PPO

User manual

PENTAX

October 26, 2019

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Chapter 1 Installation

1.1 Introduction

PPO is mainly for processing baselines of GNSS static data, then the result will be used to adjust constrained network, so as to obtain final report for control network.

This software is capable of processing data in two formats: RINEX standard data and *.dat data of G6 and GC200.

To get started quickly, you may just refer chapter 2.

Integrated with friendly interface, processed management and operation as well as better graphical operation interface and graphics service, it perfectly performs export and save of a variety of graphics including baseline network diagrams and error ellipses.

Using management of establishing project file, that engineering project exists in the form of a file, reliability is greatly enhanced. PPO provides users with the convenience to customize the projector ellipsoid parameters and select diverse coordinate system. The entire process, including baseline solution, network adjustment and other operations, are operating in the project files under save path. This software records all operations automatically, and it can export the progress of processed date which is saved at any time, then to continue processing or check the results.

It can perform functions like baseline vector solution, closed loop searching and network adjustment processing.

Using PPO to process baseline, it can easily set solution conditions and solver type of any baseline. For synchronous loop, asynchronous loop and repeating baseline, it can search automatically. In the network adjustment process, it has increased 3D constrained adjustment, plane adjustment and vertical adjustment.

1.2 Installation

Download PPO installation package, run the installation program as an administrator, choose the installation path as shown in Figure 1-1 and the default installation path is C:\Program Files (x86)\PENTAX\PPO\ without modification as shown in Figure 1-2. Click

[Finish] in the pop-up interface as shown in Figure 1-3, which means successful installation and then the software automatically creates a PPO shortcut on the desktop and the start menu. Double click the PPO shortcut as shown in Figure 1-4, and the main interface appears as shown in Figure 1-5. Now a series of operations could be done in the main interface, such as new project establishment, baseline solution, and network adjustment.

Note: If your computer is Win10 system, please don't install the PPO in disk C, or you need to run PPO as administrator.

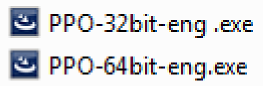


Figure 1-1

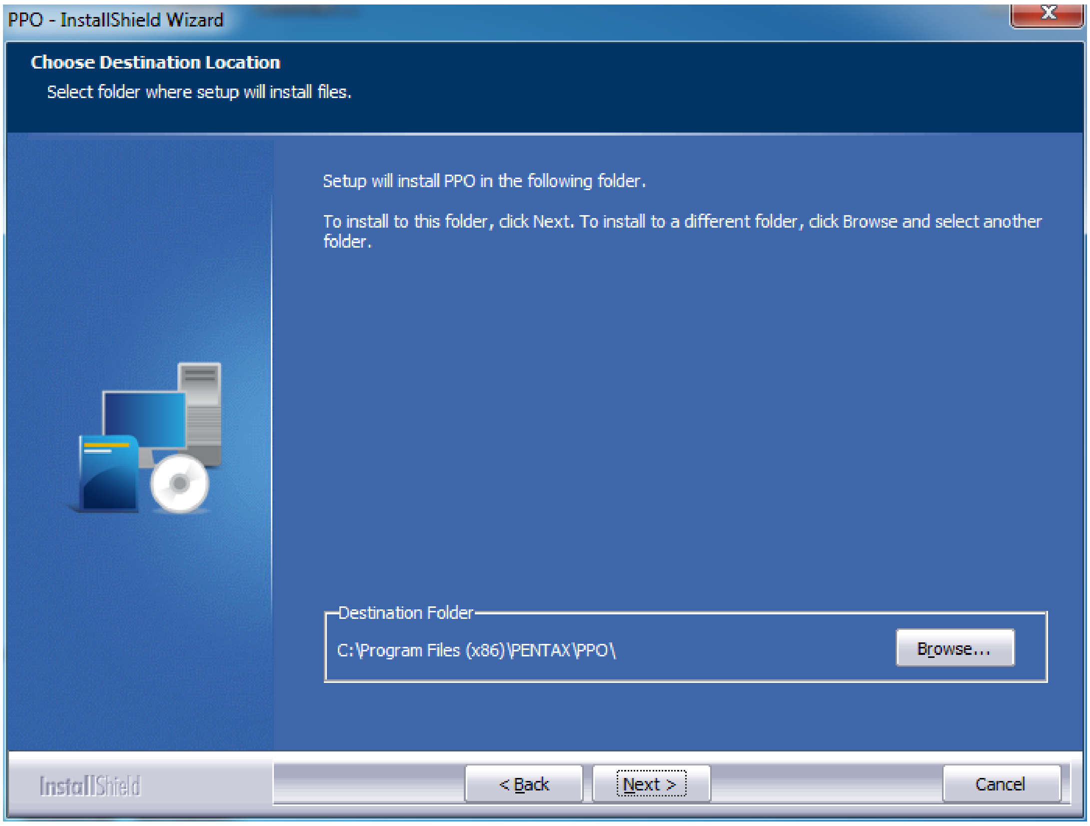


Figure 1-2

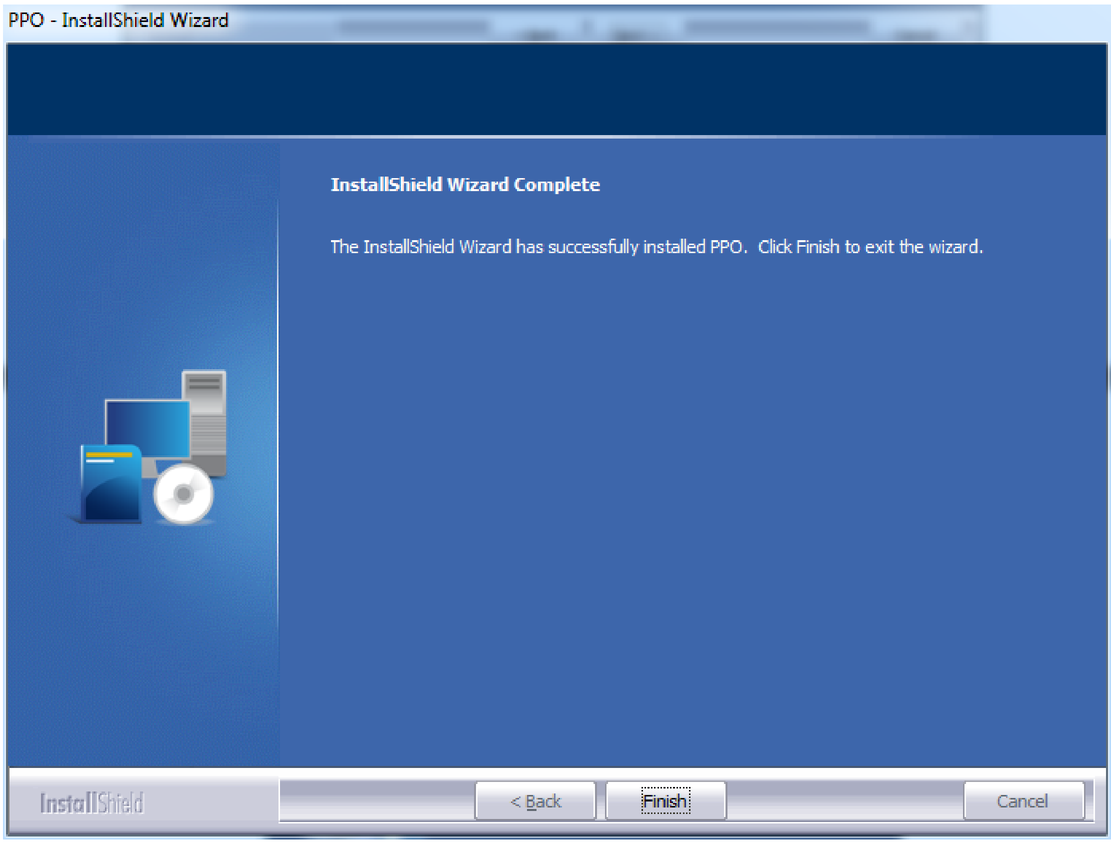


Figure 1-3

Figure 1-4

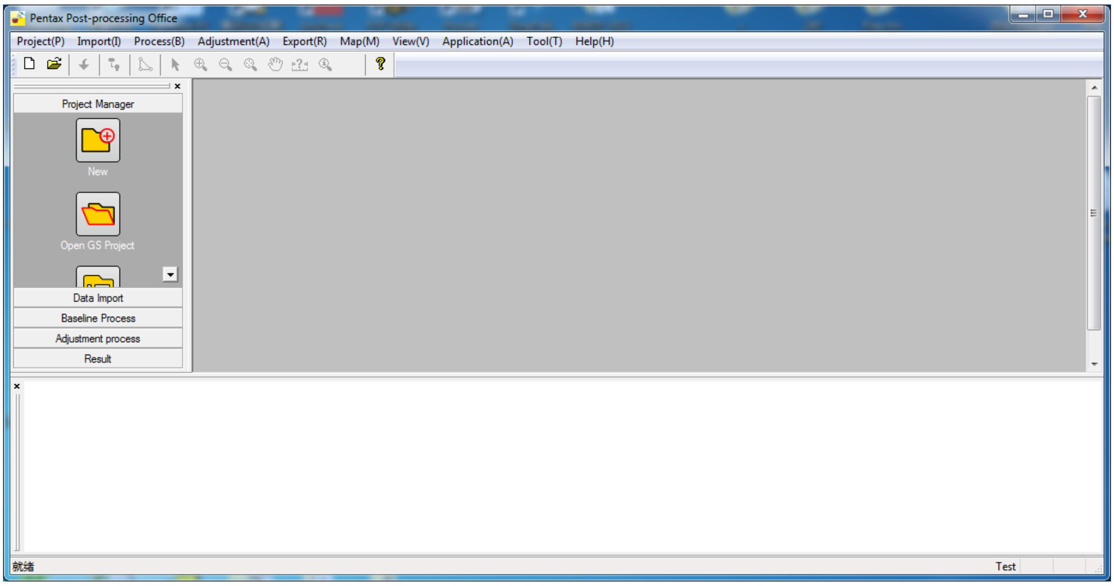


Figure 1-5

Chapter 2 Data processing

This chapter mainly explains the simple procedure that PPO data processes GNSS static data and dynamic post-differential data, so that the user can quickly understand how to use the software in a short time. The data processing process is briefly described below. Other more detailed introduction please refer to the following sections.

2.1 GNSS static data processing

1) New project

Click [Project] – [New], then pops up the interface as shown in Figure 2-1. Project name is necessary, while other items are optional. Click [Coordinate Sys.] and input coordinate system name as shown in Figure 2-2. The users could set Ellipsoid Parameter, Projections Parameter and other information in this interface.

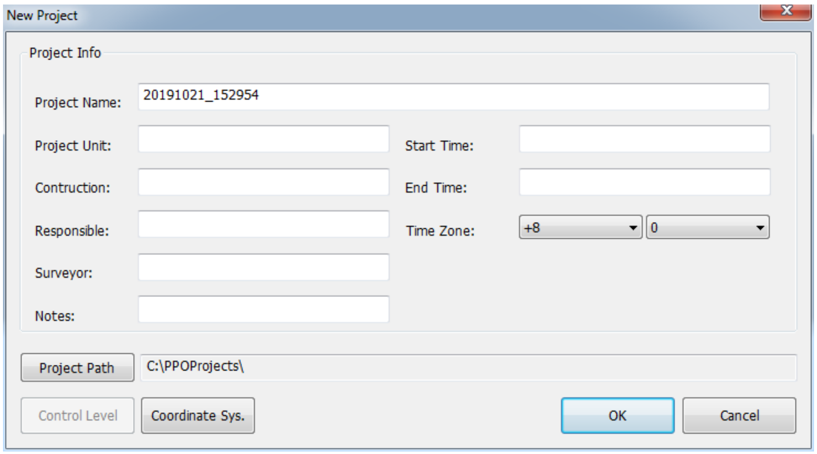


Figure 2-1

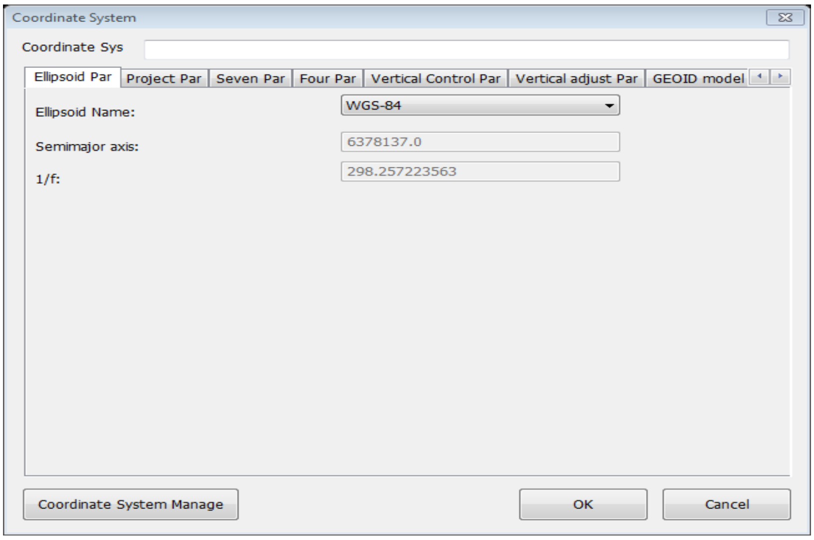


Figure 2-2

2) Import data

Click [Import] - [Observation Data] as shown in Figure 2-3, then choose the data file and click [Open]. Import succeeds as shown in Figure 2-4.

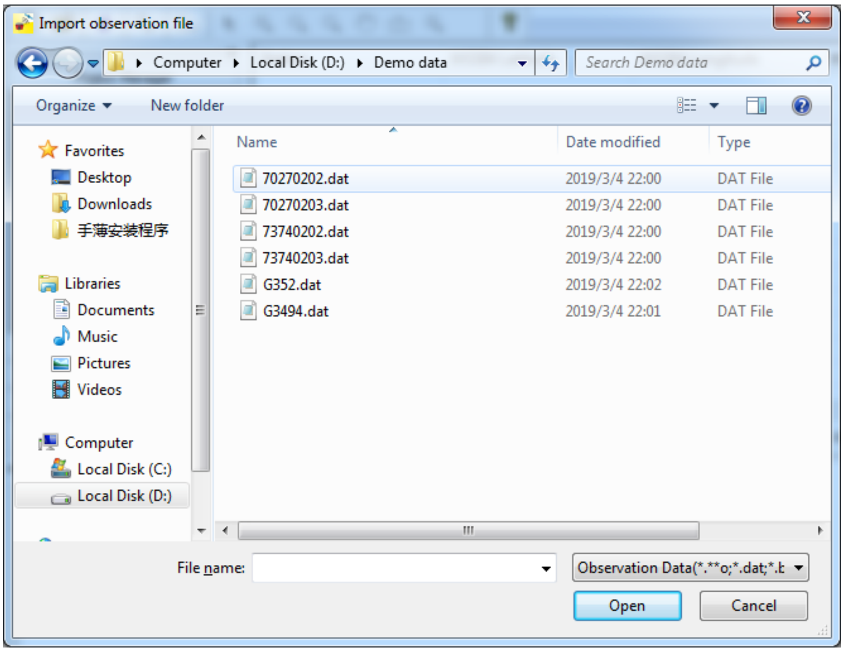


Figure 2-3

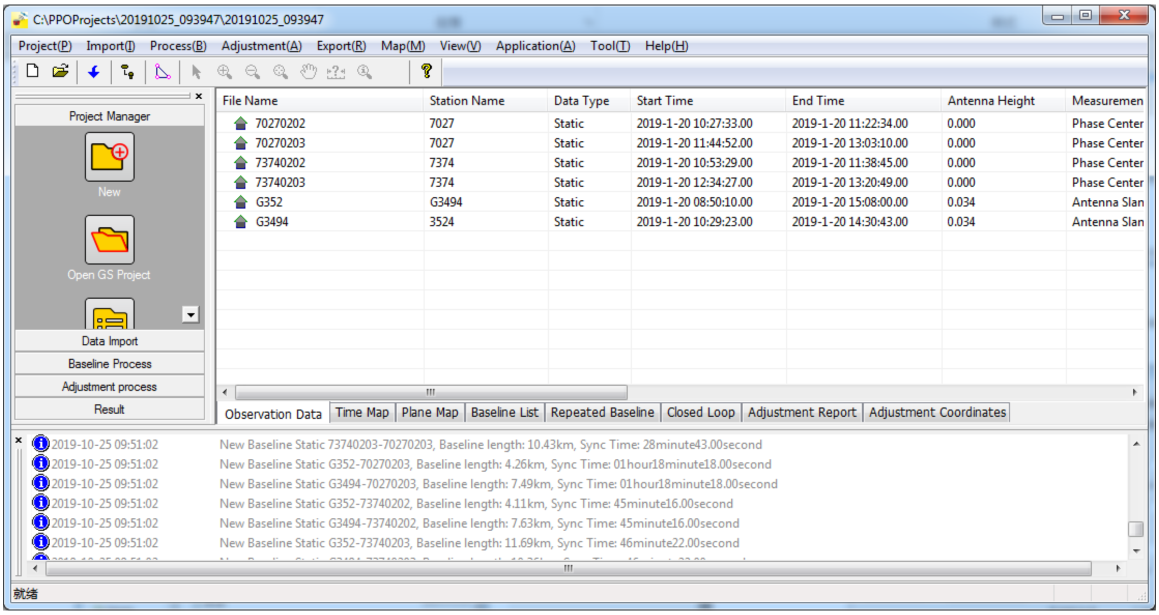


Figure 2-4

3) Static Options setting

Click [Process] - [Static Options] as shown in Figure 2-5, and click [OK] when finishing setting.

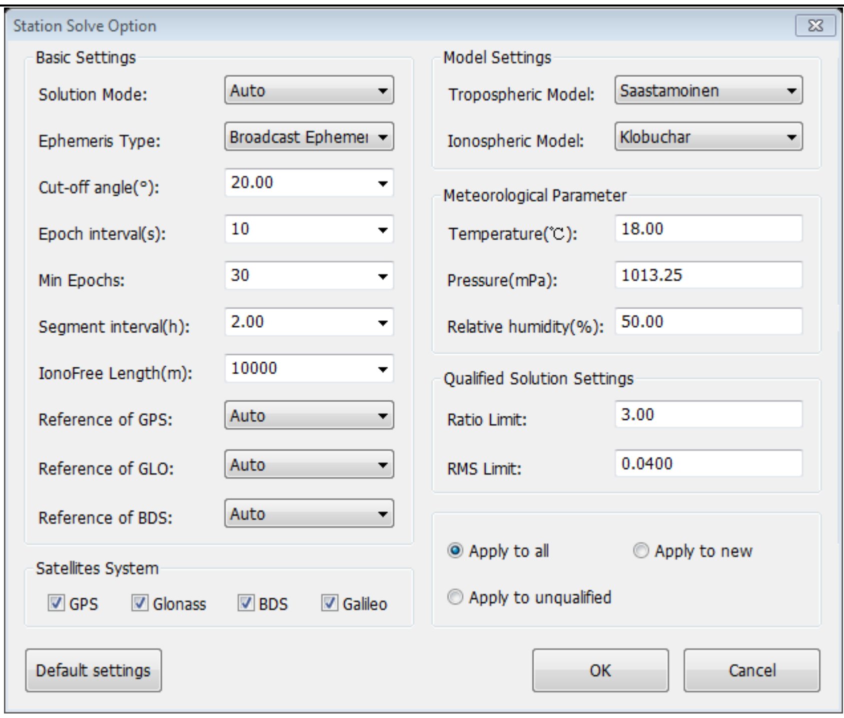


Figure 2-5

4) Baseline process

a. Click [Process] - [Process all baselines] to process all the baselines as shown in Figure 2-6. When the Figure 2-7 appears, it means process complete. green refers to baselines that succeed to process, while red refers to those failed.

b. Right-click the unqualified baselines in the baseline table, then choose [Processing settings], and modify the static setting parameters to reprocess this baseline.

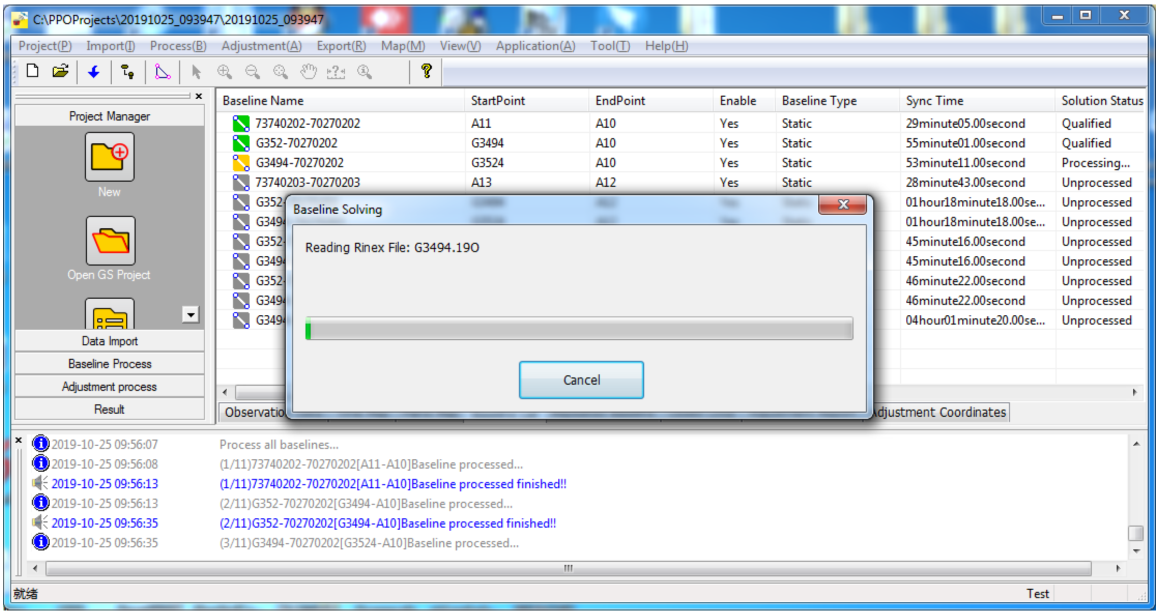


Figure 2-6

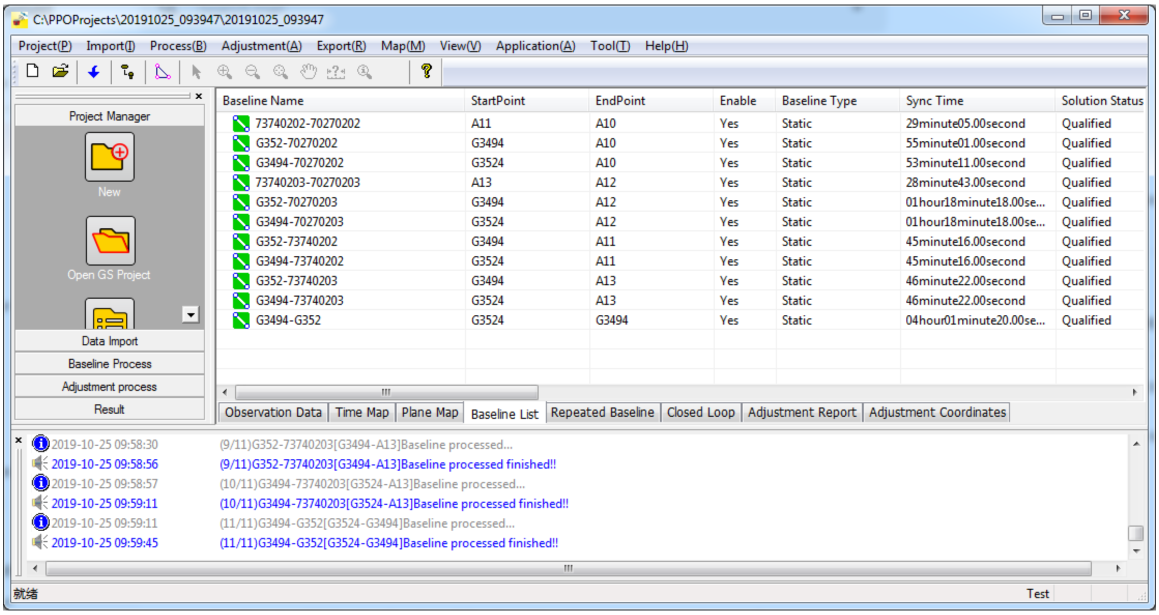


Figure 2-7

5) Network Adjustment

a. Click [Adjustment] - [Adjustment Settings] as shown in Figure 2-8.

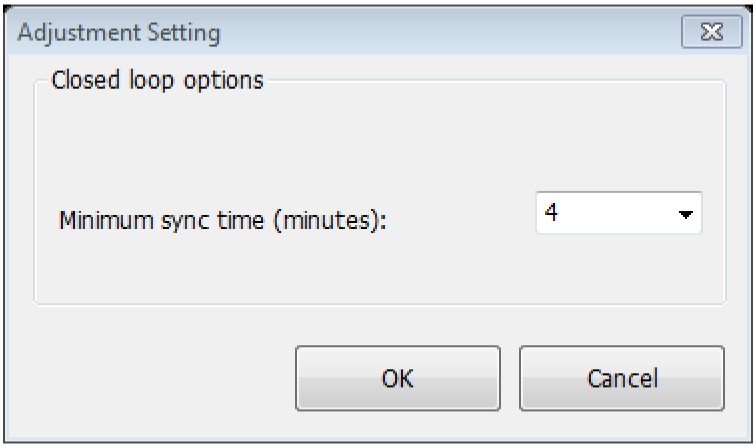


Figure 2-8

b. Click [Import] - [Known Coordinates] as shown in Figure 2-9.

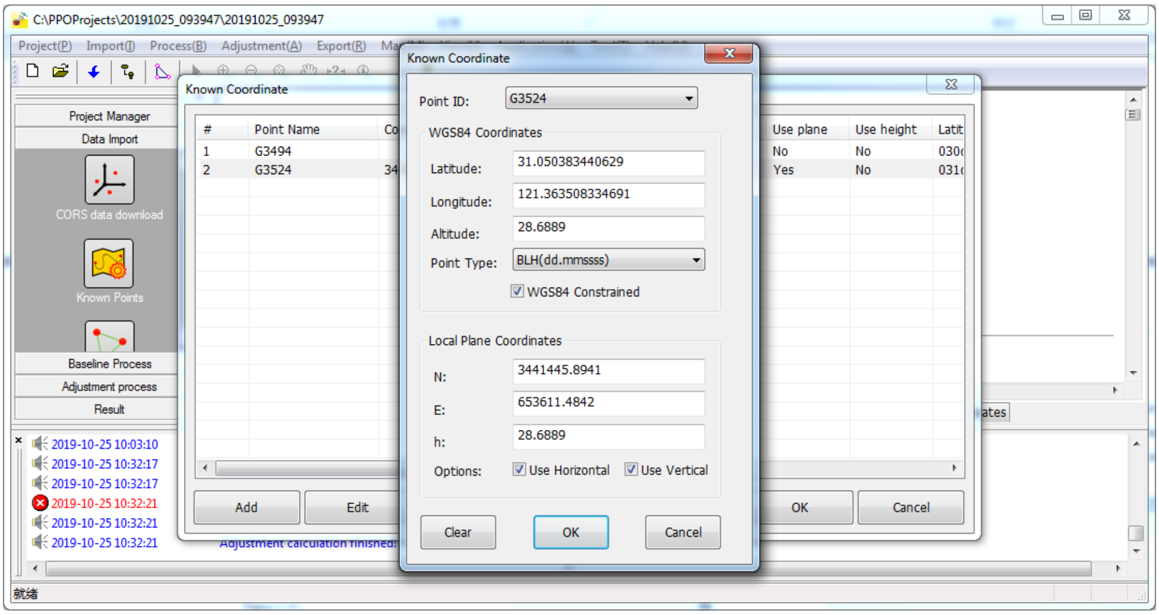


Figure 2-9

c. Click [Adjustment] - [Adjustment Processing], the adjustment report is as shown in Figure 2-10.

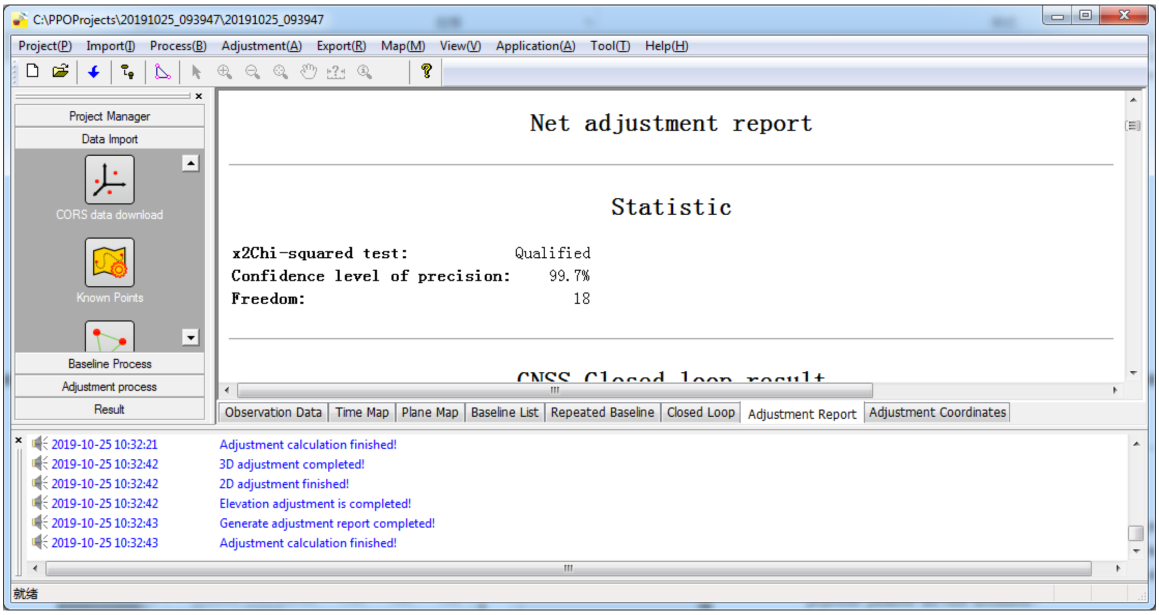


Figure 2-10

6) Export processing results

Click [Export] - [Static Processing Results] as shown in Figure 2-11. After choosing the file type and save path, click [Export], then the processing result could be exported.

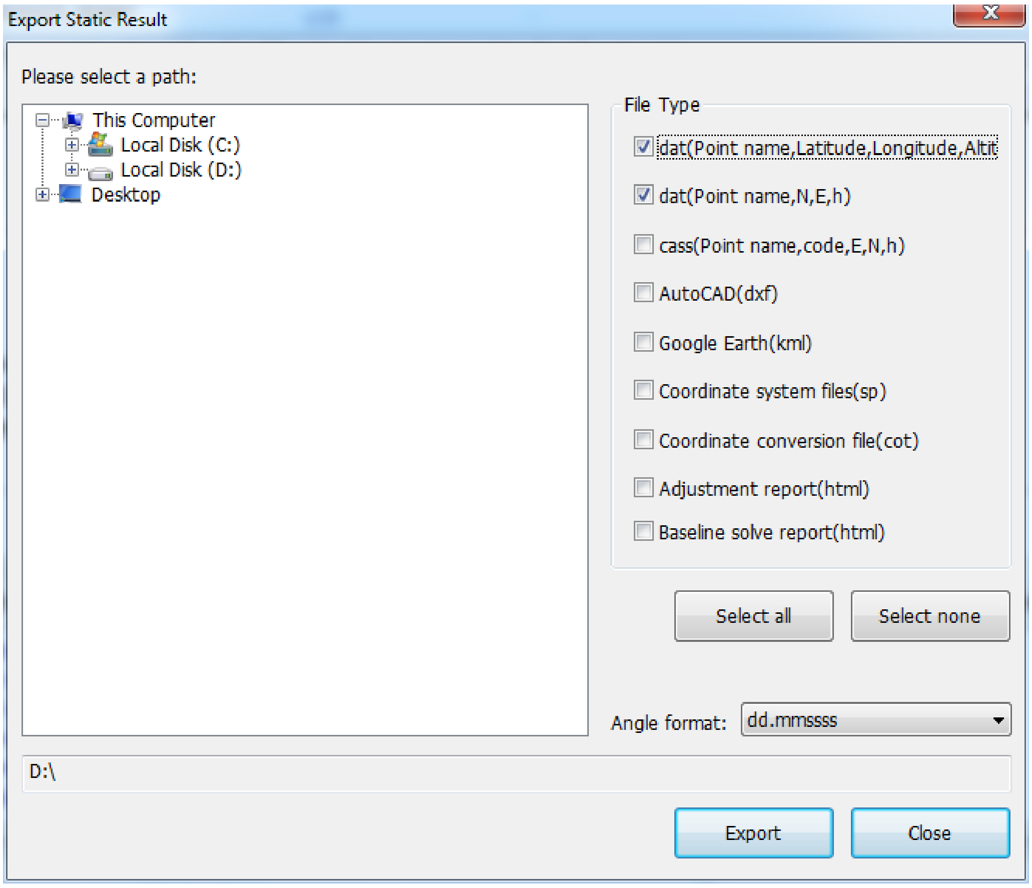


Figure 2-11

2.2 GNSS dynamic data processing

1) New project

Click [Project] - [New], pops up the interface as shown in Figure 2-12. Project name is necessary, while the other items are optional. Click [Coordinates Sys.] and input coordinate system name as shown in Figure 2-13, users can set ellipsoid parameter and projections parameter and other information.

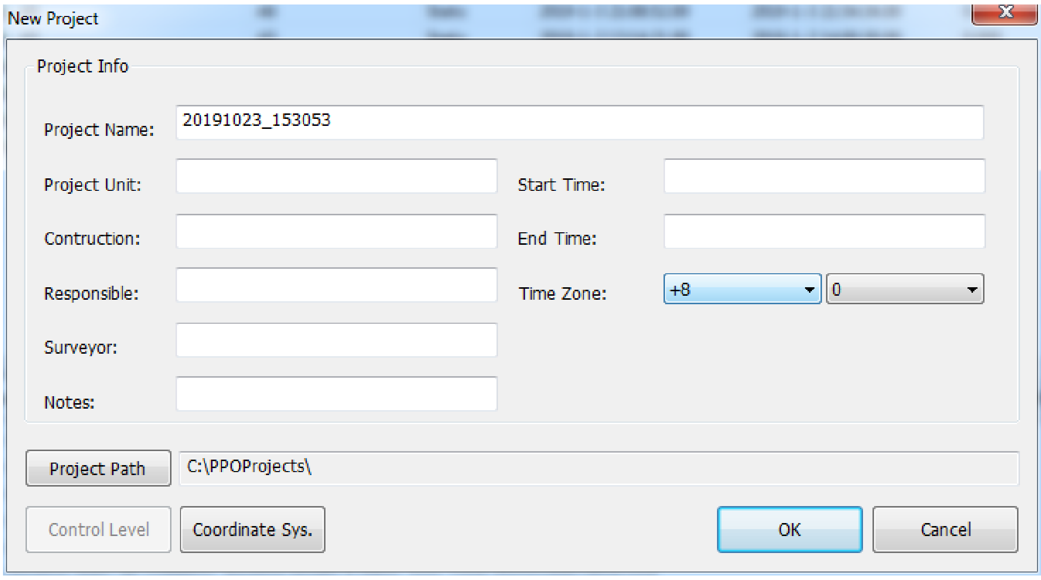


Figure 2-12

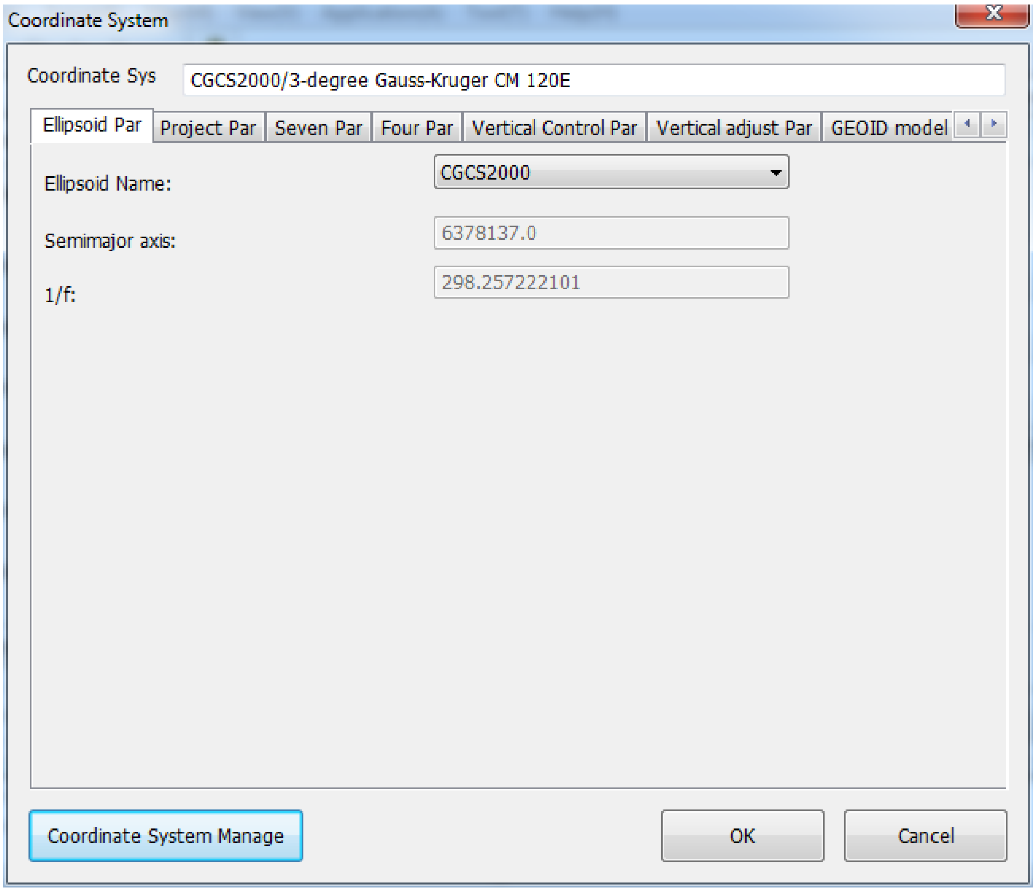


Figure 2-13

2) Import data

Click [Import] - [Observation Data] as shown in Figure 2-14, choose the data file and click [Open]. The interface as shown in the Figure 2-15 means import succeed. The imported observation data should contain two kinds of data files, base station and rover.

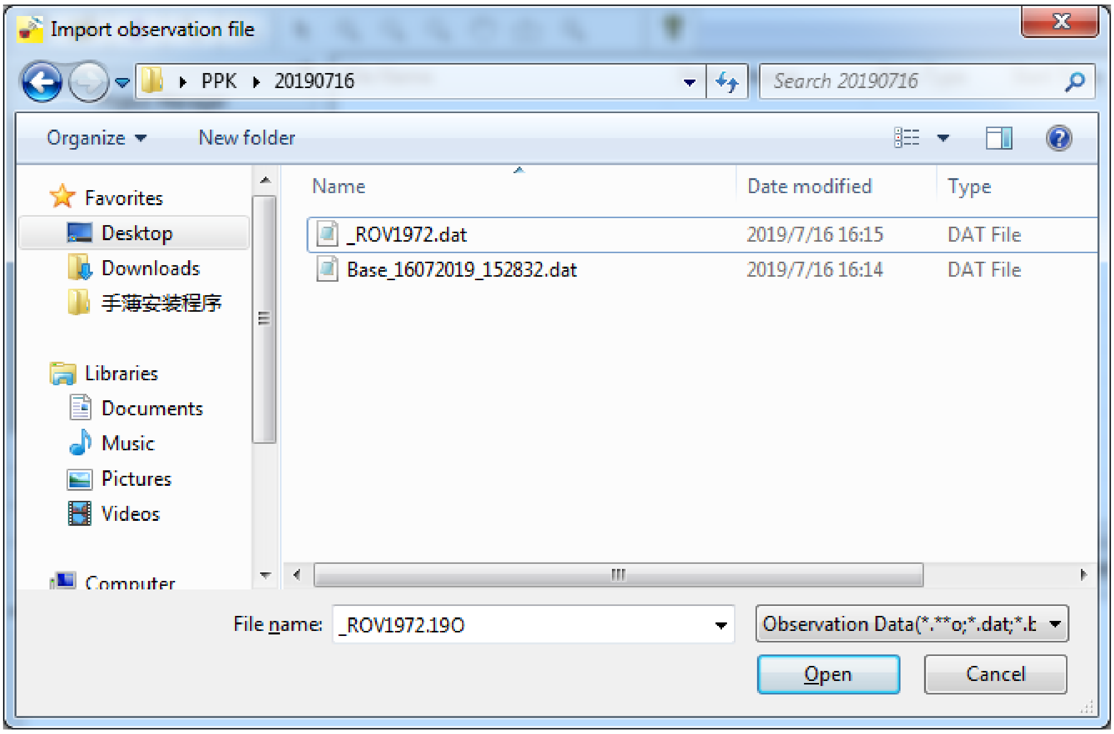


Figure 2-14

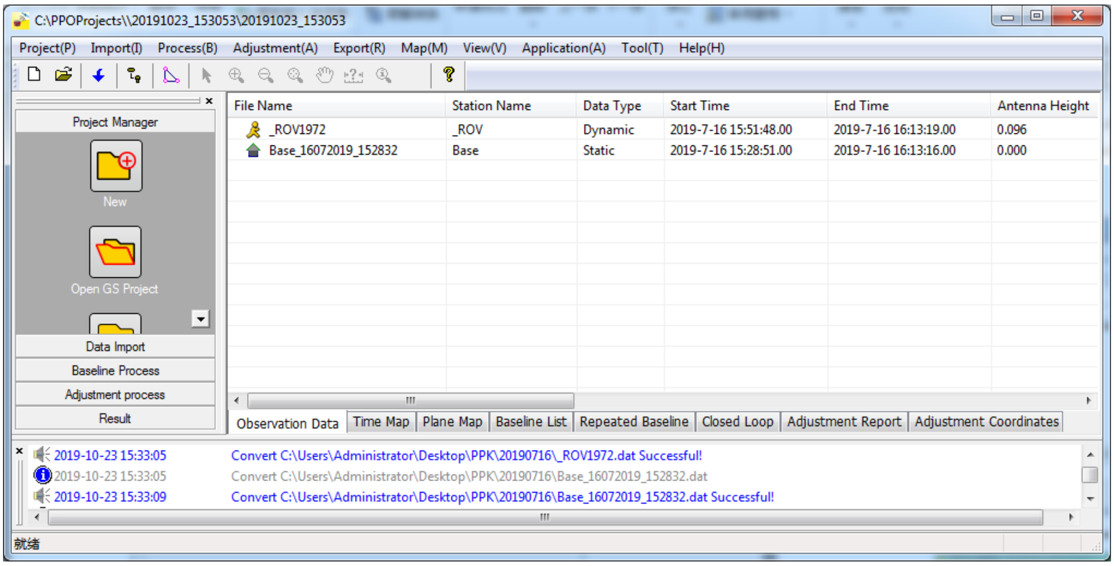


Figure 2-15

3) Modify dynamic options

Click [Process] - [Dynamic Options] as shown in Figure 2-16. Click [OK] after setting up the parameters.

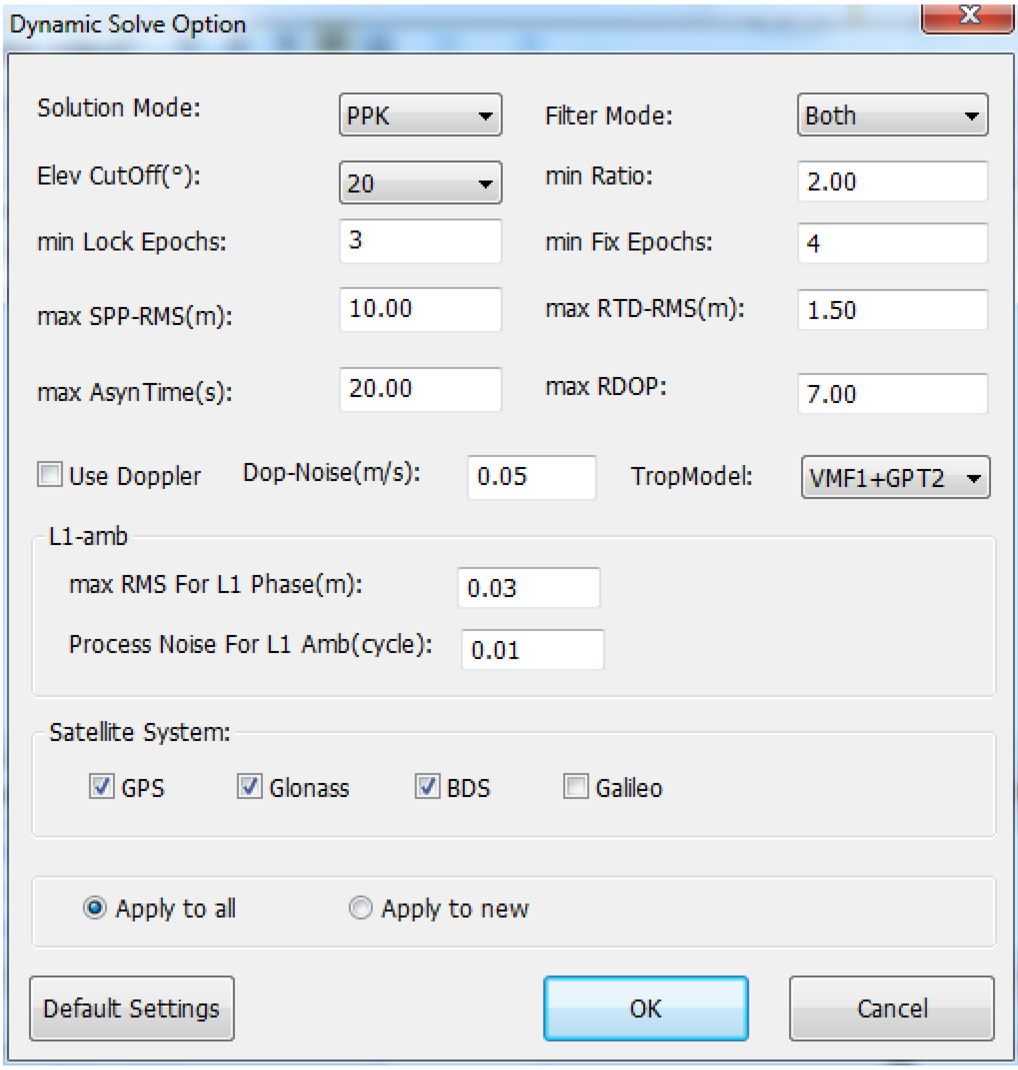


Figure 2-16

4) Baseline Processing

Click [Process] - [Process all baselines] to process all the baselines as shown in Figure 2-17. Process completes as shown in Figure 2-18. Green refers to baselines that succeed to process, while red refers to those failed.

a. Right click the unqualified dynamic baseline in the baseline table, choose [Processing settings], then modify the dynamic setting parameters to process this baseline again.

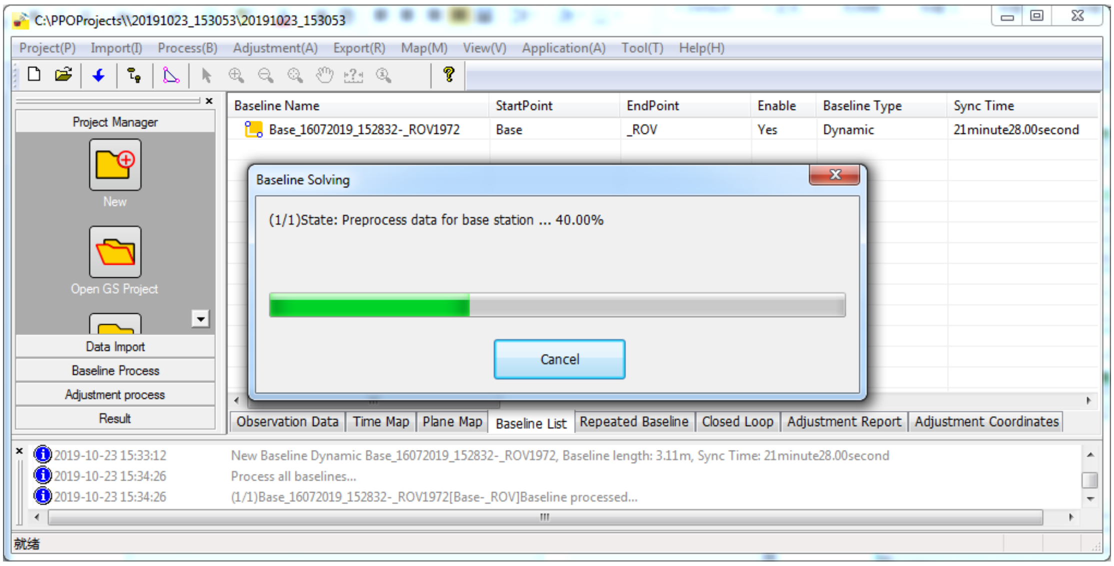


Figure 2-17

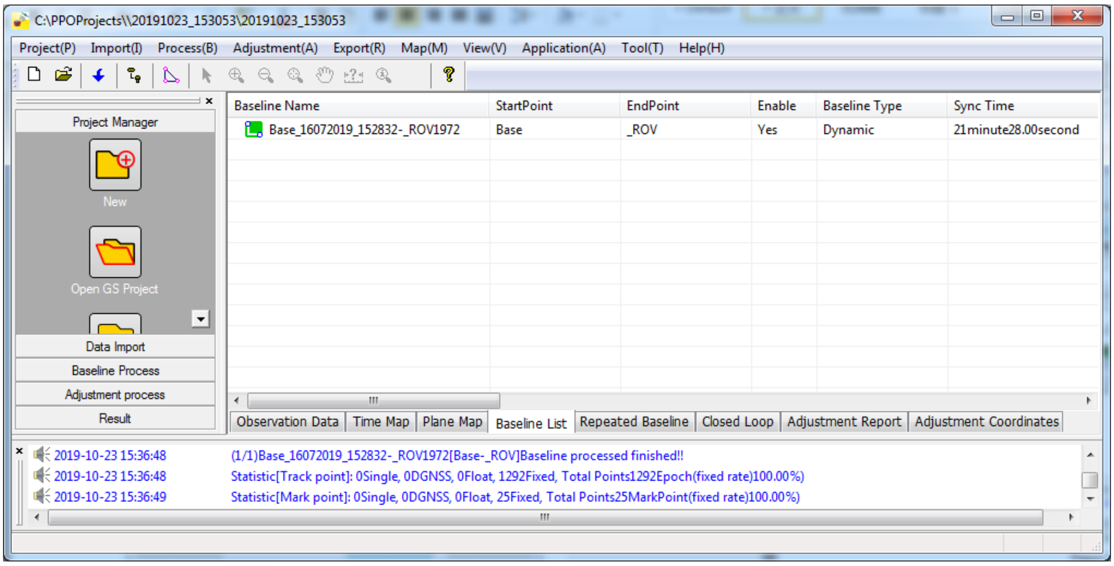


Figure 2-18

5) Check the results of the dynamic baseline solution.

Click [Result] - [View dynamic data] as shown in Figure 2-19. Green refers to points in fixed solution, yellow to points in float solution and red to points in single solution.

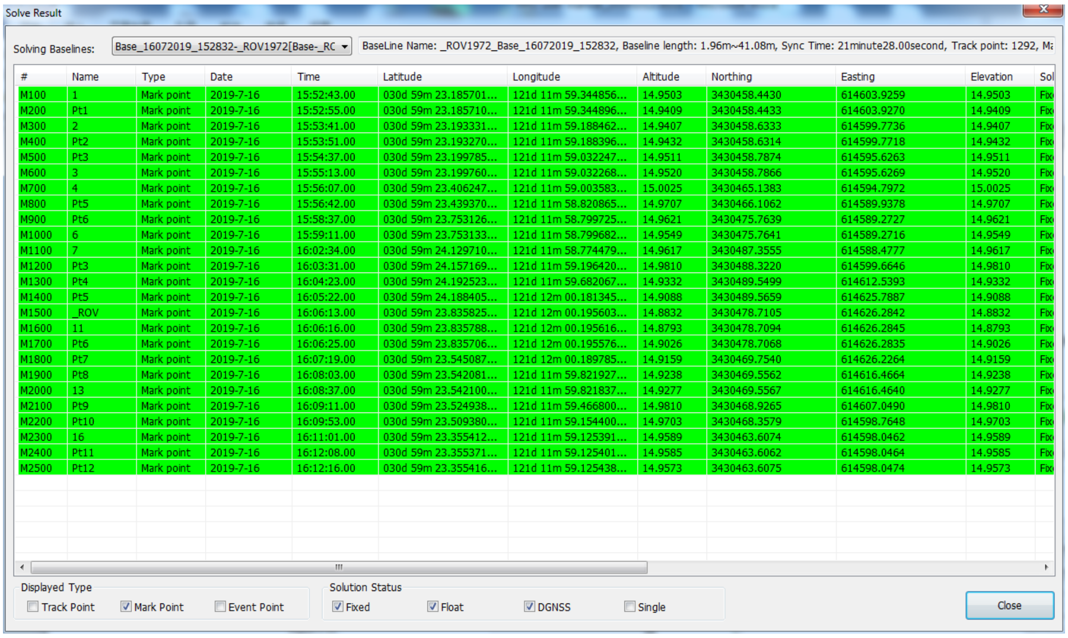


Figure 2-19

6) Export dynamic solution coordinates

Click [Export] - [Dynamic solution coordinates] as shown in Figure 2-20, choose file type, point type and solution status, then click [Export]. Select the file storage location, and the dynamic solution coordinates could be exported successfully.

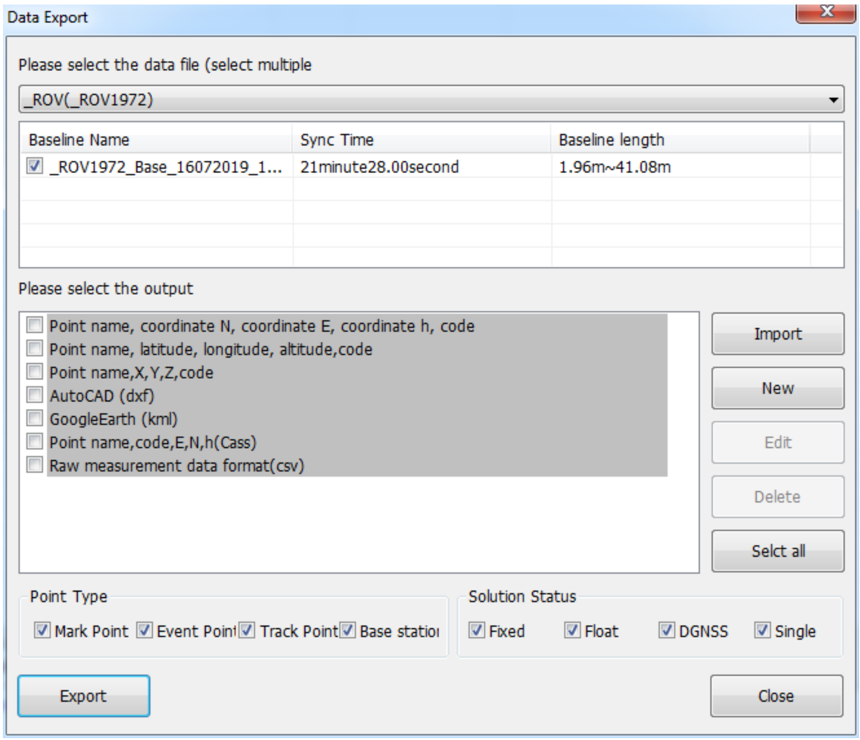


Figure 2-20

Chapter 3 PPO

PPO is a professional processing software in GNSS industry. Using management of establishing project file, it needs to create or open a project before data processing. The software can process data collected by third-party receivers with the aid of RINEX format data input, including the post-processing of mixed operation data from different kinds of GNSS receivers.

3.1 The Main Function

1) It can deal with the observation data in the standard RINEX data format, which is advantageous to process the observation data collected by the mixed operation of different receivers.
2) It can download the observation data of IGS and CORS.
3) It can process static baseline, dynamic baseline and perform network adjustment.
4) It can export dynamic/static baseline processing results and network adjustment results.
5) All baselines can be fully automatically processed and can be individually handled manually.

3.2 Main Interface of Software

Run PPO as shown in Figure 3-1. The main interface consists of a Title Bar, Menu Bar, ToolBar, Navigation Bar, Workspace, Information Bar and Status Bar.

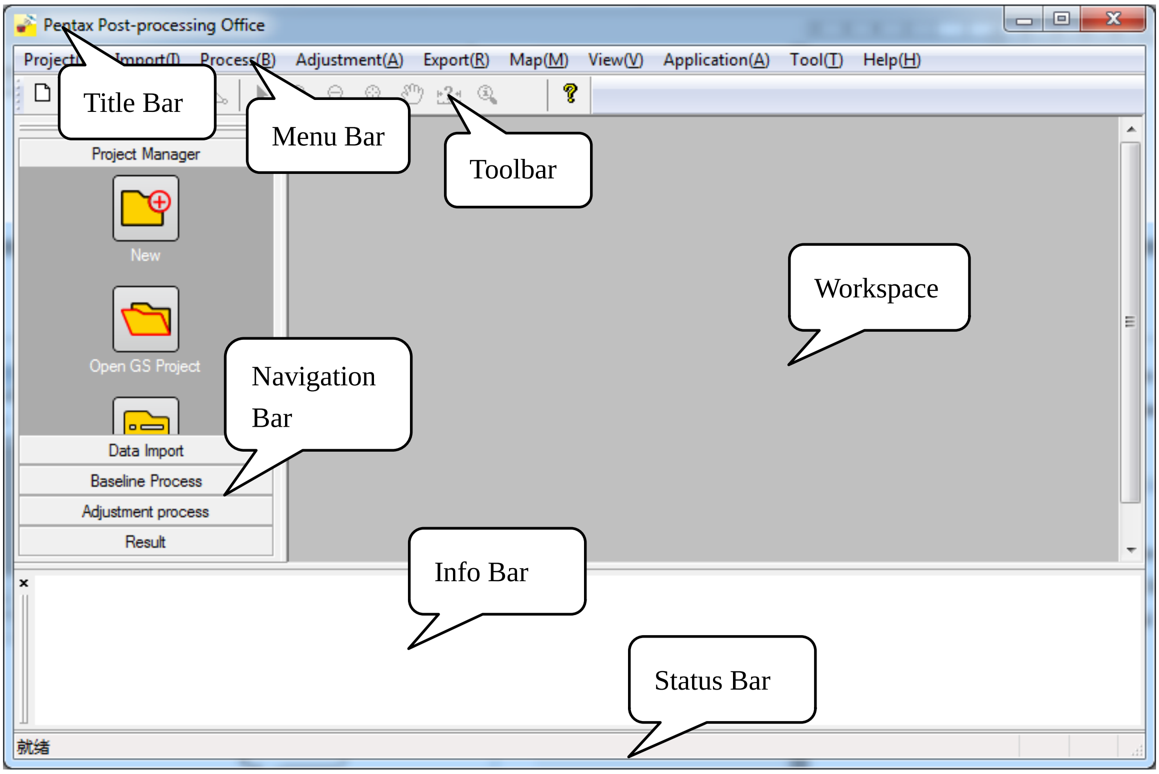


Figure 3-1

Title Bar: The initial purpose of the Title Bar is to help you quickly determine the current application class. It can provide some basic program control for you, such as restore, move, size, maximize, minimize, and close. If a project is open currently, the project save path will be displayed.

Menu Bar: The drop-down menu is an important part of any Windows application window, for providing commands of building projects, baseline solutions, network adjustment, data management, view management, etc.

Toolbar: It provides some common shortcut commands, including creating new projects, open projects, import observation data, baseline solutions, network adjustment, and the operation commands in the map of peace surface.

Navigation Bar: It stores most of the common quick commands, including project management, baseline solutions, network adjustment, and a series of commands of exporting results.

Workspace: The workspace is a major area of work for the user, usually including various diagrams related to the project.

Information Bar: It exports various status information in the processing.

Status Bar: It displays some prompt information for the current operation.

3.3 Menu Bar

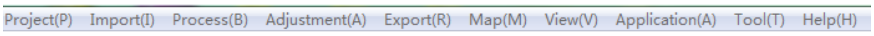


Figure 3-2

The Menu Bar contains the various functional menus of the software, namely, Project, Import, Process, Adjustment, Export, Map, View, Application, Tool, Help. The various functions are described in detail below.

3.3.1 Project

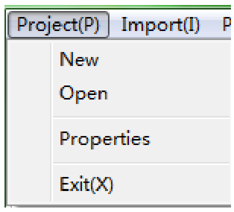


Figure 3-3

1) New

   Creating new project.

2) Open

   Open an existed project.

3) Attributes

   Check the attribute information of the project, and the attributes information can be modified after clicking open.

4) Exit

   Close the current project file and exit the software.

3.3.2 Import

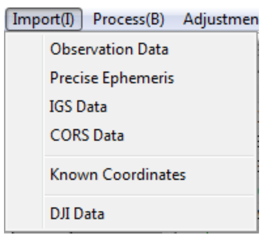


Figure 3-4

1) Observation Data

Add an observation file into the newly established project or opened project file to import observation files in formats like *.dat, *.bin(Hemisphere format), *.rt27(Trimble format), *O.RNX(blend rinex3.02 format), *.N/G/C/(format for separate import of ephemeris) and standard RINEX format.

2) Precise Ephemeris

Add a Precise Ephemeris file into the newly established project or opened project file.

3) IGS Data

Add IGS station data into the newly established project or opened project file.

4) CORS Data

Add CORS station data into the newly established project or opened project file.

5) Known coordinate

In the case of observation data import, left-click on the known coordinates, and after adding the known coordinates to the newly established project or opened project, it will be displayed as the green solid triangle in the plane map. The known coordinates that added will be used in the horizontal surface network adjustment or vertical control.

6) DJI Data

Add DJI data into the newly established project or opened project file.

3.3.3 Process

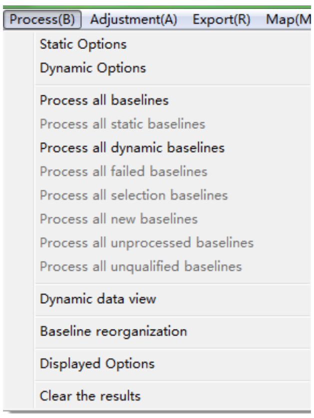


Figure 3-5

1) Static Options

Before the static baseline solution, ready to set the baseline processing condition, click the [Static Options] and the static solution setting dialog box is shown in Figure 3-6. The meaning of each setting item is as follows:

Basic Settings

- Solution Mode

The general software uses the automatic solution model in initial solution. There are seven solution modes: automatic, L1, IonoFree, L2, L1L2, LN, LW and L5/B3.

If user does not want to adopt the automatic mode, L1 solution model would be adopted in short baseline solution and IonoFree mode in long baseline solution.

- Ephemeris Type

It can choose broadcast ephemeris or precision ephemeris to process the project. Generally, using precise ephemeris can improve solution precision of long baseline, and short baseline using the broadcast ephemeris can meet the requirements.

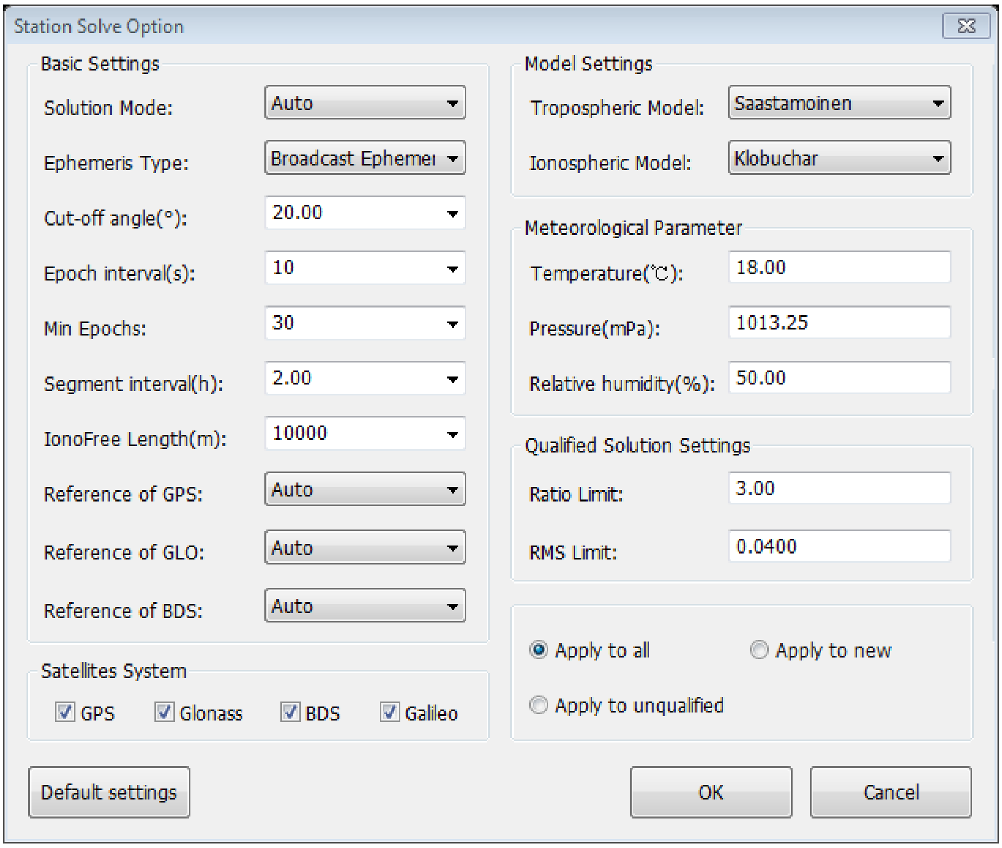


Figure 3-6

- Cut-off angle

Cut-off angle is the mask angle of satellite elevation angle, which is generally used to prevent the satellite data of low altitude from participating in the baseline solution.

The schematic diagram of mask angle is shown in Figure. 3-7.

Due to the atmosphere's influence on low altitude satellite signal is more complex, and more difficult to use model to correct. What’s more, due to the signal in low altitude is vulnerable to the influence of various factors such as multipath, electromagnetic wave, the signal quality is usually low. Therefore, usually it must eliminate them in data processing.

From the angle of atmospheric refraction, the mask angle can be reduced in the case of short distance observations. For long distance observations, the mask angle should be increased, because the shorter the distance, the more easily the atmospheric refraction effect will cancel each other out. Of course, the setting of mask angle also needs to refer to the surrounding environment.

The default mask angle of the software is 20 degrees.

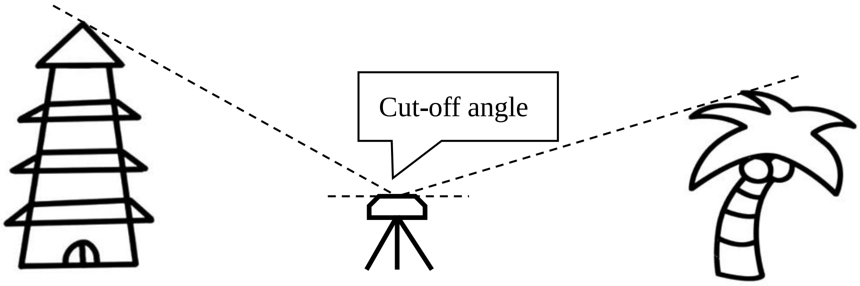


Figure 3-7

- Epoch Interval

The epoch interval is the time interval at which the software extracts data from the original observation data when the baseline is processed. For short baseline, it is appropriate to increase the epoch interval. For a long baseline, it is appropriate to decrease the epoch interval.

For example, two receivers are set to collect a set of data every 1 second in static observation, but in the case of indoor processing, such high density observational data usually can’t significantly improve the precision of the baseline, but greatly increases the time of baseline processing. Therefore, to improve the speed of baseline processing, users can appropriately increase the epoch interval of data processing.

The default epoch interval of the software is 10 seconds.

- Min Epoch

  Because in observation, the receiver must observe the continuous carrier phase. For example, if successive cycle slips occur in a piece of data, the quality of this data is usually poor and often affects the quality of the baseline processing. Therefore, the data should usually be excluded. Hence, in baseline processing, the software will remove the data segments that its consecutive observation epoch does not exceed the min epoch.

  The default min epoch of the software is 30 seconds.

- Segment Interval

  It will be divided into several time segments to process when the baseline data observation time segment exceeds the setting value. When you set the segment interval, you can set it to any value, or you can select it in the drop-down box (option 2, 4, 6).

  The default segment interval of the software is 2 hours.

- IonoFree Length: For dual-frequency data, the deionospheric combination is preferred to be used when the data exceeds 10 km.

- Reference GPS

  The double differential observed value forms when the single differential observed value is processing between the satellites. Therefore, in order to facilitate the processing, the software adopts to select the reference satellite in forming double differential observed value.

  The default setting is automatic mode. At that time, the software will select the satellite that with maximum observed data and the bigger elevation angle as a reference satellite. However, due to the influence of observation conditions, such a choice may not be the most reasonable. When choosing an inappropriate reference satellite, it will affect the baseline processing results. At this point, user is required to reset the reference satellite according to the condition of the observed data.

- Satellite System Settings

  PPO data processing software supports arbitrary combination of GPS, GLONASS and BDS (BEIDOU) satellite system for solution.

Model Settings

In general, there is no need to modify the troposphere and ionosphere model Settings. When using the medium or long baseline, it can be set according to the actual situation to improve the precision of the solution. There are two troposphere models to choose: the Saastamoinen model and the Hopfield model. The ionosphere can choose the Klobuchar model or directly choose none model.

Meteorological parameter

In general, no modification of meteorological parameter Settings is required. According to the actual situation and specific requirements of the project to modify if needed.

Qualified Solution Settings

- Ratio Limit

  Ratio is the ratio between the second smallest mean square error and the smallest root mean square error produced when the search algorithm is used to determine the integer value of the parameter of unknown number in the whole cycle.

  It reflects the reliability of the determined parameter of unknown of the whole cycle. The higher the value, the higher the reliability. When the processing value is less than the set value, the baseline solution fails.

  The default Ratio limit of the software is 3.00.

- RMS Limit

  RMS is the Root Mean Square, which is used to determine the quality of the observed data. The smaller the RMS, the better the observed data quality; Conversely, the worse the observed data quality is.

  The default RMS limit of the software is 0.04.

2) Dynamic Solve Option

   As shown in Figure 3-8, the dynamic option setting contains settings for solution parameters, measurement errors, noise processing and satellite systems and other items.

   Generally, only need to modify several settings of the following parameters, according to the specific requirements and the actual situation of project to set the rest of the settings of parameters, or to maintain the default settings can be.

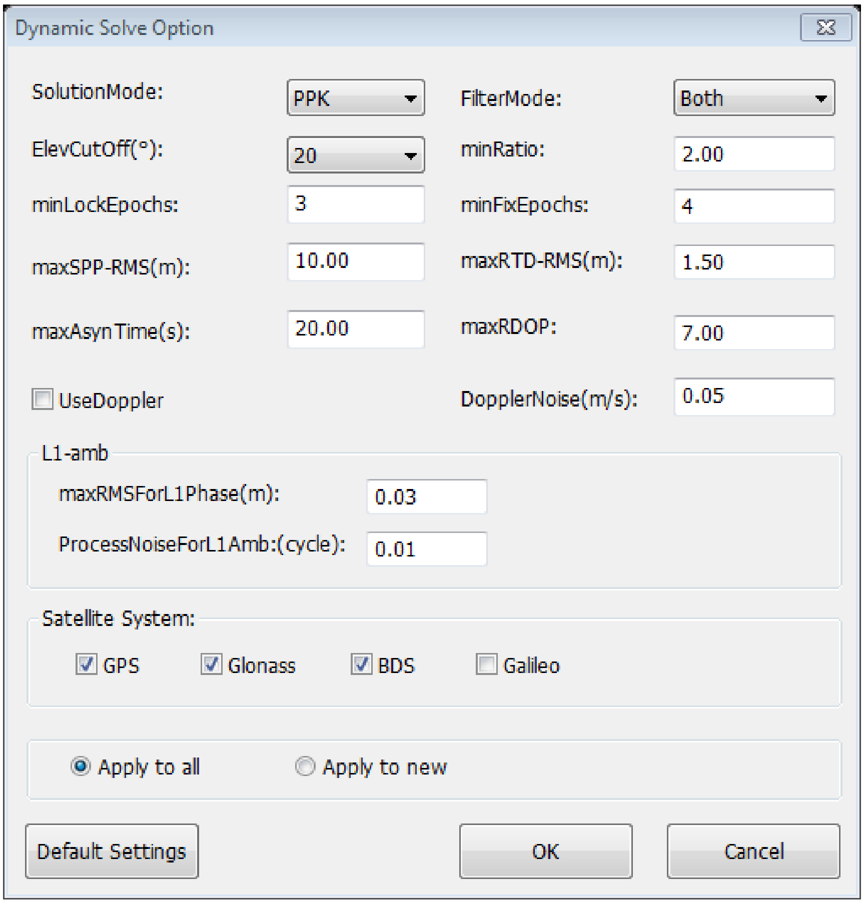


Figure 3-8

- SolutionMode: Single (Single-point positioning), RTD (Real Time Differential), PPK (Post-processed kinematic). When there's only one receiver to measure data, it can select single-point positioning to process data. When there're two or more receivers, it can select RTD and PPK to process data. Precision of PPK-processed data is relatively higher.
- FilterMode: To select filter as forward, backward or both.
- ElveCutOff: The mask angle of satellite elevation angle, which is generally used to limit the satellite data of low altitude, so that it will not participate in the baseline solution. The default mask angle of the software is 20 degrees.
- minRatio: This value reflects the reliability of the parameter of unknown number of the whole cycle. The larger the value is, the higher the reliability is. High reliability usually results in loss of fixed rate. The minRatio value for dynamic data usually is

1.5-3.0.

- minLockEpochs: PPO will eliminate data with observation continuous epochs less than this value. The larger the value is, the lower the utilization rate of the data is. And the smaller the value is, the easier the positioning is to be affected by poor satellite data.
- minFixEpochs: The value verifies if integer ambiguity is correct. A set of integer ambiguity continuous fixed epochs through ratio test is lower than the value and then they would be treated as float points. The larger the value is, the more reliable the fixed solution is, but the smaller the fixed rate is. However, the smaller the value is, the easier to lead to integer ambiguity incorrect fix. The value usually is between 3-5.
- maxSPP-RMS: RMS value refers to an important indicator set to measure the accuracy of single point positioning, which is used to indicate the extent to which the result of single point positioning deviates from its weighted average value. The larger the RMS value is, the worse the positioning accuracy is. To set Single-point RMS limit value is to keep the part below the limit.
- maxRTD-RMS: The RMS threshold is set so as to ensure the reliability of the double differential pseudorange results.
- maxAsyn Time: In the differential positioning process, the observation time of base and rover cannot be accurately matched, and Maximum allowable non-synchronous time defaults to be 20.00 seconds.
- maxRDOP: RDOP refers to elative precision attenuation factor. It is related to the environment receivers are in and the satellite geometric distribution. The smaller the value, the better. The default maxRDOP is 7.00. When RDOP exceeds 7, there is no fixed solution.

3) Baseline Solution

According to the baseline situation, it can be divided into processing all baselines, processing all static baselines, processing all dynamic baselines, processing all failure baselines, processing all chosen baselines, processing all newly increased baselines, processing all unsolved baselines, processing all unqualified baselines.

4) Dynamic data view

The dynamic data view interface, shown in Figure 3-9, allows users to view the solution results of all dynamic baselines in this interface. The display solution results include: Point Name, Type, Date, time, Latitude, Longitude, Altitude, Northing x, Easting y, Elevation h, Solution status, Satellite number, Standard residual (N), Standard residual(E), Standard residual (U), Differential delay, Ratio, Antenna height, Base station ID, Base station distance, Device Serial Number, File Name. In addition, you can select the display content, and the options available have [display type] and [solution status].

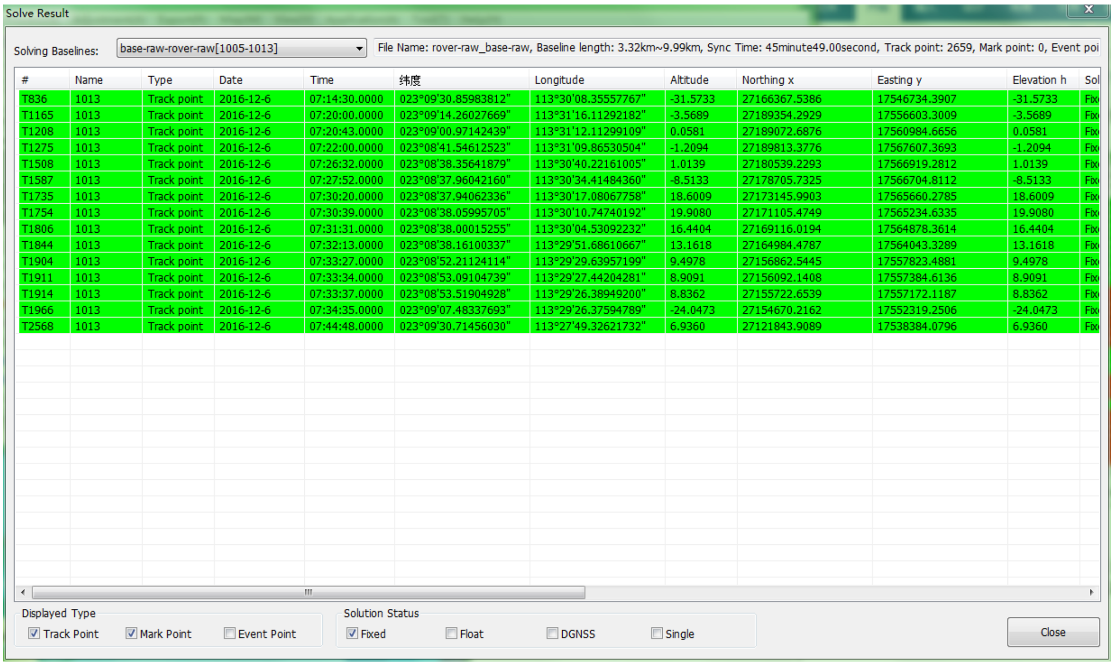


Figure 3-9

5) Baseline recognization

Cancel the results of all baselines solution.

After processing of baselines in the project, if need to modify the solution setting and solve baselines again, after modifying solution settings parameters, left-click [Baseline restructuring] and cancel all the results of the baselines, then process the baselines again. At this point, it will process based on the new solution parameters setting. Otherwise, the baseline solution is based on the original solution settings.

6) Displayed Option

Set up the display information of the plane map, including the display of the Station

Point File, Point Type, Solution Mode and Display Map, as shown in Figure 3-10.

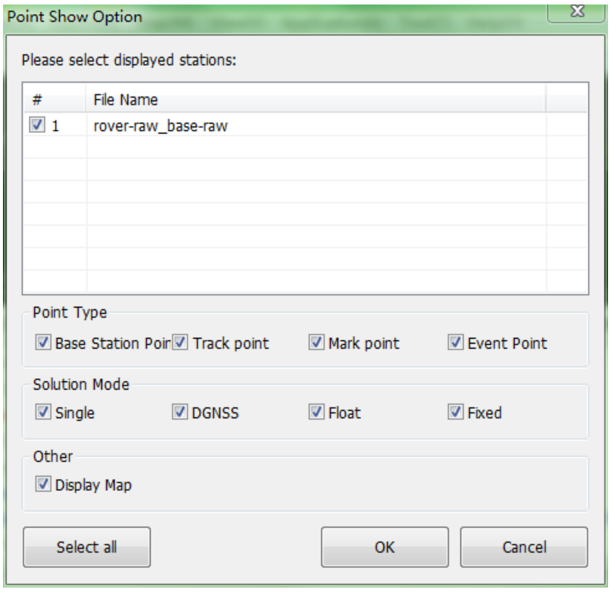
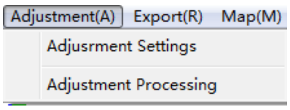


Figure 3-10

7) Clear the results

Cancel all baseline solutions.

3.3.4 Adjustment



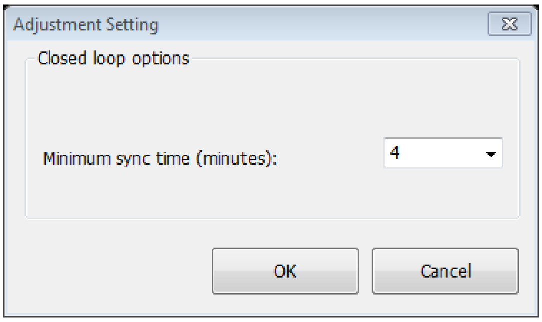


Figure 3-11 Figure 3-12

1) Adjustment Setting (show in Figure 3-12)

Minimum sync time: The baseline will not participate in closed ring combination when the synchronous observation time is less than the set synchronization time value.

2) Adjustment Processing

PPO bases on adjustment settings and control network level settings to perform network adjustment solution. The network adjustment can be divided into three-dimensional adjustment, horizontal adjustment and vertical control according to the situation of the input known point.

3.3.5 Export

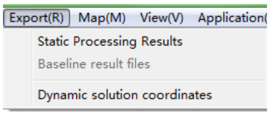


Figure 3-14

1) Static Processing Results

Static Solution results pop-up box as shown in Figure 3-15, users can export and save the static processing result file as various file type for facilitating following work. Export file type supports single and multiple selections.

File types are divided into: dat (point name, latitude, longitude and elevation), dat (point name, coordinates x, coordinate y, coordinate h), cass (point name, code, coordinates y, coordinates x, coordinates h), AutoCAD (dfx), Google Earth (kml), coordinate system files (sp), coordinate transformation file (cot), adjustment report (html), baseline solution report (html).

Users can set their own path to save the static result file.

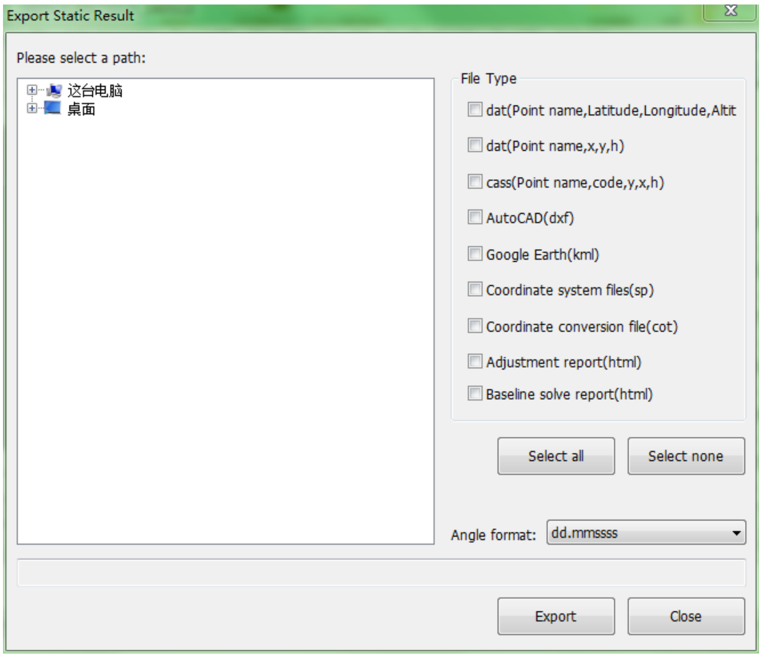


Figure 3-15

2) Baseline Result File

The pop-up box of baseline results file as shown in Figure 3-16, users can export and save the baseline results file as various file type for facilitating later. The export file type is divided into all baselines and qualified baselines.

The export format is divided into: PowerAdj3.0 Trimble, SOUTH, TGO, TGPPS Ski Pro and PENTAX. Users can set their own path to save the baseline results file.

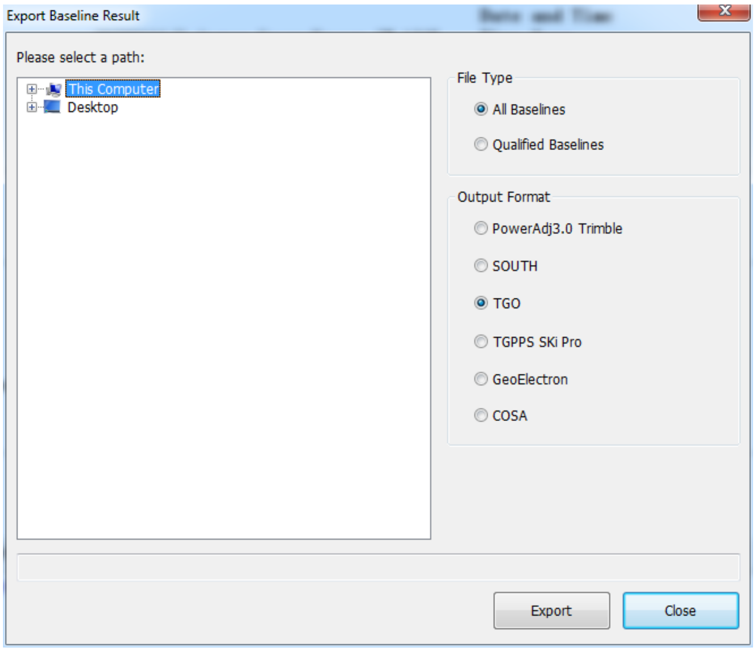


Figure 3-16

3) Dynamic Solution Coordinate

The pop-up box of dynamic solution coordinate as shown in Figure 3-17, user can export and save all or part of the dynamic solution coordinates according to the project management and analysis needs.

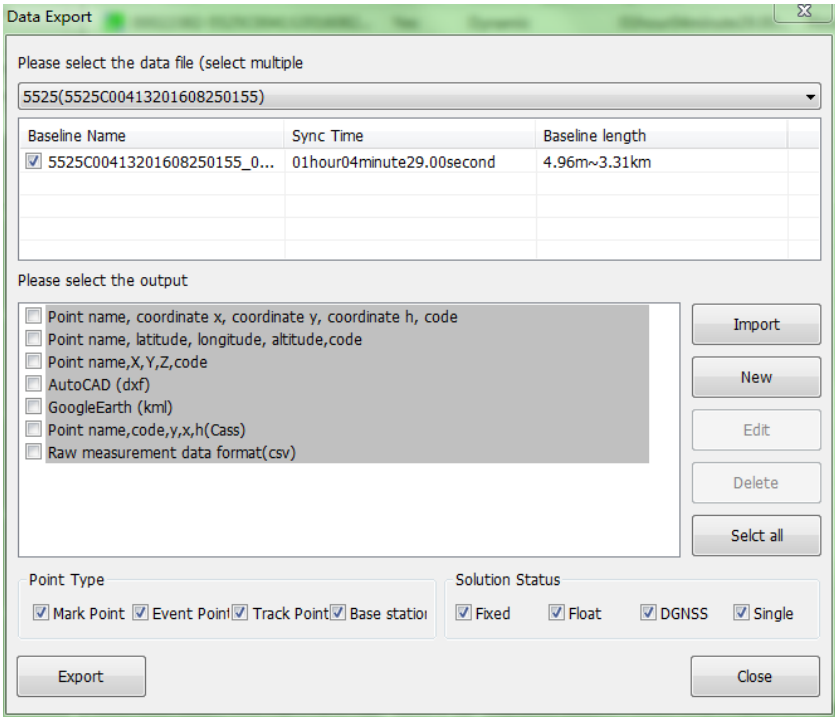


Figure 3-17

Operation step: select data file —> select baseline —>set output type —>set the point type and solution status of export data —> export.

Click [Import] on the right to import the saved output type into the project and display it in the list on the left.

Click [New] on the right to pop-up the [Custom] Output type setting box as shown in Figure 3-18.

Select the content the user wants to display, click [Add], and repeat until the user add all the displayed content they need. The display contains the following: Point name, date, time, latitude, longitude, elevation, coordinate X, coordinate Y, coordinate Z, North coordinate X, East coordinate Y, Elevation H, Solution Status, number of satellite, HRMS, VRMS, differential delay, Ratio, base station distance, covariance.

Below the pop-up settings box, you can set a custom format's separator symbol, angle format, extension name, and whether to write a file header, or keep the software defaults.

Click [OK] to complete the settings of custom format.

For new custom output types, the software provides an [Edit] and [Delete] operation. For the seven types of export that the software comes with, the software does not provide [Edit] and [Delete] operations.

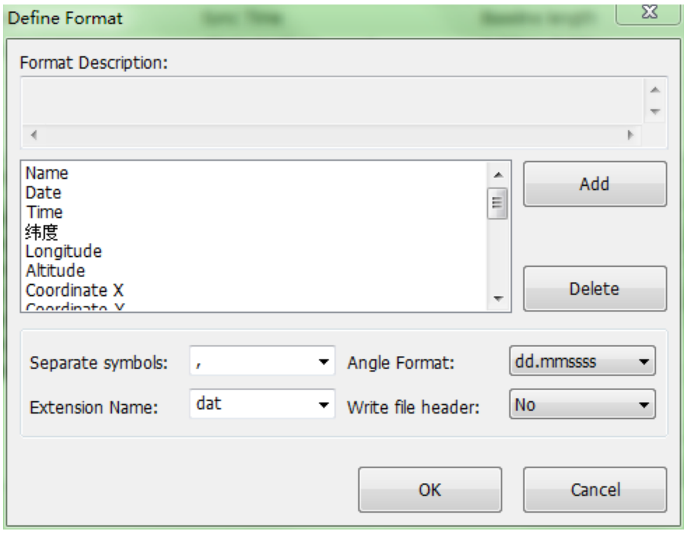
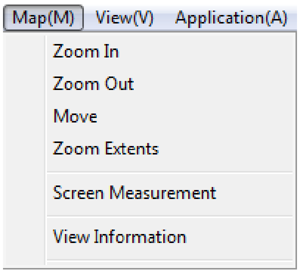
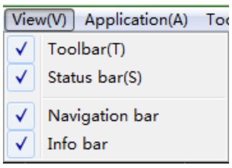


Figure 3-18

3.3.6 Map





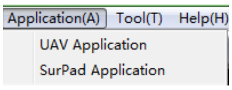


Figure 3-19 Figure 3-20 Figure 3-21

The map Menu Bar is designed specifically for planimetric maps, which contains a series of operation commands for planimetric map. Zoom In, Zoom Out, Move, Zoom Extents, Screen Measurement, View Information, Data deletion, map settings, as shown in Figure 3-19.

The meaning of the operation instructions can be referred to Toolbar introduction in section 3.4.

3.3.7 View

Toolbar, Status Bar, Navigation Bar and Information Bar can be set in view Menu Bar whether to be displayed in the main interface to facilitates user, as shown in Figure 3-20.

3.3.8 Application

The application Menu mainly includes [UVA Application] and [SurPad Application], as shown in Figure 3-21.

1)UVA Application, not finish yet.

2)SurPad Application

Surpad application is to import the data collected by the Surpad software to calibrate the precision of the data in the baseline solution, and the data imported by the Surpad application will replace the low precision part of the original observation data. Click [Open Project], as shown in Figure 3-23, open the *.GSW file, as shown in Figure 3-24, select the data file, and the data import success as shown in Figure 3-25. Select a point, click [Detailed Info], as shown in Figure 3-26, to view real-time positioning information of this point. Click [Start processing], as shown in Figure 3-27, the imported project data will be compared with the imported observation data and will automatically replace the low precision observation data.

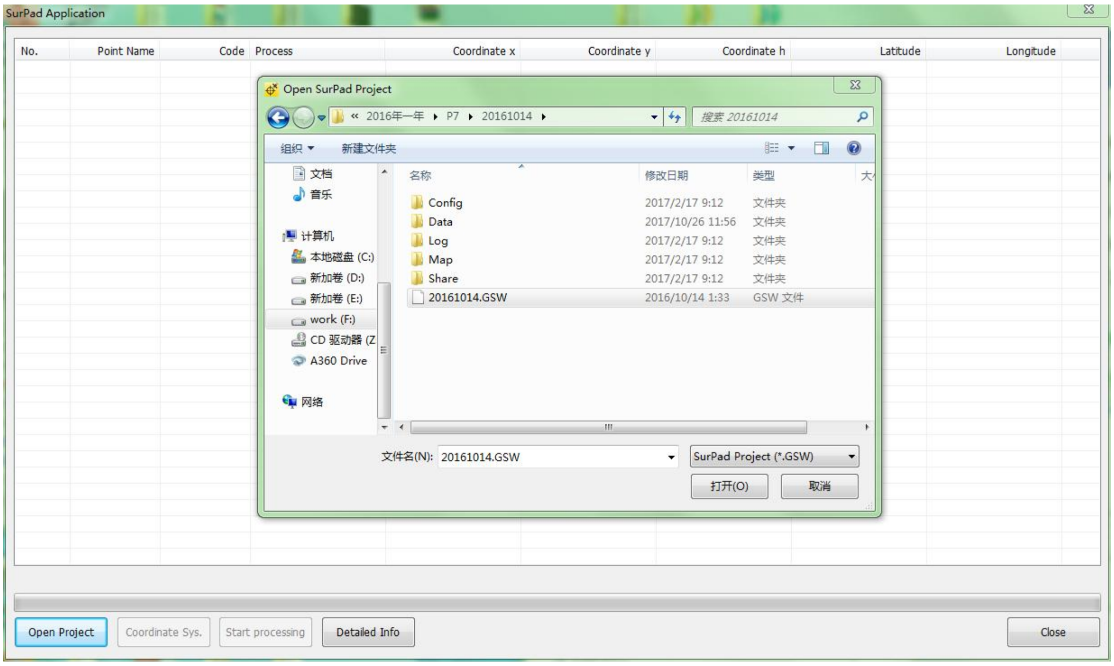


Figure 3-23

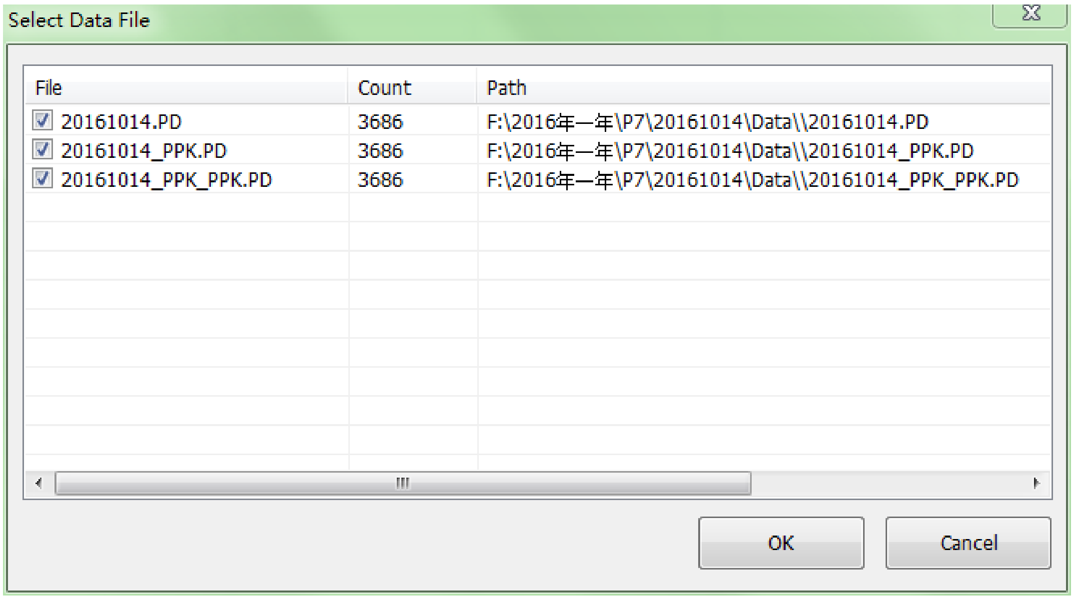
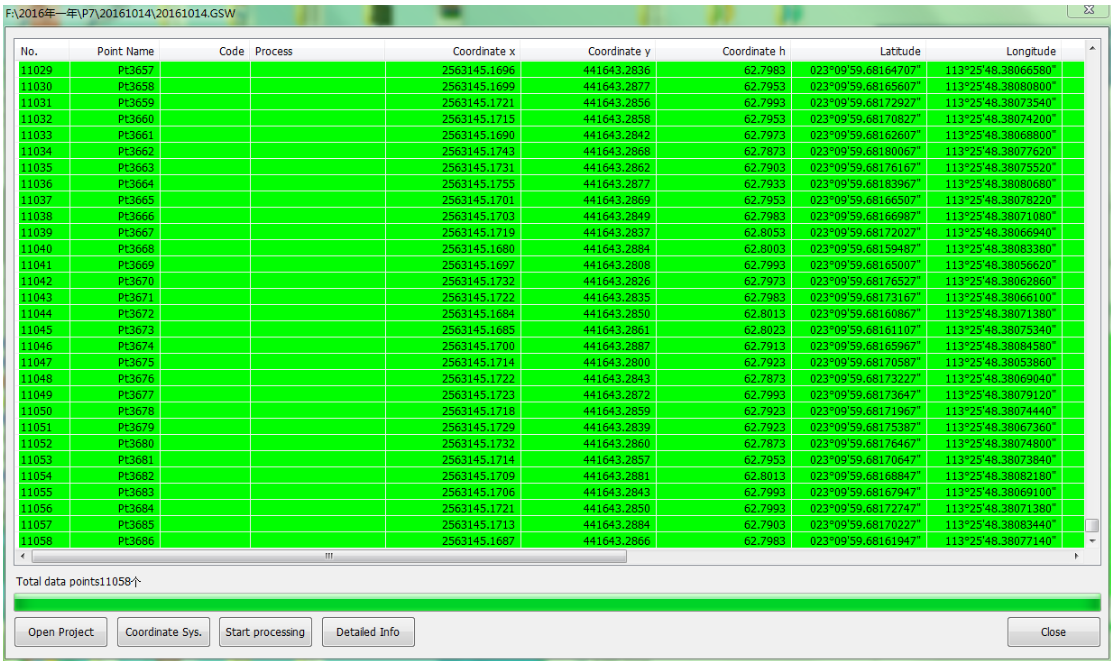


Figure 3-24



No.	Point Name	Code	Process	Coordinate x	Coordinate y	Coordinate h	Latitude	Longitude
11029	Pt3657			2563145.1696	441643.2836	62.7983	023°09'59.68164707"	113°25'48.38066580"
11030	Pt3658			2563145.1699	441643.2877	62.7953	023°09'59.68165607"	113°25'48.38080800"
11031	Pt3659			2563145.1721	441643.2856	62.7993	023°09'59.68172927"	113°25'48.38073540"
11032	Pt3660			2563145.1715	441643.2858	62.7953	023°09'59.68170827"	113°25'48.38074200"
11033	Pt3661			2563145.1690	441643.2842	62.7973	023°09'59.68162607"	113°25'48.38068800"
11034	Pt3662			2563145.1743	441643.2868	62.7873	023°09'59.68180067"	113°25'48.38077620"
11035	Pt3663			2563145.1731	441643.2862	62.7903	023°09'59.68176167"	113°25'48.38075520"
11036	Pt3664			2563145.1755	441643.2877	62.7933	023°09'59.68183967"	113°25'48.38080680"
11037	Pt3665			2563145.1701	441643.2869	62.7953	023°09'59.68166507"	113°25'48.38078220"
11038	Pt3666			2563145.1703	441643.2849	62.7983	023°09'59.68166987"	113°25'48.38071080"
11039	Pt3667			2563145.1719	441643.2837	62.8053	023°09'59.68172027"	113°25'48.38066940"
11040	Pt3668			2563145.1680	441643.2884	62.8003	023°09'59.68159487"	113°25'48.38083380"
11041	Pt3669			2563145.1697	441643.2808	62.7993	023°09'59.68165007"	113°25'48.38056620"
11042	Pt3670			2563145.1732	441643.2826	62.7973	023°09'59.68176527"	113°25'48.38062860"
11043	Pt3671			2563145.1722	441643.2835	62.7983	023°09'59.68173167"	113°25'48.38066100"
11044	Pt3672			2563145.1684	441643.2850	62.8013	023°09'59.68160867"	113°25'48.38071380"
11045	Pt3673			2563145.1685	441643.2861	62.8023	023°09'59.68161107"	113°25'48.38075340"
11046	Pt3674			2563145.1700	441643.2887	62.7913	023°09'59.68165967"	113°25'48.38084580"
11047	Pt3675			2563145.1714	441643.2800	62.7923	023°09'59.68170587"	113°25'48.38053860"
11048	Pt3676			2563145.1722	441643.2843	62.7873	023°09'59.68173227"	113°25'48.38069040"
11049	Pt3677			2563145.1723	441643.2872	62.7993	023°09'59.68173647"	113°25'48.38079120"
11050	Pt3678			2563145.1718	441643.2859	62.7923	023°09'59.68171967"	113°25'48.38074440"
11051	Pt3679			2563145.1729	441643.2839	62.7923	023°09'59.68175387"	113°25'48.38067360"
11052	Pt3680			2563145.1732	441643.2860	62.7873	023°09'59.68176467"	113°25'48.38074800"
11053	Pt3681			2563145.1714	441643.2857	62.7953	023°09'59.68170647"	113°25'48.38073840"
11054	Pt3682			2563145.1709	441643.2881	62.8013	023°09'59.68168847"	113°25'48.38082180"
11055	Pt3683			2563145.1706	441643.2843	62.7993	023°09'59.68167947"	113°25'48.38069100"
11056	Pt3684			2563145.1721	441643.2850	62.7993	023°09'59.68172747"	113°25'48.38071380"
11057	Pt3685			2563145.1713	441643.2884	62.7903	023°09'59.68170227"	113°25'48.38083440"
11058	Pt3686			2563145.1687	441643.2866	62.7983	023°09'59.68161947"	113°25'48.38077140"

Figure 3-25

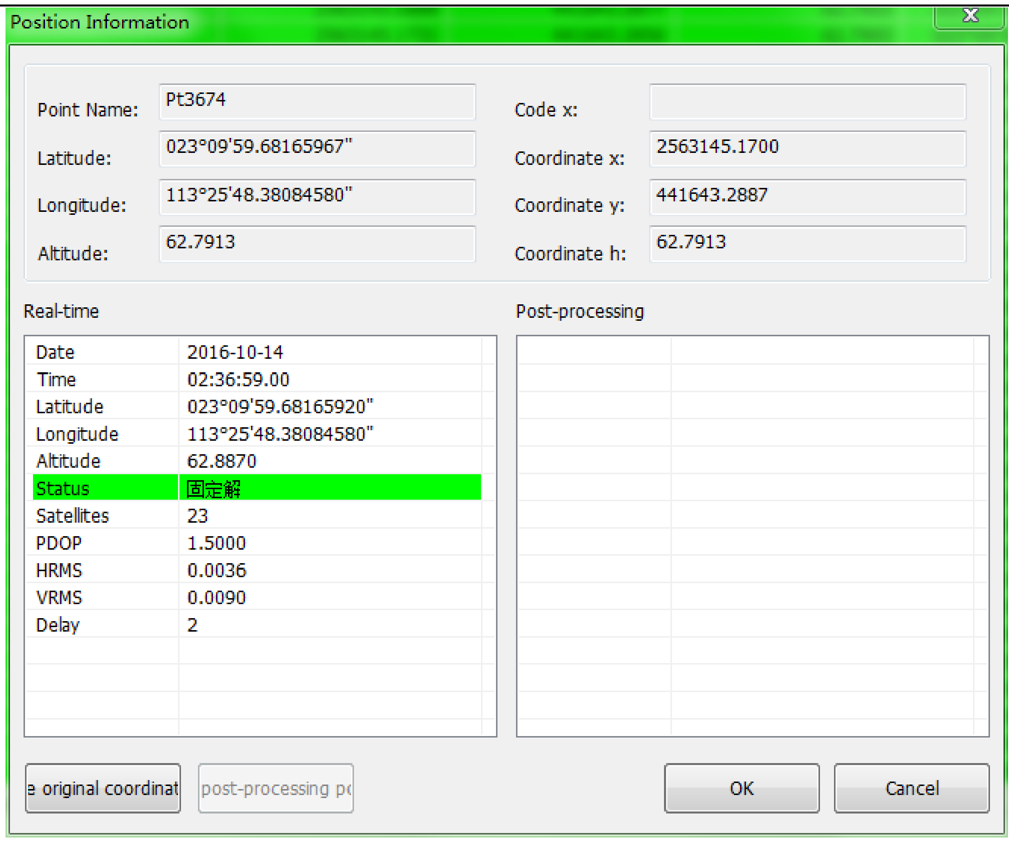


Figure 3-26

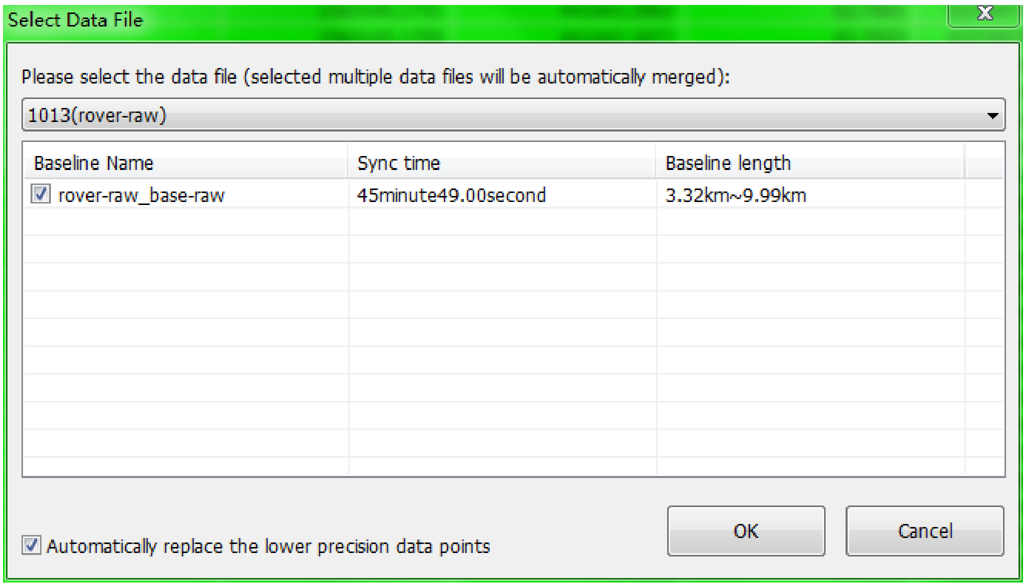


Figure 3-27

3.3.9 Tool

The tool menu mainly includes the [RINEX Converter], [Observation Files Merge], [Coordinate Convert], [Precise EPH Download] and [Antenna Management] as shown in Figure 3-28.

1) RINEX Converter Tool

Enter the RINEX Converter Tool, which can convert data files in any format, as shown in Figure 3-29. Detailed explanation of RINEX data can be queried in appendix 2.

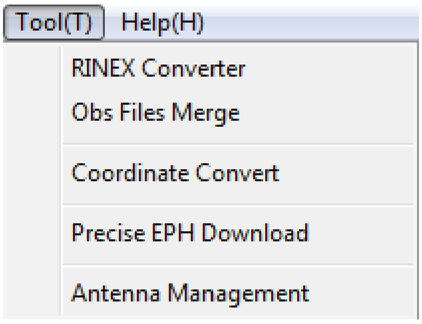


Figure 3-28

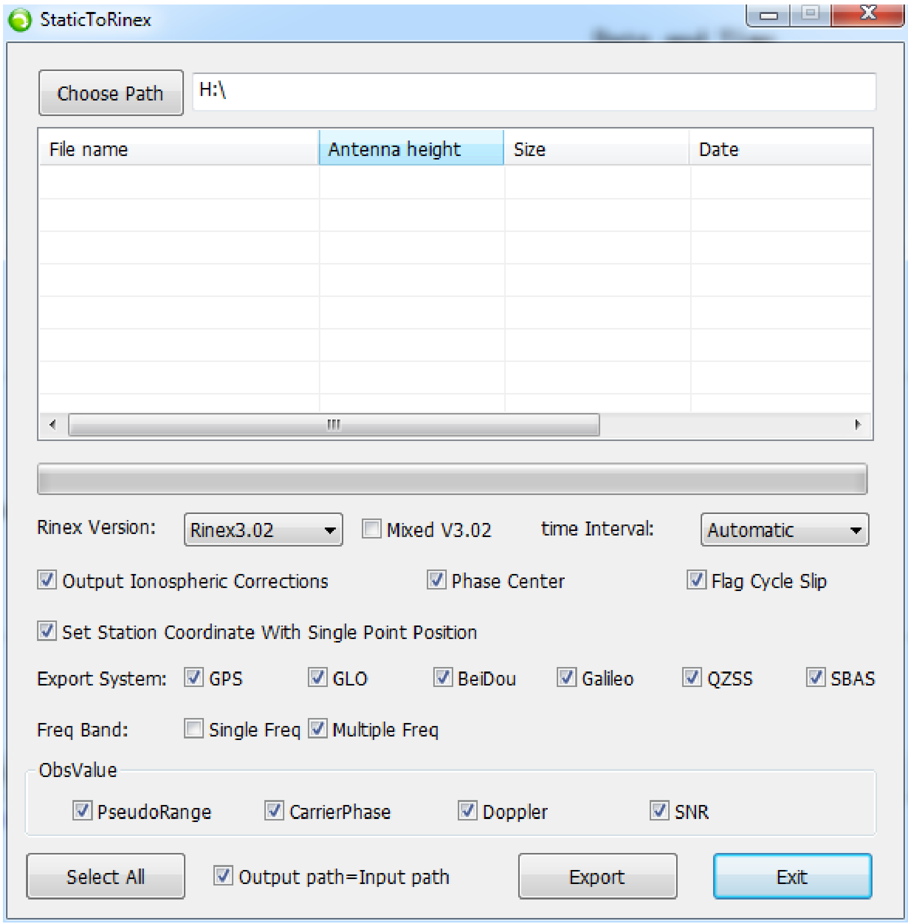


Figure 3-29

2) Observation files Merge

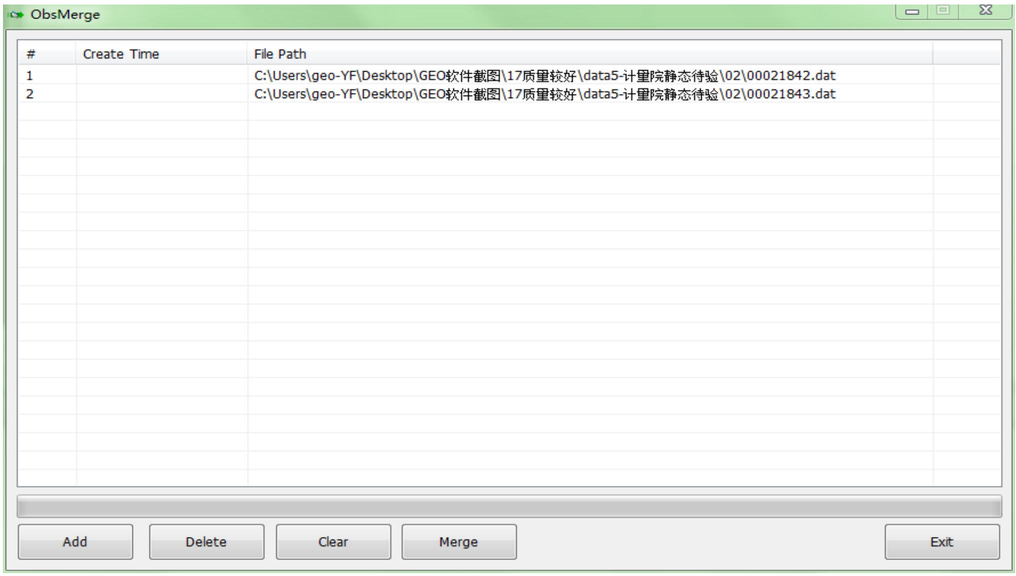


Figure 3-30

3) Coordinate Convert

Enter the Coordinate Convert tool, which can perform conversion between WGS84 coordinate and local coordinate as shown in Figure 3-31. Click [Angle] to set WGS48 coordinate format, input longitude and latitude values and press  to convert WGS84 coordinate to local coordinate. Input north and east coordinate and height and press  to convert local coordinate to WGS48 coordinate.

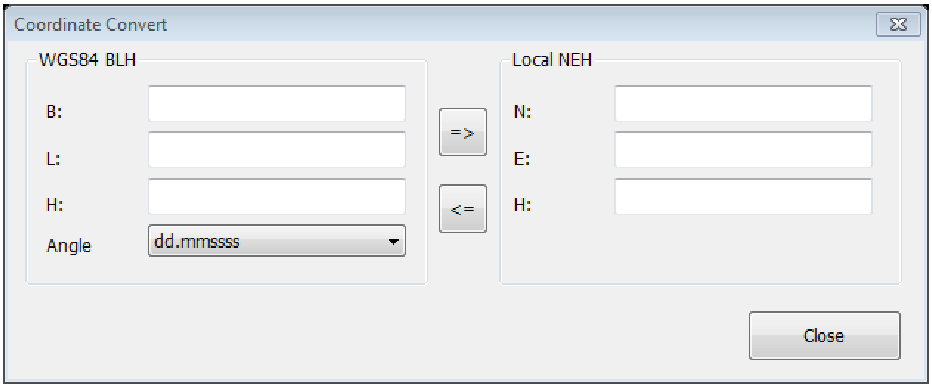


Figure 3-31

4) Precise EPH Download

Enter Precise EPH Download tool and it can download precise calendar data from CDDIS, IGN, KASI and other organizations as shown in Figure 3-32. Select provider, set start date and end date, select EPH type and click [Download] to download data. If it pops up a security warning, please click [OK] to ensure this download.

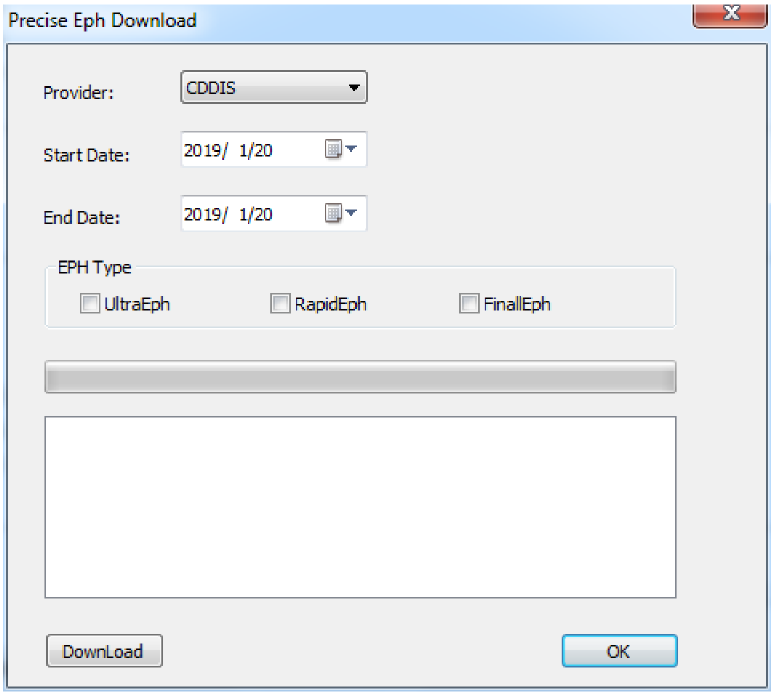
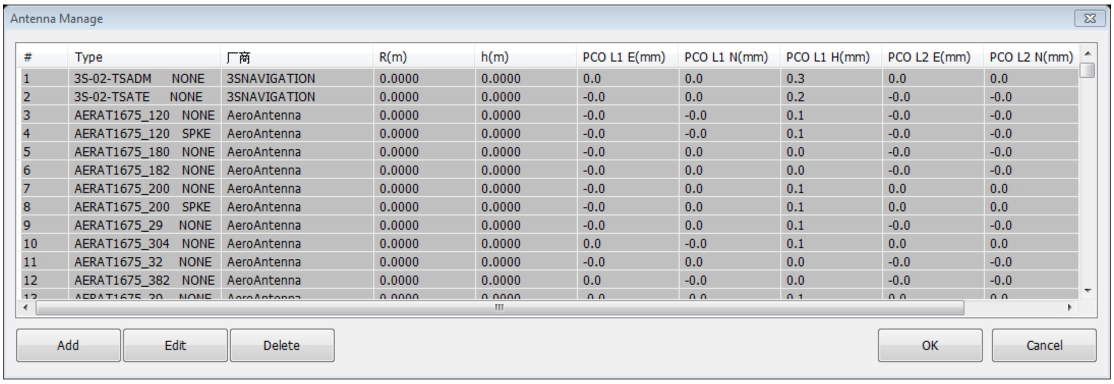


Figure 3-32

5) Antenna Management

Enter Antenna Management tool as shown in Figure 3-33. Click [Add] and it can add new antenna parameters. Click [Delete] and it can delete one antenna parameter file and the authenticated antenna parameters file cannot be deleted. Click [Edit] and it can edit the unauthenticated antenna parameter file.



#	Type	厂商	R(m)	h(m)	PCO L1 E(mm)	PCO L1 N(mm)	PCO L1 H(mm)	PCO L2 E(mm)	PCO L2 N(mm)
1	3S-02-TSADM NONE	3SNAVIGATION	0.0000	0.0000	0.0	0.0	0.3	0.0	0.0
2	3S-02-TSATE NONE	3SNAVIGATION	0.0000	0.0000	-0.0	0.0	0.2	-0.0	-0.0
3	AERAT1675_120 NONE	AeroAntenna	0.0000	0.0000	-0.0	-0.0	0.1	-0.0	-0.0
4	AERAT1675_120 SPKE	AeroAntenna	0.0000	0.0000	-0.0	-0.0	0.1	-0.0	-0.0
5	AERAT1675_180 NONE	AeroAntenna	0.0000	0.0000	-0.0	0.0	0.0	-0.0	-0.0
6	AERAT1675_182 NONE	AeroAntenna	0.0000	0.0000	-0.0	0.0	0.0	-0.0	-0.0
7	AERAT1675_200 NONE	AeroAntenna	0.0000	0.0000	-0.0	0.0	0.1	0.0	0.0
8	AERAT1675_200 SPKE	AeroAntenna	0.0000	0.0000	-0.0	0.0	0.1	0.0	0.0
9	AERAT1675_29 NONE	AeroAntenna	0.0000	0.0000	-0.0	0.0	0.1	-0.0	-0.0
10	AERAT1675_304 NONE	AeroAntenna	0.0000	0.0000	0.0	-0.0	0.1	0.0	0.0
11	AERAT1675_32 NONE	AeroAntenna	0.0000	0.0000	-0.0	0.0	0.0	-0.0	-0.0
12	AERAT1675_382 NONE	AeroAntenna	0.0000	0.0000	0.0	-0.0	0.0	-0.0	-0.0

Figure 3-33

3.3.10 Help

The Help menu, shown in Figure 3-34, contains two items: Register and About PPO.

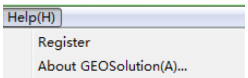


Figure 3-34

1)Register

As shown in Figure 3-35, enter the registration code after clicking [Register], user can use the full function of the software after successful registration. Click [Auto Get] when have no registration code and then user can use the software for free in 7 days.

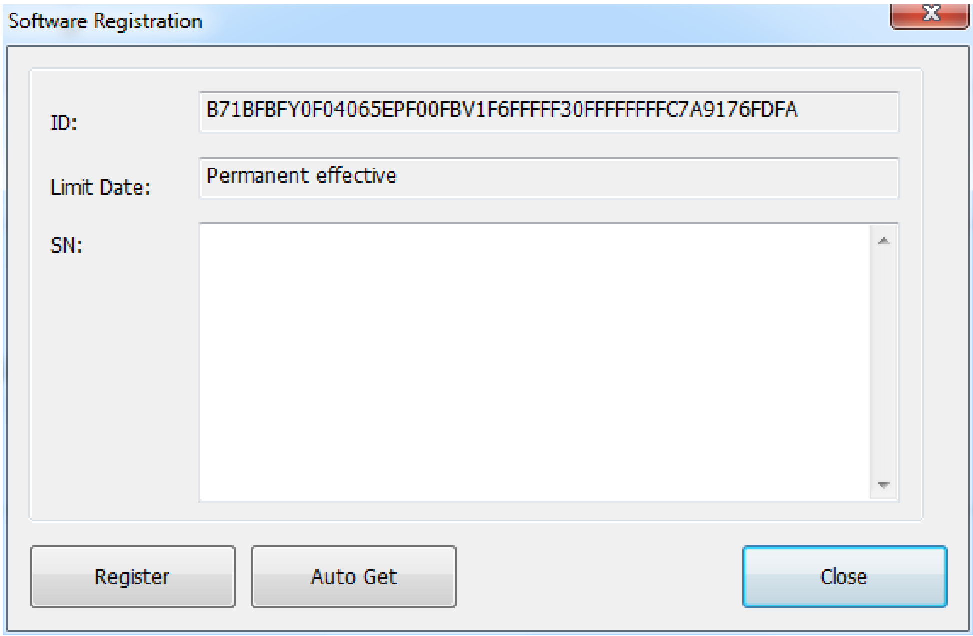


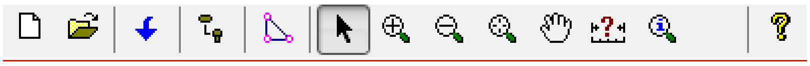
Figure 3-35

2)About PPO

Click [About PPO], as shown in Figure 3-36, to see the version and service time of the PPO.

Figure 3-36

3.4 Toolbar



There are shortcut keys of part of operation commands added to the Toolbar, and the meanings of shortcut keys are as follows:

New Project Key

Open Project Key

Import Observation Data Key

Baseline Solution key (Default all baselines)

Net Adjustment Key

Selection Key, to choose the stations and baselines in the map

Zoom in key, to zoom in the plane map to display

Zoom out key, to zoom out the plane map to display

Zoom the plane map extents to fit the screen.

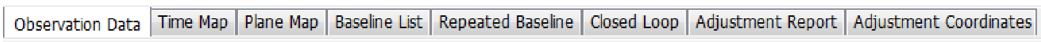
Move key, to move the plane map

Screen Measurement Key

Viewing Key, to view to station points and baselines in the map

Software Version Viewing Key

3.5 Workspace



The workspace is the main area of the user's work, which contains eight options, namely Observation Data, Time Map, Plane Map, Baseline List, Repeated Baseline, Closed Loop, Adjustment Report, Adjustment Coordinate. The eight-options display different content. The options are free to switch between, easy to operate and view the information.

3.5.1 Observation Data

In the list of observation data files in the workspace, displays detailed information about each observation data file, including file name, station name, data type, start time, end time, antenna height, method of measurement, height of measurement, antenna type, data version, device serial number, and full path of saved file.

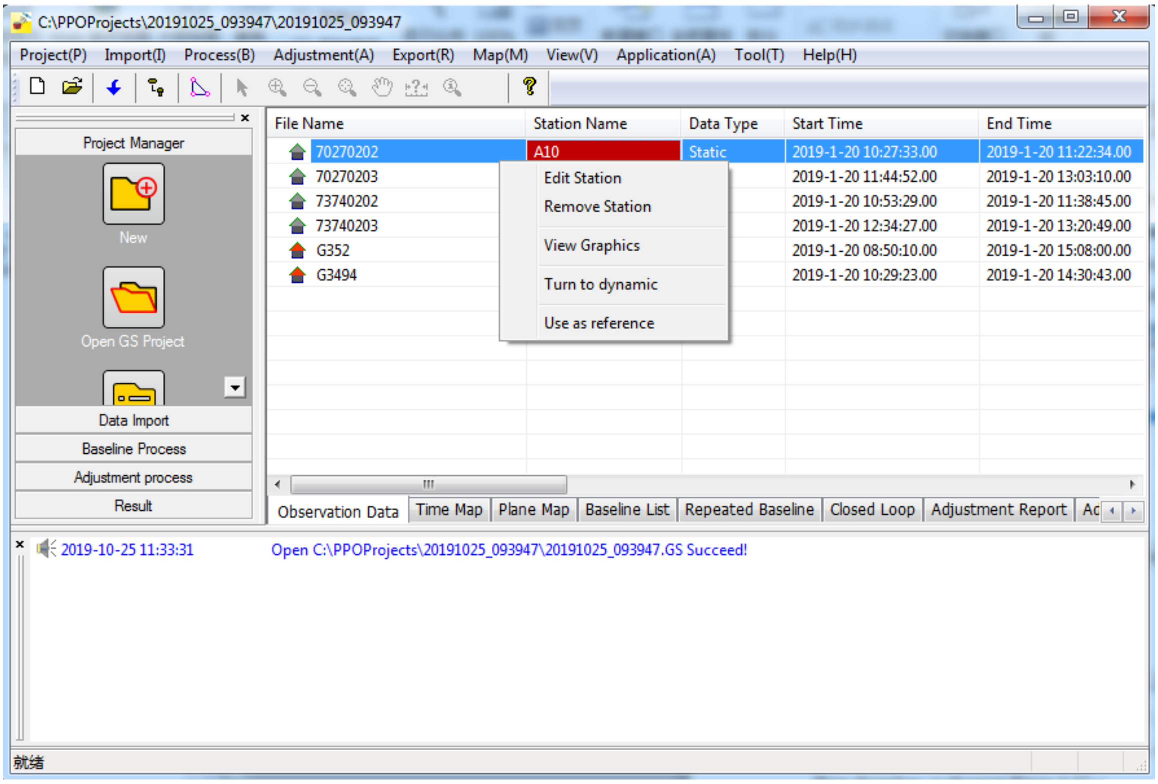


Figure 3-37

Select any one of the target files in the file list, right-click, and pop-up the Drop-down box, as shown in Figure 3-37.

[View Graphics]: As shown in Figure 3-38, you can view the tracking status of satellite data in the observation file, in which the interrupt part indicates conditions that the receiver has lost satellite's track and other conditions. It can select interrupted data(red cross×) and disable the section of data.

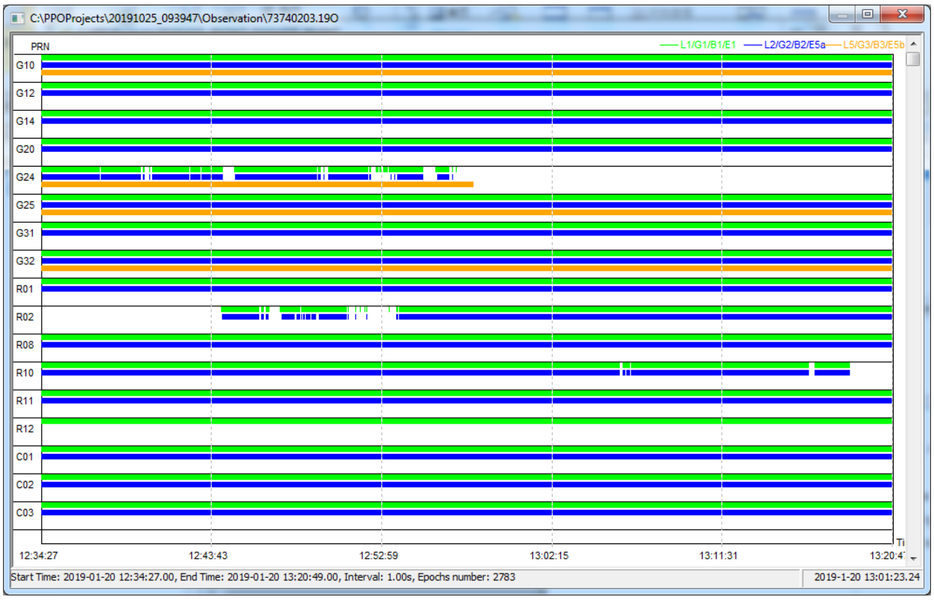


Figure 3-38

[Edit Station]: Left click "Edit Station", the pop-up dialog box is shown in Figure 3-39, which contains information such as station settings, antenna parameters, antenna height, etc. In the pop-up dialog box, you can modify the parameters of station name, antenna type, and antenna height.

[Delete Station]: you can remove the observation file from the selected station from the list.

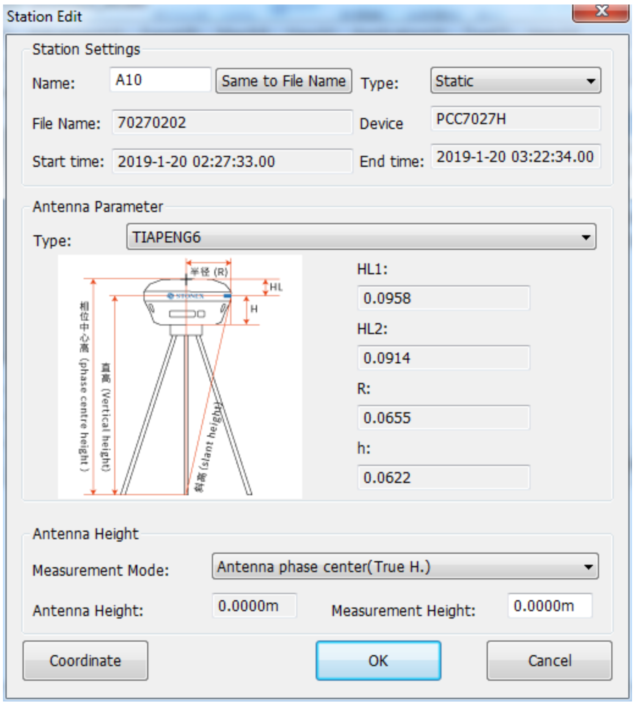


Figure 3-39

[Turn to dynamic]: The selected observation file data type can be changed from static to dynamic.

[Use as reference]: As shown in Figure 3-40, it can use the selected coordinate as reference and participate in calculation.

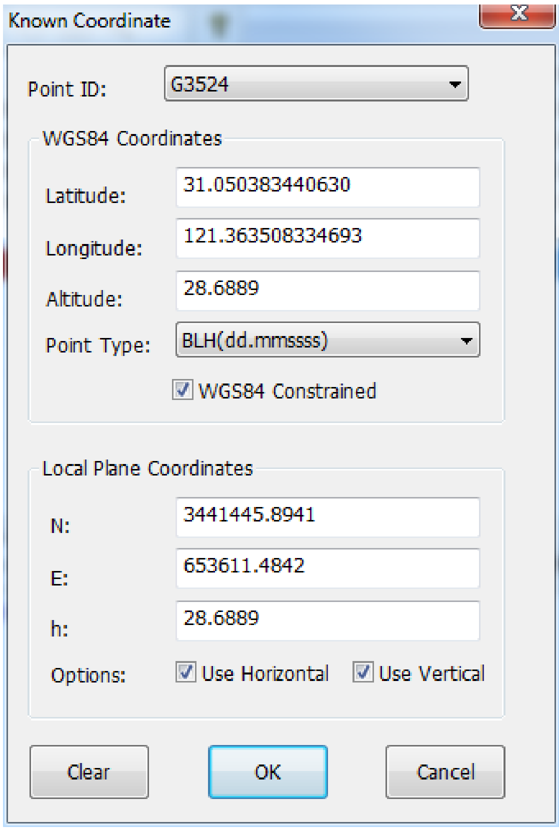


Figure 3-40

3.5.2 Time Map

As shown in Figure 3-41, the observation time of each station is shown separately according to the type of the station (Dynamic, Static). Because the precondition of the baseline solution is that there must be synchronized observation data between stations, that is, the common observation time. The user can visually observe whether there is a common observation time between the station and the station through time map, whether the data of the observation station can be baseline processed.

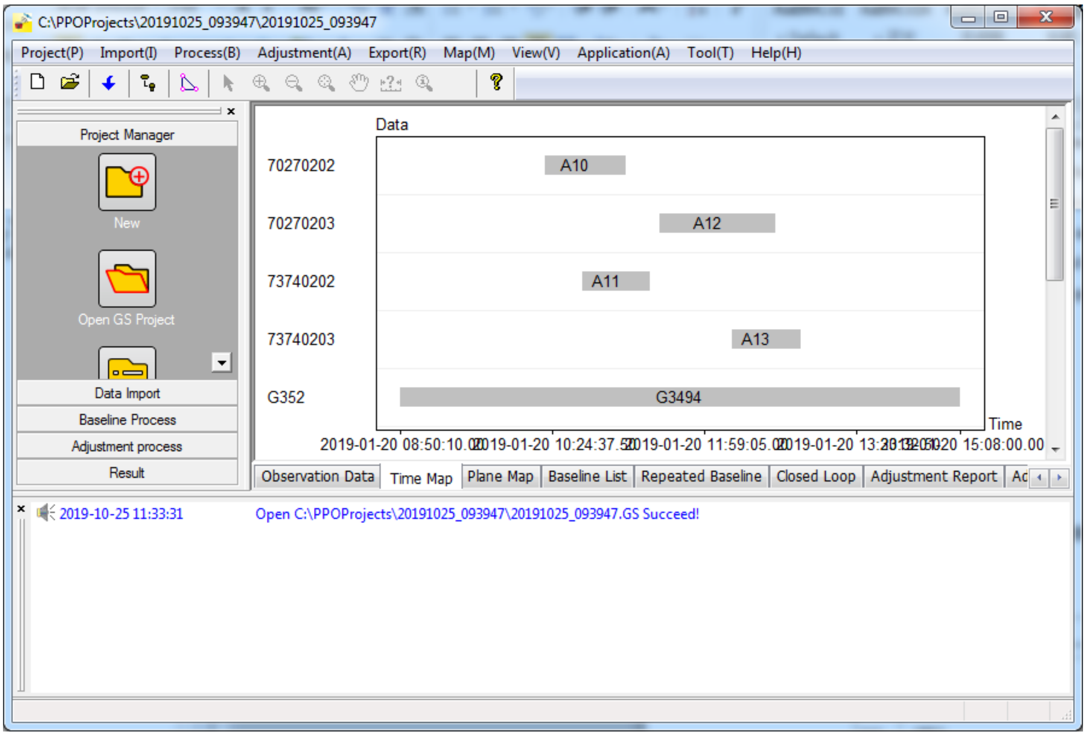


Figure 3-41

3.5.3 Plane Map

The plane map as shown in Figure 3-42 mainly shows the project's auxiliary information such as the station, baseline information and scale, grid reference line and so on.

You can view and modify the station and baseline information by using shortcut keys .

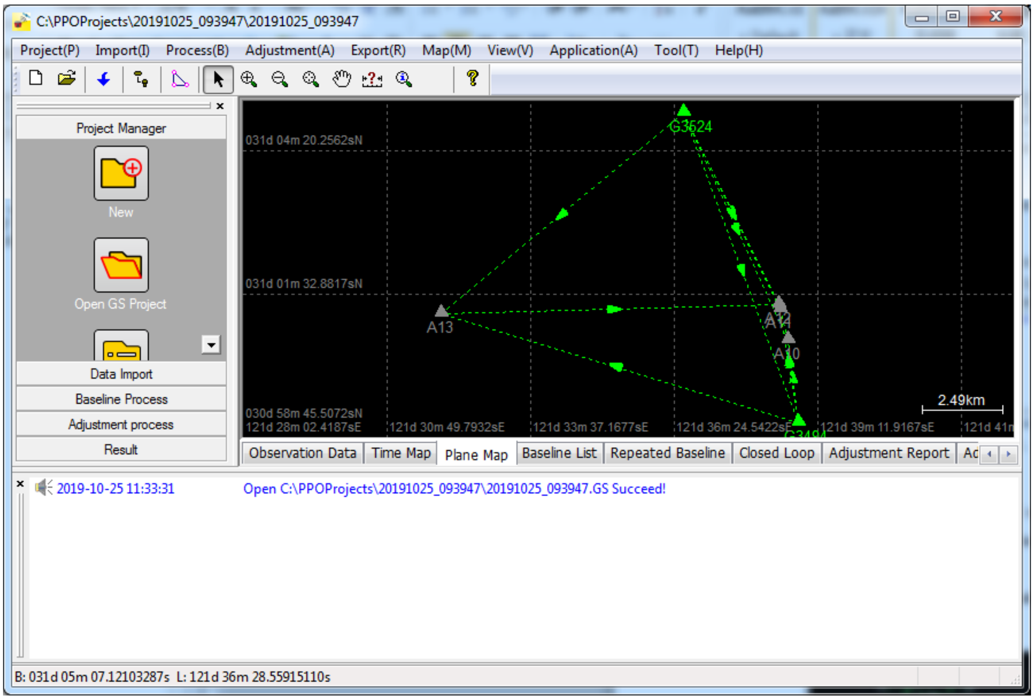


Figure 3-42

Station: The triangle represents the observation station, the gray triangle represents the general observation station, the green triangle indicates that the observation station is a known point.

Baseline: Line segments with arrows represent baselines. The gray baseline indicates that the baselines have not been processed or processed fail, and the green baseline indicates that the baselines have been successfully processed.

Error ellipses: After completion of network adjustment, the error ellipse of the baseline will be shown in blue, which can be used to judge the solution quality of the baseline.

3.5.4 Baseline List

It displays the details of all the processed baseline in list format, includes Baseline Name, StartPoint, EndPoint, whether baselines are enabled, Baseline Type, Sync Time, Solution Status, Variance Ratio, RMS, Horizontal Component, Vertical Component, X Increment, Y Increment, Z Increment, Baseline Length, Relative Error, Azimuth Angle, Horizontal Distance and Elevation Difference.

In the baseline list, the green part is the baselines of successful solution, the red part is the baselines of the failed solution, and the blue part is the new added baselines. The user can modify the parameters of solution setting and process the failed baselines again.

Select any one of the baselines, right-click and the pop-up menu as shown in Figure 3-43. The related operation of baseline can be processed through the pop-up menu, including Baseline Information, Processing Settings, Reprocess, Delete Baseline, Enable Baseline, Disable Baseline, Endpoint Exchange, Baseline Report and Residual View.

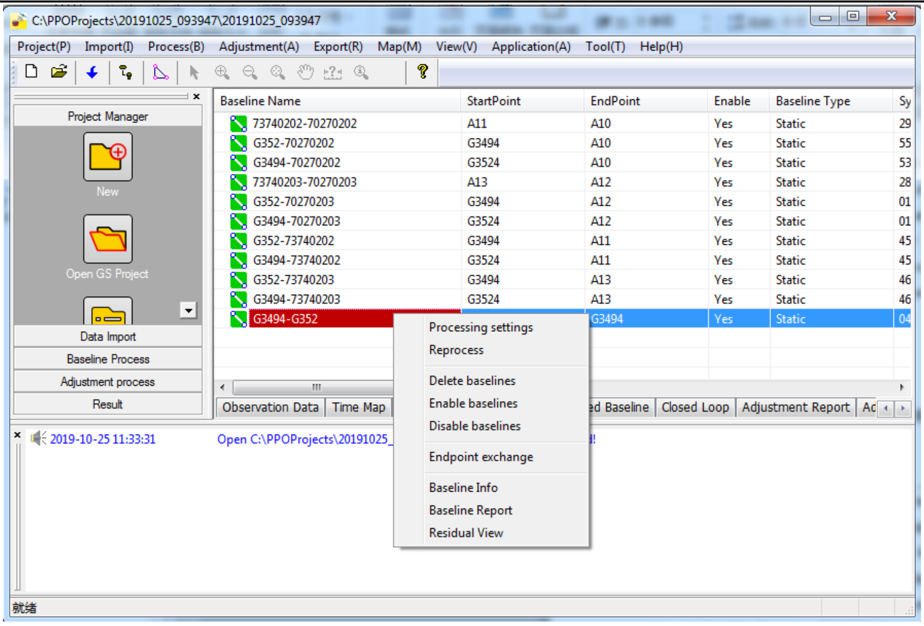


Figure 3-43

[Baseline Info]: View the detail information of selected baseline.

[Processing Settings]: Modify the condition of baseline solution and process the baselines according to the new solution settings.

[Reprocess]: Reprocess the selected baselines according to the original solution settings.

[Delete baseline]: Delete the selected baselines from the baseline list.

[Enable baselines]: Re-enable the disable baselines, that is, these baselines can be processed again in data processing, such as net adjustment.

[Disable baselines]: Disable the selected baselines, and these baselines can't be processed again in data processing, such as net adjustment.

[Endpoint exchange]: To exchange the start point and end point of the selected baseline vector, such as: baseline vector I002-I001 change to I001-I002.

[Baseline Report]: It can check current baseline processing report in website version. In report it includes: 1. Reference Station Information, 2. Rover Station Information, 3. Solving Control Parameter, 4. Baseline Solving Result, 5. Integer Ambiguity, 6. Position.

[Residual View]: It shows residual values of every baselines to reflect baseline processing quality. As shown in Figure 3-44, it can view residual value of selected satellite. If the value is large, it can disable the unqualified data. For baseline with large residual, it can modify process settings and reprocess to obtain qualified baseline, or merely disable the unqualified baseline.

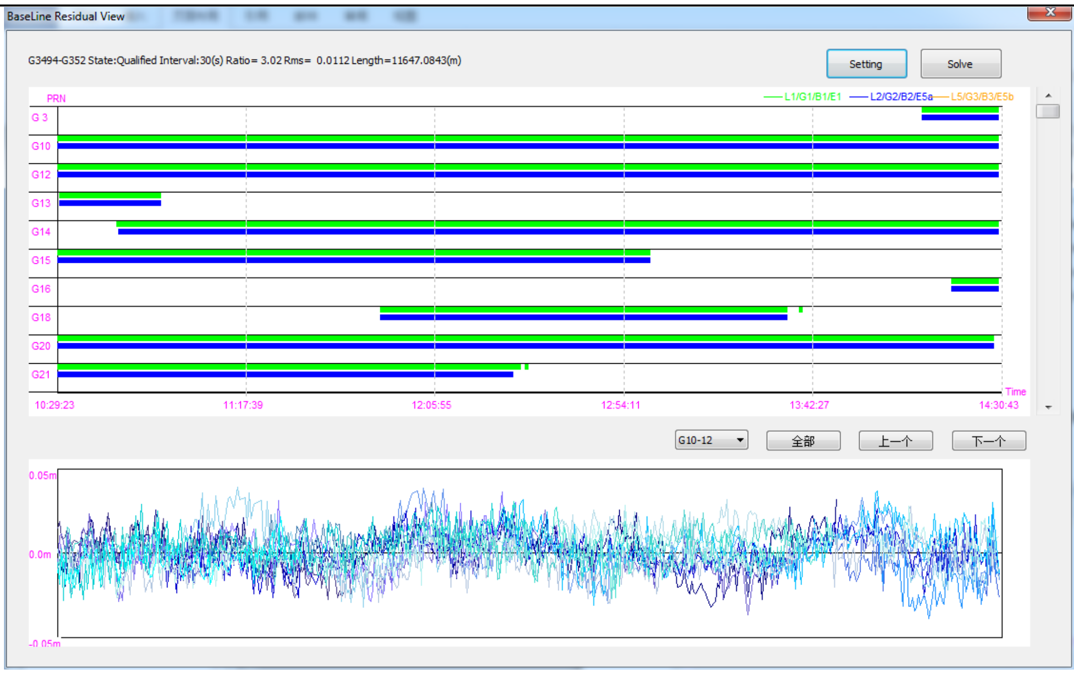


Figure 3-44

Double-click the selected baseline after processing the baseline and it can view the baseline vector's Basic Settings, Model Settings and Result as shown in Figure 3-45. Click [Detailed Info] and it can view detailed information of baseline as shown in Figure 3-46.

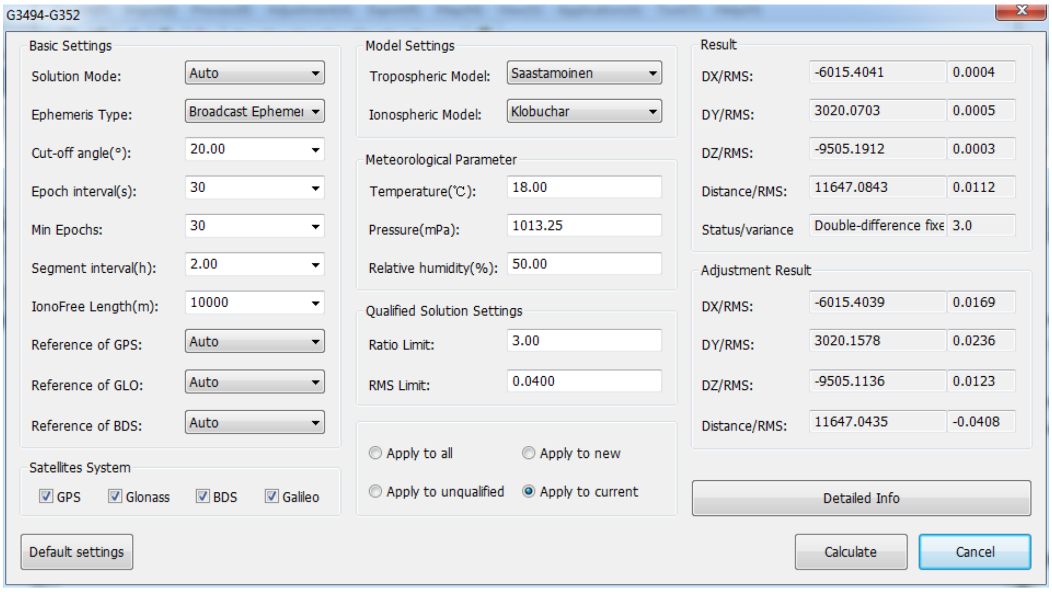


Figure 3-45

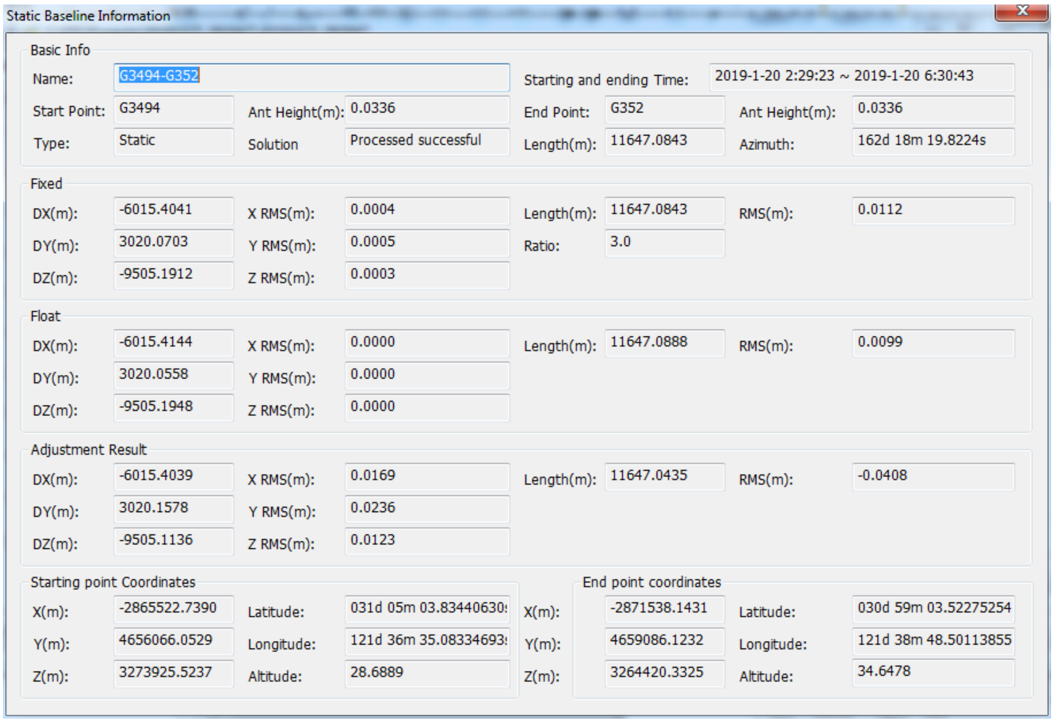


Figure 3-46

3.5.5 Repeated Baseline

Click [Repeated Baseline], as shown in Figure 3-47. Workspace will display the related information of repeated baseline, including baseline name, quality, DX (m), DY (m), DZ (m), average length, relative error, length difference, length difference limit. When the length difference is less than the limit, the repeated baseline is qualified.

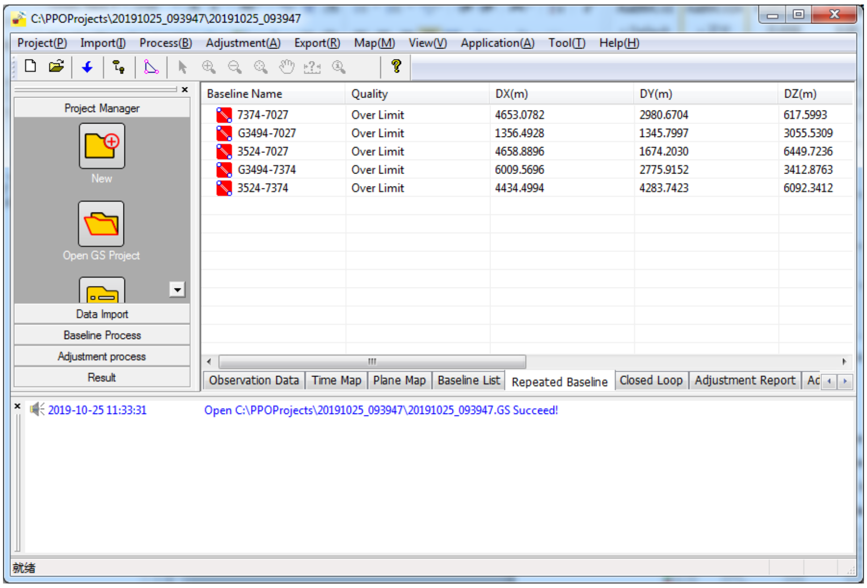


Figure 3-47

Double-click the repeated baseline, the pop-up dialog is shown in Figure 3-48, and the basic information of the repeated baseline and the detailed solution result of the two baselines will be display. Right-click the baseline as shown in Figure 3-49, and it can reset the processing settings and reprocess the baseline.

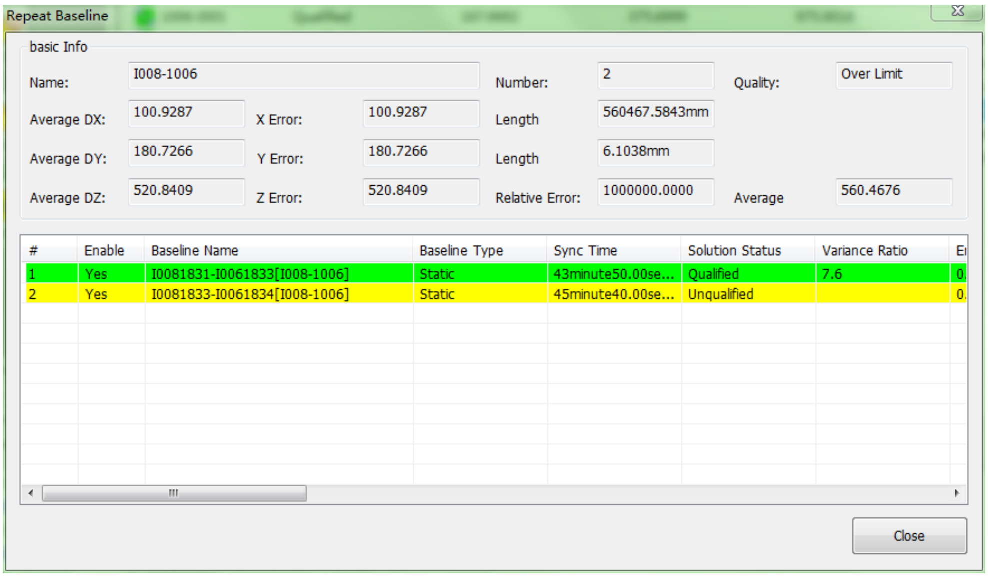


Figure 3-48

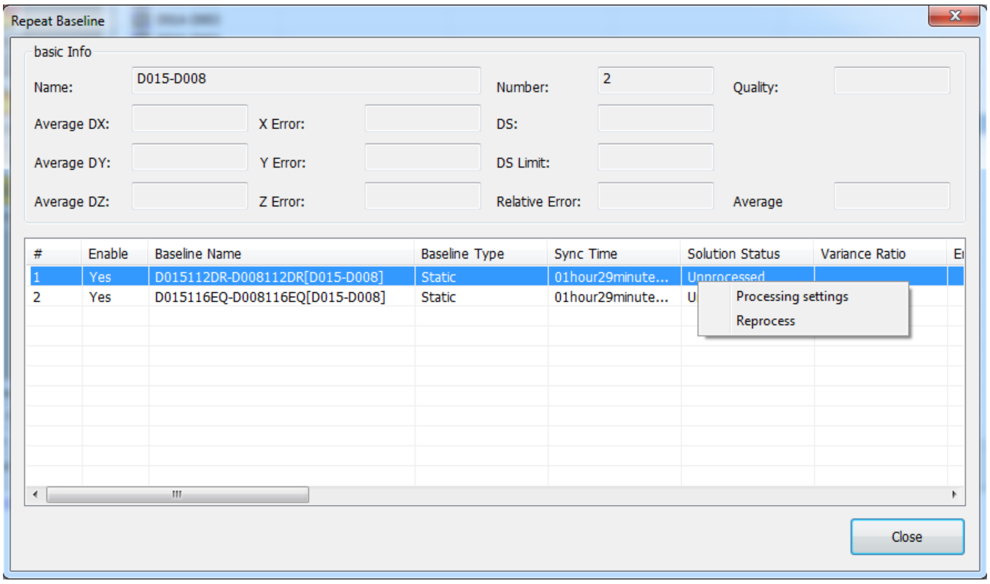


Figure 3-49

3.5.6 Closed loop

Closed loop is divided into two kinds, one is synchronous closed loop, the other is asynchronous closed loop.

Synchronous Closed Loop: It is a closed loop formed by baseline vectors that are obtained by three or more GPS receivers' synchronous observation.

Asynchronous Closed Loop: The closed loop is constituted by a set of baseline vectors (three or more baseline vectors) and any one of the baseline vectors cannot be represented by other baseline vectors of the same group.

Click [Closed Loop], as shown in Figure 3-50, workspace will display the relate information of closed loop, include the station name, Quality, observation time, Total length of loops, X Closure error (mm), Y Closure error (mm), Z Closure error (mm), Closure Error of Side (mm), Relative Error (ppm), Component difference (mm), Closure error (mm), the loop line.

The quality of the closed loop is qualified when the X Closure Error, Y Closure Error, Z Closure Error all are smaller than Component difference and the Closure Error of Side is smaller than closure Error.

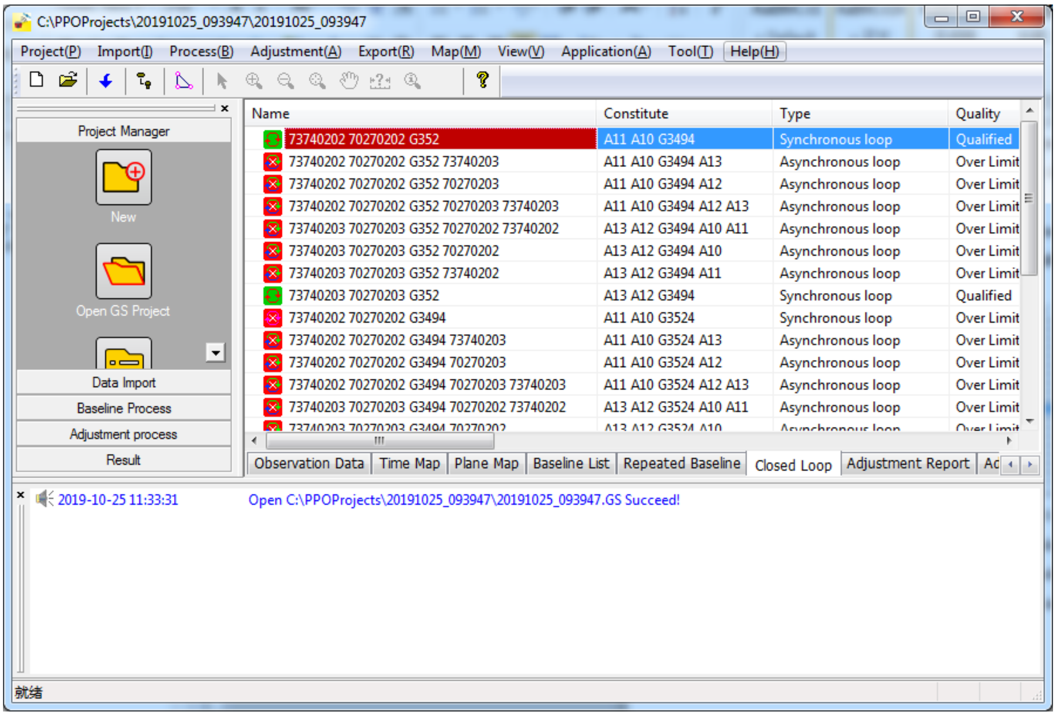


Figure 3-50

Double-click the closed loop, the pop-up dialog is shown in Figure 3-51, and the basic information of the closed loop and the detailed solution results of the closed loop baselines will be displayed. Right-click baseline as shown in Figure 3-52, it can reset the processing settings and reprocess the baseline.

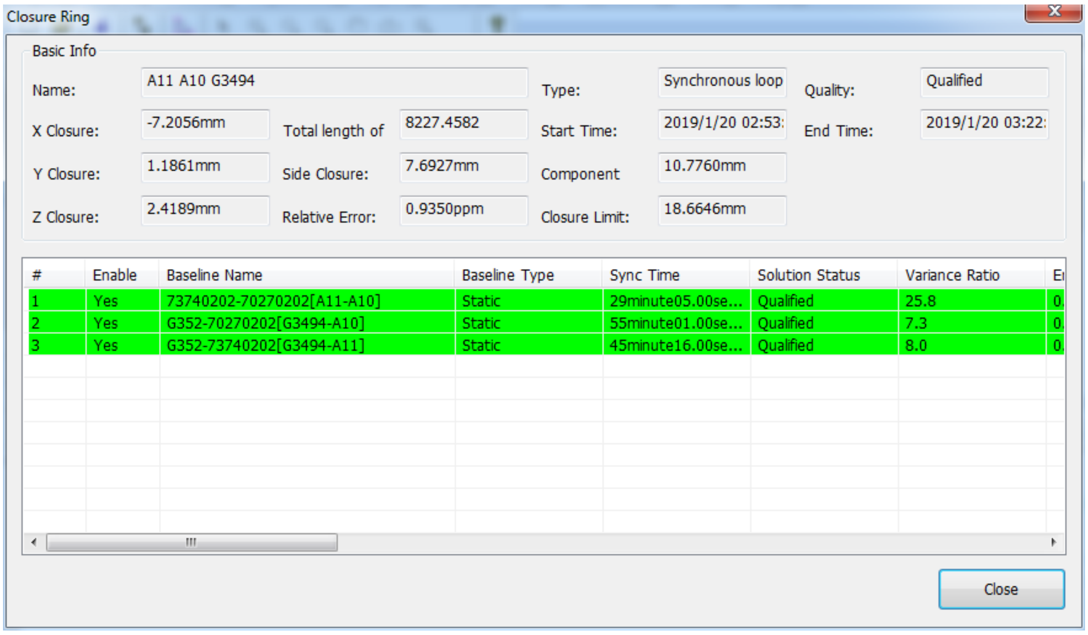


Figure 3-51

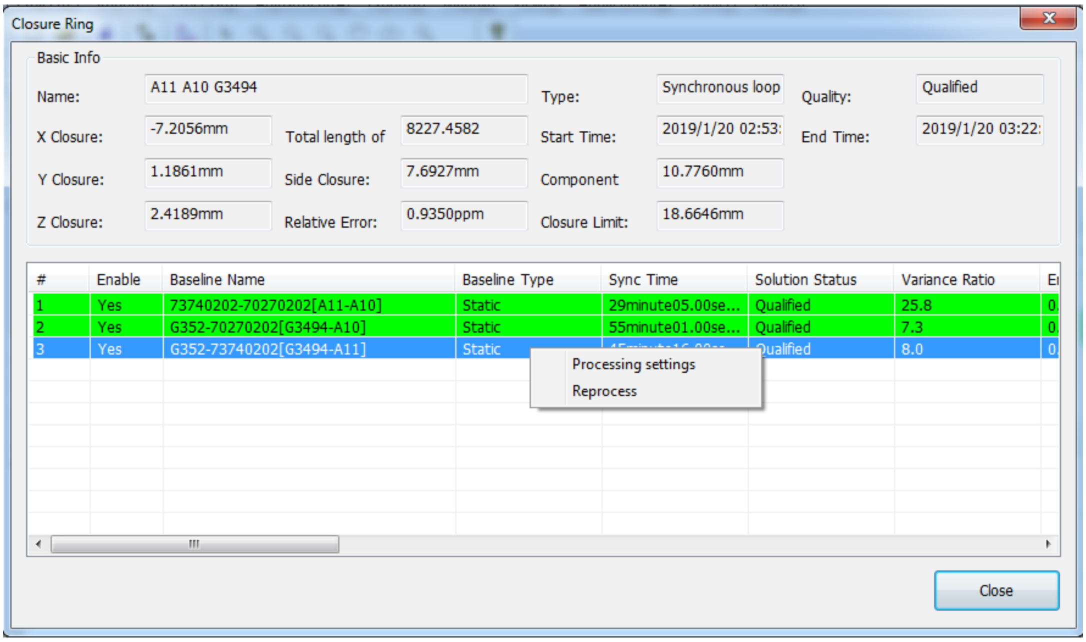


Figure 3-52

3.5.7 Adjustment Report

After the completion of the network adjustment, the workspace will automatically switch to the adjustment report interface, and the adjustment report lists the details of the closed loop, the Known coordinate X, Y, Z increment and correction value of the baseline after net adjustment, the coordinate and point precision of the observation station after adjustment. See Figure 3-53.

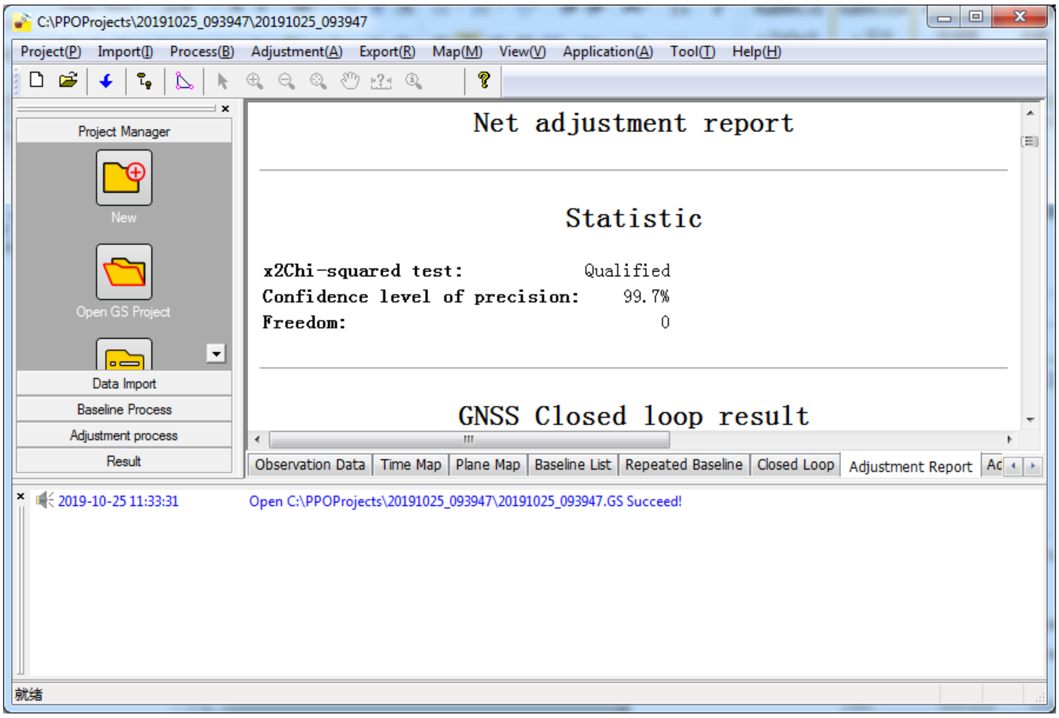


Figure 3-53

3.5.8 Adjustment Coordinate

Click the [Adjustment Coordinate], as shown in Figure 3-54. The workspace will switch to the adjustment coordinate of the station. The user can intuitively obtain the adjustment coordinates of the station from the list.

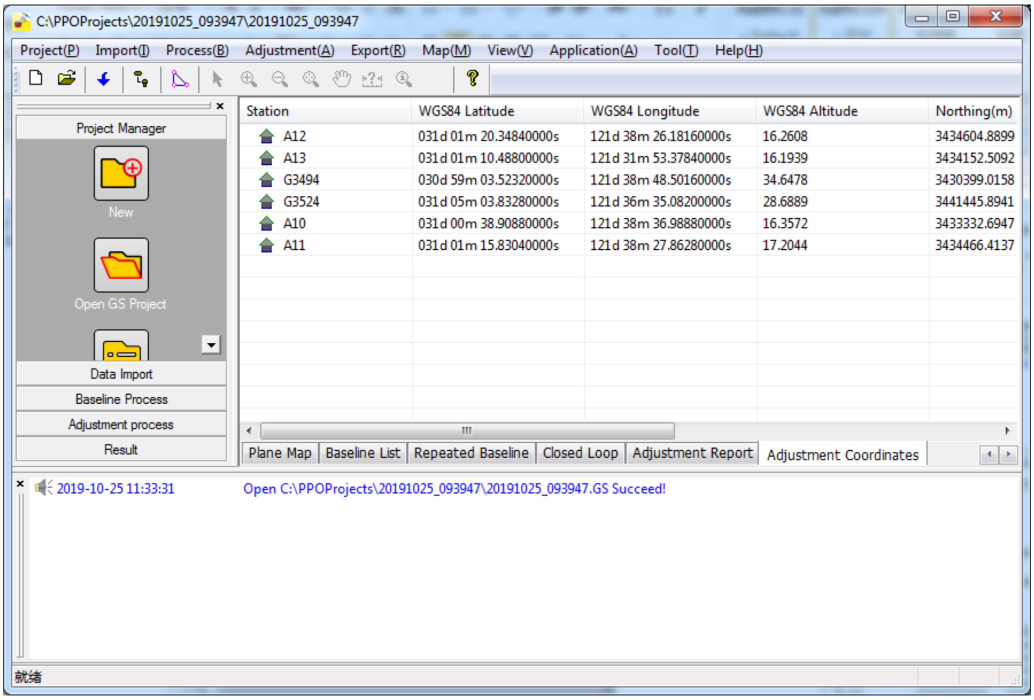


Figure 3-54

Chapter 4 Static baseline solution

In GNSS static data baseline processing, static baseline vector can be determined by static baseline processing, to determine geometrical shape of control network and control point coordinate.

4.1 New Project

PPO manage data in form of project, so it needs to perform data processing or operation order in project. Hence, before data processing, it needs to create a new project, or open an existed project.

To create a new project needs following steps:

a) Input engineer information. Project name is necessary, while other items are optional.
b) Determine project save path: click Project Path to choose and it will show in the right blank.
c) Set Control Level.
d) Set Coordinate System Parameters.

When a new project is created, its project file naming after Project Name will be generated under the save path, which contains project data, processing results and processing records. To open existed project, choose *.GS file. To transfer project files, copy the project file straightly.

Set project property

Way one: click [Project] in Menu Bar – [Properties]

Way two: click [Project Manager] – [Properties]

Project properties includes four items: Project Info, Project Path, Control Level and Coordinate System.

Project Info contains the project basic information. For Project Name and Project Path, they are determined when the project is created, and only for check but not able to modify after the project is saved. Other information can be modified at any time. As shown in Figure 4-1.

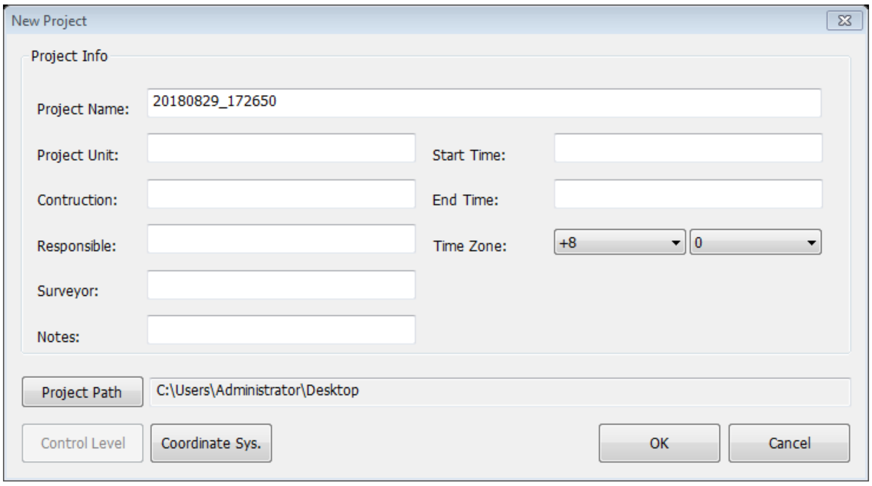


Figure 4-1

[Coordinate System Setting]: Input Coordinate system name, mainly set Ellipsoid Parameter and Projections Parameter, and set other parameters as actual project needed. For Ellipsoid parameter, it can choose built-in ellipsoid parameters like WGS-84 and krassovsky(Beijing54 Using), or choose Define to set Semimajor axis and 1/f, as shown in Figure 4-2. As shown in Figure 4-3, Projections Parameter has six built-in projection modes, namely Gauss Kruger, UTM, Transverse Mercator, Tilt Stereographic, Double Stereographic and Isometic Mercator. The software will automatically calculate measured data to obtain Central Meridian, so Central Meridian directly applying default setting is ok.

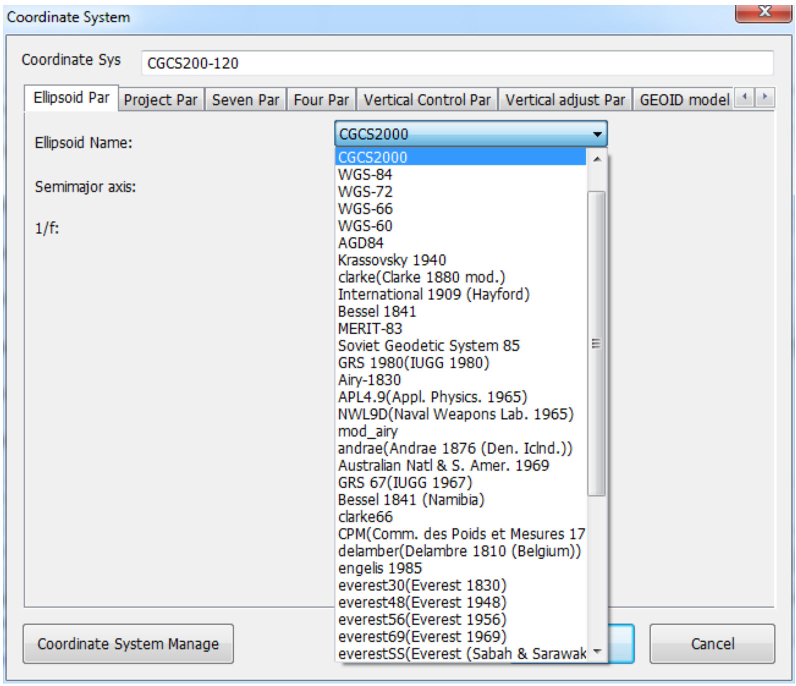


Figure 4-2

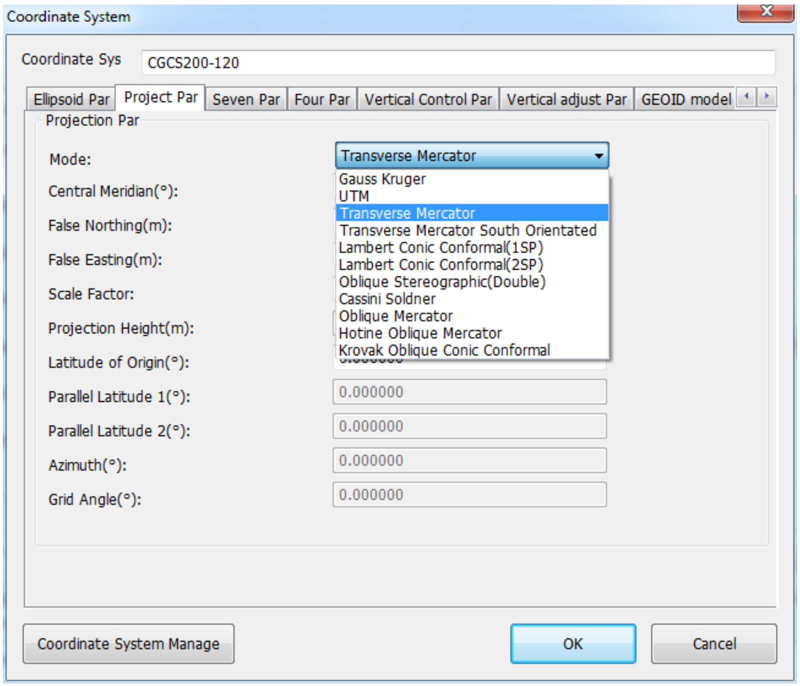


Figure 4-3

4.2 Import Observation Data

GNSS receiver exports data in two kinds of formats: ASCII (NMEA 0183) and binary system. Usually, GNSS receiver manufacturers use binary system as defined proprietary format, which features high storage efficiency and embrace of various information. However, different GPS receiver manufacturers have different defined proprietary formats. Since data processing software can only recognize limited formats, when a project's raw data is provided by different GPS receiver, data processing analysis is unable to perform.

PPO supports raw data in RINEX format and *.dat format to solve this problem. Moreover, it can import data files in formats of *.bin (Hemisphere format), *.rt27(Trimble format), *O.RNX(blend rinex3.02 format), *.N/G/C/(format for separate import of ephemeris)

4.2.1 Data import

Organize the observation data in advance and then import into PPO.

Way one: click [Import] in Menu Bar – [Observation Data]

Way two: click [Data Import] in Navigation Bar – [Observation Data]

In Import Observation Data interface, find the save path of observation data, as shown in Figure 4-4. In the lower right corner, it can choose document type, and only corresponding documents will show. Choose observation data and click [OK] to import it for following processing.

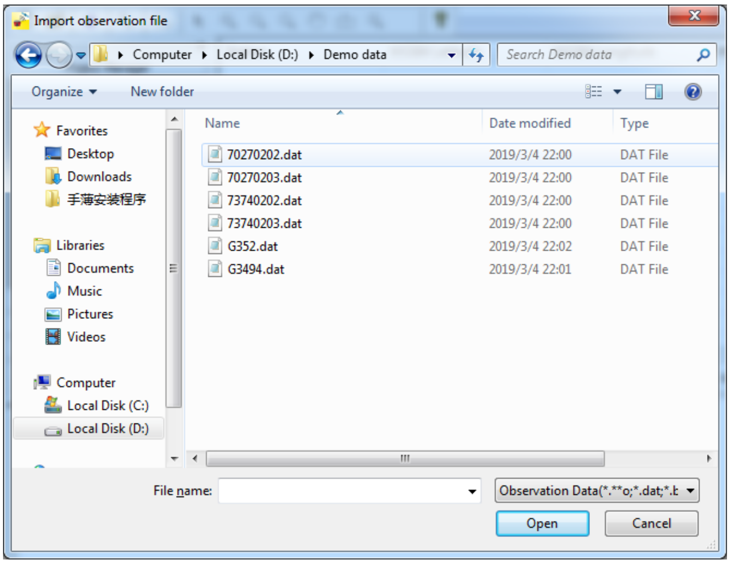


Figure 4-4

While importing the observation file, PPO automatically finds and import relevant ephemeris file. For *.dat file, as observation data and ephemeris data merge in one file, observation file and ephemeris file are imported at the same time. For RINEX file, observation data and ephemeris data save in different files. As a result, it needs to put two files in a same directory, so that the software automatically recognizes ephemeris file with format and import it. Otherwise, ephemeris file needs to be imported additionally.

After importing observation file, the software extract observation stations, and obtain static baselines and dynamic baselines according to their observation time, as shown in Figure 4-5.

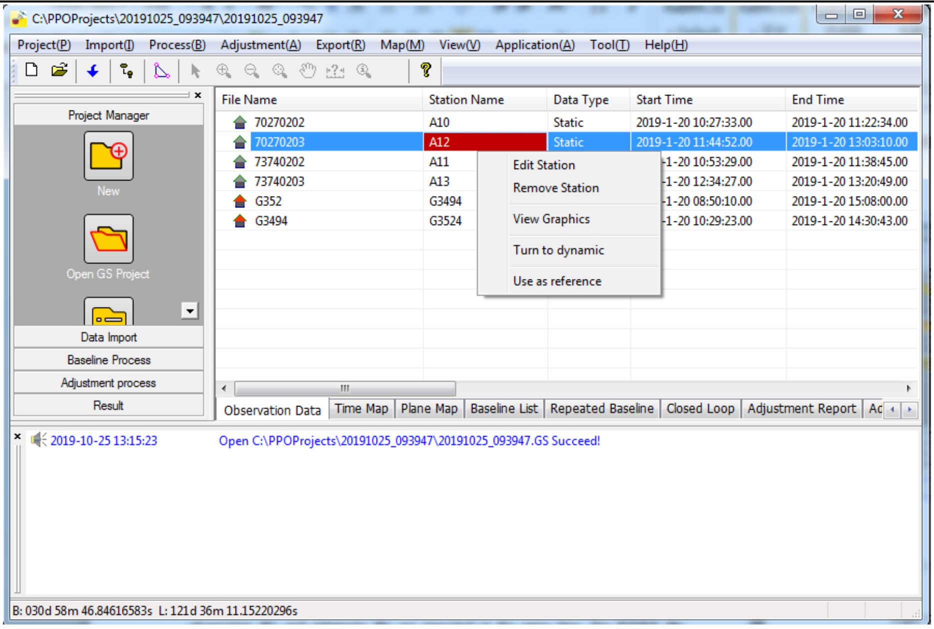


Figure 4-5

Right click target file and it includes [View Graphics], [Edit Station] and [Remove Station], [Turn to dynamic] and [Use as reference]. Find more details in Chapter 3 - 3.5.1.

4.2.2 Observation data content

Observation file mainly saves raw observation data in every epoch that GNSS receiver recorded. Each epoch contains observation time, tracking satellite information of every channel, pseudo-range of C/A code, pseudo-range of P1 code, pseudo-range of P2 code, L1 carrier phase and L carrier phase. For PPO, static observation file should at least contain observation time, pseudo-range of C/A code and L1 carrier phase; dynamic observation file should contain at least observation time and pseudo-range of C/A code.

In addition to the above information, observation file also contains point information, outline coordinate and relevant ephemeris information and other information.

4.2.3 Observation data file name

Usually, PPO distinguishes different observation files on the basis of file name. In general, observation file name consists of 8 digits and its extension, such as BJFS1234.dat.

In one project, files sharing a same name are not allowed. For example, in one project, it's not allowed to exist observation files BJFS1234.dat and BJFS1234.16O at the same time.

Naming rule for file name: observation file usually consists of station name, DOY and period number. Station name can be composed of 4 digits or 2 Chinese characters. DOY refers to the observation day of year in sequence. Period number refers to the period in sequence in the observation day, which can be represented by 1, 2, 3, …, 9, A, B, …, Z.

4.2.4 Observation data in RINEX format

RINEX format is a general data interchange format created to uniformly process data that collected by different kinds of receivers. It's put forward by Institute of astronomy, University of Bern in Switzerland. Nowadays, manufacturers, schools and research organizations use it as standard input format in software programming. And current mainstream GNSS receivers at home and abroad all support to transfer observation data into RINEX format as well. At present, to meet demand of multisystem and multi-channel observations, RINEX format has developed to 3.X version. Find more detailed description about RINEX 2.X format in relevant content and Appendix 2, description about RINEX 3.X format in official document.

4.3 Static baseline processing setting

Before static baseline processing, it needs to set up static settings. Click [Process] in Menu Bar – [Static Options], or click [Baseline Process] in Navigation Bar – [Static Settings], then pops up a dialog box as shown in Figure 4-6.

Please find Chapter 3-3.3.3 to see specific meanings of every setting parameters in static processing settings as reference to set up the parameters.

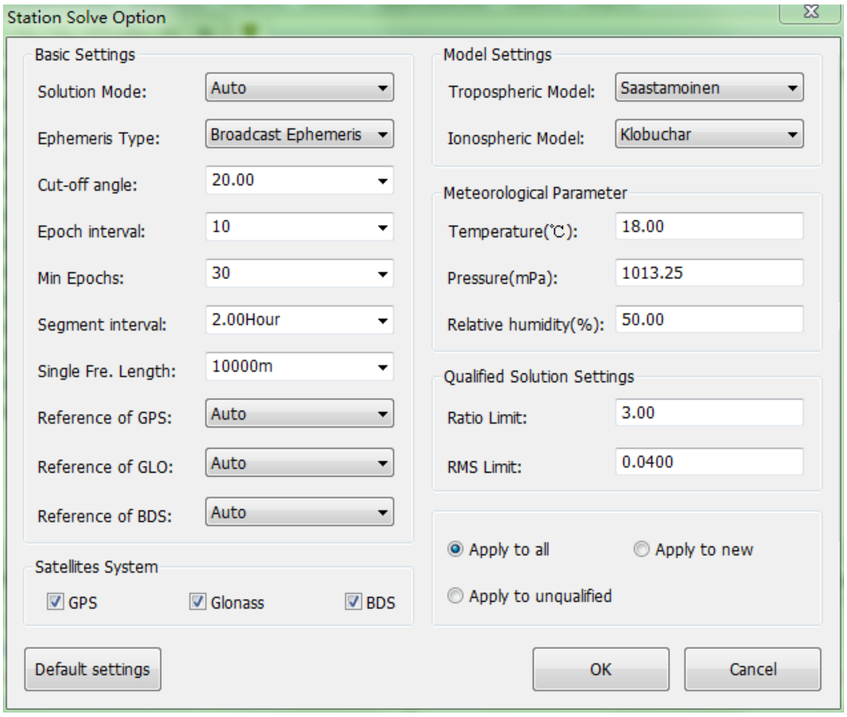


Figure 4-6

4.4 Static baseline solution

Users can perform baseline solution in the following three ways:

Way one: click [Process] in Menu Bar – [Process all baselines]

Way two: click [Baseline Process] in Navigation Bar – [Baseline Process]

Way three: click shortcut key  in toolBar

After preparation, to perform [Baseline Process], the program starts to process all baselines one by one in sequence and shows solution information in dialog box, as shown in Figure 4-7.

In dialog box would respectively appear baseline name, processing progress and baseline information of the baseline in progress. It can also click [Cancel] to stop baseline processing while operating.

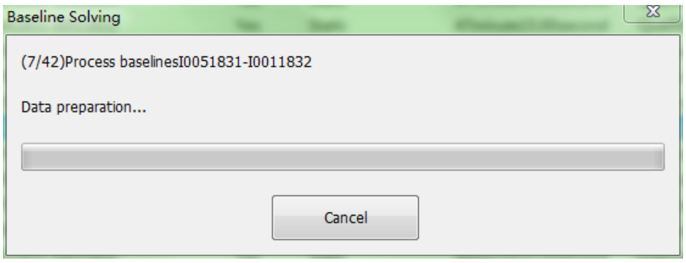


Figure 4-7

After baseline processing, click [Baseline List] to check the result, such as Solution status, Variance Ratio and Error. In the sheet, green area refers to baselines that succeed to process, while red area refers to those failed.

Through user adjusting processing settings, it can reprocess the failed baselines, to qualified all baselines in solution status as far as possible. Users can right-click the selected baseline to open residual view, check residual, modify processing settings or disable unqualified satellite data and reprocess the failed baseline so that all baselines are processed successfully as far as possibly.

Baseline Name	StartPoint	EndPoint	Enable	Baseline Type	Sync Time
73740202-70270202	A11	A10	Yes	Static	29minute05.00second
G352-70270202	G3494	A10	Yes	Static	55minute01.00second
G3494-70270202	G3524	A10	Yes	Static	53minute11.00second
73740203-70270203	A13	A12	Yes	Static	28minute43.00second
G352-70270203	G3494	A12	Yes	Static	01hour18minute18.00se...
G3494-70270203	G3524	A12	Yes	Static	01hour18minute18.00se...
G352-73740202	G3494	A11	Yes	Static	45minute16.00second
G3494-73740202	G3524	A11	Yes	Static	45minute16.00second
G352-73740203	G3494	A13	Yes	Static	46minute22.00second
G3494-73740203	G3524	A13	Yes	Static	46minute22.00second
G3494-G352	G3524	G3494	Yes	Static	04hour01minute20.00se...

Figure 4-8

Information Bar shows processing progress, solution status and warning message of every baseline in the project.

After baseline processing, double-click the baseline to view the processing settings of the baseline vector, as shown in Figure 4-9.

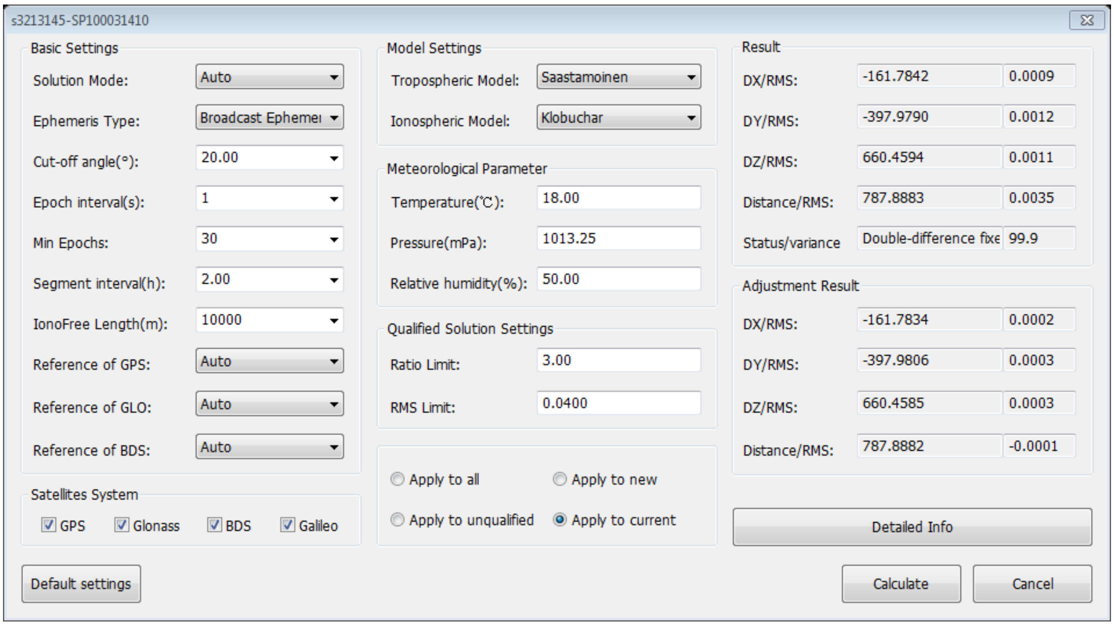


Figure 4-9

Chapter 5 Network Adjustment

GNSS data processing includes baseline solution and network adjustment. Baseline vectors from baseline solution merely can determine graphical shape of GNSS network. Hence, after baseline solution, it needs to furtherly verify baseline solution result and optimize baseline vectors, which then needs to convert to national coordinate or local coordinate as needed. And that's what exactly network adjustment performs.

5.1 Functions and basic steps of Network Adjustment

PPO can perform 3D adjustment, 2D adjustment and Elevation adjustment.

To perform network adjustment in PPO, basic steps are as follows:

1) Early preparation (done by user): It needs to complete baseline solution, set up control level and coordinate system, and load known point.
2) Calculation of network adjustment (automatically done by software)
3) Quality analysis and control of calculation result (handled by user)

PPO merely perform calculation of network adjustment. The most important is user's participation and ultimate correct judgement. The process generally repeats till it obtains a proper result.

5.1.1 Early preparation before network adjustment

Before network adjustment, it needs to complete baseline solution and solution status should be "Qualified".

Coordinate System Setting

Before network adjustment, it should check if coordinate system setting is correct. In general, it mainly sets up Ellipsoid Parameter and Projections Parameter. Other parameters are set as needed or keep default setting, as shown in Figure 5-3. For instance, Chinese users generally apply krassovsky (Beijing54 Using) as ellipsoid parameter and Gauss Kruger as projections parameter.

PPO has built-in common ellipsoid parameter and projections parameter and it would automatically calculate measured data to obtain Central Meridian. Since it has set up the control level and coordinate system in project creation, setting up these two items again is merely for further confirmation.

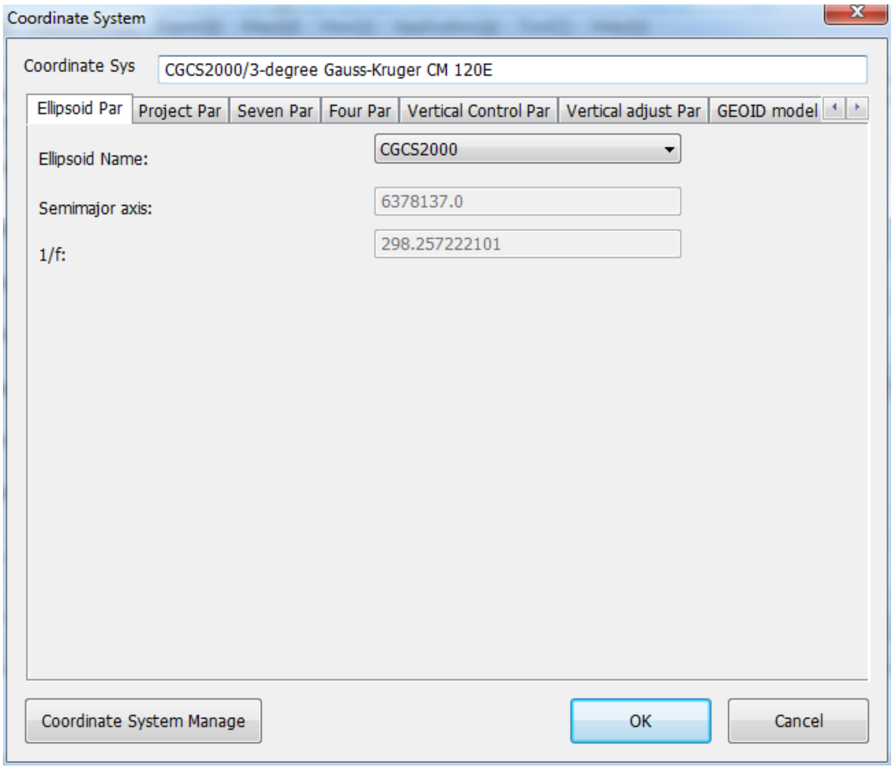


Figure 5-3

5.1.2 Network Adjustment Setting

Way one: click [Adjustment] in Menu Bar– [Adjustment Setting]

Way two: click [Adjustment Process] – [Option Settings]

It needs to set up calculation parameters of adjustment before network adjustment calculation, so as to determine the conditions that constitute a closed loop.

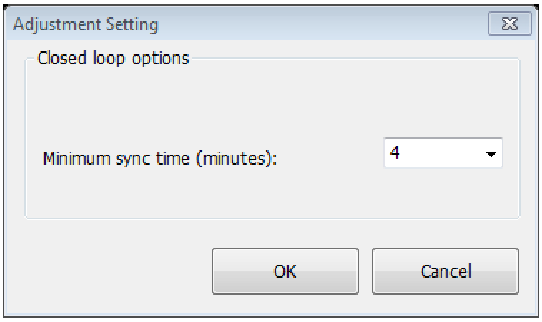


Figure 5-4

Minimum sync time: baselines whose observation time is shorter than minimum sync time has been set would not participate in closed ring combination.

5.1.3 Import Known Coordinates

It needs to import known coordinates before network adjustment, or PPO would automatically choose one station point as known point to perform 3D adjustment.

Import known coordinates:

1) Click [Import] in Menu Bar – [Known Coordinates], or click [Data Import] in Navigation Bar – [Known Points]

2) Click [Add] as shown in Figure 5-5. Input known coordinates and tick options as actually needed.

3) Or directly import the known coordinates have been saved into project through [Import]

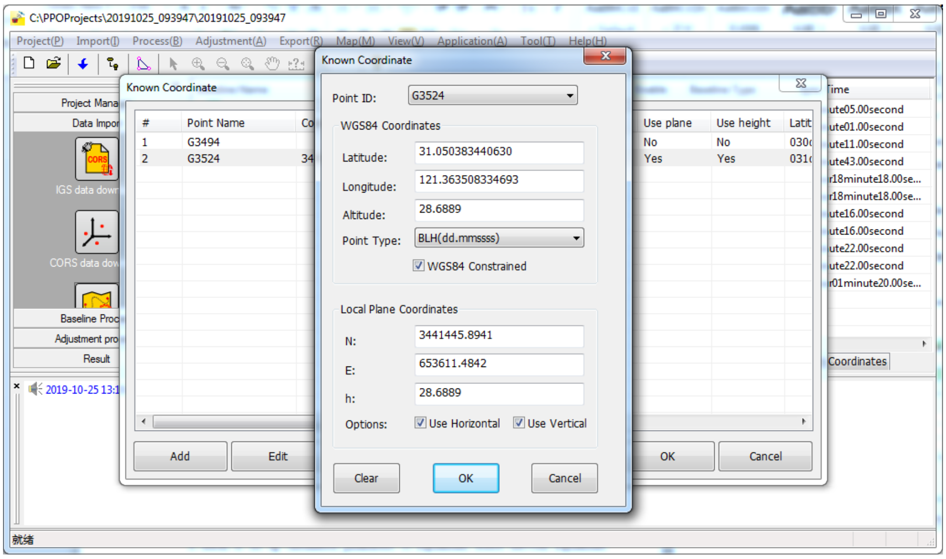


Figure 5-5

In known coordinate management, it would list the information of known coordinates. And it can edit and delete the known coordinates as well.

5.2 Perform Network Adjustment

Click [Adjustment] in Menu Bar – [Adjustment Processing], or click [Adjustment Process] in Navigation Bar – [Adjustment Process] to perform network adjustment. PPO would perform all possible adjustments (3D adjustment, 2D adjustment and Elevation adjustment) directly based on current setting, and show the processing progresses and results in Information Bar. After network adjustment, it would create a network adjustment report and automatically jump to the report interface. According to the network adjustment report, users can judge if the network adjustment meets the project demands. If the result fails, it needs to recheck baselines involved in network adjustment, reprocess the baselines, reperform network adjustment until the result meets the project requirements.

5.2.1 Extract baseline vector network

First step for network adjustment is to extract the baseline vector network. The principles of baseline vector network constitution are as follows:

1) The baseline exists in current project and is not deleted.
2) The baseline succeeds to process and its solution status shows "Qualified" in Baseline List.
3) The baseline is not disabled.
4) The baseline meets requirements of control level.

Any baseline meets above conditions would be automatically included to form baseline vector network in the first step of network adjustment.

5.2.2 Connection inspection of baseline vector network

Performing network adjustment without connection would cause network adjustment cannot converge. PPO would automatically perform connection inspection of baseline vector network before network adjustment. If network is not connected, warning window would pop up as shown in Figure 5-6.

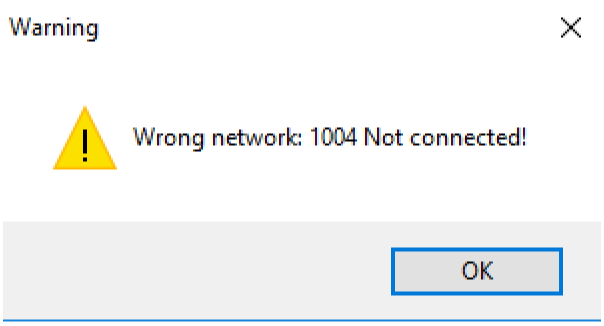


Figure 5-6

If appears above warning, please check the information of baselines that constitute baseline vector network, such as baseline vector and observation station name. Inspection steps are as follows:

1. Check if network is divided into several parts, and if there is isolated station point or baseline. If positive, it must delete the isolated point or perform network adjustment in

blocks.

2. Check if any important baseline fails to process or be disabled in network adjustment. If positive, the baseline needs to reprocess or even re-observe.

3. Check if one station has two different names in network, reflecting in network graph that these two stations locate very close to each other. These two points observe in the same location in different periods, so between them cannot form any baseline, which makes network unconnected. Solution is to correct the wrong station name in observation data properties.

5.2.3 Adjustment Report

The results of net adjustment are reflected in the adjustment report. Take 3D adjustment as example, its adjustment result is as shown in Figure 5-7. It can click [Export] in Menu Bar – tick [Adjustment report] or click [Result] in Navigation Bar – [Static result file] – tick [Adjustment report] to export and save adjustment report (html). In this way, it provides convenience for network adjustment analysis, and avoids losing the result.

3D adjustment result

Adjustment Type WGS84 Adjustment of classical free network in coordinate system
Mean error of unit weight 0.0010m

Baseline and correction

No.	Constitute	ΔX	ΔY	ΔZ	ΔXCorrection (Millimeter)	ΔYCorrection (Millimeter)	ΔZCorrection (Millimeter)	Relative Error	Distance after adjustment (m)
1	73740202-70270202	-513.1382	371.1724	-974.9385	18.5050	24.1340	9.7600	1:36399	1162.5769
2	G352-70270202	1061.9308	-1141.0163	2508.7281	5.7420	8.5830	6.6460	1:240507	2953.5288
3	G3494-70270202	-4953.4061	1878.8551	-6996.6351	22.6330	36.6110	13.8140	1:194143	8776.0601
4	73740203-70270203	-8793.0424	-5590.1263	260.2784	15.2810	21.0890	13.0140	1:358004	10422.8044
5	G352-70270203	1651.0349	-1550.5165	3602.4066	7.1450	10.8740	9.1280	1:267731	4255.2734
6	G3494-70270203	-4364.2956	1469.3392	-5902.9883	12.5030	19.5280	15.5800	1:268003	7486.7419
7	G352-73740202	1575.0402	-1512.1840	3483.6764	11.4670	12.9850	6.6240	1:221677	4111.3809
8	G3494-73740202	-4440.3185	1507.6952	-6021.6841	22.8880	26.2540	13.6420	1:204038	7632.1853
9	G352-73740203	10444.0947	4039.6083	3342.1117	10.1970	12.8530	8.1860	1:637376	11686.1995
10	G3494-73740203	4428.6092	7059.8125	-6162.9898	29.5300	43.9480	32.8970	1:166280	10365.1326
11	G3494-G352	-6015.4208	3020.1342	-9505.1259	16.9130	23.5630	12.3150	1:369620	11647.0561

Figure 5-7

Chapter 6 Dynamic baseline solution

Dynamic data processing is post-differential data processing. Post-differential is different from RTK in that RTK obtains the observation result immediately in the field while post-differential cannot obtain the result until indoor processing.

Dynamic GNSS data processing process dynamic baseline, which includes two kinds of data files, base data file and rover data file.

6.1 Early preparation for dynamic baseline solution

In dynamic baseline solution, to create new project and import observation file, its operation steps are the same as that of static data solution. Please refer to section 4.1 and 4.2. Please notice that observation data imported in dynamic baseline solution should include base and rover two kinds of data files.

Click [Process] in Menu Bar – [Dynamic Options] or click [Baseline Process] in Navigation Bar – [Dynamic Settings] to set up dynamic solution parameters, as shown in Figure 6-1. Generally, it merely needs to set up Mask angle and Ratio Limit. Other items can remain default settings or set up as actual project needed.

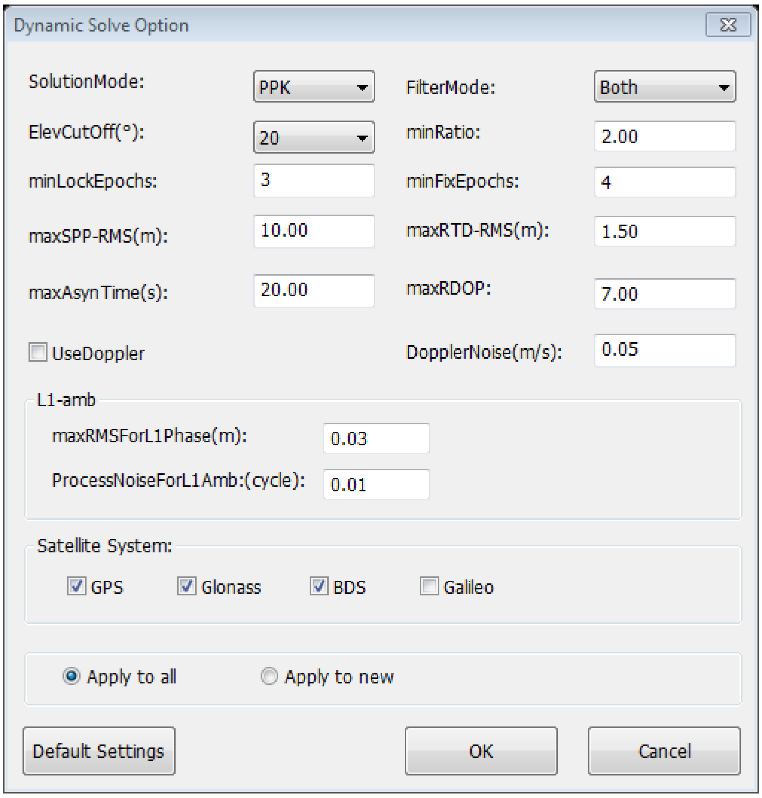


Figure 6-1

After importing observation data, Baseline List lists all possible baselines.

Choose any baseline in Baseline List and right-click to show option Bar. In option Bar, it includes Baseline Info, Processing settings, Reprocess, Delete baselines, Enable baselines, Disable baselines, Endpoint exchange and Baseline Report. Detailed description for operation order please refer to section 3.5.4 Baseline List.

6.2 Perform Dynamic Baseline Solution

PPO can perform dynamic baseline solution in several ways as follows:

Way one: click [Process] in Menu Bar – [Process all baselines], or click [Baseline Process] in Navigation Bar – [Baseline Process] to process all baselines. A dialog box would pop up to respectively show baseline name, processing progress and baseline information of the baseline in progress. The processing progress and baseline information of all baselines would also show in Information Bar.

Way two: in Baseline List right-click a dynamic baseline, click [Reprocess] in drop-down box to complete single dynamic baseline solution, and repeat the operation till all dynamic baseline solution finish.

Way three: in Baseline List right-click a dynamic baseline, click [Reprocess] in drop-down box, tick [Apply to all] and click [Calculate], and then it would automatically complete all dynamic baseline solution; or not tick [Apply to all] and click [Calculate] to complete single dynamic baseline solution, and then repeat the operation till all dynamic baseline solution finish.

6.3 Baseline solution result

After baseline processing, in Plane Map baseline succeeded to process shows in green and baselines failed to process show in gray. Also, the Plane Map shows trajectory of station point. Trajectory dot shows green in fixed solution, yellow in float, and red in single. Baseline List would also show all baseline solution result. Green area refers to baselines that succeed to process, while red area refers to those failed.

For baseline fails to process, it can reprocess through modifying process settings. If the baseline keeps fail, it can disable the baseline.

After dynamic baseline solution, it can view and download the solution result.

1) View dynamic baseline solution result

Operation: click [Process] in Menu Bar – [Dynamic data view], or click [Result] in Navigation Bar – [View dynamic data].

In [Solve Result] window, choose Solving Baselines, choose Displayed Type and Solution Status, then it shows the dynamic baseline solution result, as shown in Figure 6-2. In the upper right of the window, it shows basic information of the baseline, including File Name, Baseline length, Sync Time, Track point, Mark point and Event point. Green area refers to points in fixed solution, yellow to points in float solution and red to points in single solution.

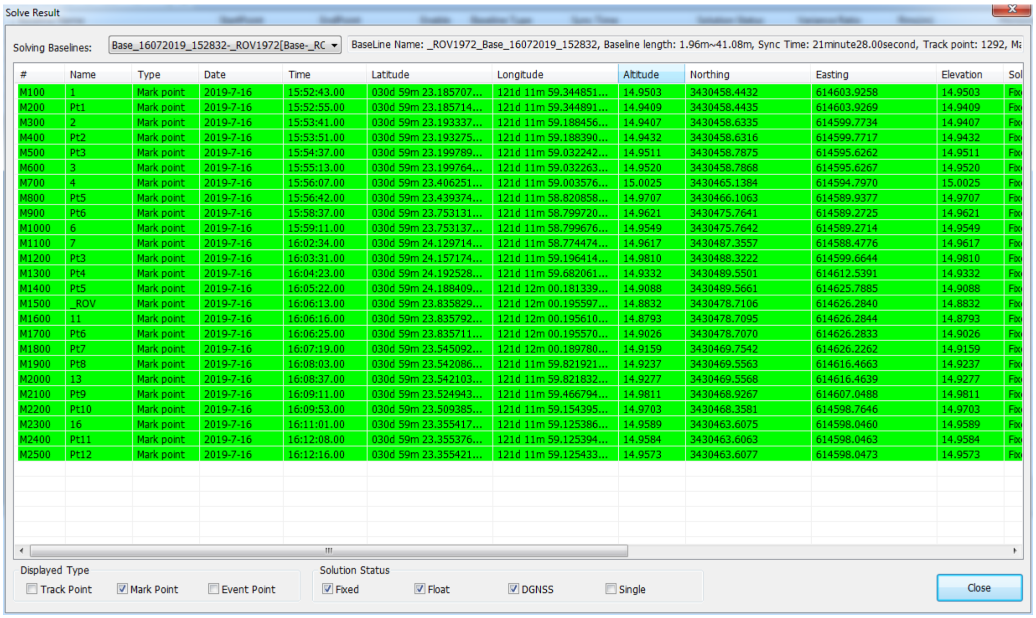


Figure 6-2

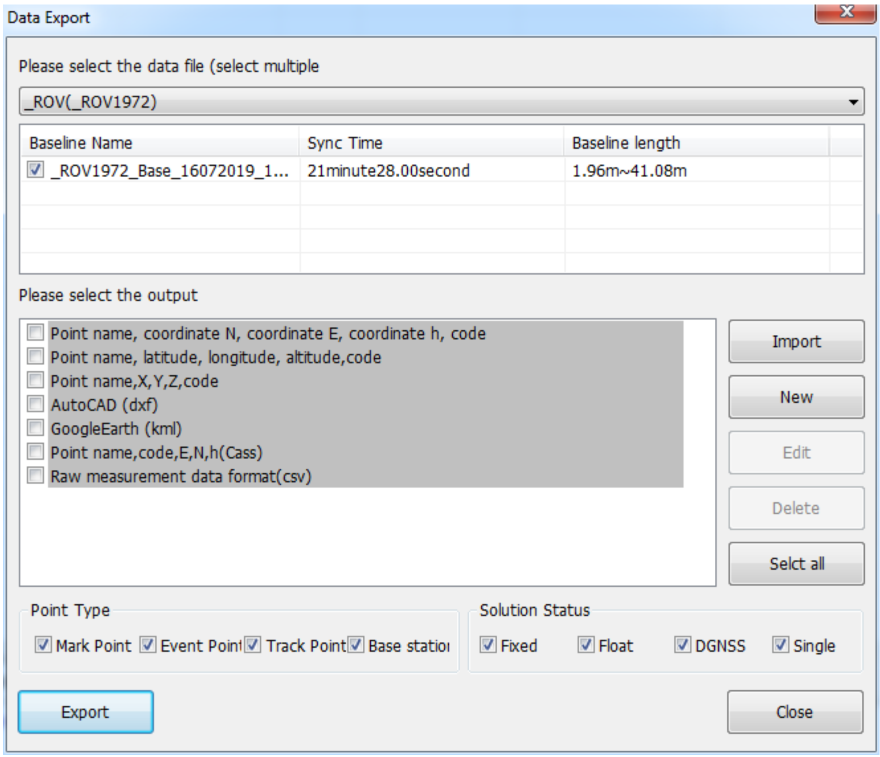


Figure 6-3

2) Download dynamic baseline solution result

Operation: click [Export] in Menu Bar – [Dynamic solution coordinates], or click [Result] in Navigation Bar – [Dynamic coordinate file].

To download dynamic coordinate file, it pops up a window, as shown in Figure 6-3.

Appendix 1 Glossary

IGS

International GPS Service for Geodynamics. Based on GPS continuously operating stations with global foundation, IGS is a model of network of GPS continuously operating station and comprehensive service system. It's made freely accessible to global users with all kinds of GPS information, such as GPS precise ephemeris, rapid ephemeris, forecasting ephemeris, coordinates and movement rates of IGS stations, phase and pseudo range of GPS signal received by IGS stations, and earth rotation rate. It supports tremendous scientific projects in geodesic and geodynamics, including ionosphere, meteorology, reference frame, precise time transmission, high-resolution projections of earth rotation rate and its variant, and crustal movement. France's DORIS and German's PRARE are considering establishing similar international organization, striving to make this kind of space-based geodetic surveying system more efficient, more automated, more precise and more reliable.

Ambiguity

An unknown value, the integer cycle value of carrier phase measured between satellite and receiver.

Baseline

Connection line between two observation points where simultaneously receive GPS signal and collect observation data.

Broadcast ephemeris

Satellite orbit parameter demodulated from telegraph text sent by satellite.

SNR (Signal-to-noise ratio)

Ratio of signal power to noise power at one endpoint.

Cycle slip

A phenomenon that with interference, cycle loop jumps several cycles from a balance point to a new balance point and stabilize on it, which cause incorrect integer cycle in phase.

Carrier

A radio wave having at least one characteristic (such as frequency, amplitude, or phase) that can be varied from a known reference value by modulation.

C/A Code

GPS rough observed/captured code, a 1023-bit pseudo-random binary code in double phase modulation. It repeats every 1023 bits and modulates at a 1MHz rate.

Difference measurement

GPS measurement with cross satellites, cross receivers and cross epochs. It can be divided into the following three kinds:

SD (Single Difference) Measurement (cross receivers): instantaneous effect rate of signal phase obtained by two receivers simultaneously observing one satellite.

DD (Double Difference) Measurement (cross receivers and cross satellites): the difference of one satellite's SD to the reference satellite's SD.

TD (Triple Difference) Measurement (cross receivers, cross satellites and cross epochs): the difference of the DD in an epoch to the DD in last epoch.

Differential positioning

Method to determine relative coordinates of two or more receivers through simultaneously tracking a same GPS signal.

Geometric Dilution Precision

A term to specify additional multiplicative effect of navigation satellite geometry on positional measurement precision in dynamic positioning, defined as:

$$DOP = \sqrt{tr(Q^T Q)^{-1}}$$

Of which, Q is the matrix of instant dynamic position solution (depends on positions of receiver and satellite). There are a number of standard terminologies in GPS as shown in following table:

Name	Description
GDOP (Geometric Dilution of Precision)	Four-dimensional geometry factor
PDOP (Position (3D) Dilution of Precision)	Three-dimensional geometry factor
HDOP (Horizontal Dilution of Precision)	Two-dimensional geometry factor
VDOP (Vertical Dilution of Precision)	Vertical geometry factor
TDOP (Time Dilution of Precision)	Time geometry factor (1:40000)
HTDOP	Horizontal and Time geometry factor

(Horizontal and Time Dilution of Precision)	

Dynamic positioning

Method to determine the time-varying coordinate of moving receiver. Each observation result is obtained by real-time calculation of single data sampling.

Eccentricity

$$e = \sqrt{\frac{a^2 - b^2}{b^2}}$$

of which, a and b respectively refer to semi-major axis and semi-minor axis.

Ellipsoid

In geodesy, it is a mathematically defined surface generates when it is rotated about its minor axis. The semi-major axis of the ellipse, a, is identified as the equatorial radius of the ellipsoid: the semi-minor axis of the ellipse, b, is identified with the polar distances (from the center). These two lengths completely specify the shape of the ellipsoid but in practice geodesy publications classify reference ellipsoids by giving the semi-major axis and the inverse flattening, 1/f. The flattening, f, is simply a measure of how much the symmetry axis is compressed relative to the equatorial radius:

$$f = \frac{1}{a}(a - b)$$

Ephemeris

A set of numerical parameters that can be used to determine a satellite's time-varying position.

Flattening

$$f = \frac{1}{a}(a - b) = 1 - \sqrt{(1 - e^2)}$$

of which, a and b respectively refer to semi-major axis and semi-minor axis, and e refers to eccentricity ratio.

Geoid

The surface of the oceans that is extended through the continents, to whom the force of gravity acts perpendicular everywhere.

Ionosphere delay

Delay occurred when electric waves pass through the ionosphere (inhomogeneous dispersive medium). Phase delay depends on electron content and it affects carrier signal, while group delay depends on ionospheric dispersion and it affects signal modulation code. Phase delay and group delay share the same amplitude but with opposite signs.

L-band

Radio frequency range of 390-1550MHz.

Multipath error

The positioning error occurs when GPS signals arrive at an antenna having traversed different paths.

Observation session

The period when two or more receivers simultaneously collect GPS data.

Pseudo range

Distance calculated by time offset used to align the GPS copy code in receiver with the received GPS code multiplying velocity of light. The time offset is the difference between the time signal be received (receiver time series) and the time signal transmit (satellites time series).

Receiver channel

RF channel, mixed frequency channel and intermediate frequency channel of GPS receivers, which can receive and track two kinds of carrier signals.

Satellite configuration

Satellite configuration for a specific user or a group of users at a certain time.

Static positioning

Point measurement that not considering the receiver movement.

Universal time

Universal time: the mean solar time on the Prime Meridian at Greenwich, London, UK.

UT: acronym for Universal Time.

UT0 is Universal Time determined by observing the diurnal motion of stars. The relationship between Universal Time and Solar Time is: solar day-sidereal day=$3^{m}56.555^{n}$.

UT1 is UT0 after polar motion correction.

UT2 is a smoothed version of UT1, filtering out periodic seasonal variations.

UTC (Universal Time Coordinated) is an atomic timescale that approximates UT2.

Interval

The process of taking a continuous change value at periodic intervals.

Observation condition

In GPS measurement, observation condition refers to the geometry and trajectory of satellite constellation.

Appendix RINEX data format

RINEX file type

Six different types of data files are defined in the second edition of the RINEX format for respectively storing different types of data, namely observation data file for GPS observation value, navigation message file for GPS satellite navigation messages, meteorological data file for meteorological data measured in station, GLONASS navigation message file for GLONASS satellite navigation messages, Geostationary satellite (GEO) navigation messages file for GEO satellite navigation messages from a geostationary satellite equipped with a similar GPS signal generator in an enhanced system, and satellite and receiver file for time information of satellite and receiver.

RINEX naming rule

RINEX format has special naming rules for data files, so that user can easily distinguish the attribution, type and time of recorded data of the data files through the file name. According to the rule, the data file in RINEX format is named with 8.3 naming method. A completed file name consists of two parts: 8-digit main target name to represent file attribution, and 3-digit extension to represent file type, its specific form as follows:

ssssdddf.yyt

of which:

ssss: measurement station code in 4 digits.

ddd: DOY in the first record in the document.

f: file sequence number (FSN) in one day, sometimes names period number. The value is from 0-9, A-Z. When it is 0, it means that the file contains all data in that day. Notice that the FSN is based on the synchronous observation period of the whole project in one day instead of observation period of one receiver in one day. For instance, at one day, a project uses four receivers to observe. In the first period, four receivers all participate in observation, then in that period the FSNs of the data files in four receivers are 1. In the second period, only three receivers participate in observation, then in that period the FSNs of the data files in three receivers are 2. In the third period, four receivers all participate in observation again, then in that period the FSNs of the data files in four receivers including the one didn't participate in the second observation are 3.

yy: year.

t: file type, one among the follows:

O——observation file;

N——GPS navigation message file;

M——meteorological data file;

G——GLONASS navigation message file;

H——GEO navigation messages file

C——clock file.

Take BJFS0010.17O for example, it is the observation data file of whole-day data for point BJFS in Jan 1^{st}, 2017 (DOY is 1). And BJFS0010.17N is its corresponding navigation message file.

Observation data file

It includes file header and data record. In Table 1 list the file headers of this file and in Table 2 list the data record. Here merely introduce a couple of terms.

Time: measuring time is the time when the signal arrives at the receiver. It is GPS time instead of UTC time. The pseudo ranges and phases of all tracking satellites are observed at that time.

Pseudo range: pseudo range is the distance calculated by time offset used to align the GPS copy code in receiver with the received GPS code multiplying velocity of light. There are three pseudo-range observations in RINEX: C1 is C/A code in L1; P1 is P code in L1; and P2 is P code in L2. Due to AS policy, plenty of receivers cannot receive P code in L2, so the delay of Y2-Y1 calculated by relevant technology is used for instead to eliminate influence of ionosphere. In this case, in RINEX it adopts P2 code composited by C/A code and the delay of Y2-Y1.

Phase: phase is the small value of integer cycle in beat frequency in actual L1 and L2. When using square technology to extract phase, if it is small value of half cycle, it must transfer to that of integer cycle.

Doppler: using specific processing software in receiver, it can record value of Doppler, D1, D2, Hz as units.

Table 1 Header description for GPS observation data file

Header label (column 61~80)	Description	Format
RINEX VERSION/TYPE	Version number of RINEX format (2.10 in this version) File type ("O" in this file) Satellite system where observation data from: (space or "G" for GPS, "R" for GLONASS, "S" for synchronous satellite signal payload, "T" for NNSS Meridian Satellite, "M" for combined system)	F9.2，11X， A1，19X， A1，19X
PGM / RUN BY / DATE	Program name that creates the data file Agency name that creates the data file Date when data file is created	A20， A20， A20
COMMENT	Comment line	A60
MARKER NAME	Name of antenna mark (point name)	A60
MARKER NUMBER	Number of antenna mark (point number)	A20
OBSERVER / AGENCY	Observer name/Observation agency name	A20，A40
REC # / TYPE / VERS	SN, type and version (internal software version) of receiver	3A20
ANT # / TYPE	SN and type of antenna	2A20
APPROX POSITION	Approximate position of mark (WGS84)	3F14.4

XYZ		
ANTENNA:DELTA H/E/N	Antenna height(H): higher than the lower surface height of marked antenna Antenna center offset in east and north	3F14.4
WAVELENGTH FACT L1/2	Wavelength factor of L1 and L2 1: ambiguity of whole cycle 2: ambiguity of half cycle 0: L1 single frequency Tracking satellite number (maximum as 7, more than 7 repeats record) PRN: satellite number	2I6 I6 7(3X，A1，I2)
#/TYPES OF OBSERV	The number of different observed value types stored in the file. Observed value type list: Description: in RINEX 2.10 define the following observed value types: L1, L2: phases observed value in L1 and L2; C1: pseudo range measured by C/A code in L1; P1, P2: pseudo ranges measured by P code in L1 and L2; D1, D2: Doppler frequencies in L1 and L2; T1, T2: Doppler integrations in 150(T1) of Meridian Satellite and 400MHz (T2) signal; S1, S2: initial signal strength of phase observed value in L1, L2 given by receiver or SNR value. Units of observed value:	I6 9(3X，A1，I2) 6X，9(4X，A2)

	Cycle for carrier phase; Meter(m) for pseudo range; Hz for Doppler; Cycle for Meridian Satellite; SNR depends on receiver.	
INTERVAL	Epoch interval of observed value, second as unit.	F10.3
TIME OF FIRST OBS	The first recorded moment in the data file (year, month, day, hour, minute, second). Time system: GPS for GPS time, GLO for UTC time Description: in GPS/GLONASS file it must include the time system field. Default field for pure GPS file is GPS, and for pure GLONASS file is GLO.	5I6，F13.7 5X，A3
TIME OF LAST OBS	The last recorded moment in the data file (year, month, day, hour, minute, second). Time system: same as TIME OF FIRST OBS	5I6，F13.7 5X，A3
LEAP SECONDS	Leap seconds from Jan 6th, 2017 in GPD/GLONASS file.	I6
#OF SATELLITES	The number of satellites have observed value storied in file	I6
PRN/# OF OBS	The PRN (satellite number) involved by every observation values indicated in #/TYPES OF OBSERV record and the number of their observed value If types of observed value are over 9, then use a continuous line.	3X，A1， I2，9I6 6X，9I6

	Description: there is a record for each satellite in observation data file.	
END OF HEADER	The last record in header	60X

Notes:

The above introduction formats are RINEX2.10:

In introduction of RINEX format, data types used are as follows:

X——space

A——alphabet

I——integral

F——float

D——double

Table 2 Observed value format description for GPS observation data file

Observed value record	Description	Format
EPOCH/SAT OR EVENT FLAG	Observed epoch: Year (2 digits, add 0 in the front as needed), month, day, hour, minute, second Epoch symbol: 0 for normal; 1 for a power failure occurred between the previous one and the current one; >1 for event symbol Satellite number observed in current epoch Satellite PRN list (satellite number with satellite system identifier) observed in current epoch Deviation of receiver clock (s as unit) If satellites are over 12, then use a continuous line.	1X，I2.2 4(1X，I2) F11.7 2X，I1 I3 I2(A1，I2) F12.9 32X 12(A1，I2) [2X，I1]

	If epoch symbol is 2-5, it indicates that: 2: antenna starts moving; 3: new station is set (dynamic data ends); 4: following is information similar to header, describing certain special conditions in observation; 5: external event. “satellite number in current epoch” describes the following record number, i.e., how many lines in the following used to describe event. Maximum is 999. For a time that does not specify a moment in the epoch, the epoch field can be empty. Description: if epoch field is 6, it indicates in the following is record of cycle slips detected and repaired. This item is optional.	[I3]
OBSERVATIONS	Observed value LLI (Loss of Lock Indicator) Signal strength	m(F14.3，I1，I1)

Navigation message file

Satellite ephemeris is broadcast navigation message from satellites, which is the essential data of ground location calculation. In navigation message, it includes satellite's orbital elements and satellite clock parameter and other information. To speed up ground location calculation, broadcast navigation message is sent by satellite once per second and updated once per hour. Hence, every observation merely needs to record a set of broadcast navigation message. In Table 3 and Table 4 respectively are header description of navigation message file and record format description of navigation message file.

Table 3 Header description of GPS navigation message file

Header label (column 61-80)	Description	Format
RINEX VERSION / TYPE	Version number of RINEX format File type (N)	F9.2，11X A1，19X
PGM / RUN BY / DATE	Program name that creates the data file Agency name that creates the data file Date when data file is created	A20 A20 A20
COMMENT	Comment line	A60
ION ALPHA	Ionospheric parameter A0~A3 in ephemeris	2X，4D12.4
ION BETA	Ionospheric parameter B0~B3 in ephemeris	2X，4D12.4
DELTA-UTC：A0，A1，T，W	Ephemeris parameters used to calculate UTC time: A0, A1: multinomial coefficient T: reference moment of UTC data W: Reference cycle of UTC, as continuous counting	3X， 2D19.12 I9 I9
LEAP SECONDS	Time difference caused by leap seconds	I6
END OF HEADER	The last record in header	60X

Table 4 Observed value format description for GPS navigation message file

Observed value record	Description	Format
PRN number/ Epoch/ Satellite	PRN number of satellite Epoch: TOC (reference moment of satellite clock) Year (2 digits, add 0 in the front as needed) month, day, hour, minute	I2 1X，I2.2 4(1X, I2)

clock	second Deviation of satellite clock (s) Drifting of satellite clock (s/s) Drift speed of satellite clock (s/s^2)	F5.1 3D19.12
Broadcast channel-1	IODE (Issue of Data，Ephemeris/Released time of data, epoch) C_{rs}(m) △n(rad/s) M_0(rad)	3X， 4D19.12
Broadcast channe-2	C_{us}(rad) e orbital eccentricity C_{us}(radians) sqrt(A)(m1/2)	3X， 4D19.12
Broadcast channe-3	TOE reference of ephemeris time (the number of seconds in the GPS cycle) C_{ic}(rad) Ω (rad)(OMEGA) C_{is}(rad)	3X， 4D19.12
Broadcast channe-4	i_0(rad) C_{rc}(m) w(rad) Ω (rad/s) (OMEGA DOT)	3X， 4D19.12
Broadcast channe-5	i(rad/s) (IDOT) Code in L_2 GPS cycle number (together with TOE indicates time). It is continuous counting, not remainder of 1024. L_2 P-code data symbol	3X， 4D19.12
Broadcast	Satellite accuracy(m)	3X，

channe-6	Satellite state TGD(sec) AODC of IODC	4D19.12
Broadcast channe-7	Released time of message (second in GPS cycle as unit, calculated by Z in transition word (HOW)) Fitting range(h), as 0 if unknown	3X， 4D19.12

End.