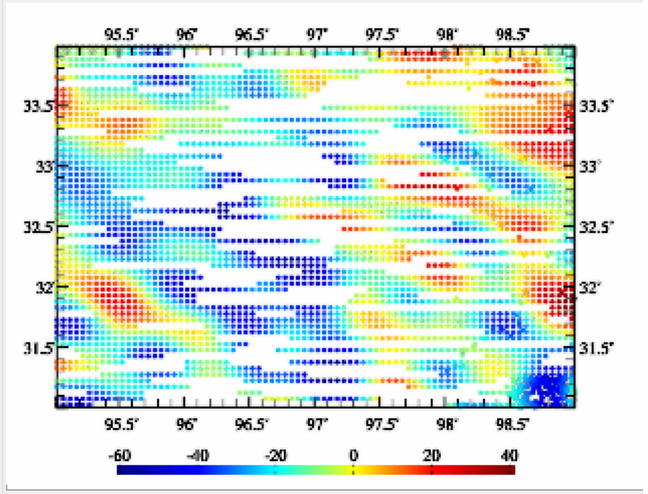
Extract elements to be plot | Plot↓

Save computation process as | Al…

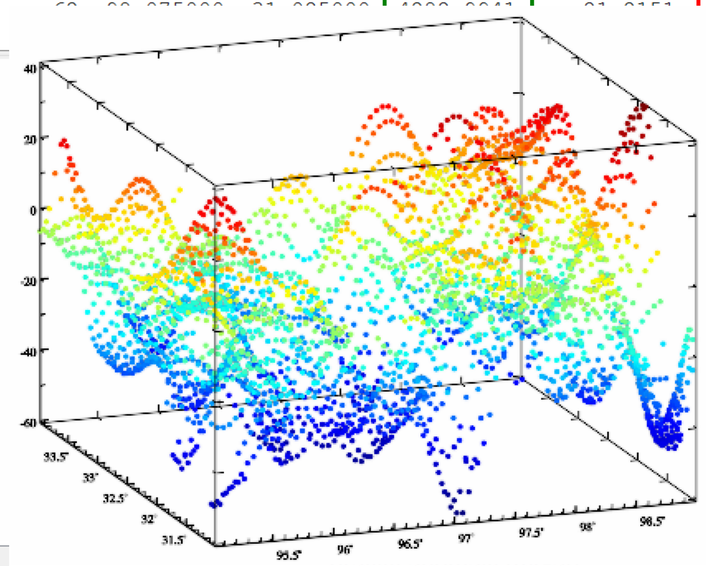
```
  ** Click the [Open global geopotential coefficient model file] control button, or the [Open geopotential model] tool bu…
>> Open global geopotential coefficient model file C:/PAGravf4.5_win64en/data/EGM2008.gfc.
  ** The window below only shows the geopotential coefficients data with no more than 2000 rows in it.
>> Open space calculation point location file C:/PAGravf4.5_win64en/examples/Terraininflexercise/TerComplbgprocess/obsgrav.txt.
  ** Look at the file information in the window below and set the discrete point file format...
>> Save the results as C:/PAGravf4.5_win64en/examples/Terraininflexercise/TerComplbgprocess/Obsgravmdl.txt.
  ** Behind the record of the calculation point file, appends one or more columns of model values of anomalous field elements, and keeps 4 significant figures.
>> The parameter settings have been entered into the system!
  ** Click the [Start Computation] control button, or the [Start Computation] tool button...
  ** The calculation process need wait, during which you can open the output file to look at the calculation progress...
>> Computation start time：2023-03-18 13:24:55
>> Complete the calculation of the model value of (residual) gravity field element!
>> Computation end time: 2023-03-18 13:27:24
```

Save the results as | Import setting parameters | Start Computation

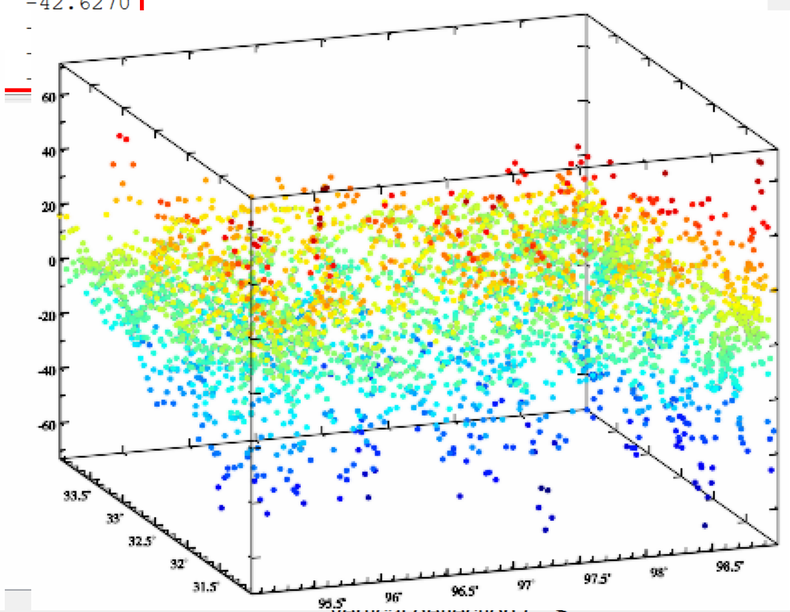
no	lon(degree decimal)	lat	ellipHgt(m)	rga(mGal)	
1	95.025000	31.025000	4593.2264	-27.6576	-49.5225
2	95.075000	31.025000	4224.9678	-22.1858	-49.1208
3	95.125000	31.025000	4587.8601	-17.4344	-46.0653
4	95.175000	31.025000	4537.8310	-19.4157	-44.5180
5	95.225000	31.025000	4385.2290	-21.9257	-43.5038
6	95.275000	31.025000	4282.1950	-17.7709	-42.6270
61	98.025000	31.025000	4409.0269	-3.5995	-



gravity disturbance (mGal)



The model gravity disturbances at the observed points (mGal)



The residual gravity disturbances at the observed points (mGal)

When the minimum and maximum degree n to be set is equal, the program calculates the contribution of the degree n geopotential coefficients to the anomalous gravity field element, which can be employed to analyze and evaluate the spectral and space properties of the geopotential coefficients.

Computation of residual terrain effect on various field elements outside geoid

(3) Calculate and remove the residual terrain effects on the gravity disturbance at the observed points.

Follow example

Numerical integral of land-sea residual terrain effects on various gravity field elements

FFT algorithm of land-sea residual terrain effects on various gravity field elements

Calculator of land terrain effect or c

Open high-resolution land-sea terrain model file

Open the land-sea low-pass terrain model file

Open the ellipsoidal height grid file of the land-sea surface

Select calculation point file format

discrete calculation points file

Open the calculation point position file

Set input point file format

Number of rows of file header 1

Column ordinal number of ellipsoidal height in the record 4

Select gravity field elements

- [ ] height anomaly (m)
- [ ] gravity anomaly (mGal)
- [x] gravity disturbance (mGal)
- [ ] vertical deflection (", SW)
- [ ] disturbing gravity gradient (E, radial)

Integral radius 90 km

Extract effects

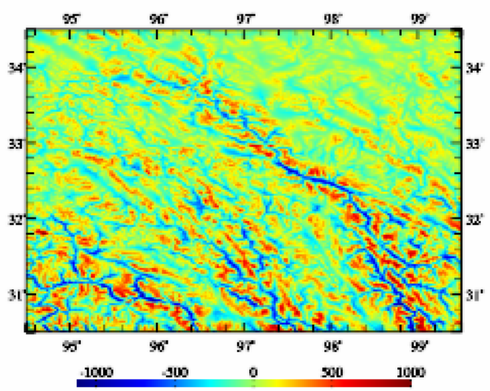
Plot↓

>> Computation Process ** Operation Prompts

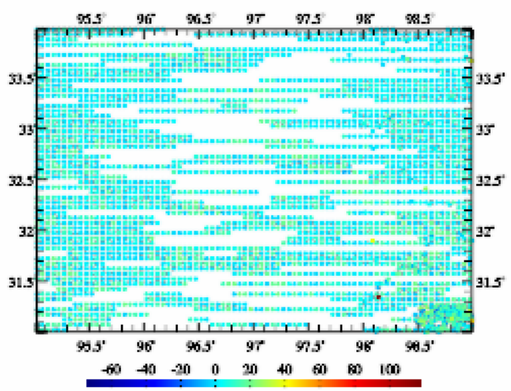
** The program subtracts the land-sea high-resolution terrain model and land-sea low-pass terrain model with the same grid
the land-sea residual terrain model (RTM) grid, while the land-sea high-resolution terrain model is also used to separate land a
finite radius integral cannot deal with terrain zero-degree term, the program removes the average of the residual terrain model (RT
>> Open the high-resolution land-sea terrain model file C:/PAGravf4.5_win64en/examples/Terraininflexercise/TerComplbgprocess/extdtm
>> Open the land-sea low-pass terrain model file C:/PAGravf4.5_win64en/examples/Terraininflexercise/TerComplbgprocess/mdldtm60s.dtm.
>> Open the ellipsoidal height grid file of the land-sea surface C:/PAGravf4.5_win64en/examples/Terraininflexercise/TerComplbgprocess/surfhgt60s.dat.
>> Open the calculation point location file C:/PAGravf4.5_win64en/examples/Terraininflexercise/TerComplbgprocess/Obsgravmdlresd.txt.
** Look at the file information in the window below, set the input file format parameters...
>> Save the results as C:/PAGravf4.5_win64en/examples/Terraininflexercise/TerComplbgprocess/Obsgravresdtm.txt.
** Record format: Behind the source calculation points file record, appends several columns of residual terrain effects on specified types of field elements, keeps 4 significant figures.
>> The parameter settings have been entered into the system!
** Click the [Start Computation] control button, or the [Start Computation] tool button...
>> Computation start time：2023-03-18 16:18:50

Save the results as | Import setting parameters | Start Computation

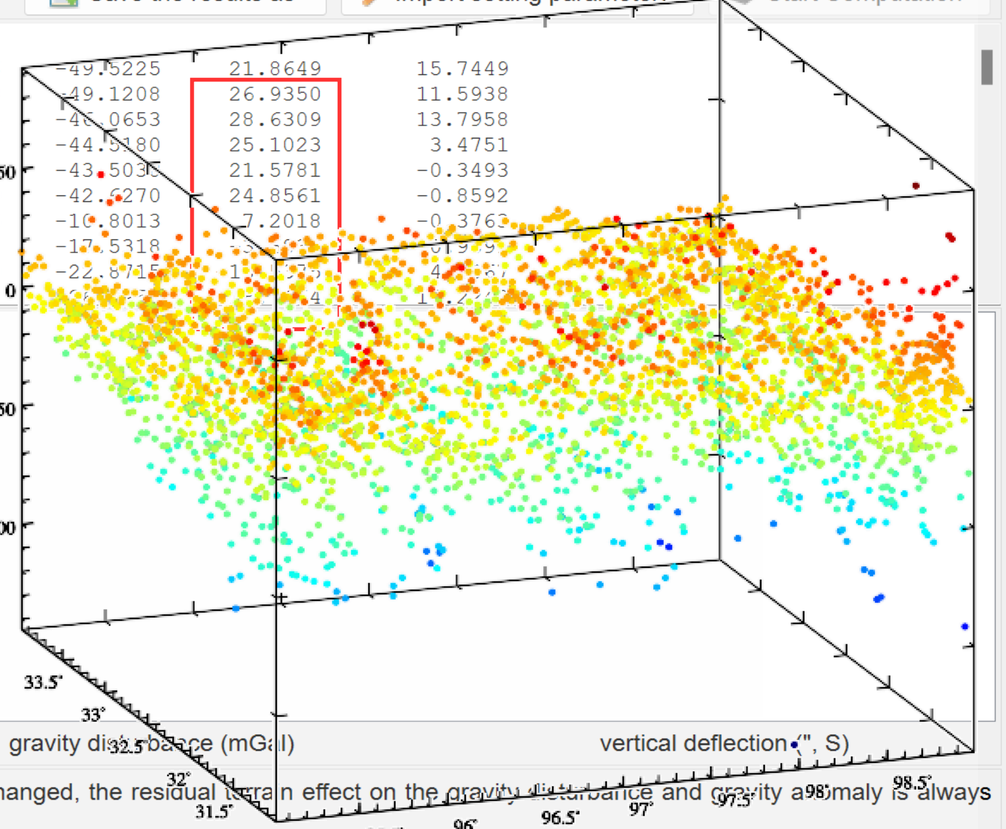
no	lon(degree decimal)	lat	elliphgt(m)	rga(mGal)			
1	95.025000	31.025000	4593.2264	-27.6576	-49.5225	21.8649	15.7449
2	95.075000	31.025000	4224.9678	-22.1858	-49.1208	26.9350	11.5938
3	95.125000	31.025000	4587.8601	-17.4344	-48.0653	28.6309	13.7958
4	95.175000	31.025000	4537.8310	-19.4157	-44.5180	25.1023	3.4751
5	95.225000	31.025000	4385.2290	-21.9257	-43.5038	21.5781	-0.3493
6	95.275000	31.025000	4282.1950	-17.7709	-42.6270	24.8561	-0.8592
61	98.025000	31.025000	4409.0269	-3.5995	-10.8013	7.2018	-0.3763
62	98.075000	31.025000	4282.9941	-21.2151	-17.5318	[illegible]	[illegible]
63	98.125000	31.025000	4129.0804	-36.4090	-22.8715	[illegible]	[illegible]
64	98.175000	31.025000	3972.1226	-45.0622	[illegible]	[illegible]	[illegible]



residual terrain model (m)



gravity disturbance (mGal)

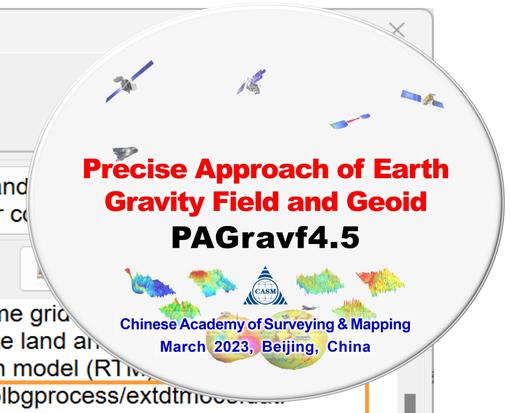


gravity disturbance (mGal) vertical deflection (", S)

The remaining residual gravity disturbance (mGal)

The calculation point may be on the geoid and its outer near-Earth space. Since the normal gravity field keeps unchanged, the residual terrain effect on the gravity disturbance and gravity anomaly is always equal to the residual terrain effect on gravity.

The program subtracts the land-sea high-resolution terrain model and land-sea low-pass terrain model with the same grid specifications to generate the land-sea residual terrain model (RTM) grid, while the land-sea high-resolution terrain model is also employed to separate land and sea areas.



Gross error detection and basis function gridding of discrete field elements

(4) Griding on the remaining residual gravity disturbance into 120″×120″ grids on the terrain equiheight surface.

Save process Follow example

Gross error detection on observations based on low-pass reference surface

Estimation of observation weight with specified reference attribute

Gridding of heterogeneous data by basis function weighted interpolation

The discrete geodetic observation file

Number of rows of file header 1

Column ordinal number of the attribute to be grid 9

Select the basis function

Gauss function Equal weight

Save computation process as

```
>> Select the computation function from the three control buttons at the top of the interface...
>> [Function] According to the given grid specifications (grid range and spatial resolution), and specified basis function, grid the specified attribute in the input discrete geodetic point file by the weighted basis function interpolation method.
>> Open the discrete geodetic file C:/PAGravf4.5_win64en/examples/Terraininflexercise/TerComplbgprocess/Obsgravresidual.txt.
  ** Look at the file information in the window below and set the discrete point file format...
>> Save the results as C:/PAGravf4.5_win64en/examples/Terraininflexercise/TerComplbgprocess/distgravresidual.dat.
>> The parameter settings have been entered into the system!
  ** Click the [Start Computation] control button, or the [Start Computation] tool button...
>> Computation start time：2023-03-18 16:43:27
>> Complete computation!
>> Computation end time: 2023-03-18 16:43:32
```

Save the results as

Import setting parameters

Start Computation

Set parameters

Number of neighboring points 50

Kurtosis of basis function [1,20] 2

Grid specification

maxLat 34.000°

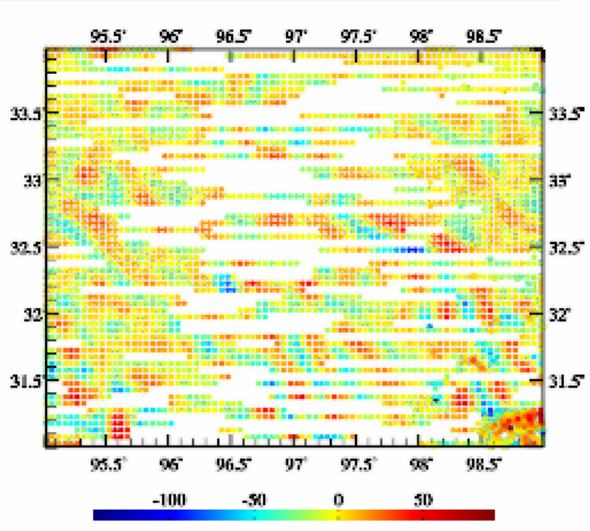
minLon 95.000° resolution 2.000′ maxLon 99.000°

minLat 31.000°

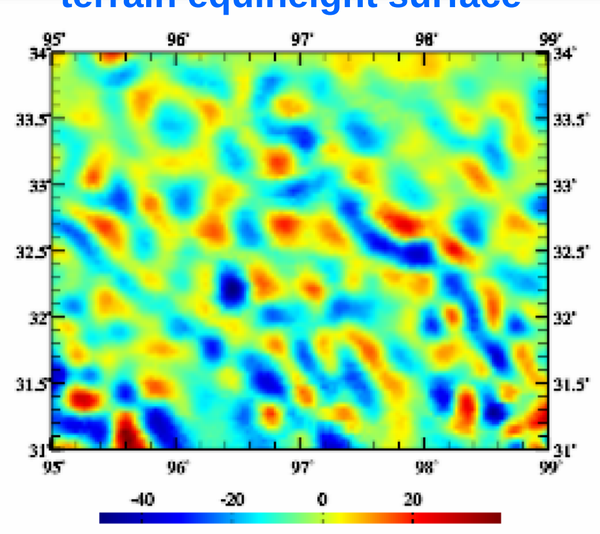
95.000000	99.000000	31.000000	34.000000	0.03333333	0.0
5.4912	8.7346	10.0258	9.1047	9.9525	
7.6809	14.2793	21.6982	28.5658	33.5367	
-31.0776	-29.7887	-24.5498	-22.4716	-17.8027	
-11.7546	-15.4609	-17.2719	-18.3561	-20.0680	
-2.3418	-5.2626	-8.2132	-16.2106	-22.0369	
-12.0456	-7.3175	-6.0417	-3.5252	-2.4801	
-9.2724	-11.8917	-11.3700	-11.1539	-16.4457	
-10.2183	-7.1565	-7.2403	-8.4751	-13.4060	
1.0154	5.4660	6.6695	8.5389	9.7455	
4.0836	16.2977	27.4113	35.9807	36.5720	
-31.4164	-28.5338	-22.7653	-20.4875	-17.8144	
-12.4799	-13.7954	-17.4646	-19.9317	-19.4601	
-3.7885	-1.9273	-5.5496	-10.5246	-20.7430	
-10.8099	-7.2387	-3.9721	-3.4047	-0.9118	
				7	-14.5682
				8	-9.7660
				5	-3.8726
				6	39.0230
				8	-15.0054
				4	-19.2414

Omit the analytical continuation process for the remaining residual gravity disturbance here.

Extract plot data Plot



Source observations input

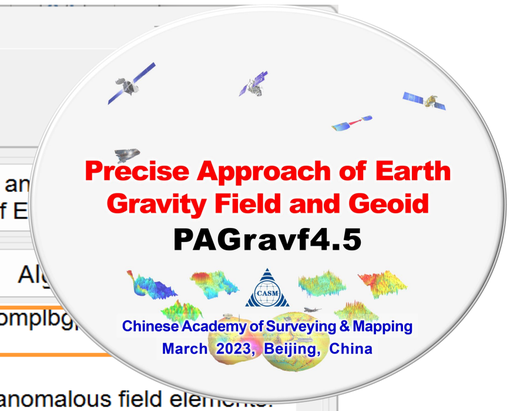


Griding results

120″ remaining residual gravity disturbance grid (mGal) on the terrain equiheight surface

Calculation of global geopotential model and its spectral character analysis

(5) Calculate the 120″ EGM2008 2~720th degree model value grid of the gravity disturbance on the terrain equiheight surface.



Calculation of gravity field elements from global geopotential model | Calculation of model value for residual terrain (complete Bouguer) effects | Global geopotential coefficient model Calculator | Calculation an character of E

Open global geopotential coefficient model file

Select calculation file format

Ellipsoidal height grid file

Open ellipsoidal height grid file of calculation surface

Select elements to be calculated

- [ ] height anomaly (m)
- [ ] gravity anomaly (mGal)
- [x] gravity disturbance (mGal)
- [ ] vertical deflection (", SW)
- [ ] disturbing gravity gradient (E, radial)
- [ ] tangential gravity gradient (E, NW)
- [ ] Laplace operator (E)

Minimum degree 2

Maximum degree 720

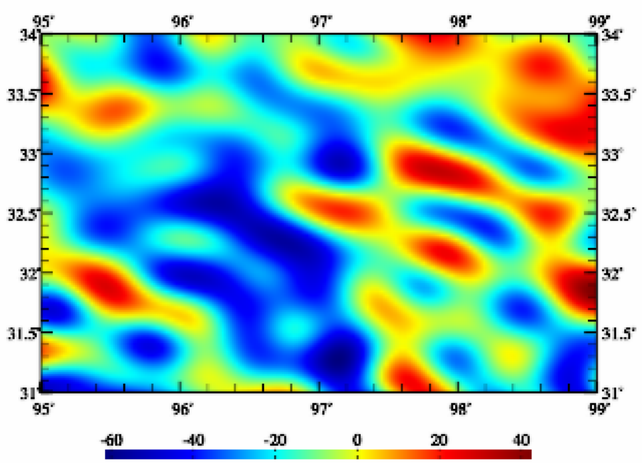
Extract elements to be plot | Plot↓

Save computation process as | Al

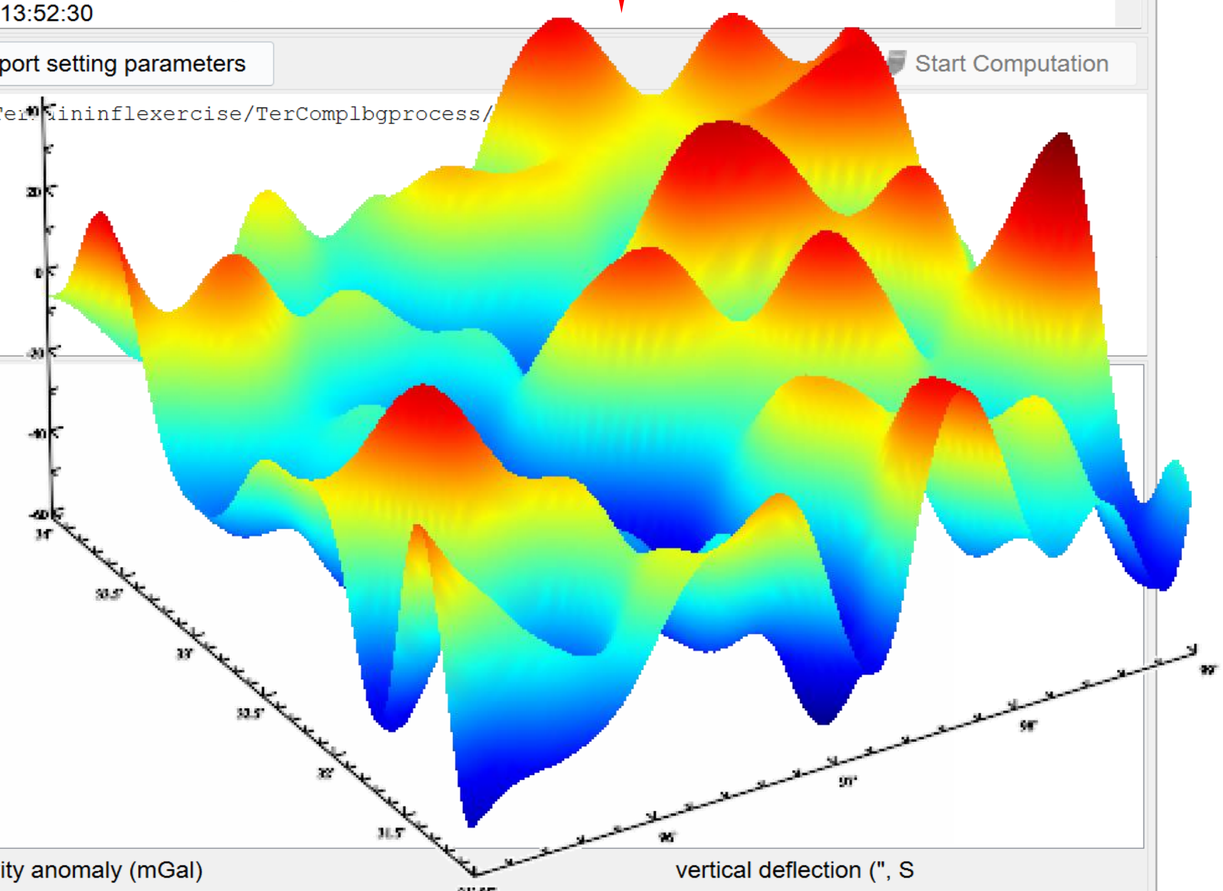
```
>> Open ellipsoidal height grid file of calculation surface C:/PAGravf4.5_win64en/examples/Terraininflexercise/TerComplbg/
equihgt120s1.dat.
>> Save the results as C:/PAGravf4.5_win64en/examples/Terraininflexercise/TerComplbgprocess/distgravmdl.txt.
  ** The record format: point no/name, longitude, latitude, ellipsoidal height, several columns of the model values of anomalous field elements.
  ** The program also outputs (residual) height anomaly (*.ksi), gravity anomaly (*.gra), gravity disturbance (*.rga), vertical deflection vector
(*.dft), disturbing gravity gradient (*. grr), tangential gravity gradient vector (*.hgd) or Laplace operator (*.lps) model value grid file into the
current directory. Where * is the output file name entered in the interface, and the program outputs the corresponding (residual) model value
grid file according to the selected gravity field element type.
>> The parameter settings have been entered into the system!
  ** Click the [Start Computation] control button, or the [Start Computation] tool button...
  ** The calculation process need wait, during which you can open the output file to look at the calculation progress...
>> Computation start time：2023-03-18 13:48:20
>> Complete the calculation of the model value of (residual) gravity field element!
>> Computation end time: 2023-03-18 13:52:30
```

Save the results as | Import setting parameters | Start Computation

C:/PAGravf4.5_win64en/examples/Terraininflexercise/TerComplbgprocess/



gravity disturbance (mGal)



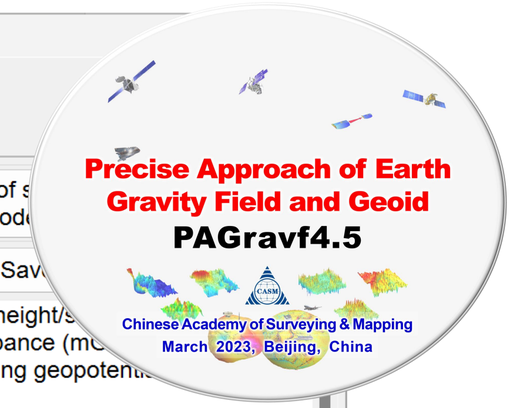
gravity anomaly (mGal)

vertical deflection (", S

When the minimum and maximum degree n to be set is equal, the program calculates the contribution of the degree n geopotential coefficients to the anomalous gravity field element, which can be employed to analyze and evaluate the spectral and space properties of the geopotential coefficient model.

Spherical harmonic synthesis of complete Bouguer or residual terrain effects

(6) Calculate the 120″ model complete Bouguer effect grid on the gravity disturbance on the terrain equiheight surface.



Calculation of model value for complete Bouguer or residual terrain effects

Calculator of global land-sea terrain effects model

Calculation and analysis of s of global terrain effects mod

Open global land-sea terrain mass spherical harmonic coefficient model file

Select calculation file format

Ellipsoidal height grid file

Open ellipsoidal height grid file of calculation surface

Select elements to be calculated

- [ ] terrain height/sea depth (m)
- [ ] height anomaly (m)
- [x] gravity anomaly/disturbance (mGal)
- [ ] vertical deflection (", SW)
- [ ] disturbing gradient (E, radial)
- [ ] tangential gradient (E, NW)
- [ ] disturbing potential/geopotential (m²/s²)

Minimum degree 2

Maximum degree 900

>> Computation Process ** Operation Prompts

Sav

>> [Function] From global land-sea terrain mass spherical harmonic coefficient model (kg/m²), calculate the model value of terrain height/s the land-sea unified complete Bouguer or residual terrain effects on the height anomaly (m), gravity anomaly (mGal), gravity disturbance (mG deflection vector (", south, west), disturbing gravity gradient (E, radial), tangential gravity gradient vector (E, north, west), or disturbing geopotenti the geoid or in its outer space.

** Click the [Open global land-sea terrain mass spherical harmonic coefficient model file] control button, or the [Open terrain model] tool button...

>> Open global land-sea terrain mass spherical harmonic coefficient model file C:/PAGravf4.5_win64en/data/ETOPOcs1800.dat.

** The window below only shows the geopotential coefficients data with no more than 2000 rows in it.

>> Open ellipsoidal height grid file of calculation surface C:/PAGravf4.5_win64en/examples/Terraininflexercise/TerComplbgprocess/equihgt120s1.dat.

>> Save the results as C:/PAGravf4.5_win64en/examples/Terraininflexercise/TerComplbgprocess/distgravmdlcmpbg.txt.

** The record format: point no/name, longitude, latitude, ellipsoidal height, several columns of the model values of complete Bouguer or residual terrain effects.

** The program also outputs the model values grid file for complete Bouguer or residual terrain effects on height anomaly (*.ksi), gravity anomaly (*.gra), gravity disturbance (*.rga), vertical deflection vector (*.dft), disturbing gravity gradient (*. grr), tangential gravity gradient vector (*.hgd) or disturbing geopotential (*.get) into the current directory, where * is the output file name entered from the interface.

>> The parameter settings have been entered into the system!

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

** The calculation process need wait, during which you can open the output file to look at the calculation progress

Save the results as

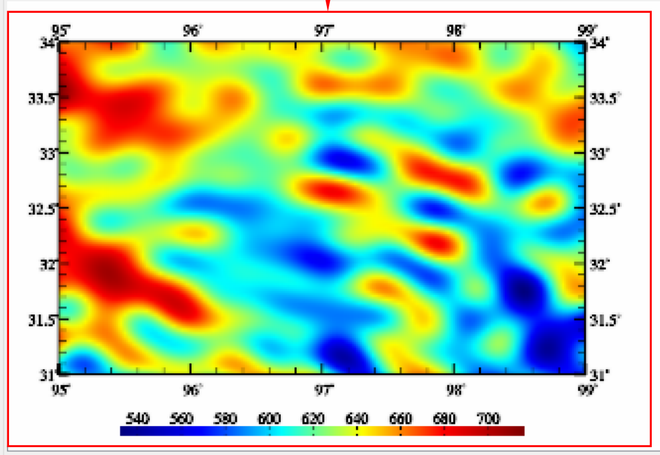
Import setting parameters

Start Computation

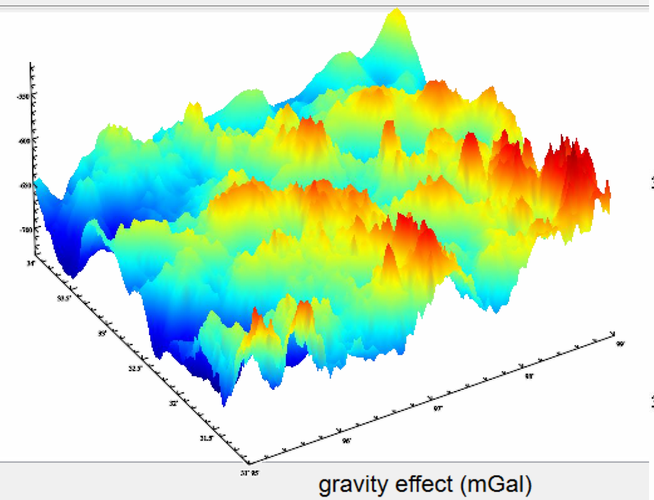
95.000000	99.000000	31.000000	34.000000	0.033333333	31.033333				
4476.8360	4476.8348	4476.8365				4476.8522	4476.8577	4476.8643	4476.8
4476.9302	4476.9403	4476.9518	4476.9660	4476.9835	4476.9976	4477.0134	4477.0306	4477.0509	4477.0745	4477.0
4477.1683	4477.1826	4477.2002	4477.2126	4477.22					
4477.3383	4477.3369	4477.3402	4477.3426	4477.34					
4477.3162	4477.3113	4477.3065	4477.3017	4477.29					
4477.2949	4477.3014	4477.3107	4477.3215	4477.33					
4477.5921	4477.6261	4477.6627	4477.7016	4477.74					
4478.2944	4478.3510	4478.4090	4478.4673	4478.52					

Extract effects

Plot↓

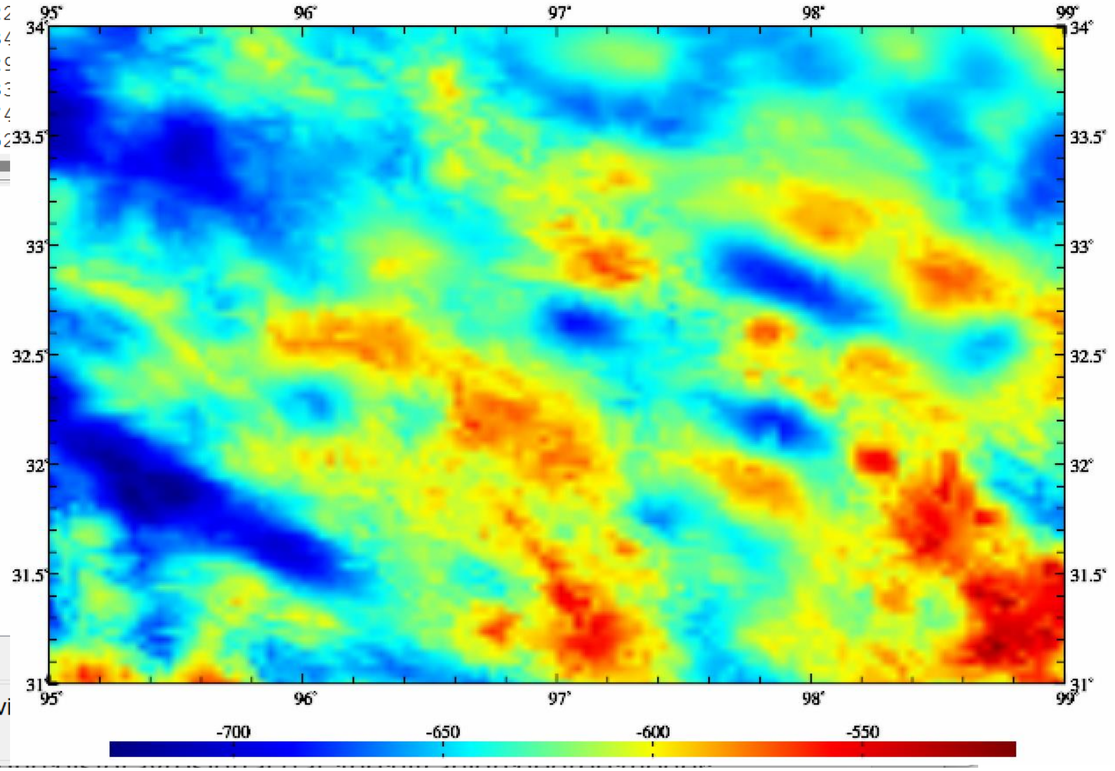


gravity effect (mGal)



gravity effect (mGal)

(7) Generate the 120″ complete Bouguer gravity disturbance on the terrain equiheight surface.



The program is suitable for the unified computation of the complete Bouguer and residual terrain effects on various gravi the geoid and its outer Earth space.

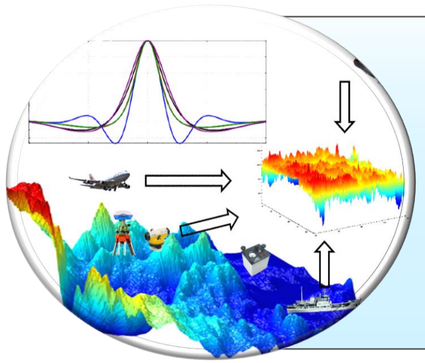
Precise Approach of Earth Gravity Field and Geoid

PAGravf4.5

Chinese Academy of Surveying & Mapping

March 2023, Beijing, China

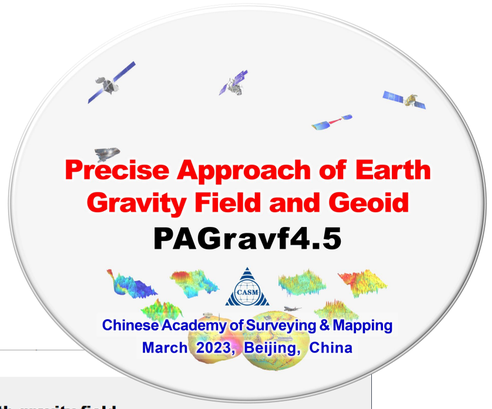
The analytic relations of gravity field as strong constraints

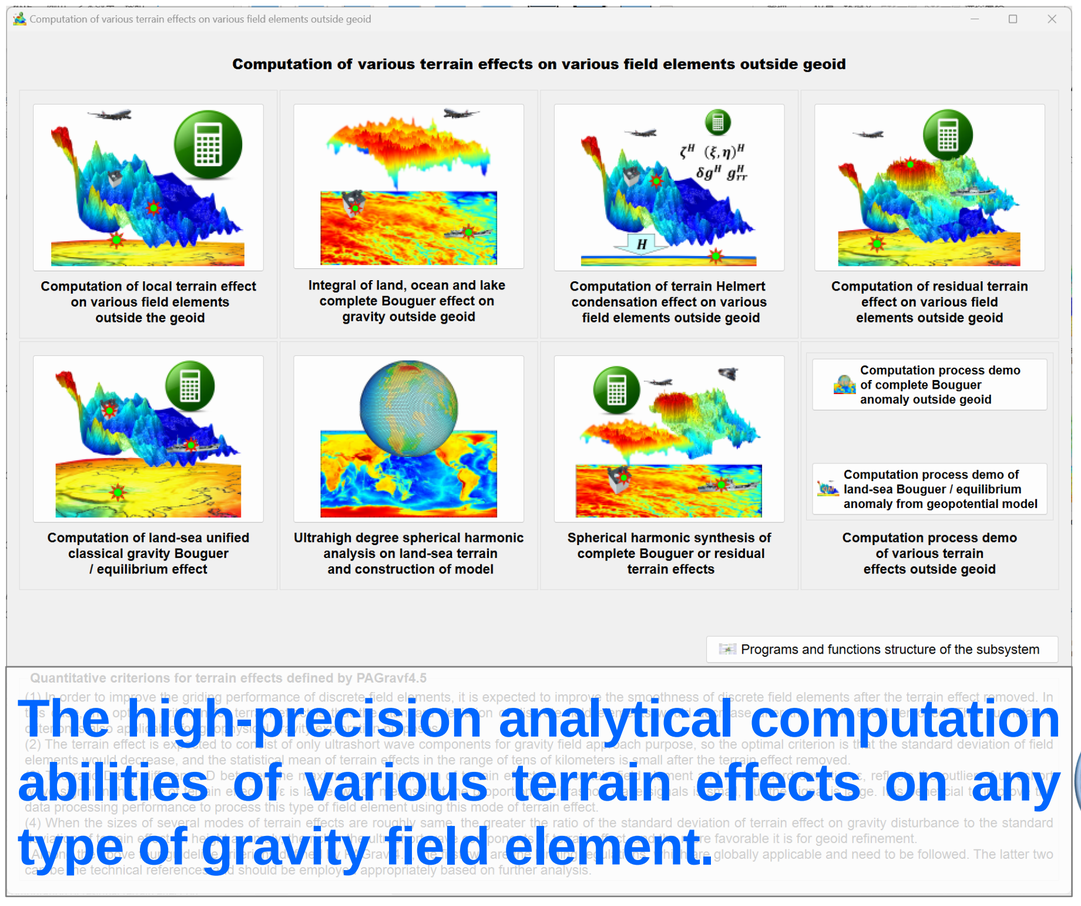


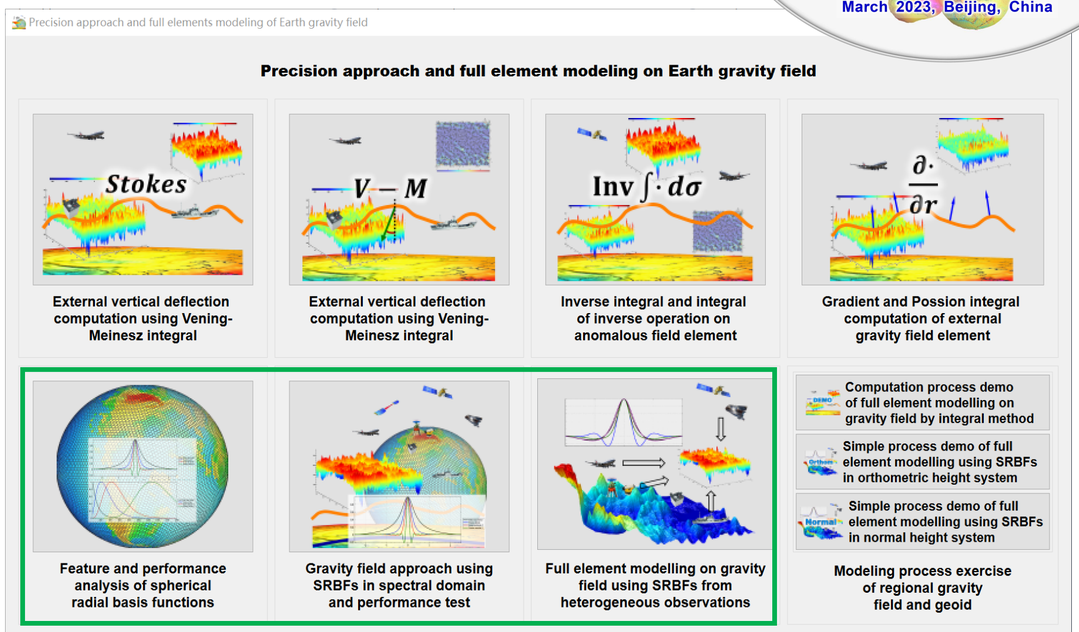
Computation scheme of gravity prospecting by analytic fusion of heterogeneous observations

- **Observation mode:** Terrestrial, marine, aviation, altimeter and satellite.
- **Observations:** Gravity, gravity gradient, vertical defection, and GNSS-leveling etc.
- **Target type:** Gravity anomaly, gravity gradient, and vertical defection etc.

Computation theory of gravity prospecting by analytic fusion of heterogeneous observations by PAGravf4.5







The high-precision analytical computation abilities of various terrain effects on any type of gravity field element.

The full-element analytic modelling functions on gravity field from various heterogeneous observations.

The computation of fine gravity prospecting that can deeply fuse all the gravity field information in multi-source heterogeneous observations in any complex cases with the analytic relations of gravity field as strong constraints.

The general computation process for the fine gravity prospecting model from heterogeneous observations by PAGravf4.5

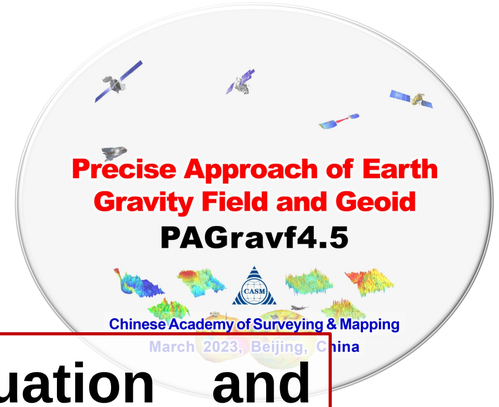
☆ Select the calculation area, target calculation surface (terrain equiheight surface is recommended here) for gravity exploration and obtain (or collect) all the gravity field and geodetic observations as much as possible.

☆ Call the related programs in the subsystem [Precision approach and full element modelling on Earth gravity field] to determine the high-resolution grid of gravity field element corresponding to the target prospecting model on the calculation surface.

☆ Call the related programs in the subsystem [Computation of various terrain effects on various field elements outside geoid] to determine the terrain effect grid on gravity field element corresponding to the target prospecting model on the calculation surface.

☆ By subtracting the terrain effect grid from the gravity field element grid directly, you can obtain the target gravity prospecting model which have deeply fuse all the gravity field information in heterogeneous observations.

Solve a series of bottleneck problems to achieve a comprehensive technical breakthrough



No derect reduction and continuation → **Control signal attenuation and algorithm inaccurate**

No non-analytical gridding required → **Solve the problems for gravity field distortion and terrain effect difficult to control**

One step of direct and analytical modeling from various heterogene-ous observations → **Achieve the major breakthrough in gravity exploration from single type of observation to multi-source heterogeneous observations.**

Analytically fuse all the gravity field signal in in any complex cases

The full-element analytical modeling of gravity prospecting such as compete Bouguer gravity gradient and vertical deflection etc. → **Significantly improve the fine characteristics detection of gravity field for gravity exploration.**

👇Theoretical basis and support technology👇

External terrain effect +
Approach of gravity field

More innovation and application potential need to be discovered and excavated in the future computing practice !

zcyphygeodesy.com/en/