

# **Introduction to RTK Data Processing**

## **How to get centimeter level accuracy?**

### **Part - 2**

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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

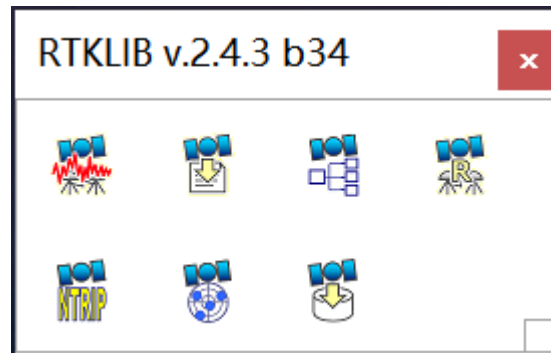
```
rtklib_<ver>
./src          source programs of RTKLIB library *
./rcv         source programs depending on GPS/GNSS receivers *
./bin         executable binary APs and DLLs for Windows
./data        sample data for APs
./app         build environment of APs *
  ./rtknavi   RTKNAVI      (GUI) *
  ./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**: Shows a network diagram of stations with colored lines representing connections and a data table on the right.
- RTKNAVI**: Displays a solution summary for a GPS station, including coordinates (N: 35° 43' 08.2300", E: 138° 27' 02.1531", H: 367.442 m) and a bar chart showing signal strength over time.
- RTKCONV**: Shows a window for converting data, with a list of stations and their corresponding output files.
- RTKGET**: Displays a window for downloading data from a server, showing the URL and file list.
- STRSVR**: Shows a window for a TCP server, with a list of connections and data transfer statistics.
- NTRIP BROWSER**: Shows a window for browsing NTRIP streams, with a list of stations and their coordinates.
- RTKPOST**: Shows a window for post-processing data, with a list of stations and their corresponding output files.

Each screenshot also includes a small 'About' dialog box with the RTKLIB logo and copyright information (Copyright (C) 2007-2013 by T. Takasu, All rights reserved.).

# RTKLIB Manual

RTKLIB ver. 2.4.2 Manual



April 29, 2013












## Contents

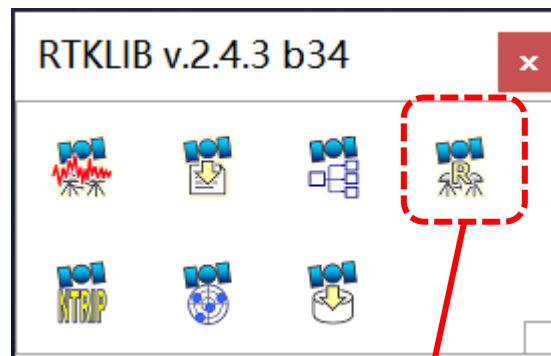
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• [http://www.rtklib.com/prog/manual\\_2.4.2.pdf](http://www.rtklib.com/prog/manual_2.4.2.pdf)

# 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



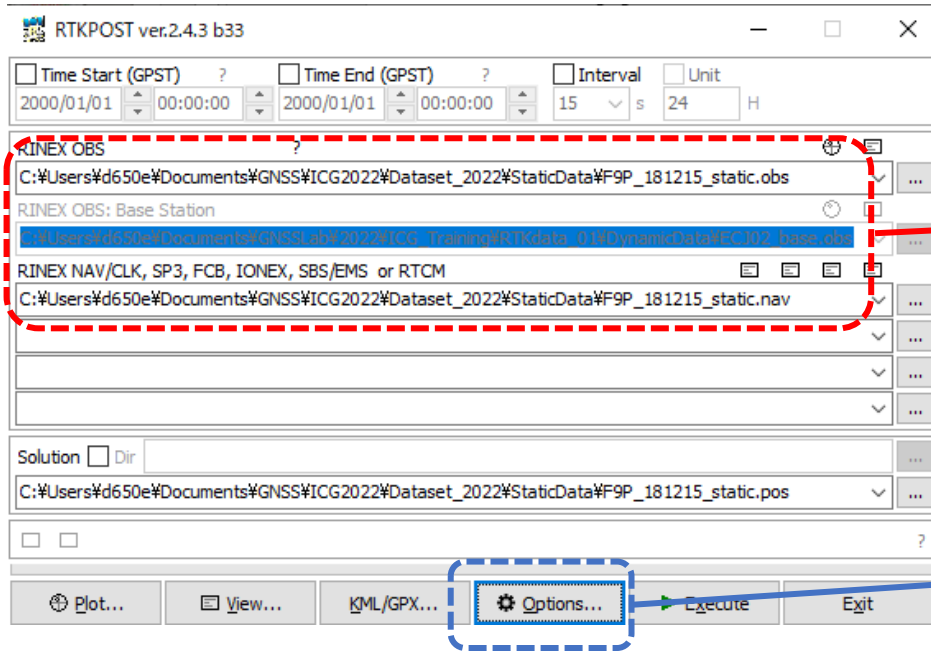
# Data preparation

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

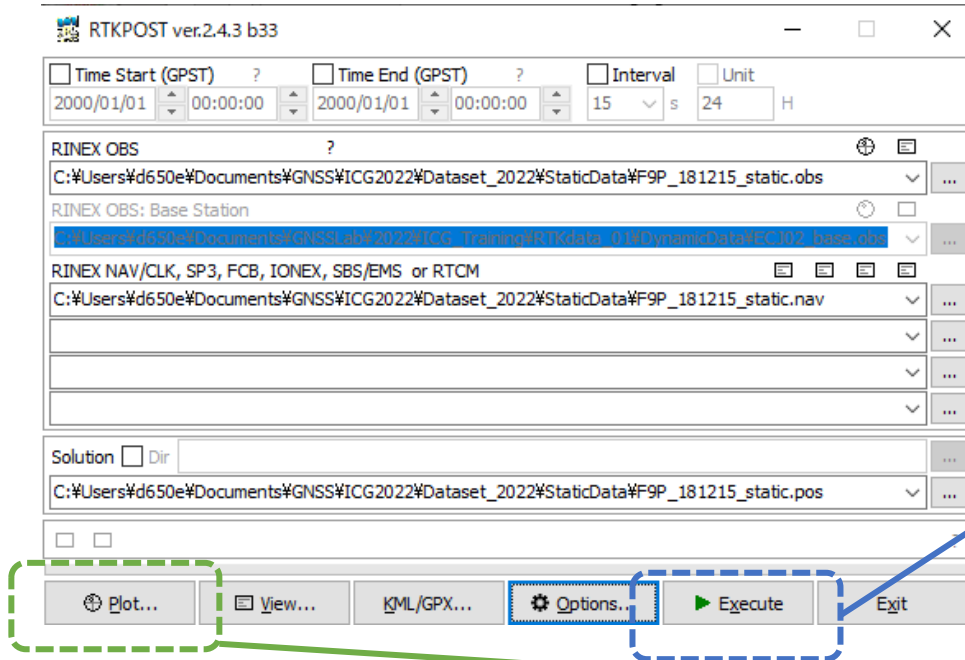
Output Solution Status / Output Debug Trace: OFF OFF

Load... Save... OK Cancel

Setting of output .pos file

# 1. SPP Processing

## Execute and plot result



If settings are finished,  
execute!

Then Plot...



## 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

The screenshot shows the RTKPOST ver.2.4.3 b33 interface. At the top, there are fields for Time Start (GPST) (2022/01/05 17:00:00), Time End (GPST) (2000/01/01 00:00:00), Interval (15 s), and Unit (24 H). Below this, there are sections for RINEX OBS: Rover, RINEX OBS: Base Station, and RINEX NAV/CLK, SP3, FCB, IONEX, SBS/EMS or RTCM. The Rover section is highlighted with a red dashed box and contains the file path: C:\Users\d650e\Documents\GNSSLab\2022\ICG\_Training\Dataset\_2022\StaticData\F9P\_181215\_static.obs. The Base Station section contains the file path: C:\Users\d650e\Documents\GNSSLab\2022\ICG\_Training\Dataset\_2022\StaticData\NetR9\_181215\_static.obs. The NAV/CLK section contains the file path: C:\Users\d650e\Documents\GNSSLab\2022\ICG\_Training\Dataset\_2022\StaticData\NetR9\_181215\_static.nav. Below these sections, there is a Solution Dir field with the file path: C:\Users\d650e\Documents\GNSSLab\2022\ICG\_Training\Dataset\_2022\StaticData\F9P\_181215\_static.pos. At the bottom, there is a status bar with the text 'done' and a question mark. The bottom toolbar contains buttons for Plot..., View..., KML/GPX..., Options..., Execute, and Exit. The Options button is highlighted with a blue dashed box.

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): Continu 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/s<sup>2</sup>): 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

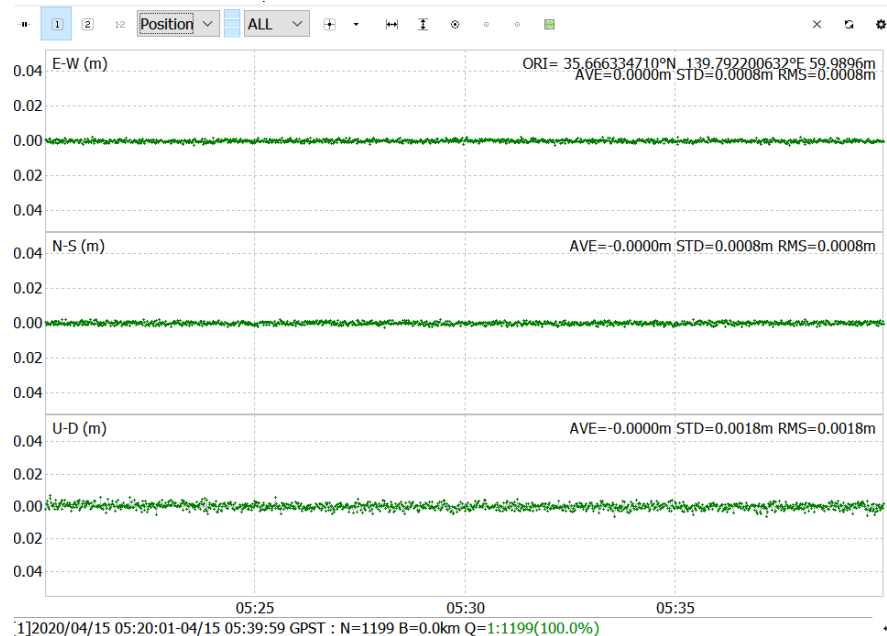
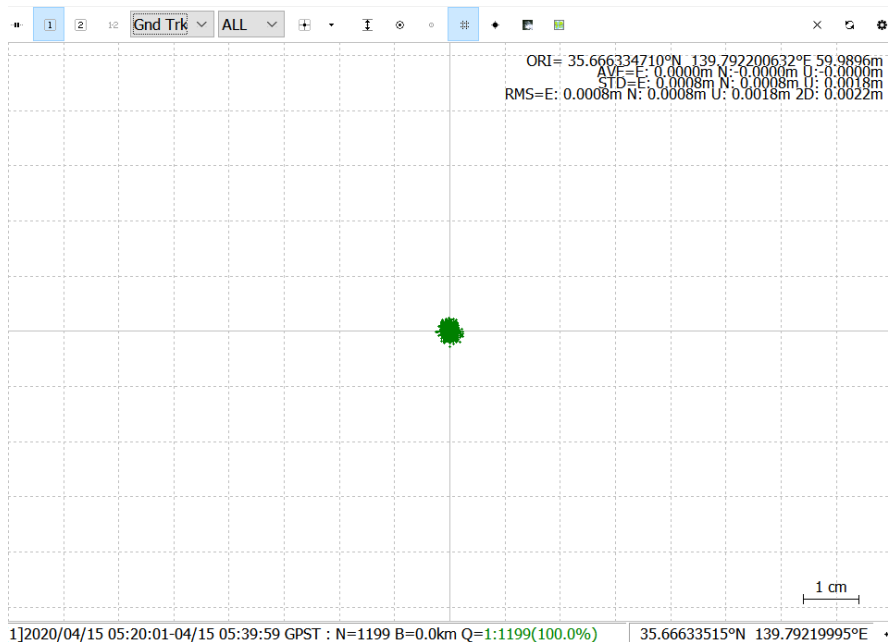
done

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

If settings are finished,  
execute!

Then Plot...

# RTK result in RTKPLOTT



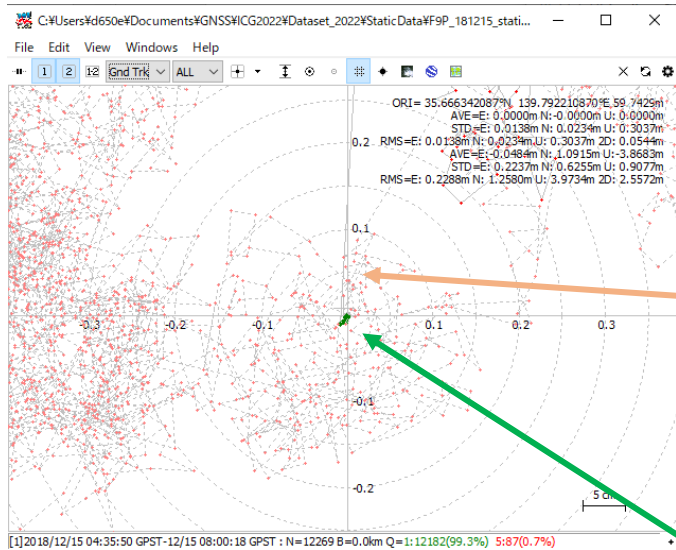
# Comparison of SPP and RTK

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
- RINEX NAV/CLK, SP3, FCB, IONEX, SBS/EMS or RTCM: 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 <sup>2</sup> )	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

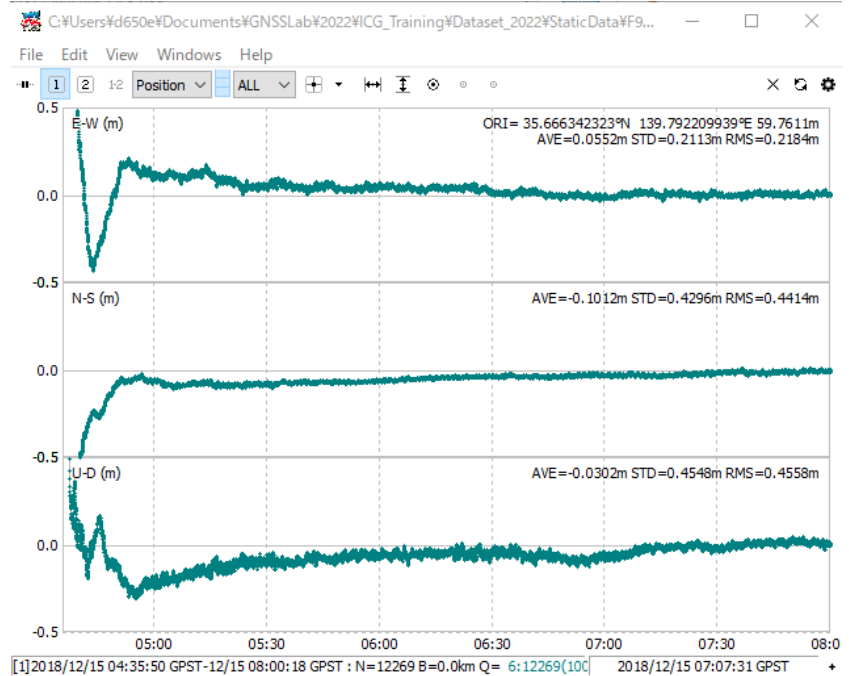
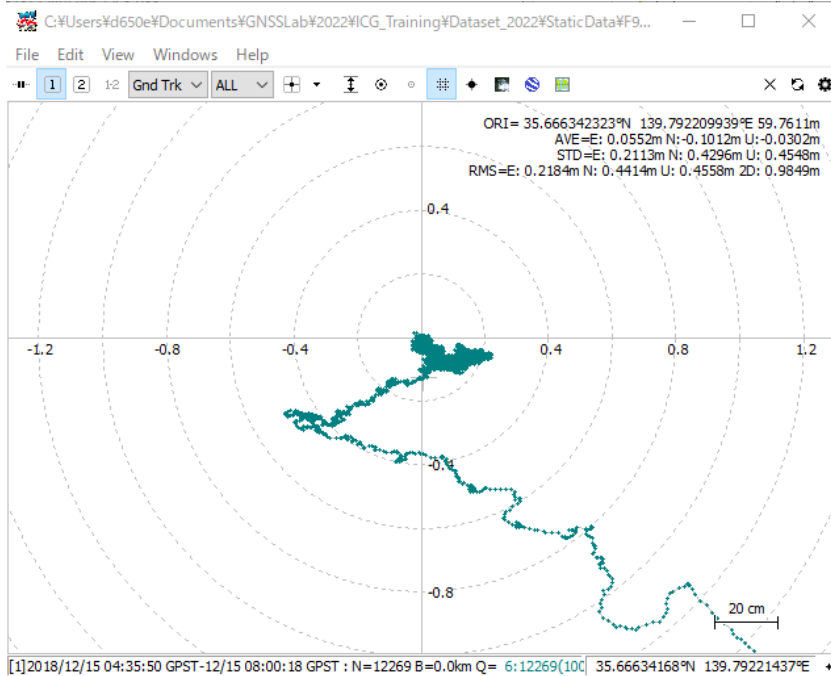
Ionosphere Data File

Load... Save... OK Cancel

PPP\_correction\igs14.atx

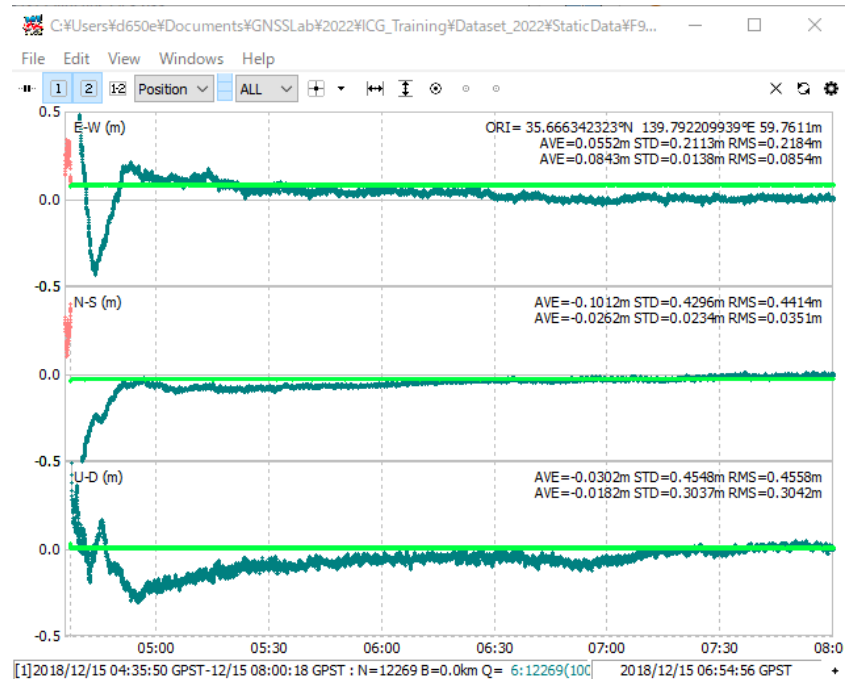
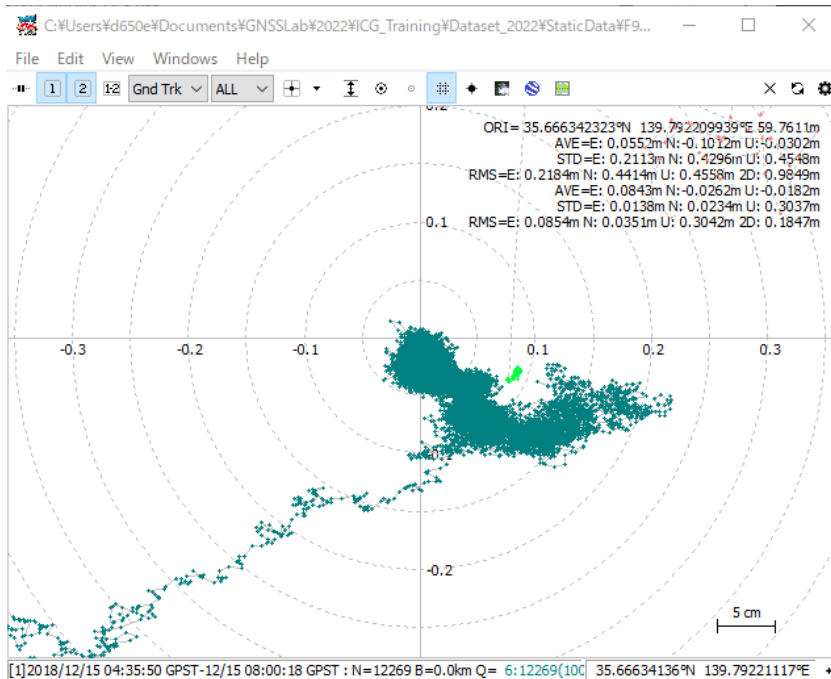
PPP\_correction\P1C1\_ALL.DCB

# 3. PPP with static data



# 3. PPP with static data

## Comparison with RTK





# 4. If we use kinematic data

The screenshot shows the RTKPOST software interface (version 2.4.3 b33) with the following configuration:

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

The data source list is as follows:

- RINEX OBS: Rover**  
C:\Users\d650e\Documents\GNSSLab\2022\ICG\_Training\Dataset\_2022\DynamicData\F9P\_dynamic\_rover.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\DynamicData\ECJ02\_base.nav

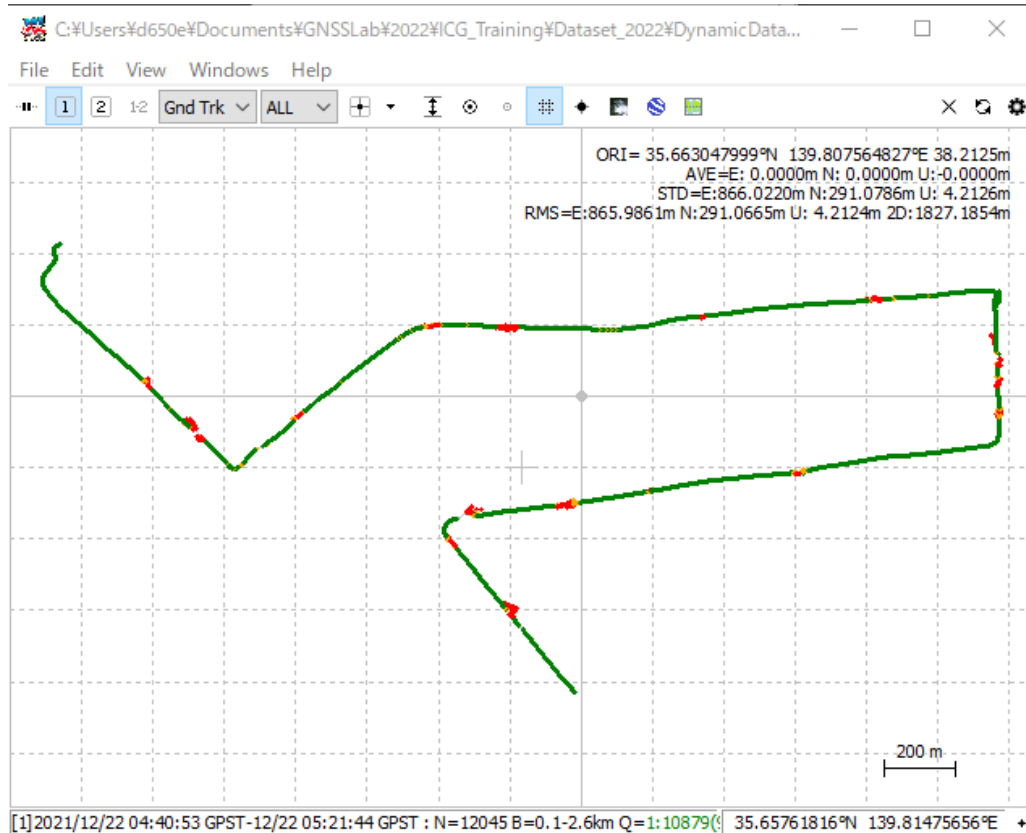
The Solution directory is set to: C:\Users\d650e\Documents\GNSSLab\2022\ICG\_Training\Dataset\_2022\DynamicData\F9P\_dynamic\_rover.pos

The status bar shows "done".

Buttons at the bottom: Plot..., View..., KML/GPX..., Options..., Execute, Exit.

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](https://github.com/YizeZhang/RTKLIB_modify)
- **Net\_Diff :** [https://github.com/YizeZhang/Net\\_Diff](https://github.com/YizeZhang/Net_Diff)
- RTKDROID :

*Thank you!*