

GravNetAdj: A MATLAB-based software for gravity network adjustment

User Manual

## **1. Introduction**

Gravity measurement is very important for modeling the gravity field model and building a gravity datum for a nation. Even though there are some software for processing the observations with relative gravity measurement, but a detail error correction are not been given in detail or not a graphical user interface (GUI). Especially, there are no good method to detect multiple outlier in observations or reduce the influence for parameter estimation. Considering the limited number of the alternatives, GravNetAdj was developed to benefit the potential advantages of the robust estimation method. the GravNetAdj is fast, simple, and user-friendly, which makes it easy to carry out the gravity network adjustment when the technicians are not familiar with the gravity data processing. Through its user-friendly graphical user interface, GravNetAdj allows users to specify the options, models, and parameters related to gravity data processing and robust estimation for adjustment computation.

## **2. Installation**

GravNetAdj was developed in MATLAB environment since its matrix-based structure and built-in graphics are highly suitable for technical computing, programming, and data visualization. GravNetAdj does not entail any toolbox for function except for MATLAB core files and SPOTL for computing ocean tide correction. Two steps should be followed to open the graphical user interface (GUI) of GravNetAdj:

- (1) Add the folder containing the source codes of GravNetAdj into MATLAB search path
- (2) Type GravNetAdj\_English in MATLAB command line

The interface of GravNetAdj was developed using the MATLAB App Designer which is special environment to design and develop visual components of a user interface. For this reason, MATLAB version 2018a or newer is required for running GravNetAdj.

## **3. GravNetAdj**

GravNetAdj is able to perform relative gravity observations and gravity network adjustment computation with robust estimation. GravNetAdj allows specifying options, models, and parameters about gravity field processing and adjustment computation through its user-friendly interface. Fundamentally, GravNetAdj consists of four main components which are relative gravity processing, data importing for adjustment computation, observations analysis and adjustment of gravity network.

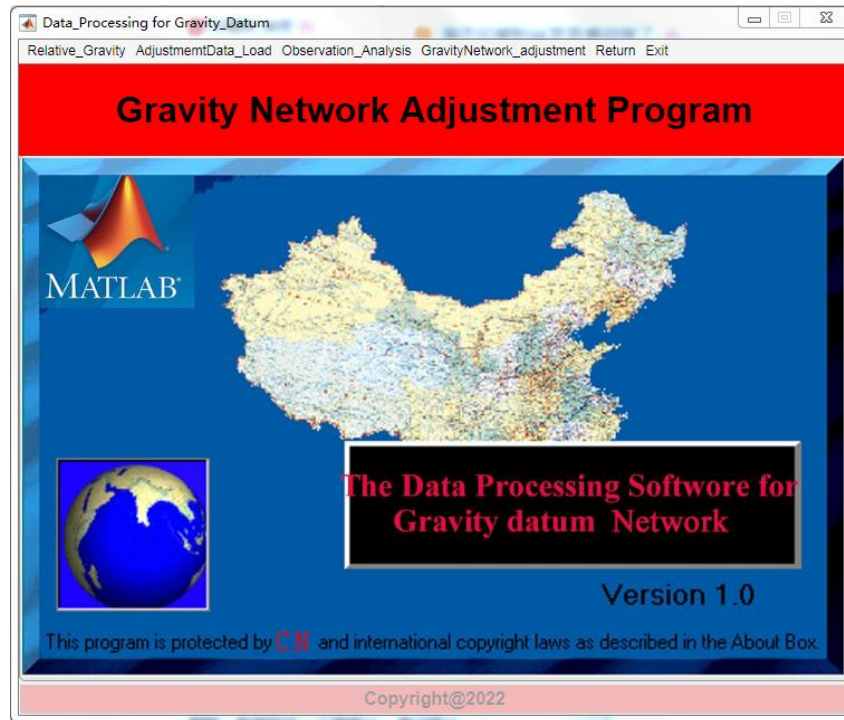


Fig.1 Main components of GravNetAdj

Figure 1 shows the main window of GravNetAdj. Four fundamental tabs representing the components of the software are located on the top of the main window. The explanation of each tab along with its preferences is respectively given below.

### 3.1 Relative gravity data processing

We can realize the function by using the Relative\_Gravity tabs. There are four tabs. They are parameter setting (para\_set), data importing (Input\_Data), relative gravity computation (RelGrav\_Comp), and Outlier detection (Outlier\_detection). Firstly, we must choose the error correction like Solid Tide (earth tide) and Ocean Tide (Figure 2).

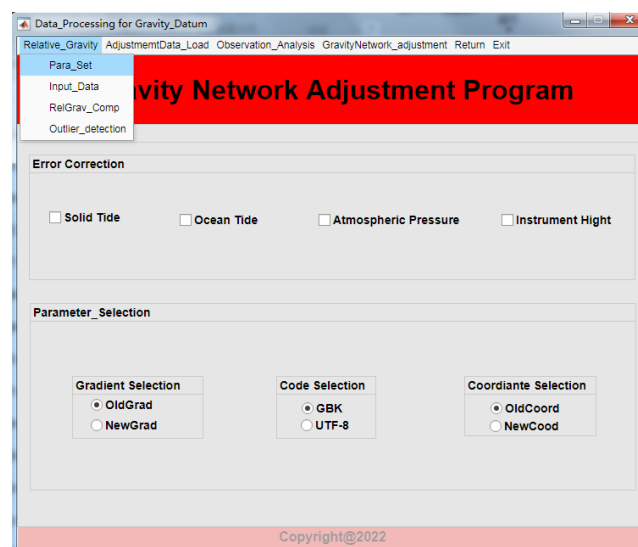


Fig.2 Paramter setting of relative gravity data processing

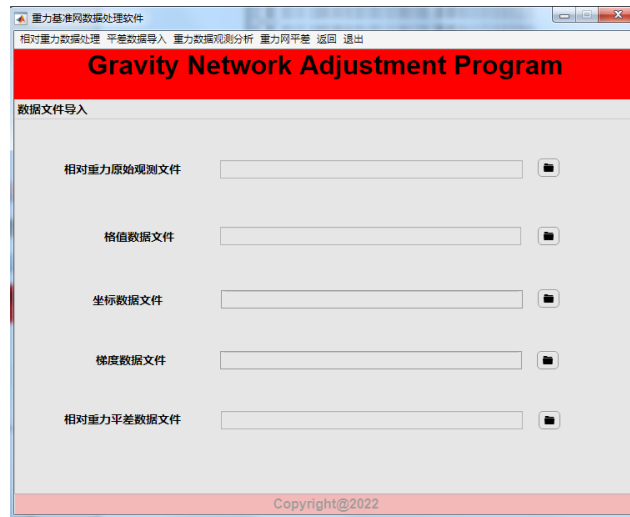



Fig.3 Data import of relative gravity data processing

GravNetAdj requires foundational data sources to perform relative gravity data processing; original observations of relative gravity, grid value, high precision coordinates, or gradient data. Then The whole necessary files should be introduced to GravNetAdj by clicking the selection box  to the related field. Each observation is stored in one file shown in Fig.4, and their detail explanation is expressed in Tab1. All observation file must be placed into the same folder but without any other contents.

```

18
C 063 3 11
B090 Hengshan 2019 9 28 5.433333 2526.545 645.0 345.0 -5.0 3814.0 C063 Liuxing Likai 56.0 0 0 77 3 12 36 26 52 3 0
C076 Hengshan 2019 9 28 6.200000 2528.655 642.0 345.0 -5.0 3828.0 C063 Liuxing Likai 56.0 0 0 77 6 19 36 27 39 3 0
B090 Hengshan 2019 9 28 6.500000 2567.67 640.0 345.0 -5.0 3814.0 C063 Liuxing Likai 56.0 0 0 77 3 12 36 26 52 3 0
C 534 3 11
B090 Hengshan 2019 9 28 5.483333 6363.972 643.0 476.0 -5.0 3814.0 C534 Liuxing Likai 56.0 0 0 77 3 12 36 26 52 3 0
C076 Hengshan 2019 9 28 6.033333 6367.376 639.0 476.0 -5.0 3823.0 C534 Liuxing Likai 56.0 0 0 77 6 19 36 27 39 3 0
B090 Hengshan 2019 9 28 6.533333 6363.039 640.0 476.0 -5.0 3814.0 C534 Liuxing Likai 56.0 0 0 77 3 12 36 26 52 3 0
C 056 3 11
B090 Hengshan 2019 9 28 5.533333 2510.021 643.0 314.0 -5.0 3814.0 C056 Liuxing Likai 56.0 0 0 77 3 12 36 26 52 3 0
C076 Hengshan 2019 9 28 6.100000 6367.376 639.0 314.0 -5.0 3828.0 C056 Liuxing Likai 56.0 0 0 77 6 19 36 27 39 3 0
B090 Hengshan 2019 9 28 6.516667 6363.039 640.0 314.0 -5.0 3814.0 C056 Liuxing Likai 56.0 0 0 77 3 12 36 26 52 3 0
C 1066 3 11
B090 Hengshan 2019 9 28 5.166667 4774.981 643.0 472.0 -5.0 3814.0 C1066 Liuxing Likai 56.0 0 0 77 3 12 36 26 52 3 0
C076 Hengshan 2019 9 28 6.066666 6367.419 639.0 472.0 -5.0 3828.0 C1066 Liuxing Likai 56.0 0 0 77 6 19 36 27 39 3 0
B090 Hengshan 2019 9 28 6.483333 6363.104 640.0 472.0 -5.0 3814.0 C1066 Liuxing Likai 56.0 0 0 77 3 12 36 26 52 3 0
C 1064 3 11
B090 Hengshan 2019 9 28 5.500000 4649.614 643.0 474.0 -5.0 3814.0 C1064 Liuxing Likai 56.0 0 0 77 3 12 36 26 52 3 0
C076 Hengshan 2019 9 28 6.050000 4654.057 639.0 474.0 -5.0 3828.0 C1064 Liuxing Likai 56.0 0 0 77 6 19 36 27 39 3 0
B090 Hengshan 2019 9 28 6.450000 4649.714 640.0 474.0 -5.0 3814.0 C1064 Liuxing Likai 56.0 0 0 77 3 12 36 26 52 3 0
C 052 3 11
B090 Hengshan 2019 9 28 5.516667 2669.625 643.0 314.0 -5.0 3814.0 C052 Liuxing Likai 56.0 0 0 77 3 12 36 26 52 3 0
C076 Hengshan 2019 9 28 6.516667 2674.045 639.0 314.0 -5.0 3828.0 C052 Liuxing Likai 56.0 0 0 77 6 19 36 27 39 3 0
B090 Hengshan 2019 9 28 6.450000 2669.662 640.0 314.0 -5.0 3814.0 C052 Liuxing Likai 56.0 0 0 77 3 12 36 26 52 3 0

```

Fig.4 The data format of relative gravity observations

Tab.1 The explanation of relative gravity observations

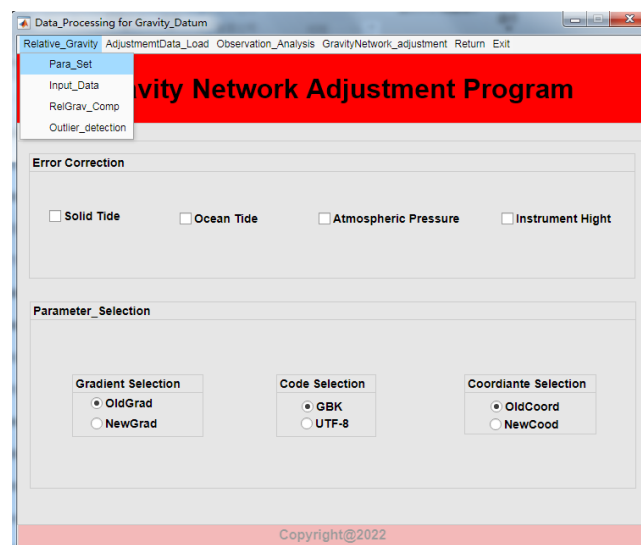
First line	18	Total number of observations
Second line	C	Initial character of the used instrument
	063	Series number of instrument
	3	Number of stations
	11	Measurement type
Third line	B090	Point number
	Hengshan	Name of point
	2019	Years
	9	Month

	29	Day
	5.433333	Mean time
	2526.545	Mean of reading number
	645.0	Atmospheric pressure
	345.0	Instrument height
	-5.0	Overflow
	3814.0	Height
	C063	Name of instrument
	Liuxing	Observer
	Likai	Recorder
	56.0	Inward overflow
	0	Amplitude
	0	Weather
	77	Longitude(degree)
	3	Longitude(minute)
	12	Longitude(second)
	36	latitude (degree)
	26	latitude (minute)
	52	latitude (second)
	3	grade
	0	Vehicle

### 3.2 The detail step for gravity network adjument

It should be declared that the data and results shown below are not real data. The main function is to perform the processing of computing.

step 1: Click on the menu bar **【 Relative\_Gravity- Para\_Set 】** to select the corresponding error correction and data selection



step 2: Click on the menu bar **【Relative\_Gravity- Input\_Data】** to import the required data for data processing. Including the observation data of relative gravity

measurement, grid value data and coordinate data.

Data\_Processing for Gravity\_Datum  
Relative\_Gravity AdjustmentData\_Load Observation\_Analysis GravityNetwork\_adjustment Return Exit

## Gravity Network Adjustment Program

Input File

Relative Observation File

Gezhi File

Coordiante File

Gradient File

Relative adjustment File

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```
1003 3 11  
1004 Hengshan 2019 9 28 5.433333 2526.545 646.0 346.0 -5.0 3814.0 C063 Lixiang Likai 56.0 0 0 7 3 12 36 26 52 3 0  
1005 Hengshan 2019 9 28 6.200000 2520.655 642.0 346.0 -5.0 3828.0 C063 Lixiang Likai 56.0 0 0 7 3 12 36 27 29 3 0  
1006 Hengshan 2019 9 28 6.500000 2507.07 640.0 346.0 -5.0 3814.0 C063 Lixiang Likai 56.0 0 0 7 3 12 36 26 52 3 0  
1007 3 11  
1008 Hengshan 2019 9 28 5.483333 6363.972 643.0 476.0 -5.0 3814.0 C534 Lixiang Likai 56.0 0 0 7 3 12 36 26 52 3 0  
1009 Hengshan 2019 9 28 6.033333 6367.376 639.0 476.0 -5.0 3822.0 C534 Lixiang Likai 56.0 0 0 7 3 12 36 27 29 3 0  
1010 Hengshan 2019 9 28 6.533333 6363.039 640.0 476.0 -5.0 3814.0 C534 Lixiang Likai 56.0 0 0 7 3 12 36 26 52 3 0  
1011 3 11  
1012 Hengshan 2019 9 28 5.533333 2510.021 643.0 314.0 -5.0 3814.0 C056 Lixiang Likai 56.0 0 0 7 3 12 36 26 52 3 0  
1013 Hengshan 2019 9 28 6.100000 6367.376 639.0 314.0 -5.0 3828.0 C056 Lixiang Likai 56.0 0 0 7 3 12 36 27 29 3 0  
1014 Hengshan 2019 9 28 6.536667 6363.039 640.0 314.0 -5.0 3814.0 C056 Lixiang Likai 56.0 0 0 7 3 12 36 26 52 3 0  
1015 3 11  
1016 Hengshan 2019 9 28 5.166667 4774.981 643.0 472.0 -5.0 3814.0 C1066 Lixiang Likai 56.0 0 0 7 3 12 36 26 52 3 0  
1017 Hengshan 2019 9 28 6.066667 4781.418 639.0 472.0 -5.0 3828.0 C1066 Lixiang Likai 56.0 0 0 7 3 12 36 27 29 3 0  
1018 Hengshan 2019 9 28 6.483333 6363.104 640.0 472.0 -5.0 3814.0 C1066 Lixiang Likai 56.0 0 0 7 3 12 36 26 52 3 0  
1019 3 11  
1020 Hengshan 2019 9 28 5.500000 4649.614 643.0 474.0 -5.0 3814.0 C1064 Lixiang Likai 56.0 0 0 7 3 12 36 26 52 3 0  
1021 Hengshan 2019 9 28 6.050000 4654.057 639.0 474.0 -5.0 3828.0 C1064 Lixiang Likai 56.0 0 0 7 3 12 36 27 29 3 0  
1022 Hengshan 2019 9 28 6.483333 6363.104 640.0 474.0 -5.0 3814.0 C1064 Lixiang Likai 56.0 0 0 7 3 12 36 26 52 3 0  
1023 3 11  
1024 Hengshan 2019 9 28 5.516667 2669.626 643.0 314.0 -5.0 3814.0 C052 Lixiang Likai 56.0 0 0 7 3 12 36 26 52 3 0  
1025 Hengshan 2019 9 28 6.516667 2674.045 639.0 314.0 -5.0 3828.0 C052 Lixiang Likai 56.0 0 0 7 3 12 36 27 29 3 0  
1026 Hengshan 2019 9 28 6.483333 6363.039 640.0 314.0 -5.0 3814.0 C052 Lixiang Likai 56.0 0 0 7 3 12 36 26 52 3 0
```

Data\_Processing for Gravity\_Datum  
Relative\_Gravity AdjustmentData\_Load Observation\_Analysis GravityNetwork\_adjustment Return Exit

## Gravity Network Adjustment Program

Input File

Relative Observation File

Gezhi File

Coordiante File

Gradient File

Relative adjustment File

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```
0.999927  
100 100.0000 1.00000  
200 200.0000 1.00000  
300 300.0000 1.00000  
400 400.0000 1.00000  
500 500.0000 1.00000  
600 600.0000 1.00000  
700 700.0000 1.00000  
800 800.0000 1.00000  
900 900.0000 1.00000  
1000 1000.0000 1.00000  
1100 1100.0000 1.00000  
1200 1200.0000 1.00000  
1300 1300.0000 1.00000  
1400 1400.0000 1.00000  
1500 1500.0000 1.00000  
1600 1600.0000 1.00000  
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2200 2200.0000 1.00000  
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2400 2400.0000 1.00000  
2500 2500.0000 1.00000  
2600 2600.0000 1.00000  
2700 2700.0000 1.00000  
2800 2800.0000 1.00000
```

Data\_Processing for Gravity\_Datum  
Relative\_Gravity AdjustmentData\_Load Observation\_Analysis GravityNetwork\_adjustment Return Exit

## Gravity Network Adjustment Program

Input File

Relative Observation File

Gezhi File

Coordiante File

Gradient File

Relative adjustment File

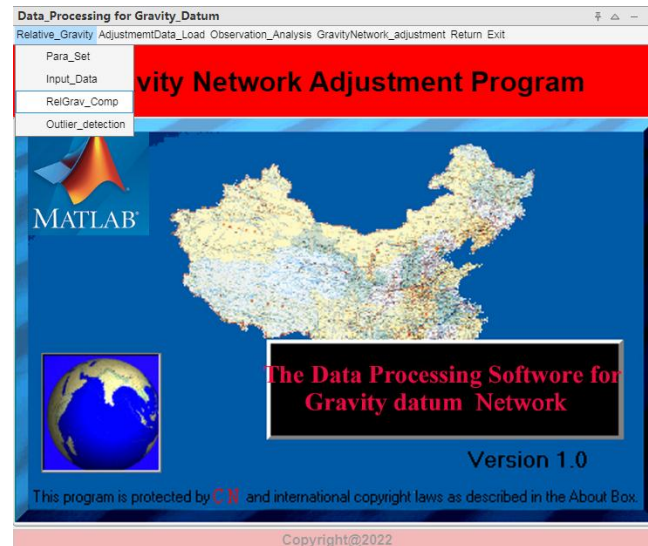
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```
A001 432718.8135 1212058.6000 322.621  
A002 510829.3185 1224558.5346 401.394  
A003 445243.1286 1222537.6153 224.300  
A004 493003.8150 1115316.0371 214.370  
A005 432215.4351 1211654.7780 49.207  
A006 452643.2521 1225232.5211 213.458  
A007 442109.9189 1271408.1919 138.179  
A008 452600.3382 1280845.9315 107.934  
A009 484441.2873 1263509.2974 291.731  
A010 414016.1689 1264513.1293 134.628  
A011 421604.6710 1214906.4084 51.238  
A012 402600.0328 1265428.9950 821.128  
A013 144659.4947 1201547.5548 315.717  
A014 523435.1650 1234337.8640 480.830  
A015 441613.7395 1154428.5042 639.621  
A016 421258.3808 1281401.7768 641.595  
A017 435716.9677 1124249.2888 348.689  
A018 450226.3272 1120138.2019 375.195  
A019 423557.4981 1123848.2836 1113.479  
A020 420151.1758 1245725.9724 1238.549  
A021 495223.7544 1100342.3394 344.036  
A022 483805.4968 1315631.4944 916.887  
A023 481030.6457 1290057.0173 854.900  
A024 451430.6457 1255849.3951 1200.349  
A025 431701.8007 1180439.9066 1130.661  
A026 425837.3259 1322530.9610 1262.328  
A027 453613.4529 1200116.7824 1177.700  
A028 441548.5417 1243027.2903 1281.936  
A029 334117.5287 1164841.9641 1192.718  
A030 473013.7309 1322303.5269 162.581
```

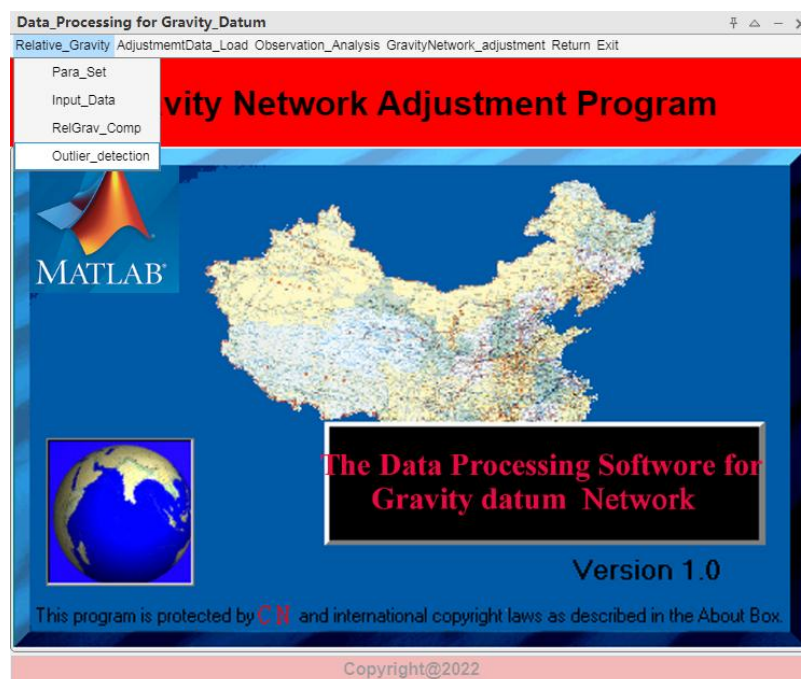
The gradient data is not necessary if there is not the gradient data. Therefore, we can

using the empiric value. The ending result is stored in file by chooseing click the button in

Step 3: Click on the menu bar **【Relative\_Gravity- RelGrav\_Comp】** to start the preprocessing of relative gravity data.

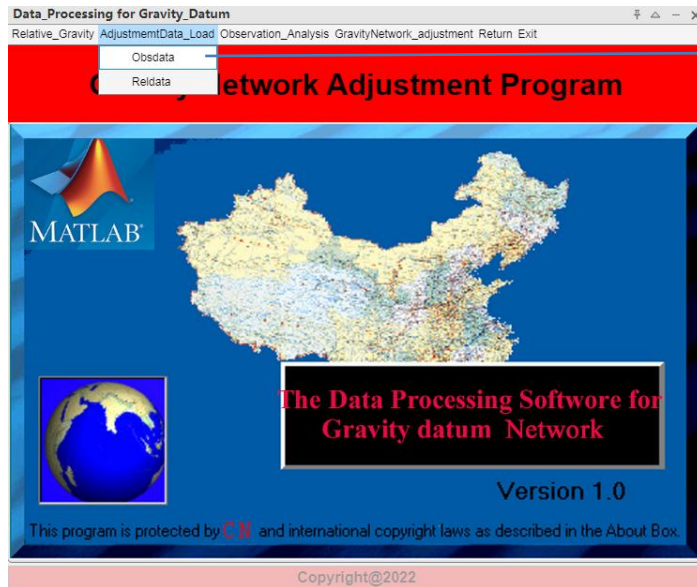


Step 4: Click on the menu bar **【Relative\_Gravity- Outlier\_detection】** to start gross error detection for the relative gravity data.

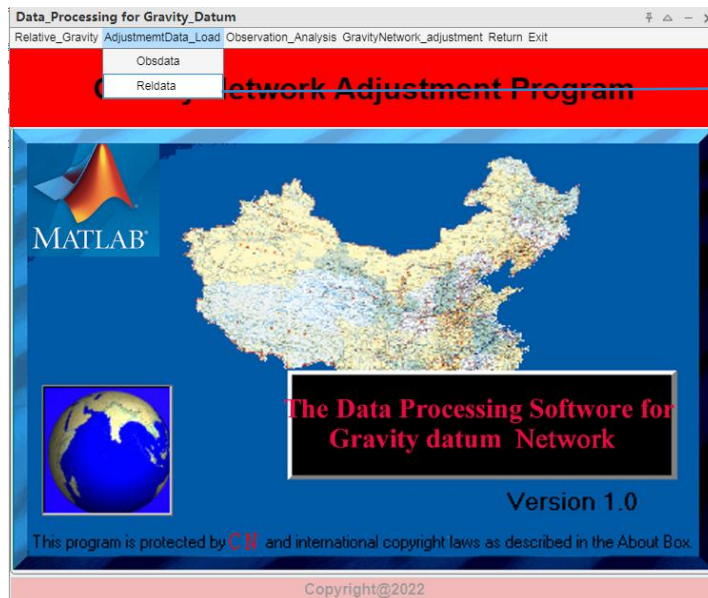


Step 5: Click on the menu bar **【 Adjustmentdata\_load - Obsdata】** to start importing absolute gravity adjustment data and Click on the menu bar **【Adjustmentdata\_load - Reldata】** to start importing relative gravity adjustment data.





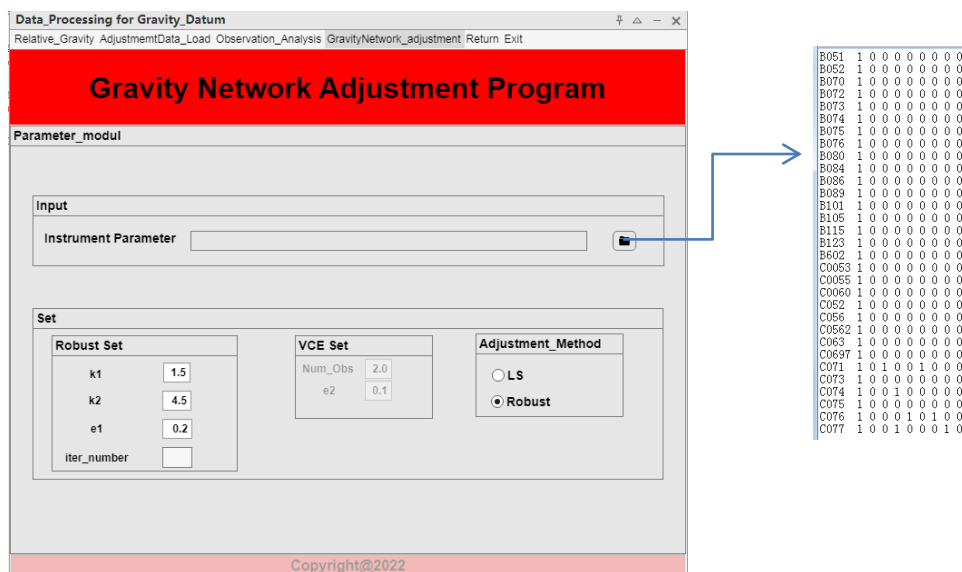
```
AA01 980105068.124 24
AA01 980105064.973 24
A001 981253015.190 24
A002 980198020.450 24
A003 980941162.320 24
A004 980881030.600 24
A005 980916118.900 24
A006 980777231.660 24
A007 980793185.490 24
A008 980692728.470 24
A008 860692728.440 24
A009 980640430.190 24
A009 980640430.290 24
A010 980630240.970 24
A010 980630240.000 24
A011 980630210.430 24
A011 980634209.690 24
A012 980105068.124 24
A013 978536911.150 24
A013 978536914.260 24
A014 980979434.020 24
A015 980830006.832 24
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A018 980615927.855 24
A018 980615928.352 24
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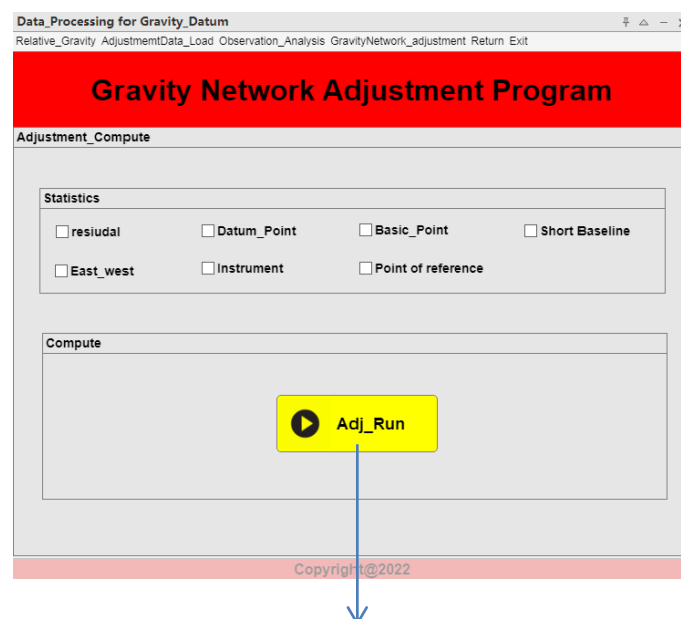
```
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C1135 20180528 A001 B001 7622.303 7524.012 7624005.902 7524005.902 -98437.264 0 0 1
C1404 20180528 A001 B001 5552.279 5453.978 5453973.689 5453973.689 -98405.423 0 0 1
C1406 20180528 A001 B001 6049.595 5961.333 5961333.782 5961333.689 -98548.392 0 0 1
C1407 20180528 A001 B001 5283.337 5184.851 5283478.577 5184929.782 -98548.392 0 0 1
C1407 20180528 A001 B001 5869.395 5771.081 5869536.577 5771087.834 -98448.734 0 0 1
C1130 20180526 A001 B013 5117.429 5784.351 6117512.139 5784647.471 -332864.668 0 0 1
C1135 20180526 A001 B013 7620.906 7288.011 7620988.214 7287891.999 -333096.214 0 0 1
C1404 20180526 A001 B013 5551.020 5218.204 5551104.389 5218101.910 -333003.079 0 0 1
C1405 20180526 A001 B013 6028.272 5715.487 6048355.138 5715384.390 -332970.748 0 0 1
C1406 20180526 A001 B013 5282.398 4949.364 5282481.755 4949397.630 -333144.125 0 0 1
C1407 20180526 A001 B013 5868.118 5535.202 5868201.755 5535108.729 -333093.026 0 0 1
C1130 20180529 A001 C001 6119.016 6069.657 6119178.124 6069779.406 -49398.719 0 0 1
C1135 20180529 A001 C001 7622.977 7573.625 7623197.549 7573727.854 -49409.695 0 0 1
C1404 20180529 A001 C001 5552.886 5503.511 5553049.976 5503630.548 -49149.428 0 0 1
C1405 20180529 A001 C001 6050.225 6000.897 6050386.132 6001011.469 -49374.663 0 0 1
C1406 20180529 A001 C001 5283.756 5234.309 5283920.006 5234449.892 -49470.115 0 0 1
C1407 20180529 A001 C001 5870.227 5820.781 5870389.542 5820948.732 -49460.810 0 0 1
C1130 20180606 A002 C002 5851.177 5808.402 5851345.712 5808568.015 -42777.698 0 0 1
C1135 20180606 A002 C002 7356.170 7313.385 7356326.903 7313525.529 -42801.374 0 0 1
C1404 20180606 A002 C002 5285.542 5242.761 5285707.929 5242916.871 -42791.058 0 0 1
C1405 20180606 A002 C002 5783.194 5740.417 5783352.580 5740557.575 -42817.805 0 0 1
C1406 20180606 A002 C002 5014.871 4972.044 5015060.161 4972242.380 -42817.805 0 0 1
C1407 20180606 A002 C002 5802.788 5560.004 5802960.184 5560163.302 -42796.859 0 0 1
C442 20180529 A002 B004 6868.023 6919.385 6868197.944 6919382.290 51683.682 0 0 1
C936 20180529 A002 B004 5312.644 5364.389 5364470.951 5363906.243 51666.801 0 0 1
C939 20180529 A002 B004 6702.062 6753.856 6702222.562 6753906.243 51683.682 0 0 1
C940 20180529 A002 B004 6811.694 6863.508 6811854.553 6863498.870 52644.338 0 0 1
```

Step 6: Click on the menu bar **GravityNetwork\_Adjustment - Parameter Settings** to import data, set adjustment parameters, and select adjustment methods. For example, we must give the parameter  $k_1$ ,  $k_2$  and  $e_1$  for conducting the robust estimation.





Step 7: Click on the menu bar **GravityNetwork\_Adjustment - Parameter Settings** , select the adjustment parameter results statistics, and click on the menu **adjustment computation**



1.number of measurement for adjustment computation: 1357    2.Number of gravity point and instrument:  
3.Sigma: 15.199    4.Vaiance of gravity point: 3.487

5.The ending gravity value of observaiton point: Series number of point    Gravity value    Precision

A001	981252015.196	2.540
A002	980980100.853	3.231
A003	980941163.183	4.240
A004	980881028.095	3.640
A005	980777293.116	4.270
A006	980793186.791	3.468
A007	980640429.304	5.236
A008	980634209.004	3.640
A008	980476448.943	5.552
A010	978536910.618	4.359
A011	980979442.482	3.356
A012	980830067.546	4.565
A013	980716358.213	3.115