

Introduction to RTK Data Processing How to get centimeter level accuracy? Part - 2

GNSS Data Processing for High-Accuracy Positioning using
Low-Cost Receiver Systems

3 - 6 January 2023

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Before this course, you should...

1. Have some basic knowledge of RTK

2. Have installed RTKLIB

<http://www.rtklib.com/>

3. Download the GNSS data we provide

During this course, we will...

1. Learn how to perform RTK post processing using RTKLIB
2. Process RTK with real data using RTKLIB
3. Know what affects the precision of RTK results












Package of RTKLIB

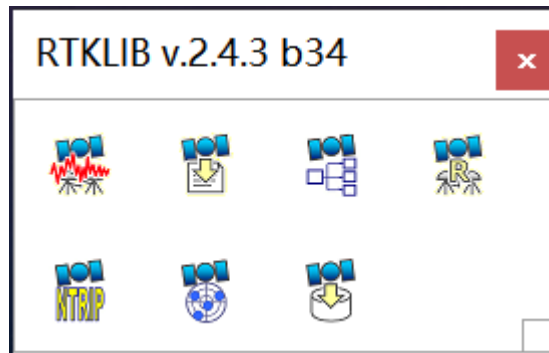
```
rtklib_<ver>
./src          source programs of RTKLIB library *
./rcv         source programs depending on GPS/GNSS receivers *
./bin         executable binary APs and DLLs for Windows
./data       sample data for APs
./app        build environment of APs *
  ./rtknavi   RTKNAVI      (GUI) *
  ./rtknavi_mkl RTKNAVI_MKL (GUI) *
  ./strsvr    STRSVR      (GUI) *
  ./rtkpost   RTKPOST     (GUI) *
  ./rtkpost_mkl RTKPOST_MKL (GUI) *
  ./rtkplot   RTKPLOT     (GUI) *
  ./rtkconv   RTKCONV     (GUI) *
  ./srctblbrows NTRIP Browser (GUI) *
  ./rtkget    RTKGET      (GUI) *
  ./rtklaunch RTKLAUNCH  (GUI) *
  ./rtkrcv    RTKRVC      (CUI) *
  ./rnx2rtkp  RNX2RTKP   (CUI) *
  ./pos2kml   POS2KML    (CUI) *
  ./convbin   CONVBIN    (CUI) *
  ./str2str   STR2STR     (CUI) *
  ./appcmn    common routines for GUI APs *
  ./icon      icon data for GUI APs *
./lib         library generation environment *
./test       test programs and data *
./util       utilities *
./doc        document files
```

* not included in the binary package rtklib_<ver>_bin.zip

Launch RTKLIB

› E (E:) › Program › RTKLIB-rtklib_2.4.3_b34 › bin

名称	修改日期
 rnx2rtkp.exe	2020/12/29 19:28
 rtkconv.exe	2020/12/29 19:28
 rtkget.exe	2020/12/29 19:28
 rtklaunch.exe	2020/12/29 19:28
 rtklib_gmap.htm	2020/12/29 19:28
 rtknavi.exe	2020/12/29 19:28
 rtkplot.exe	2020/12/29 19:28
 rtkplot_gm.htm	2020/12/29 19:28
 rtkplot_ll.htm	2020/12/29 19:28
 rtkpost.exe	2020/12/29 19:28
 srctblbrows.exe	2020/12/29 19:28



RTKLIB GUIs

The image displays a collection of screenshots for various RTKLIB GUIs, arranged in a grid-like fashion. Each screenshot is labeled with its respective GUI name in large red text.

- RTKPLLOT**: Two screenshots showing network diagrams and a 2D plot of a trajectory.
- RTKNAVI**: A screenshot showing a 3D plot of a trajectory and a table of solution data.
- RTKCONV**: A screenshot showing a list of stations and their coordinates.
- RTKGET**: A screenshot showing a file selection dialog box.
- STRSVR**: A screenshot showing a network diagram and a table of station data.
- NTRIP BROWSER**: A screenshot showing a map interface with a yellow location marker.
- RTKPOST**: A screenshot showing a table of station data and a list of output files.

The screenshots are arranged in a grid-like fashion, with some overlapping. The labels are placed over the corresponding screenshots.

GUI Name	Description
RTKPLLOT	Network diagram and 2D plot of a trajectory.
RTKNAVI	3D plot of a trajectory and solution data table.
RTKCONV	List of stations and their coordinates.
RTKGET	File selection dialog box.
STRSVR	Network diagram and station data table.
NTRIP BROWSER	Map interface with a location marker.
RTKPOST	Station data table and output file list.

RTKLIB Manual

RTKLIB ver. 2.4.2 Manual



April 29, 2013












Contents

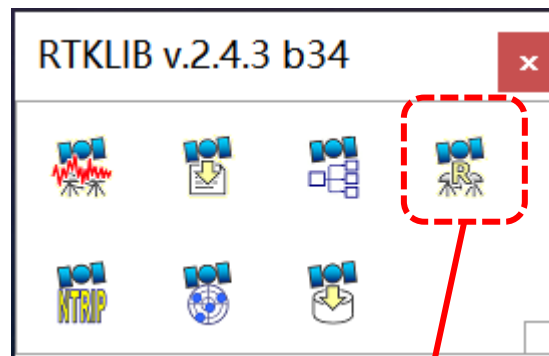
1	Overview	1
2	User Requirements	3
2.1	System Requirements	3
2.2	License	4
3	Instructions	5
3.1	Installation and Uninstallation	5
3.2	Real-Time Positioning with RTKNAVI	7
3.3	Configure Input, Output and Log Streams for RTKNAVI	22
3.4	Post-Processing Analysis with RTKPOST	29
3.5	Configure Positioning Options for RTKNAVI and RTKPOST	34
3.6	Convert Receiver Raw Data to RINEX with RTKCONV	50
3.7	View and Plot Solutions with RTKPLOT	55
3.8	View and Plot Observation Data with RTKPLOT	69
3.9	Download GNSS Products and Data with RTKGET	77
3.10	NTRIP Browser	83
3.11	Use CUI APs of RTKLIB	86
4	Build APs or Develop User APs with RTKLIB	87
4.1	Rebuild GUI and CUI APs on Windows	87
4.2	Build CUI APs	88
4.3	Develop and Link User APs with RTKLIB	89
Appendix A	CUI Command References	90
A.1	RTKRCV	90

• http://www.rtklib.com/prog/manual_2.4.2.pdf

RTKPOST

› E (E:) › Program › RTKLIB-rtklib_2.4.3_b34 › bin

名称	修改日期
 rnx2rtkp.exe	2020/12/29 19:28
 rtkconv.exe	2020/12/29 19:28
 rtkget.exe	2020/12/29 19:28
 rtklaunch.exe	2020/12/29 19:28
 rtklib_gmap.htm	2020/12/29 19:28
 rtknavi.exe	2020/12/29 19:28
 rtkplot.exe	2020/12/29 19:28
 rtkplot_gm.htm	2020/12/29 19:28
 rtkplot_ll.htm	2020/12/29 19:28
 rtkpost.exe	2020/12/29 19:28
 srctblbrows.exe	2020/12/29 19:28



RTKPOST

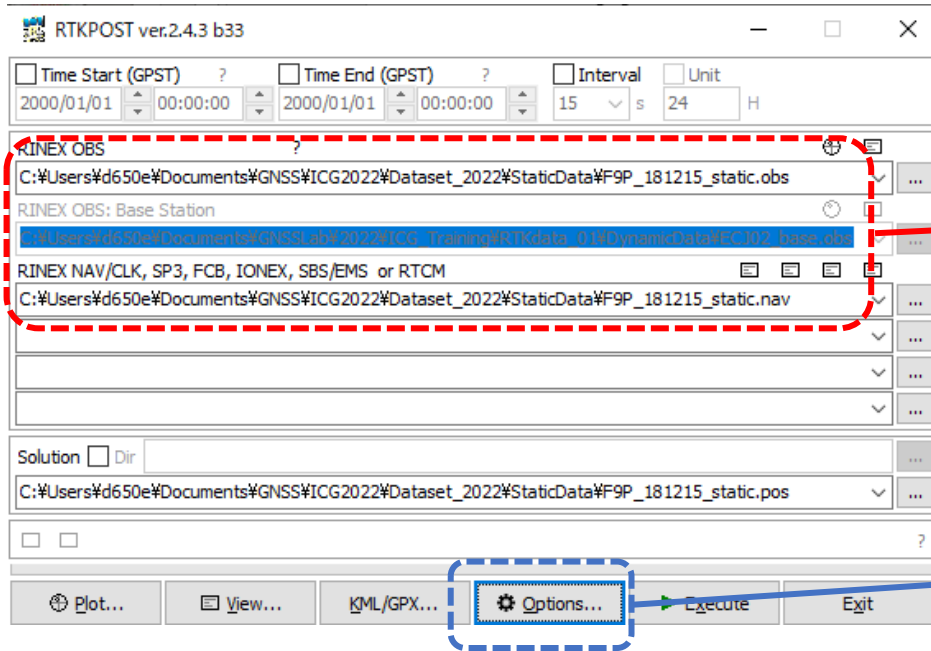
Data preparation

Make sure that you have the following data:

名前	更新日時	種類	サイズ
PPP_correction	2022/01/07 11:41	ファイル フォルダー	
BaseStationPosition.txt	2022/01/07 11:32	Text Document	1 KB
F9P_181215_static.nav	2022/01/07 11:18	NAV ファイル	128 KB
F9P_181215_static.obs	2022/01/07 11:18	OBS ファイル	63,921 KB
F9P_181215_static.ubx	2020/01/07 12:53	u-blox Log File	55,461 KB
F9P_181215_static_PPP_sample.pos	2020/10/29 14:14	POS ファイル	1,703 KB
F9P_181215_static_RTK.pos_sample	2022/01/07 11:39	POS_SAMPLE ファ...	1,595 KB
NetR9_181215_static.binex	2020/01/07 12:55	BINEX ファイル	61,899 KB
NetR9_181215_static.nav	2022/01/07 11:18	NAV ファイル	377 KB
NetR9_181215_static.obs	2022/01/07 11:18	OBS ファイル	334,257 KB
PPP.conf	2020/10/29 14:16	CONF ファイル	6 KB

1. SPP Processing

Single Point Positioning is most basically positioning.
Only .obs data and .nav data of Rover is required.



Input files:

- Obs. file
- Navigation file

We need to change some settings for SPP mode

1. SPP Processing

Option settings

Options

Setting1 Setting2 Output Statistics Positions Files Misc

Positioning Mode: Single

Frequencies / Filter Type: L1+L2 Forward

Elevation Mask (°) / SNR Mask (dBHz): 15 ...

Rec Dynamics / Earth Tides Correction: OFF OFF

Ionosphere Correction: Broadcast

Troposphere Correction: Saastamoinen

Satellite Ephemeris/Clock: Broadcast

Sat PCV Rec PCV PhWU Rej Ed RAIM FDE DBCorr

Excluded Satellites (+PRN: Included):

GPS GLO Galileo QZSS SBAS BeiDou IRNSS

Load... Save... OK Cancel

Constellations to use

Options

Setting1 Setting2 Output Statistics Positions Files Misc

Solution Format: Lat/Lon/Height

Output Header / Output Processing Options: ON ON

Time Format / # of Decimals: ww ssss GPST 2

Latitude Longitude Format / Field Separator: ddd.dddddd ,

Output Single if Sol Outage / Max Sol Std (m): ON 0

Datum / Height: WGS84 Ellipsoidal

Geoid Model: Internal

Solution for Static Mode: All

NMEA Interval (s) RMC/GGA, GSA/GSV: 0 0

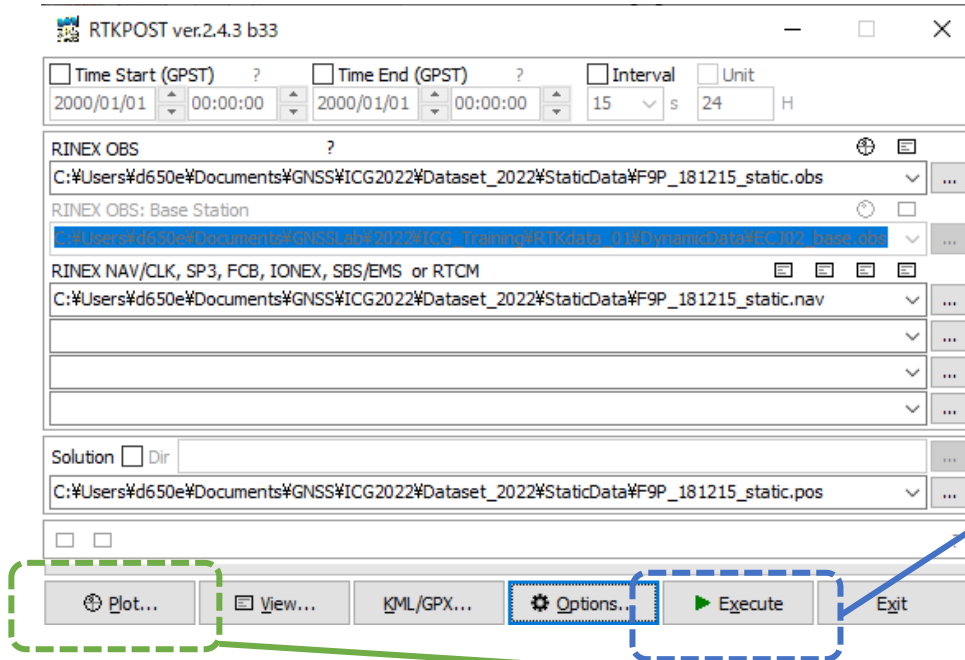
Output Solution Status / Output Debug Trace: OFF OFF

Load... Save... OK Cancel

Setting of output .pos file

1. SPP Processing

Execute and plot result

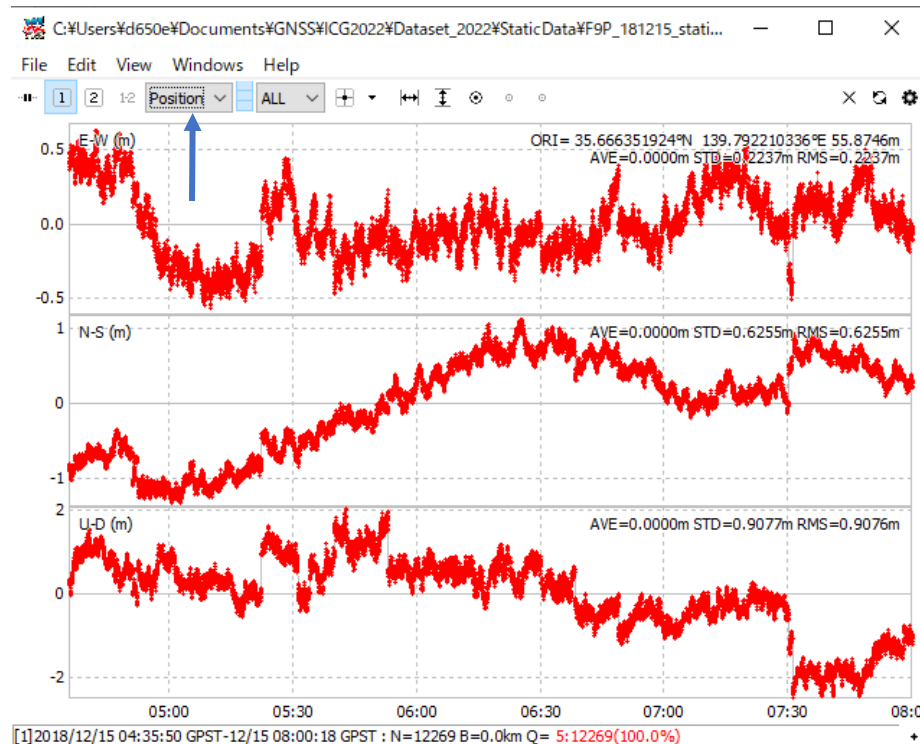
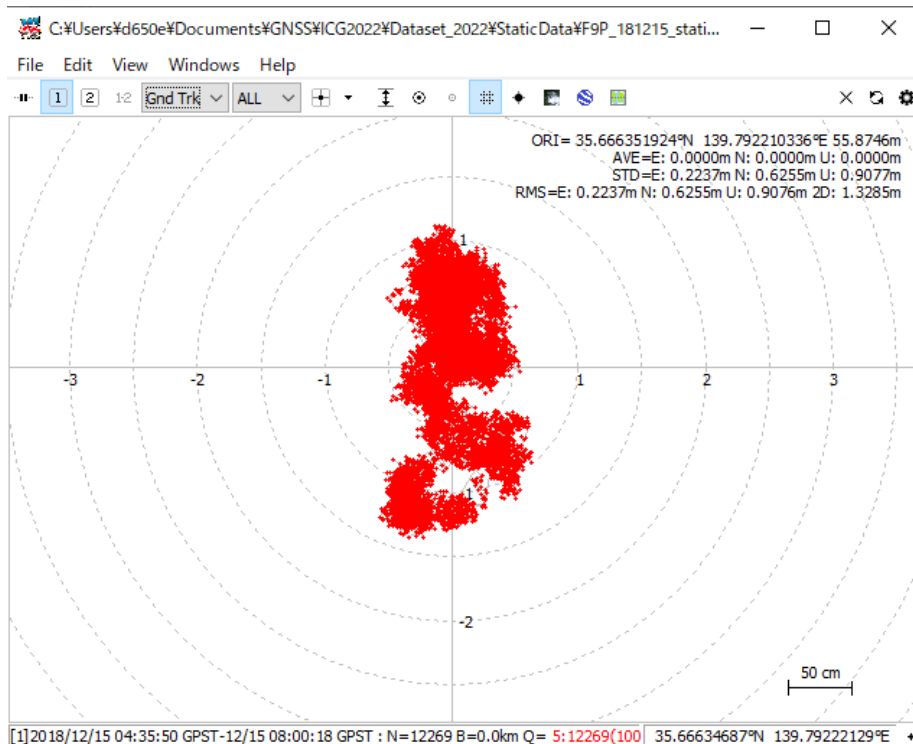


If settings are finished,
execute!

Then Plot...

1. SPP Processing

Result plotting



2. RTK processing using static data

RTKPOST ver.2.4.3 b34

Time Start (GPST) ? Time End (GPST) ? Interval Unit

2000/01/01 00:00:00 2000/01/01 00:00:00 0 s 24 H

RINEX OBS ?

KINEX OBS: Base Station

RINEX NAV/CLK, SP3, FCB, IONEX, SBS/EMS or RTCM

Solution Dir

?

Default processing mode of RTKLIB is SPP, we need to change it to RTK from here:

Options

Setting1 Setting2 Output Statistics Positions Files Misc

Positioning Mode **Kinematic**

Frequencies / Filter Type ?

Elevation Mask (°) / SNR Mask (dBHz)

Rec Dynamics / Earth Tides Correction

Ionosphere Correction

Troposphere Correction

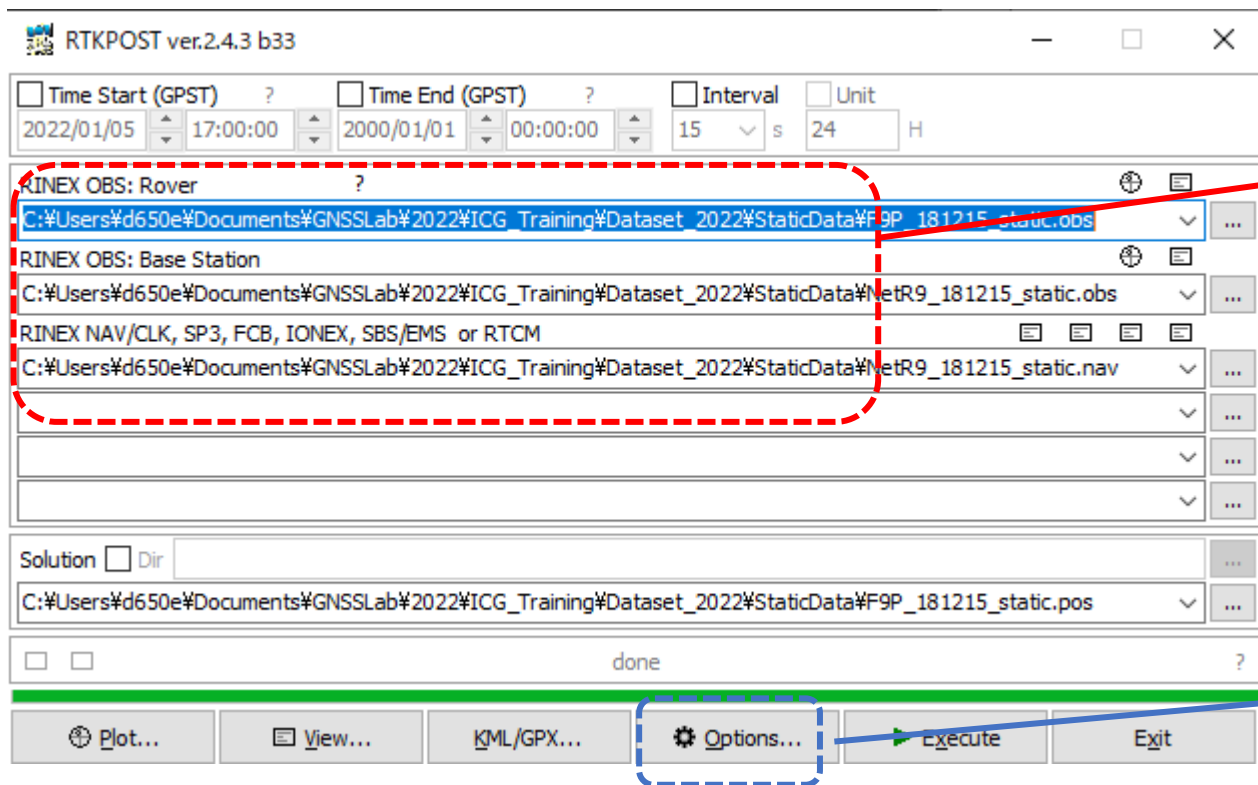
Satellite Ephemeris/Clock

Sat PCV Rec PCV PhWU Rej Ecl RAIM FDE DBCorr

Excluded Satellites (+PRN: Included)

GPS GLONASS Galileo QZSS BDS NavIC SBAS

Settings of RTK



Input files:

- Obs. file of rover
- Obs. file of base station
- Navigation file

We need to change some settings for RTK mode

Settings of RTK

Options

Setting1 Setting2 Output Statistics Positions Files Misc

Positioning Mode: Kinematic

Frequencies / Filter Type: L1+2 Forward

Elevation Mask (°) / SNR Mask (dBHz): 15

Rec Dynamics / Earth Tides Correction: OFF OFF

Ionosphere Correction: Broadcast

Troposphere Correction: Saastamoinen

Satellite Ephemeris/Clock: Broadcast

Sat PCV Rec PCV PhWU Rej Ecl RAIM FDE DBCorr

Excluded Satellites (+PRN: Included):

GPS GLONASS Galileo QZSS BDS NavIC SBAS

Load... Save... OK Cancel

Options

Setting1 Setting2 Output Statistics Positions Files Misc

Integer Ambiguity Res (GPS/GLO/BDS): Continui ON ON

Min Ratio to Fix Ambiguity: 3

Min Confidence / Max FCB to Fix Amb: 0.9999 0.25

Min Lock / Elevation (°) to Fix Amb: 0 0

Min Fix / Elevation (°) to Hold Amb: 10 0

Outage to Reset Amb/Slip Thres (m): 5 0.050

Max Age of Diff (s) / Sync Solution: 30.0 ON

Reject Threshold of GDOP/Innov (m): 30.0 30.0

Max # of AR Iter/# of Filter Iter: 1 1

Baseline Length Constraint (m): 0.000 0.000

Load... Save... OK Cancel

Options

Setting1 Setting2 Output Statistics Positions Files Misc

Measurement Errors (1-sigma)

Code/Carrier-Phase Error Ratio L1/L2: 100.0 100.0

Carrier-Phase Error a+b/sinE1 (m): 0.003 0.003

Carrier-Phase Error/Baseline (m/10km): 0.000

Doppler Frequency (Hz): 10.000

Process Noises (1-sigma/sqrt(s))

Receiver Accel Horiz/Vertical (m/s²): 1.00E+01 1.00E+01

Carrier-Phase Bias (cycle): 1.00E-04

Vertical Ionospheric Delay (m/10km): 1.00E-03

Zenith Tropospheric Delay (m): 1.00E-04

Satellite Clock Stability (s/s): 5.00E-12

Load... Save... OK Cancel

Options

Setting1 Setting2 Output Statistics Positions Files Misc

Rover

Lat/Lon/Height (deg/m): 90.000000000 0.000000000 -6335367.6285

Antenna Type (*: Auto) Delta-E/N/J (m): 0.0000 0.0000 0.0000

Base Station

Lat/Lon/Height (deg/m): 35.666342070 139.792210860 59.7710

Antenna Type (*: Auto) Delta-E/N/J (m): 0.0000 0.0000 0.0000

Station Position File

Load... Save... OK Cancel

Main settings of RTK
(For the detailed meaning
of each option, please
refer to the user manual).

Settings of RTK

RTKPOST ver.2.4.3 b33

Time Start (GPST) ? Time End (GPST) ? Interval Unit
2022/01/05 17:00:00 2000/01/01 00:00:00 15 s 24 H

RINEX OBS: Rover ?

C:\Users\d650e\Documents\GNSSLab\2022\ICG_Training\Dataset_2022\StaticData\F9P_181215_static.obs

RINEX OBS: Base Station

C:\Users\d650e\Documents\GNSSLab\2022\ICG_Training\Dataset_2022\StaticData\NetR9_181215_static.obs

RINEX NAV/CLK, SP3, FCB, IONEX, SBS/EMS or RTCM

C:\Users\d650e\Documents\GNSSLab\2022\ICG_Training\Dataset_2022\StaticData\NetR9_181215_static.nav

Solution Dir

C:\Users\d650e\Documents\GNSSLab\2022\ICG_Training\Dataset_2022\StaticData\F9P_181215_static.pos

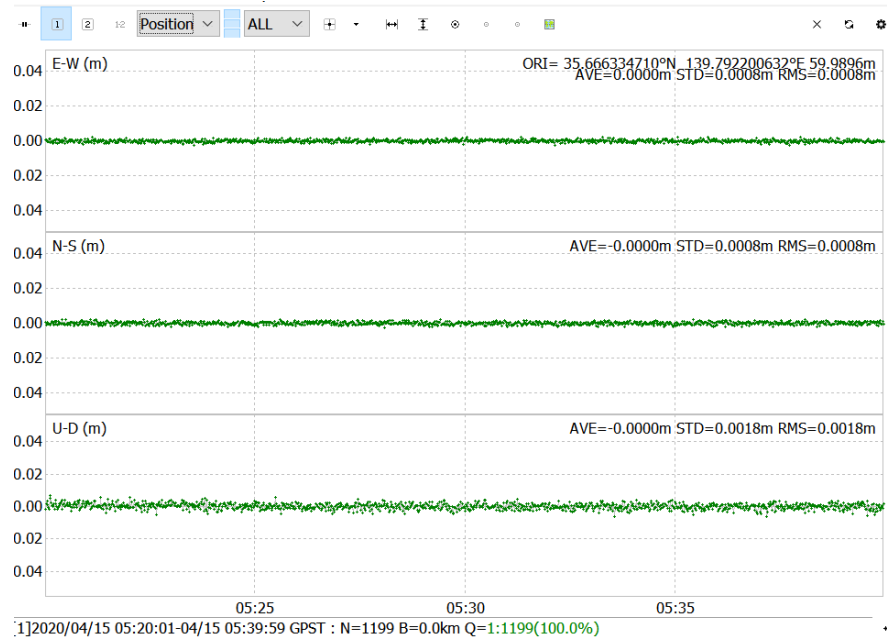
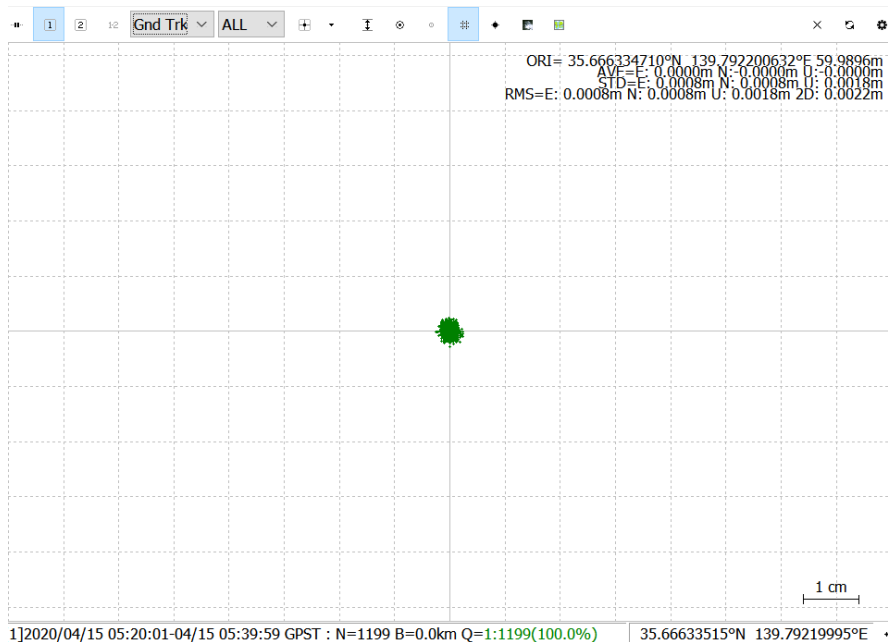
done

Plot... View... KML/GPX... Options... Execute Exit

If settings are finished,
execute!

Then Plot...

RTK result in RTKPLOTT



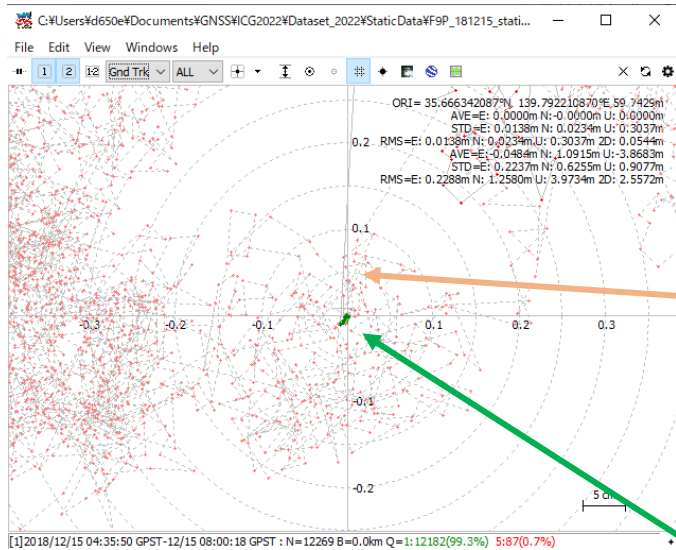
Comparison of SPP and RTK

Select plot filed “2” and drag and drop SPP .pos file.

The screenshot shows a software window titled "C:\Users\d650e\Documents\GNSS\ICG2022\Dataset_2022\StaticData\F9P_181215_stati...". The window contains a plot area with three y-axes: "E-W (m)", "N-S (m)", and "U-D (m)". The x-axis represents time, ranging from 05:00 to 08:00. The plot area is currently empty. To the right of the plot is a file explorer showing a list of files. The file "F9P_181215_static_SPP_sample.pos" is selected and highlighted in blue. A blue arrow points from the selected file to the plot window.

File Name	Timestamp
F9P_181215_static_RTK.pos_sample	2022/01/07 11:39
<input checked="" type="checkbox"/> F9P_181215_static_SPP_sample.pos	2022/01/08 17:09
NetR9_181215_static.binex	2020/01/07 12:55

Comparison of SPP and RTK



SPP



RTK

3. PPP with static data

The screenshot shows the RTKPOST software interface with the following settings:

- Time Start (GPST): 2022/01/05 17:00:00
- Time End (GPST): 2000/01/01 00:00:00
- Interval: 15 s
- Unit: 24 H
- RINEX OBS: C:\Users\d650e\Documents\GNSSLab\2022\ICG_Training\Dataset_2022\StaticData\F9P_181215_static.obs
- RINEX OBS: Base Station: C:\Users\d650e\Documents\GNSSLab\2022\ICG_Training\Dataset_2022\DynamicData\ECJ02_base.obs
- RINEX NAV/CLK, SP3, FCB, IONEX, SBS/EMS or RTCM: C:\Users\d650e\Documents\GNSSLab\2022\ICG_Training\Dataset_2022\StaticData\PPP_correction\gbm20316.sp3 and C:\Users\d650e\Documents\GNSSLab\2022\ICG_Training\Dataset_2022\StaticData\PPP_correction\gbm20316.clk
- Solution Dir: C:\Users\d650e\Documents\GNSSLab\2022\ICG_Training\Dataset_2022\StaticData\F9P_181215_static.pos

The status bar shows "done" and the "Options..." button is highlighted.

Change the data of the nav to .sp3 & .clk

3. PPP with static data

Options

Setting1 Setting2 Output Statistics Positions Files Misc

Positioning Mode: PPP Kinematic

Frequencies / Filter Type: L1+L2+L5 Forward

Elevation Mask (°) / SNR Mask (dBHz): 15 ...

Rec Dynamics / Earth Tides Correction: OFF OFF

Ionosphere Correction: Iono-Free LC

Troposphere Correction: Estimate ZTD

Satellite Ephemeris/Clock: Precise

Sat PCV Rec PCV PhWU Rej Ed RAIM FDE DBCorr

Excluded Satellites (+PRN: Included):

GPS GLO Galileo QZSS SBAS BeiDou IRNSS

Load... Save... OK Cancel

Options

Setting1 Setting2 Output Statistics Positions Files Misc

Integer Ambiguity Res (GPS/GLO/BDS): Continu OFF ON

Min Ratio to Fix Ambiguity: 3

Min Confidence / Max FCB to Fix Amb: 0.9999 0.25

Min Lock / Elevation (°) to Fix Amb: 10 15

Min Fix / Elevation (°) to Hold Amb: 10 0

Outage to Reset Amb/Slip Thres (m): 10 0.050

Max Age of Diff (s) / Sync Solution: 30.0 ON

Reject Threshold of GDOP/Innov (m): 30.0 30.0

Max # of AR Iter/# of Filter Iter: 1 1

Baseline Length Constraint (m): 0.000 0.000

Load... Save... OK Cancel

Options

Setting1 Setting2 Output Statistics Positions Files Misc

Measurement Errors (1-sigma)

Code/Carrier-Phase Error Ratio L1/L2	300.0	300.0
Carrier-Phase Error a+b/sinE (m)	0.003	0.003
Carrier-Phase Error/Baseline (m/10km)	0.000	
Doppler Frequency (Hz)	10.000	

Process Noises (1-sigma/sqrt(s))

Receiver Accel Horiz/Vertical (m/s ²)	1.00E+01	1.00E+01
Carrier-Phase Bias (cycle)	1.00E-04	
Vertical Ionospheric Delay (m/10km)	1.00E-03	
Zenith Tropospheric Delay (m)	1.00E-04	
Satellite Clock Stability (s/s)	5.00E-12	

Load... Save... OK Cancel

Options

Setting1 Setting2 Output Statistics Positions Files Misc

Satellite/Receiver Antenna PCV File ANTEX/NGS PCV

C:\Users\d650e\Documents\GNSSLab\2022\ICG_Training\Dataset_2022\S

Geoid Data File

DCB Data File

C:\Users\d650e\Documents\GNSSLab\2022\ICG_Training\Dataset_2022\S

EOP Data File

OTL BLQ File

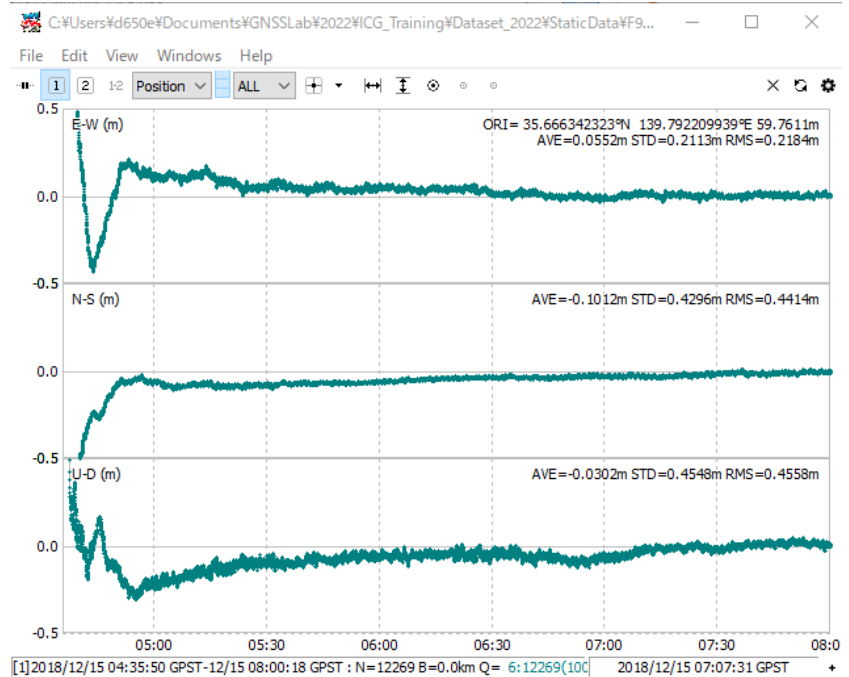
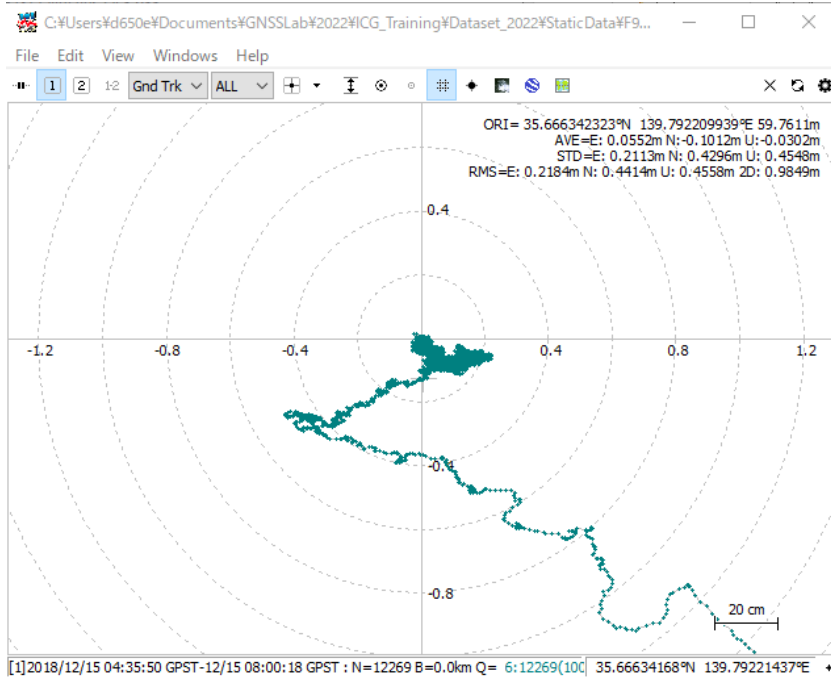
Ionosphere Data File

Load... Save... OK Cancel

PPP_correction\igs14.atx

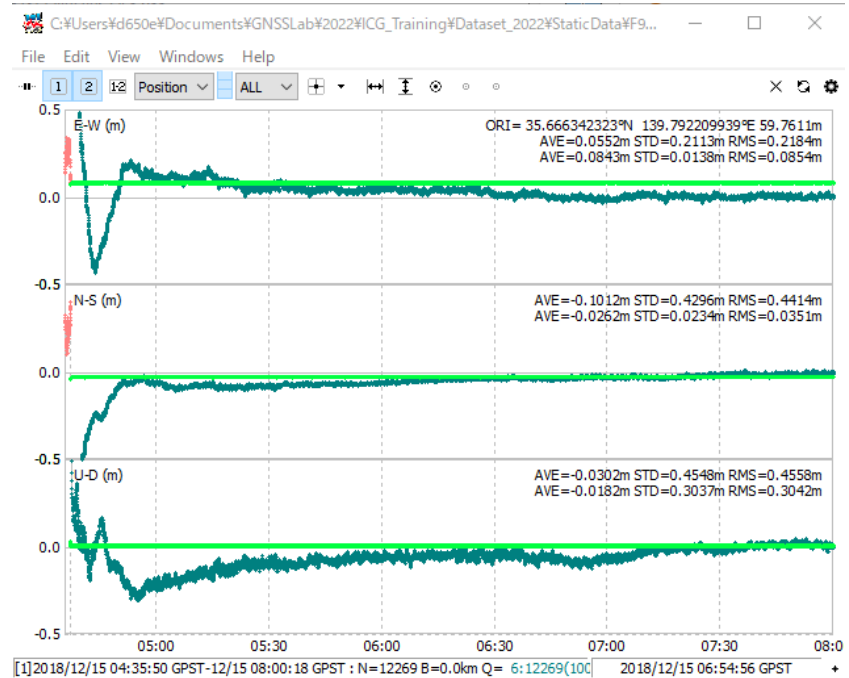
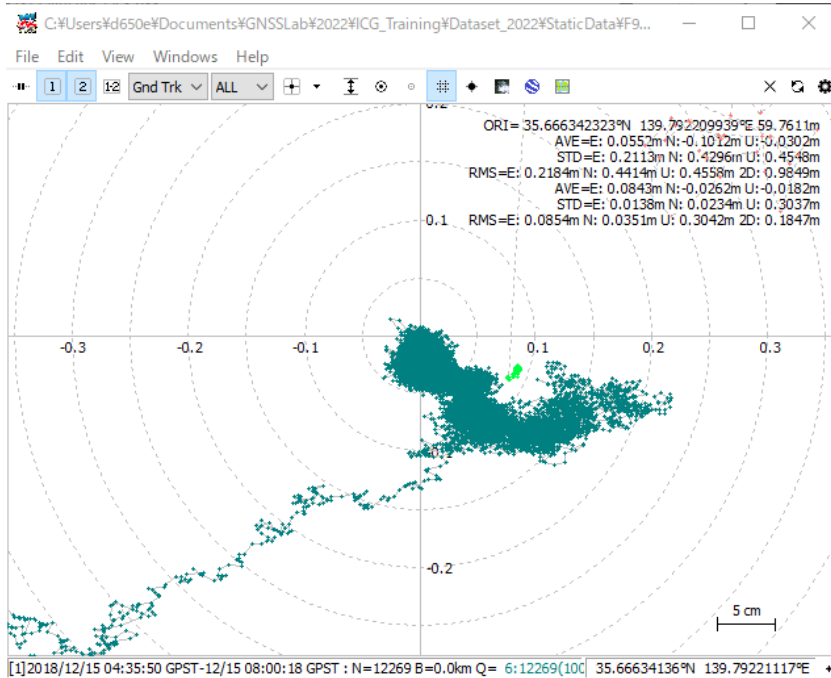
PPP_correction\P1C1_ALL.DCB

3. PPP with static data

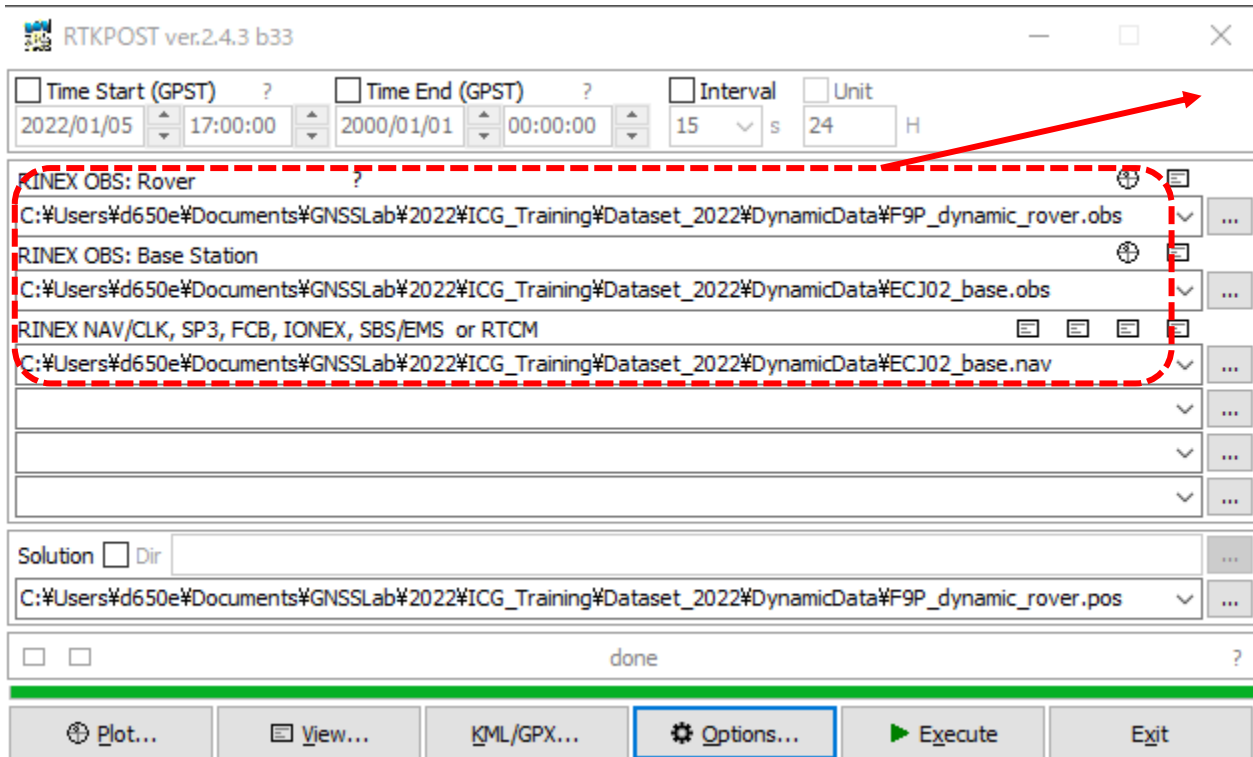


3. PPP with static data

Comparison with RTK

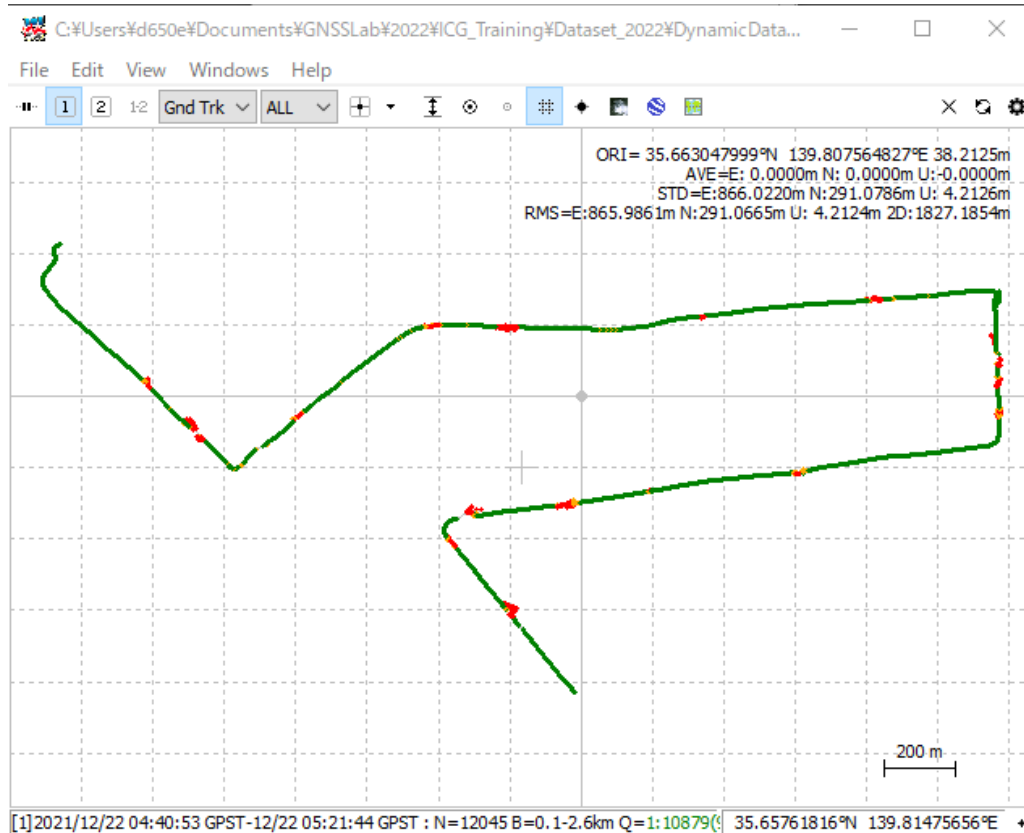


4. If we use kinematic data



Change the data of the
rover obs
base obs
base nav

RTK result of the kinematic data



3 Other settings

- How about the low-cost receiver data?
- If we choose different GNSS systems...
- If we change elevation mask...
- If we change code-phase ratio...
- If we change min ratio...
- If we...

Try it by yourself!

Conclusions:

- RTK performance for static data is much better than kinematic data
- It is recommended to use instantaneous mode for kinematic data
- ...

What other results and conclusions can you get?

Other software

Since RTKLIB does not performs the best for kinematic data, here are some other software.

If you have extra time, you can try one of them.

- **RTK explorer:** <http://rtkexplorer.com/>
- **RTKLIB_p01:** https://github.com/YizeZhang/RTKLIB_modify
- **Net_Diff :** https://github.com/YizeZhang/Net_Diff
- RTKDROID :

Thank you!