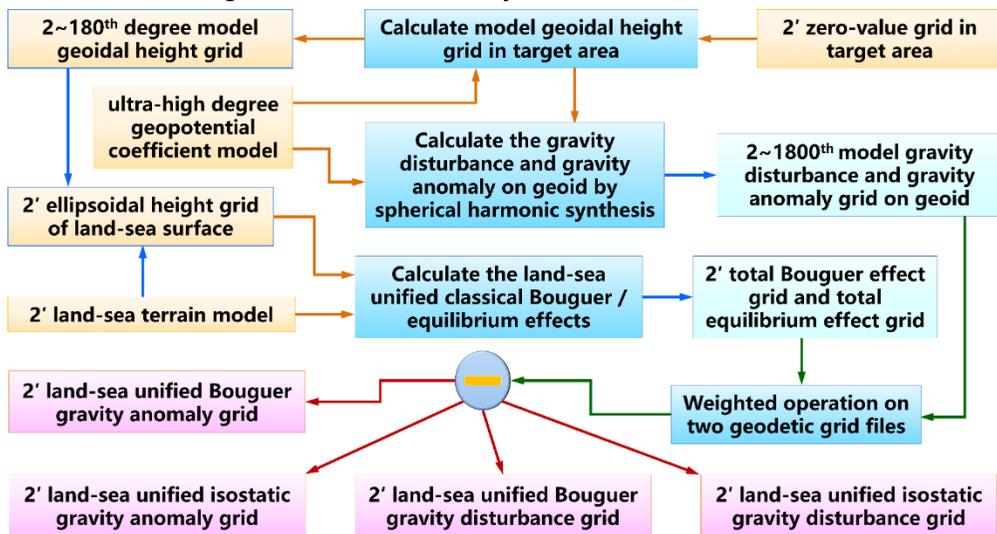


## Computation process demo of land-sea Bouguer / equilibrium anomaly from geopotential model

From the Earth geopotential coefficient model and land-sea topographic relief model, the classical Bouguer gravity anomaly (disturbance) and isostatic gravity anomaly (disturbance) are calculated synchronously in four steps in any region of the world to demonstrate the fast and convenient computation process of the land-sea unified classical Bouguer / isostatic anomaly.



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

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

Call the function [Calculation of gravity field elements from global geopotential model] with the minimum degree 2 and the maximum degree 180, input the file EGM2008.gfc and the zero-value grid file zero2m.dat of the target area, and select the calculation type 'height anomaly', to generate 2'×2' model geoidal height grid file GMgeoidh2m\_180.ksi.

The 2~180<sup>th</sup> degree model geoidal height grid here is employed as the reduction surface and location for the classical Bouguer / equilibrium anomaly.

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

Call the function [Calculation of gravity field elements from global geopotential model] with the minimum degree 2 and the maximum degree 1800, input the file EGM2008.gfc and model geoidal height grid file GMgeoidh2m\_180.ksi, and select the calculation type 'gravity anomaly' and 'gravity disturbance', to generate the 2'×2' gravity anomaly grid file EGM2008\_2m\_1800.gra and gravity disturbance grid file EGM2008\_2m\_1800.rga in the target area.

Calculation of global geopotential model and its spectral character analysis

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

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 and analysis of spectral character of Earth's gravity field

Open global geopotential coefficient model file | Save computation process as | Algorithmic Formulas

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)  
 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

Extract elements to be plot |  Plot

Save the results as | Import setting parameters | Start Computation

```

>> [Function] From global geopotential coefficient model, calculate the model value of the (residual) height anomaly (m), gravity anomaly (mGal), gravity disturbance (mGal), vertical deflection vector (*, south, west), disturbing gravity gradient (E, radial), tangential gravity gradient vector (E, 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:/PAGrav4.5_win64en\data/EGM2008.gtc.
** 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:/PAGrav4.5_win64en/examples/TerrainInExercise/GMBouqEquilibrium/zero2m.dat.
>> Save the results as C:/PAGrav4.5_win64en/examples/TerrainInExercise/GMBouqEquilibrium/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 (*.grg), 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!
  
```

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

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

When the minimum and maximum degree n to be set is equal, the program calculates the contribution of the degree n geopotential coefficient model. 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

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

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 and analysis of spectral character of Earth's gravity field

Open global geopotential coefficient model file | Save computation process as | Algorithmic Formulas

Select calculation file format: Ellipsoidal height grid file

Open ellipsoidal height grid file of calculation surface

Select elements to be calculated:  gravity anomaly (mGal),  gravity disturbance (mGal)

height anomaly (m)  
 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 the results as | Import setting parameters | Start Computation

```

>> Open global geopotential coefficient model file C:/PAGrav4.5_win64en\data/EGM2008.gtc.
** 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:/PAGrav4.5_win64en/examples/TerrainInExercise/GMBouqEquilibrium/GMGeoidh2m_180.ksi.
>> Save the results as C:/PAGrav4.5_win64en/examples/TerrainInExercise/GMBouqEquilibrium/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 (*.grg), 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
  
```

1	122.01667	32.01667	13.0311	4.2037	8.2077
2	122.05000	32.01667	13.1534	2.4193	6.4517
3	122.08333	32.01667	13.2760	1.3041	5.3727
4	122.11667	32.01667	13.3989	0.3653	4.4667
5	122.15000	32.01667	13.5220	-0.2572	3.8777
6	122.18333	32.01667	13.6452	-0.6185	3.5509
7	122.21667	32.01667	13.7683	-0.6312	3.5738
8	122.25000	32.01667	13.8914	-0.0317	4.2101
9	122.28333	32.01667	14.0142	1.4957	5.7760
10	122.31667	32.01667	14.137	4.0866	8.4071

The 2~180th degree model gravity disturbance on geoid

When the minimum and maximum degree n to be set is equal, the program calculates the contribution of the degree n geopotential coefficient model. The 2~180th degree model gravity disturbance on geoid

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

Call the function [Computation of land-sea unified classical gravity Bouguer / equilibrium effect], input the land-sea topographic relief model file extlandseadm2m.dat and land-sea surface ellipsoidal height grid file extlandseahgt2m.dat, and set the land integral radius 90km, sea integral radius 200km and equilibrium compensation depth 30km. to generate the 2'×2' total Bouguer effect grid file BougEquinfl2m.bgr and total equilibrium effect grid file BougEquinfl2m.ist.

Because the normal gravity field has nothing to do with the terrain effect, the Bouguer / equilibrium effect on the gravity anomaly, gravity disturbance and gravity is equal everywhere and does not need to be distinguished.

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

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

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

Algorithms land-sea unified classic Bouguer and equilibrium effects

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 computation process as

Save the results as C:\PA\Grav4.5\_win64en/examples/TerrainInflexercise/GMBougEquilibrium/BougEquinfl2m.txt

\*\* 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.

no	lon(deg/decimal)	lat	height/depth	local terrain	plane layer	sea-water	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

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.

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

Subtract the gravity anomaly grid EGM2008\_2m\_1800.gra and gravity disturbance grid EGM2008\_2m\_1800.rga on geoid from the total Bouguer effect grid (the grid edge removed) BougEquinfl2m0.bgr respectively to get the classical Bouguer gravity anomaly grid model Clsbggravanom2m.dat and classical Bouguer gravity disturbance grid model Clsbgdistgrav2m.dat.

Subtract the gravity anomaly grid EGM2008\_2m\_1800.gra and gravity disturbance

grid EGM2008\_2m\_1800.rga on geoid from the total isostatic effect grid (the grid edge removed) BougEquinfl2m0.ist respectively to get the classical isostatic gravity anomaly grid model Istbggravanom2m.dat and classical isostatic gravity disturbance grid model Istbgdistgrav2m.dat.

**(4) Generate the 2'x2' land-sea unified classical Bouguer / isostatic anomaly grid model.**

Weighted operation on two specified attributes in record file | **Weighted operation on two geodetic grid files** | Weighted operation on two vector grid files | Weighted operation on two harmonic coefficient files

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 specifications.
- >> Open geodetic grid file 1 C:/PAGrav4\_5\_win64en/examples/TerrainInflexercise/GMBougEquilibrium/EGM2008\_2m\_1800.gra.
- >> Open geodetic grid file 2 C:/PAGrav4\_5\_win64en/examples/TerrainInflexercise/GMBougEquilibrium/BougEquinfl2m0.bgr.
- >> Save the results as C:/PAGrav4\_5\_win64en/examples/TerrainInflexercise/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...
- >> Computation...
- >> Open geode...
- >> Open geode...
- >> Save the res...
- >> The paramet...
- \*\* Click the [St...
- >> Computation...
- >> Complete th...
- >> Computation...

Save the r...

Display of the input-output file:

122.000000	130.000000	32.000000	38.000000	0.03
8.3775	6.8966	5.6899	4.8540	4.3
19.2133	17.4019	15.8291	14.7983	14.1
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	1
22.0979	22.6739	23.1295	23.1236	2
23.9972	26.5997	28.6183	30.3440	2
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	1
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	9.5

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

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