

Expedited Workflow Demonstration for All-element Gravity Field Modeling Using SRBFs

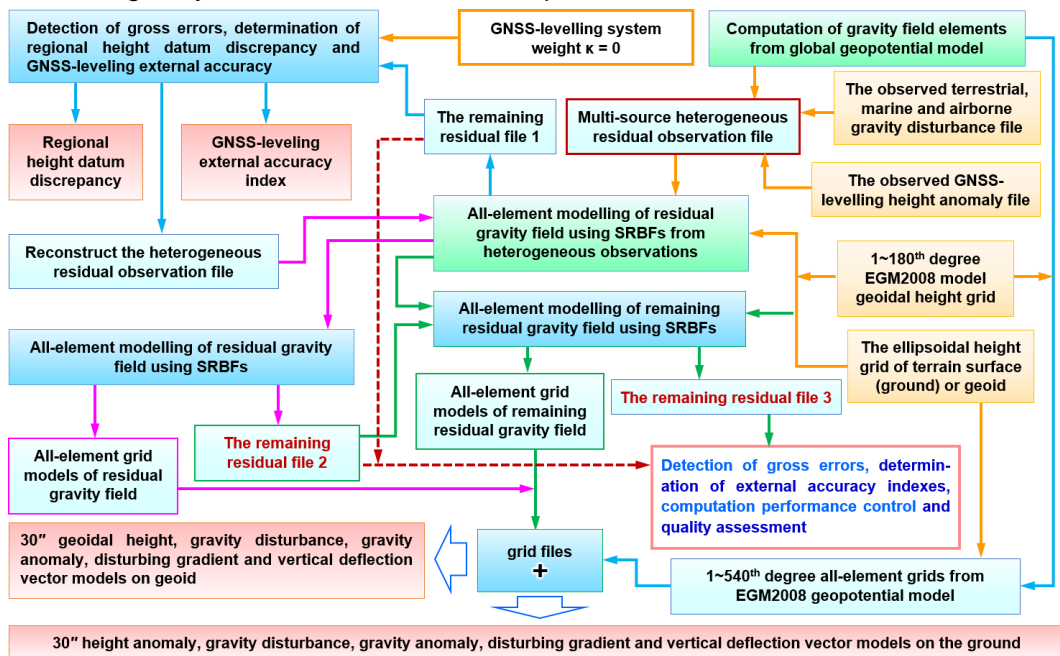
PAGrav4.5; <https://www.zcyphygeodesy.com/en/>

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[Purpose] This example demonstrates a streamlined, six-step workflow for all-element gravity field modeling based on the Spherical Radial Basis Function (SRBF) approximation method on both the ground and the geoid. The approach directly utilizes observed gravity disturbances (terrestrial, marine, and airborne) and GNSS-leveling height anomalies (or geoidal heights) without employing complex schemes of terrain effects and traditional pre-processing. This workflow aims to facilitate a rapid understanding of key aspects in spectral-domain local SRBF modeling, including observation data analysis, computational quality control, and gravity field reconstruction techniques.



Expedited Workflow for All-element Gravity Field Modeling Using SRBFs

Primary Data Sources

(1) Observed Gravity Disturbances (obsdistgrav.txt)

Format: Point ID/Station Name, Longitude (decimal degrees), Latitude (decimal degrees), Ellipsoidal Height (m), Observation Gravity Disturbance (mGal).

(2) GNSS-Leveling Observation Height Anomalies (obsGNSSlksi.txt)

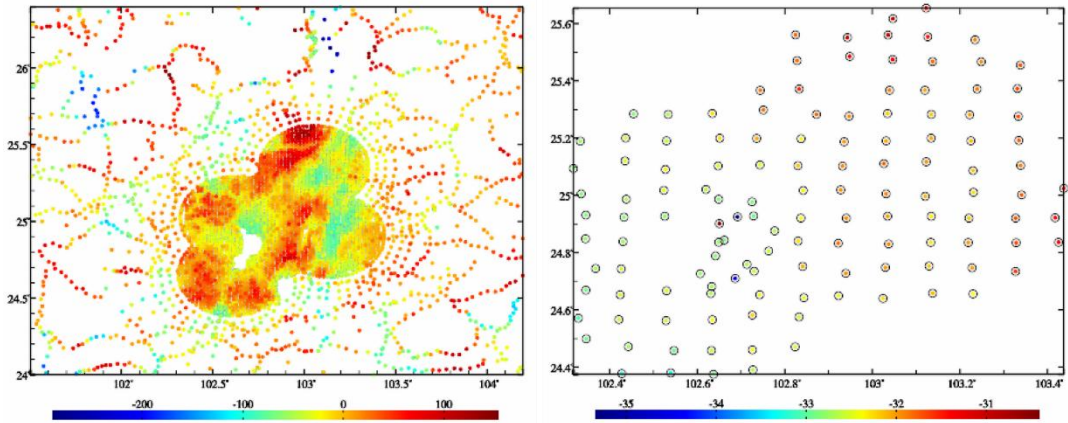
Format: Point ID/Station Name, Longitude (decimal degrees), Latitude (decimal degrees), Ellipsoidal Height (m), Observation Height Anomaly or Geoidal Height (m).

Normal Height System: The "Ellipsoidal Height" attribute corresponds to the GNSS-

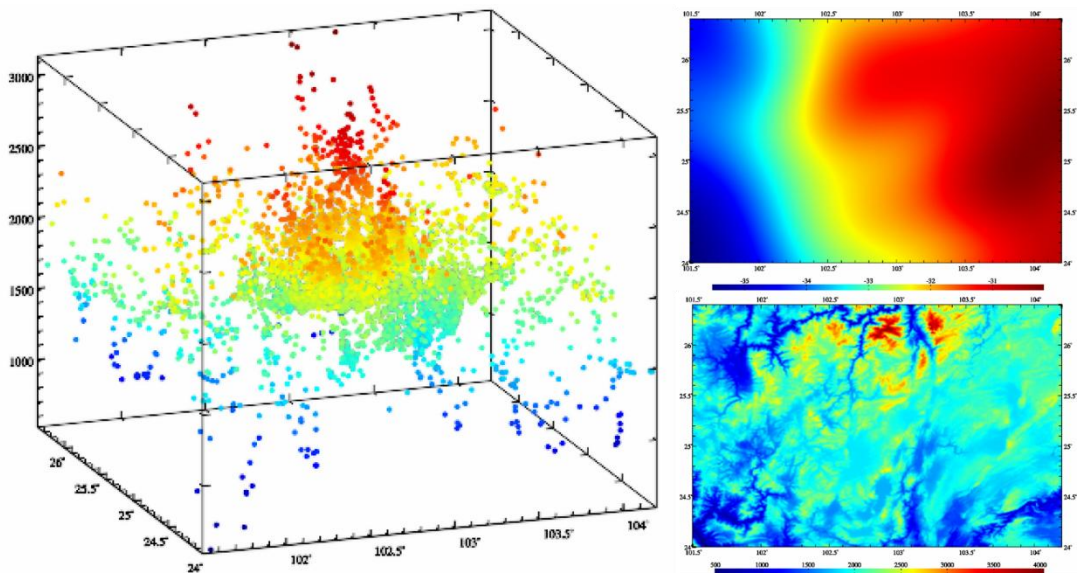
derived ellipsoidal height at the GNSS-leveling site.

Orthometric Height System: The observation geoidal height represents the ellipsoidal height of the geoid. In the file record, this value populates the "Ellipsoidal Height" field.

Note: The SRBF-based all-element modeling workflow is identical for both height systems; only the appropriate ellipsoidal heights for the GNSS-leveling sites are required. This example employs observation height anomalies under the Normal Height System. Both datasets are simulated by adding noise to EGM2008 model values (degrees 1 – 1800).



The observed gravity disturbances (mGal) and observed GNSS-leveling height anomalies (m)



The distribution of gravity points, 1~180th degree model geoidal height and ellipsoidal height of the terrain surface

(3) Computation Surface Ellipsoidal Height Grids

For Geoidal Modeling: The computation surface is defined by the model geoidal height grid. In this example: mdlgeoidh30s.dat.

For Ground Modeling: The computation surface is defined by the ground ellipsoidal height grid. In this example: surfhgt30s.dat (= Land-Sea DEM DEM30s.dat + Model Geoidal Height mdlgeoidh30s.dat).

Model Derivation: Model geoidal heights and ground height anomalies are derived from

a 180-degree gravity field model (steps omitted).

Requirement: The extent of the computation surface grid must exceed the target extent to mitigate edge effects.

Step 1: Remove Reference Model Values and Construct Multi-source Heterogeneous Residual Observations

Function: [Computation of Gravity Field Elements from a Global Geopotential Model].

Settings: Maximum degree = 540.

Procedure:

- Compute and remove reference gravity field values from obsdistgrav.txt and obsGNSSiksi.txt.
- Merge results into a Multi-source heterogeneous discrete residual observation file: obsresiduals0.txt.

File Convention (obsresiduals0.txt):

- Columns: ID, Lon, Lat, Ellipsoidal Height (m), Residual Value, Element Type (0 – 5), Obs Weight, Sys Weight, ...
- Fixed Attributes: The first five columns are fixed in position and order.
- Element Types: 0 = Residual Gravity Disturbance (mGal); 1 = Residual Height Anomaly (m).

Critical Action: Set the System Weights for all GNSS-leveling sites in obsresiduals0.txt to zero.

Step 2: Gross Error Detection via SRBF and Data Reconstruction

Function: [All-element Gravity Field Modeling Using Multi-source Heterogeneous Data with SRBFs].

Inputs: obsresiduals0.txt and surfhgt30s.dat.

Outputs:

- Residual ground all-element grids: SRBFsurfhgt30s0.xxx (.ksi, .rga, .gra, .grr, .dft).
- Remaining residual observation file: SRBFsurfhgt30s0.chs.

Gross Error Detection Protocol:

- Extract remaining residual gravity disturbances (rntobsdistgrav0.txt) and GNSS-leveling height anomalies (rntobsGNSSiksi0.txt) from SRBFsurfhgt30s0.chs.
- Use the remaining residual value (Column 5) as the statistical metric for outlier detection:
 - Gravity disturbances: Reject observations exceeding 5σ (5 times the standard deviation).
 - GNSS-Leveling sites: Reject observations exceeding 3σ .

Regenerate the cleaned heterogeneous residual observation file: obsresiduals01.txt.

Step 2: Gross Error Detection via SRBF and Data Reconstruction

Open Multi-source Heterogeneous Residual Observations File

number of rows of file header: 1
 Ellipsoidal Height Column Index: 6
 Observation Weight Column Index: 7
 System Weight Column Index: 8

Select SRBF: radial multipole kernel
 Order m: 5
 Minimum degree: 360
 Maximum degree: 1800
 Burial depth of Bierhammer sphere: 10.0km
 Action distance of SRBF center: 100km
 Reuter network level Q: 3600

Open Computation Surface ellipsoidal Height grid File

```
>> Save the results as C:\PA\Grav4_5_win64\examples\Grav\molexercise\SRBFApp\withGNSS\ks\SRBFsurfhgt30s0.txt
** Record Format: Point ID, Lon, Lat, Height (m), Res. Grav. Dist. (mGal), Res. Height Anom. (m), Res. Grav. Anom. (mGal), Res. Grad. Radial (E), Res. V.D. South (*), Res. V.D. West (*).
>> The program also outputs Heterogeneous Observation Residual File *.chs into the current directory. Header Format: Field Element Type (0-5), System Weight, Number of Observations (Group), Original Obs (Mean, StdDev, Min, Max); Residuals (Mean, StdDev, Min, Max).
** Record Format: Point ID/Station Name, Longitude, Latitude, Ellipsoidal height, Residual Value, Original Observation, Field Element Type, Observation Weight, Observation System Weight.
>> The parameter settings have been entered into the system!
** Click the [Start Computation] control button, or the [Start Computation] tool button...
>> Computation start time: 2026-04-14 08:39:16
GNSS-leveling System Weights = 0
>> Complete the computation!
>> Computation end time: 2026-04-14 08:44:14
>> The program outputs Result All Residual Gravity Field Element Grid Files (Prefix * specs match input grid): Residual Gravity Disturbance (*.rga), Residual Height Anomaly (*.ksi), Residual Gravity Anomaly (*.gra), Residual Disturbing Gravity Gradient (*.grr), and Residual Vertical Deflection Vector (*.dft)
>> The program also outputs SRBF center file *.center.txt into the current directory.
>>> Observation Type 0 System Weight 1.000 Number of observations 4219
** Source observations: mean 0.3186 standard deviation 42.1772 minimum -296.0915 maximum 165.2611
** Residual observations: mean 0.1048 standard deviation 12.9208 minimum -105.2839 maximum 114.8811
>>> Observation Type 1 System Weight 0.000 Number of observations 125
** Source observations: mean -0.3452 standard deviation 0.2739 minimum -0.9755 maximum 0.3702
** Residual observations: mean -0.3425 standard deviation 0.0784 minimum -0.7278 maximum -0.1465
```

ID	lon	lat	ellipsoid height	gravity	dist	residuals	residuals	residuals
1	101.50417	24.00417	244	1	102.39280	24.48440	2226.150	16.41599
2	101.521250	24.00417	244	2	102.39590	24.50890	2170.200	-4.76888
3	101.52083	24.00417	241	3	102.39270	24.52960	2013.330	-18.3876
4	101.52917	24.00417	222	4	102.39660	24.54530	2122.500	1.0011
5	101.53750	24.00417	201	5	102.39690	24.56360	1971.280	-0.0346
6	101.53750	24.00417	201	6	102.39380	24.58130	1940.310	-12.0941
7	101.54583	24.00417	194	7	102.39520	24.60360	1945.580	12.1850
8	101.54583	24.00417	194	8	102.39310	24.61780	1997.720	20.5312
9	101.54583	24.00417	194	9	102.39350	24.63840	1916.150	3.5848

Select the remaining residuals (column 5) as the statistical reference.

Algorithm of gravity field approach using SRBFs

After the first estimation is completed, it is recommended to employ the output residual observation file *.chs as the input residual observations file again to refine target field elements by cumulative SRBF approximation scheme. Typically, stable and high-precision solutions are achieved after accumulating just 1 to 2 SRBF approximation steps.

Validity Principles for Single SRBF Approximation: (1) The target field element grid should remain spatially continuous and differentiable, and the standard deviation of residual observations in file *.chs is as small as possible. (2) As cumulative steps proceed, the statistical mean of the residual observations must converge toward zero without exhibiting significant sign reversals.

Extract data to be plot Plot

Observations with zero observation weights or zero system weights can be extracted from the *.chs file (indicating they were excluded from the SRBF coefficient estimation) to determine and evaluate their external accuracy.

Spatial distribution of observations spherical radial basis function spatial curve residual gravity disturbance (mGal)

residual height anomaly (m) residual disturbing gradient (E) residual vertical deflection S (")

Step 3: Determination of Height Datum Discrepancy and GNSS-Leveling External Accuracy

Input: Cleaned file obsresiduals01.txt.

Procedure: Repeat Step 2 to re-estimate residual grids (rntSRBFdatum30s.xxx) and output the remaining residual observation file rntSRBFdatum30s.chs.

Methodological Note: Since GNSS-leveling sites' system weights were previously set to zero, this step effectively uses only the discrete residual gravity disturbances to evaluate the

external accuracy of the GNSS-leveling height anomalies.

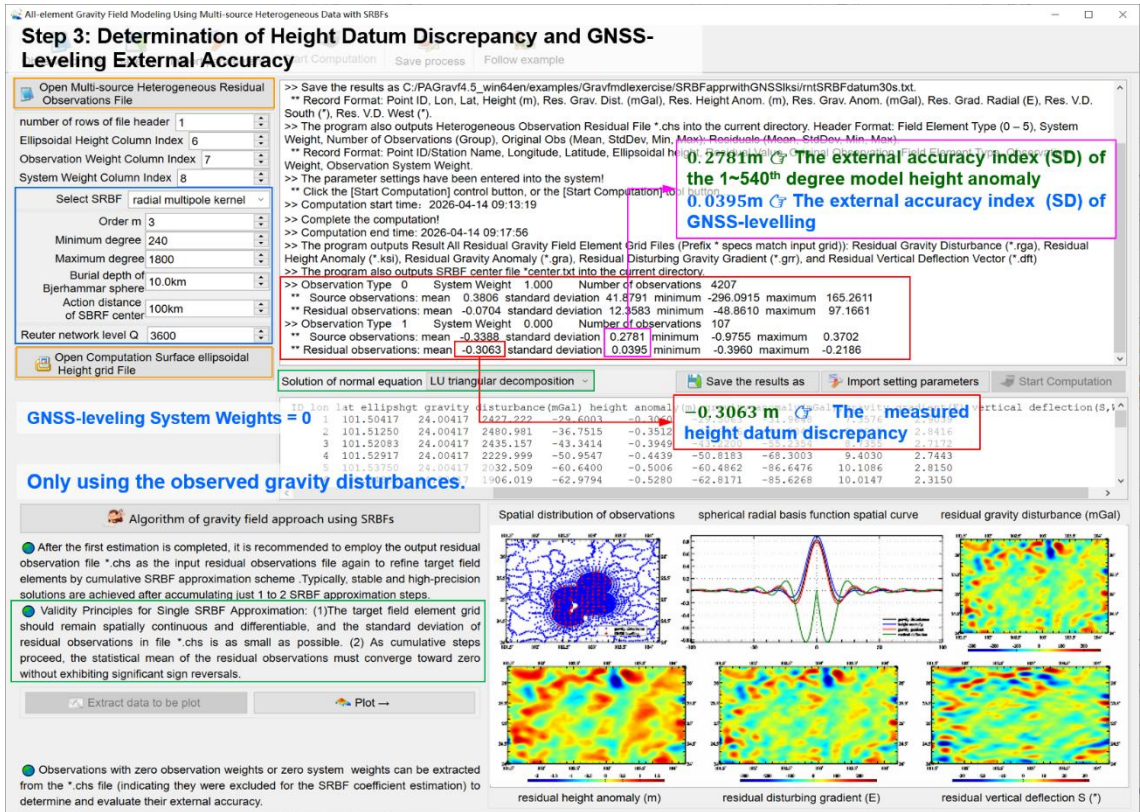


Table 4.35: Statistics of Residual Observations before and after Gross Error Detection/Elimination (SRBF Approximation)

Data Type	Stage	Count	Mean	Std. Dev.	Min	Max
Gravity Disturbance (mGal)	Original Residuals	4219	0.3186	42.1772	-296.0915	165.2611
	Post-Rejection Residuals	4215	0.2695	42.0737	-296.0915	165.2611
	Remaining Residuals	4215	-0.5677	13.8957	-80.4161	64.8276
GNSS-Leveling Height Anomaly (m)	Original residuals	125	-0.3452	0.2739	-0.9755	0.3702
	Residuals without error	123	-0.3404 ⁽¹⁾	0.2735	-0.9755	0.3702
	Remaining residuals	123	-0.0069 ⁽²⁾	0.0233 ⁽³⁾	-0.1295	0.0528

Regional Height Datum Discrepancy: The statistical mean of the GNSS-leveling residual height anomalies (-0.3404 m marked as ⁽¹⁾) represents the determined discrepancy between the regional height datum and the global height datum (gravimetric geoid). This illustrates the SRBF method for datum unification.

GNSS-Leveling External Accuracy Index: The standard deviation of the remaining residuals (e.g., 0.0233 m marked as ⁽³⁾, corresponding to 2.33 cm) serves as the external accuracy index. This indicates that the external accuracy of the GNSS-leveling data is no worse than this standard deviation value.

Standard Practice: Typically, one iterates the SRBF approximation 1 – 2 more times using the *.chs file to minimize the standard deviation of remaining residuals, establishing the final accuracy index.

Critical Action:

- Remove the determined regional height datum discrepancy (e.g., -0.3404 m) from the observation GNSS-leveling residual height anomalies.
- Restore the System Weights for GNSS-leveling sites.
- Regenerate the final heterogeneous residual observation file: obsresiduals1.txt.

🔗 Step 4: Computation of Residual Ground All-Element Gravity Field Models via SRBF Approximation

Function: [All-element Gravity Field Modeling Using Multi-source Heterogeneous Data with SRBFs].

Inputs:

- Multi-source heterogeneous residual observation file: obsresiduals1.txt.
- Ground ellipsoidal height grid: surfhgt30s.dat.

Step 4: Computation of Residual Ground All-Element Gravity Field Model via SRBF Approximation

Open Multi-source Heterogeneous Residual Observations File

number of rows of file header: 1
 Ellipsoidal Height Column Index: 6
 Observation Weight Column Index: 7
 System Weight Column Index: 8

Select SRBF: radial multipole kernel
 Order m: 3
 Minimum degree: 240
 Maximum degree: 1800
 Bural depth of Bjerhanmar sphere: 10.0km
 Action distance of SRBF center: 100km
 Reuter network level Q: 3600

Open Computation Surface ellipsoidal Height Grid File

Save the results as: C:/PA/Grav4.5_win64en/examples/Grav/molexercise/SRBFapprwithGNS/Siks/SRBFsurfhtg30s1.txt.
 ** Record Format: Point ID, Lon, Lat, Height (m), Res. Grav. Dist. (mGal), Res. Height Anom. (m), Res. Grav. Anom. (mGal), Res. Grad. Radial (E), Res. V.D. South (*), Res. V.D. West (*).
 ** The program also outputs Heterogeneous Observation Residual File *.chs into the current directory. Header Format: Field Element Type (0 – 5), System Weight, Number of Observations (Group), Original Obs (Mean, StdDev, Min, Max); Residuals (Mean, StdDev, Min, Max).
 ** Record Format: Point ID/Station Name, Longitude, Latitude, Ellipsoidal height, Residual Value, Original Observation, Field Element Type, Observation Weight, Observation System Weight.
 ** The parameter settings have been entered into the system!
 ** Click the [Start Computation] control button, or the [Start Computation] tool button...
 ** Computation start time: 2026-04-14 10:07:25
 ** Complete the computation!
 ** Computation end time: 2026-04-14 10:12:15
 ** The program outputs Result All Residual Gravity Field Element Grid Files (Prefix * specs match input grid): Residual Gravity Disturbance (*.rga), Residual Height Anomaly (*.rsa), Residual Gravity Anomaly (*.rga), Residual Disturbing Gravity Gradient (*.gir), and Residual Vertical Deflection Vector (*.dvt)
 ** The program also outputs SRBF center file "center.txt" into the current directory.

>> Observation Type 0 System Weight 1.000 Number of observations 4207
 ** Source observations: mean 0.3806 standard deviation 41.8791 minimum -296.0915 maximum 165.2611
 ** Residual observations: mean -0.2127 standard deviation 12.9909 minimum -52.5778 maximum 97.1661
 >> Observation Type 1 System Weight 1.000 Number of observations 107
 ** Source observations: mean -0.0325 standard deviation 0.2781 minimum -0.6692 maximum 0.6765
 ** Residual observations: mean -0.0001 standard deviation 0.0104 minimum -0.0289 maximum 0.0223

Solution of normal equation LU triangular decomposition

ID	lon	lat	ellipsoidht	gravity disturbance (mGal)	height anomaly (m)	gravity anomaly (mGal)	gravity gradient (E)	vertical deflection (S, I)
1	101.50417	24.00417	8427.222	-30.8761	-0.3100	-30.7808	-35.5163	7.8968 2.4591
2	101.51250	24.00417	2480.981	-37.4605	-0.3510	-37.3527		
3	101.52083	24.00417	2435.157	-43.5143	-0.3905	-43.3943		
4	101.52917	24.00417	2229.999	-50.6406	-0.4352	-50.5069		
5	101.53750	24.00417	2032.509	-59.0856	-0.4848	-58.9366		
6	101.54583	24.00417	1906.019	-61.6008	-0.5104	-61.4440		

Restore the System Weights for GNSS-leveling sites.

Can further detect and remove the observation gross errors from *.chs, and then repeat the step 4.

Algorithm of gravity field approach using SRBFs

After the first estimation is completed, it is recommended to employ the output residual observation file *.chs as the input residual observations file again to refine target field elements by cumulative SRBF approximation scheme. Typically, stable and high-precision solutions are achieved after accumulating just 1 to 2 SRBF approximation steps.

Validity Principles for Single SRBF Approximation: (1) The target field element grid should remain spatially continuous and differentiable, and the standard deviation of residual observations in file *.chs is as small as possible. (2) As cumulative steps proceed, the statistical mean of the residual observations must converge toward zero without exhibiting significant sign reversals.

Extract data to be plot Plot

Observations with zero observation weights or zero system weights can be extracted from the *.chs file (indicating they were excluded for the SRBF coefficient estimation) to determine and evaluate their external accuracy.

Spatial distribution of observations spherical radial basis function spatial curve residual gravity disturbance (mGal)

All-element models SRBFsurfhtg30s1.xxx of the residual gravity field

residual height anomaly (m) residual disturbing gradient (E) residual vertical deflection S (*)

Procedure:

- Estimate the residual ground all-element gravity field grids: SRBFsurfhtg30s1.xxx.

- Output the remaining residual observation file: SRBFsurfhgt30s1.chs.

Quality Control (QC):

- The .chs file can be utilized for further gross error detection using the 5σ criterion for gravity disturbances and the 3σ criterion for GNSS-leveling sites.
- Upon outlier rejection, the workflow should restart from Step 3. This iterative refinement is omitted in the current example.

Step 5: Cumulative SRBF Approximation using Remaining Residuals

Function: [All-element Gravity Field Modeling Using Multi-source Heterogeneous Data with SRBFs].

Inputs:

- Remaining residual observation file: SRBFsurfhgt30s1.chs.
- Ground ellipsoidal height grid: surfhgt30s.dat.

Procedure:

- Estimate the higher-order remaining residual ground all-element gravity field grids: SRBFsurfhgt30s2.xxx.
- Output the updated remaining residual observation file: SRBFsurfhgt30s2.chs.

Step 5: Cumulative SRBF Approximation using Remaining Residuals

Open Multi-source Heterogeneous Residual Observations File

number of rows of file header: 2
 Ellipsoidal Height Column Index: 7
 Observation Weight Column Index: 8
 System Weight Column Index: 9

Select SRBF: Poisson wavelet kernel
 Order m: 3
 Minimum degree: 540
 Maximum degree: 5400
 Burial depth of Bjerhammar sphere: 6.0km
 Action distance of SRBF center: 60km
 Reuter network level Q: 5400

Open Computation Surface ellipsoidal Height grid File

South (*), Res. V.D. West (*)

>> The program also outputs Heterogeneous Observation Residual File *.chs into the current directory. Header Format: Field Element Type (0 - 5), System Weight, Number of Observations (Group), Original Obs (Mean, StdDev, Min, Max), Residuals (Mean, StdDev, Min, Max).
 ** Record Format: Point ID/Station Name, Longitude, Latitude, Ellipsoidal height, Residual Value, Original Observation, Field Element Type, Observation Weight, Observation System Weight.
 >> Open Computation Surface ellipsoidal Height grid File C:/PAGrav4.5_win64en/examples/Gravfmdlexercise/SRBFApprwithGNSKs/surfhgt30s.dat.
 >> The burial depth is required to be no greater than 1/5 of the SRBF center action distance and no less than 1/20!
 >> The parameter settings have been entered into the system!
 ** Click the [Start Computation] control button, or the [Start Computation] tool.
 >> Computation start time: 2026-04-14 10:19:56
 >> Complete the computation!
 >> Computation end time: 2026-04-14 10:24:07
 >> The program outputs Result All Residual Gravity Field Element Grid Files (Prefix * specs match input grid): Residual Gravity Disturbance (*.rga), Residual Height Anomaly (*.ks), Residual Gravity Anomaly (*.gra), Residual Disturbing Gravity Gradient (*.grr), and Residual Vertical Deflection Vector (*.dvt)
 >> The program also outputs SRBF center file "center.txt into the current directory.
 >> Observation Type 0 System Weight 1.000 Number of observations 4207
 ** Source observations: mean -0.2127 standard deviation 12.9909 minimum -52.5778 maximum 97.1661
 ** Residual observations: mean 0.0275 standard deviation 8.2176 minimum -37.5506 maximum 58.9054
 >> Observation Type 1 System Weight 1.000 Number of observations 107
 ** Source observations: mean -0.0001 standard deviation 0.0104 minimum -0.0289 maximum 0.0223
 ** Residual observations: mean 0.0000 standard deviation 0.0025 minimum -0.0064 maximum 0.0072

Input the file SRBFsurfhgt30s1.chs that is output from the previous step.

0.0025m ≈ 0.25 cm The accuracy index (SD) of height anomaly modeling.

ID	lon	lat	ellipsoid height (m)	gravity disturbance (mGal)	height anomaly (m)	gravity anomaly (mGal)	gravity gradient (E)	vertical deflection (S, m)
1	101.50417	24.00417	2427.222	-1.0291	0.0082	-1.0366		
2	101.51250	24.00417	2480.981	6.9867	0.0220	6.9799		
3	101.52083	24.00417	2435.157	15.9460	0.0365	15.9388		
4	101.52917	24.00417	2229.999	23.8074	0.0487	23.7924		
5	101.53750	24.00417	2032.509	28.8688	0.0561	28.8516		
6	101.54583	24.00417	1906.019	28.9951	0.0555	28.9781	172.5171	-2.8060 0.7857

Algorithm of gravity field approach using SRBFs

After the first estimation is completed, it is recommended to employ the output residual observation file *.chs as the input residual observations file again to refine target field elements by cumulative SRBF approximation scheme. Typically, stable and high-precision solutions are achieved after accumulating just 1 to 2 SRBF approximation steps.

Validity Principles for Single SRBF Approximation: (1) The target field element grid should remain spatially continuous and differentiable, and the standard deviation of residual observations in file *.chs is as small as possible. (2) As cumulative steps proceed, the statistical mean of the residual observations must converge toward zero without exhibiting significant sign reversals.

Extract data to be plot Plot →

Observations with zero observation weights or zero system weights can be extracted from the *.chs file (indicating they were excluded for the SRBF coefficient estimation) to determine and evaluate their external accuracy.

Spatial distribution of observations spherical radial basis function spatial curve residual gravity disturbance (mGal)

All-element models SRBFsurfhgt30s2.xxx of the remaining residual gravity field

residual height anomaly (m) residual disturbing gradient (E) residual vertical deflection S (*)

Table 4.36: Statistical Comparison of Residuals Before and after Cumulative SRBF Approximations

Data Type	Stage	Mean	Std. Dev.	Min	Max
Residual gravity disturbance	Initial Residuals	0.2695	42.0737	-296.0915	165.2611
	After 1st SRBF	0.0620	12.9866	-80.4161	64.8276

(mGal)	After 2nd SRBF	0.1309	8.5135	-50.6030	57.3920
Residual GNSS-levelling height anomaly (m)	Initial Residuals	-0.0071	0.2768	-0.6571	0.6846
	After 1st SRBF	-0.0014	0.0291	-0.1886	0.0595
	After 2nd SRBF	-0.0013	0.0154 ⁽⁴⁾	-0.0708	0.0315

Accuracy Metric: The value 0.0154 m ⁽⁴⁾ = 1.54 cm cited in the analysis serves as the accuracy index for gravity disturbance-derived ground height anomaly modeling.

Quality Control (QC) Measures:

- Gross error detection (5 σ for gravity disturbances, 3 σ for GNSS-leveling sites) can be repeated using SRBFsurfhtg30s2.chs, necessitating a restart from Step 3 if outliers are found (omitted here).
- If result quality is insufficient, further cumulative approximations may be performed. This is also omitted for brevity.

🔍 Step 6: Restoration of Reference Field Values to Generate Final Ground All-Element Models

Function: [Computation of Gravity Field Elements from a Global Geopotential Model].

Settings: Maximum degree = 540.

Input: Ground ellipsoidal height grid (edge-effect corrected): surfhtg30srst.dat.

Procedure: Compute the 540-degree reference gravity field element grids: GMSurfhtg30s540.ksi (Height Anomaly), GMSurfhtg30s540.rga (Gravity Disturbance), GMSurfhtg30s540.gra (Gravity Anomaly), GMSurfhtg30s540.grr (Disturbing Gravity Gradient), and GMSurfhtg30s540.dft (Vertical Deflection).

Final Model Synthesis: Sum the following three components (after trimming edges from SRBF grids):

- 1st SRBF Residuals: surfhtg30s1.xxx (derived from SRBFsurfhtg30s0.xxx).
- 2nd SRBF Remaining Residuals: surfhtg30s2.xxx (derived from SRBFsurfhtg30s1.xxx).
- 540-degree Reference Field: GMSurfhtg30s540.xxx.

Output Products: The final ground all-element gravity field model grids (30"x30" resolution) are generated, comprising:

- Ground Height Anomaly: surfhtg30srst.ksi
- Ground Gravity Disturbance: surfhtg30srst.rga
- Ground Gravity Anomaly: surfhtg30srst.gra
- Ground Disturbing Gravity Gradient: surfhtg30srst.grr
- Ground Vertical Deflection Vector: surfhtg30srst.dft
- Regional Datum Application: Add the determined regional height datum discrepancy (-0.3063 m) to surfhtg30srst.ksi to obtain the ground height anomaly grid referenced to the regional height datum: surfhtg30srgn.ksi.

Completion: The ground all-element gravity field modeling is now complete, yielding ground 30"x30" all-element grid models.

Step 6: Restoration of Reference Field Values to Generate Final Ground All-Element Models

From the four control buttons at the top of the interface plot, extraction or multiplication on grid cell elements from two (vector) grid

Open Global Geopotential Coefficient Model File

Select computation file format

Surface Ellipsoidal height grid file

Open Computation Surface Ellipsoidal Height Grid File

Select elements to be computed

- 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)

Save computation process as

Save the results as

Import setting parameters

Start Computation

Full element models
surfhtg30srst.rxx

Residuals
surfhtg30s1

Remaining residuals
surfhtg30s2

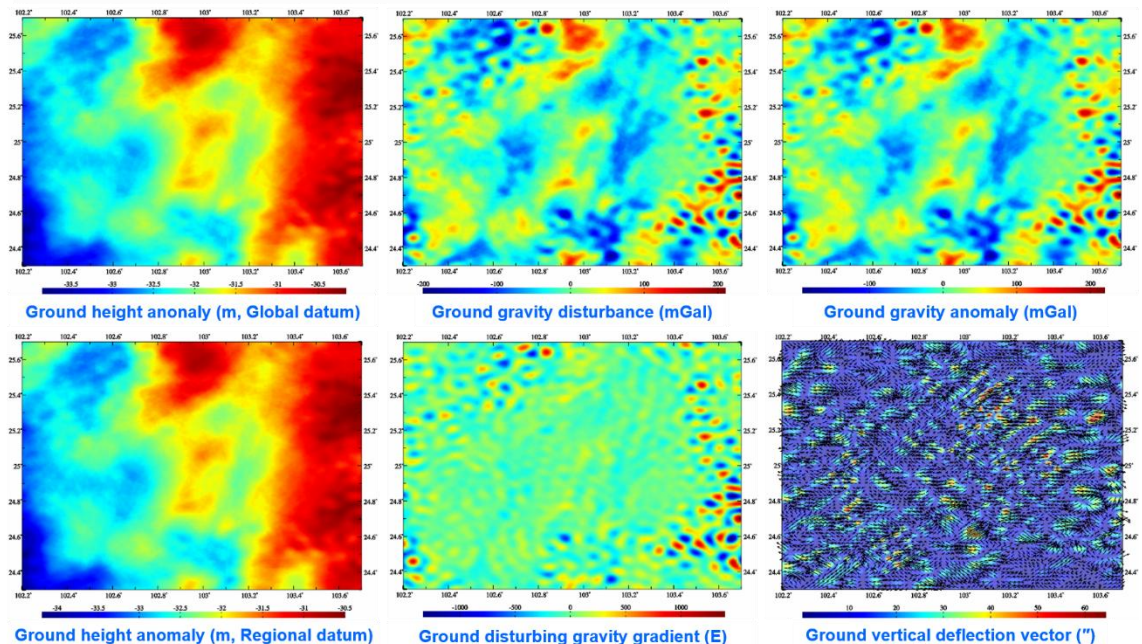
Reference models
GMsurfhtg30s540

height anomaly (m)

gravity disturbance (mGal)

Model ground vertical deflection vector (")

30"×30" all-element gravity field models on terrain surface



Generation of the Geoidal Model

By switching the computation surface to the geoid, the 30"×30" all-element gravity field model on the geoid can be directly generated.

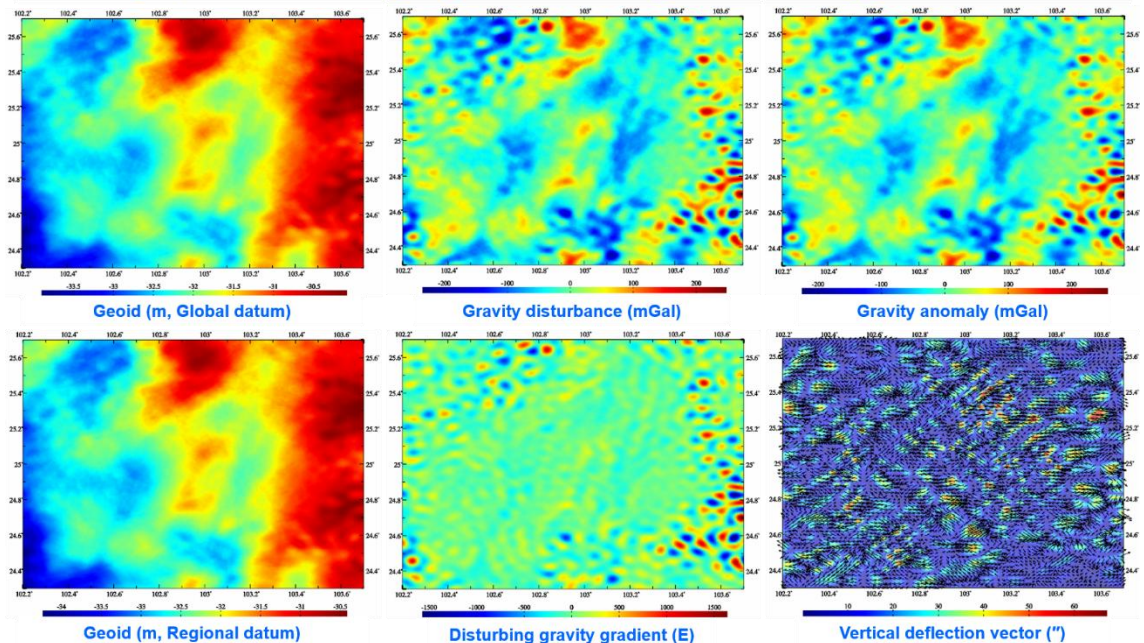
Workflow: In Steps 3 through 6, maintain all input data files and parameter settings

unchanged. Only replace the computation surface with the model geoidal height grid (e.g., mdlgeoidh30s.dat).

Synchronous Outputs: Following the identical workflow above yields the geoidal all-element model geoidh30srst.xxx, including:

- Geoidal Height: geoidh30srst.ksi
- Gravity Disturbance: geoidh30srst.rga
- Gravity Anomaly: geoidh30srst.gra
- Disturbing Gravity Gradient: geoidh30srst.grr
- Vertical Deflection Vector: geoidh30srst.dft
- Gravimetric Geoid (Regional Datum): geoidh30srgn.ksi

In Steps 3 through 6, maintain all input data files and parameter settings unchanged. Switching computation surface to geoid, 30"×30" all-element gravity field models on the geoid can be directly generated.



🌐 Technical Features of the SRBF Gravity Field Approximation Program

- Rigorous Analytical Relationships: Strict analytical mathematical relationships exist between observation elements, target elements, and among the elements themselves. The algorithm's performance remains robust regardless of the error distribution characteristics within the observation data.
- One-Step Analytical Fusion of Heterogeneous Data: Capable of fusing multiple types of heterogeneous gravity observations (varying heights, cross-distributed, land-sea coexistence) in a single analytical step. No preprocessing such as reduction, continuation, or gridding is required.
- Unified Modeling Framework: Enables synchronous analytical modeling of the geoid and all external gravity field elements. Effectively integrates sparse data sources, such as astronomical vertical deflections and GNSS-leveling observations.
- Robust Quality Control: Possesses advanced capabilities for gross error detection in

gravity observations, precise determination of external accuracy indices and height datum discrepancies, and rigorous control over computational performance.