

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

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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

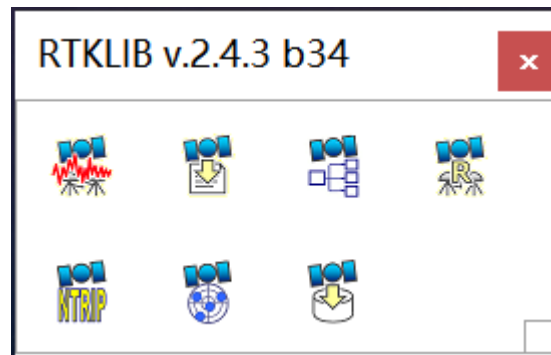
```
rtklib_<ver>
./src          source programs of RTKLIB library *
./rcv         source programs depending on GPS/GNSS receivers *
./bin         executable binary APs and DLLs for Windows
./data        sample data for APs
./app         build environment of APs *
  ./rtknavi   RTKNAVI      (GUI) *
  ./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 with coordinates (N: 35° 43' 08.2300", E: 138° 27' 02.1531", H: 367.442 m) and a bar chart.
- RTKCONV**: Shows a window for converting data, with a 'Convert' button.
- RTKGET**: Displays a file selection dialog for downloading data from a server.
- STRSVR**: Shows a window for setting up a TCP server for data streaming.
- NTRIP BROWSER**: Shows a map interface with a yellow line indicating a route.
- RTKPOST**: Shows a window for configuring data output, including file names and formats.

At the bottom right, there is a vertical stack of 'About' dialog boxes for each GUI, providing version information and copyright details (© 2007-2013 by T. Takasu).

RTKLIB Manual

RTKLIB ver. 2.4.2 Manual



April 29, 2013












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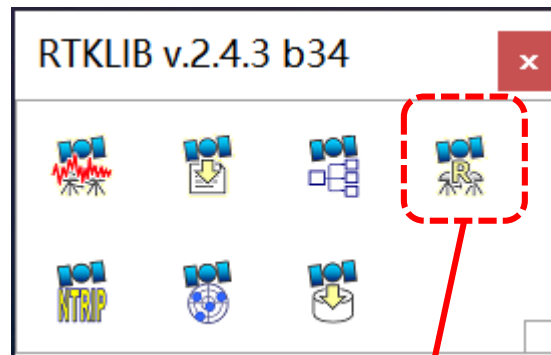
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• http://www.rtklib.com/prog/manual_2.4.2.pdf

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:

port (G:) > data > 2021_GNSSTraining_DataSet > RTKdata

搜索"RTKdata"

名称	修改日期	类型	大小
 base coordinate.txt	2021/1/14 21:29	TXT 文件	1 KB
 base.nav	2020/4/15 19:22	NAV 文件	85 KB
 base_NetR9.20o	2021/1/14 21:41	20O 文件	11,825 KB
 base_ubx.obs	2021/1/14 21:42	OBS 文件	6,175 KB
 rover_NetR9.20o	2021/1/14 21:41	20O 文件	42,491 KB
 rover_ubx.obs	2021/1/14 21:42	OBS 文件	25,019 KB

Data information:

■ Base station(Static):

- High-end receiver → [base_NetR9.20o](#)
- Low cost receiver → [base_ubx.obs](#)

■ Rover station(Kinematic):

- High-end receiver → [rover_NetR9.20o](#)
- Low cost receiver → [rover_ubx.obs](#)

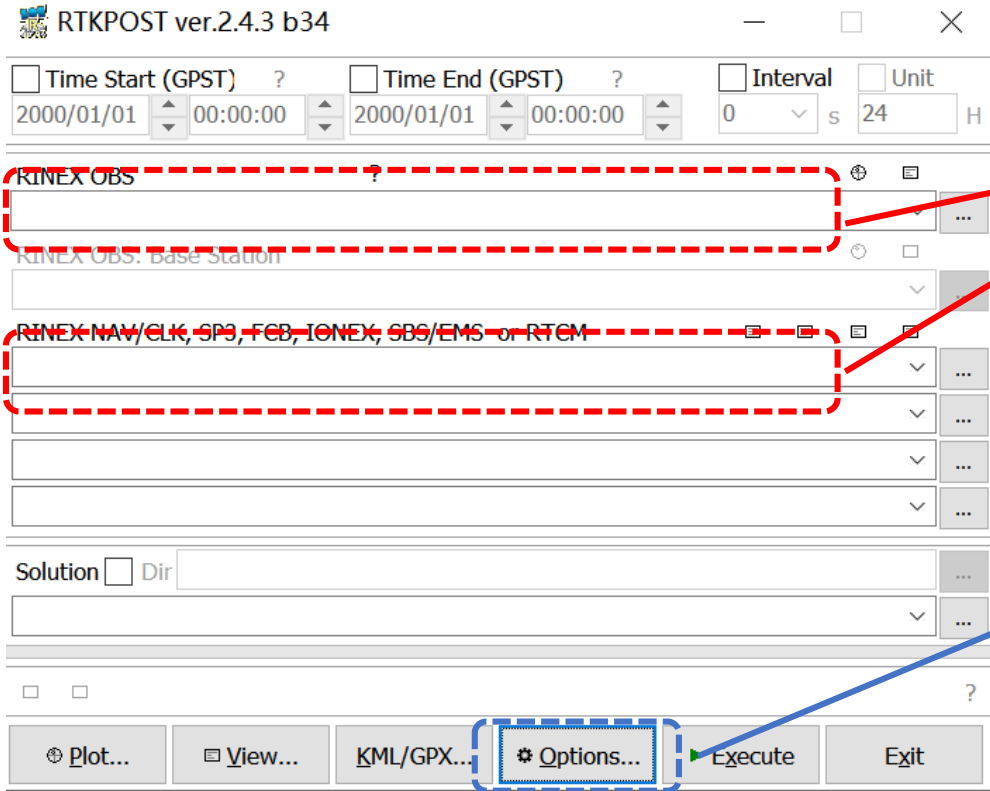
With this data, we will...

- 1 SPP

- 2 DGNS

- 3 RTK

1.1 SPP processing using static data



The default processing mode of RTKLIB is SPP, all we need to do is to drag files here:

You can change some settings from the options

Settings of SPP

Options

Setting1 Setting2 Output Statistics Positions Files Misc

Positioning Mode: Single

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

Solution Format: Lat/Lon/Height

Output Header / Proc. Options / Velocity: ON ON OFF

Time Format / # of Decimals: hh:mm:ss GPST 3

Latitude Longitude Format / Field Separator: ddd.dddddd

Output Single if Sol Outage / Max Sol Std (m): OFF 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 / Debug Trace: OFF OFF

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/sinEl (m): 0.003 0.003

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

Doppler Frequency (Hz): 1.000

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

Leave most options as default is OK. You can also change some of them as you want.

SPP result in RTKPLOTT

Discover the function of this function by yourself



RMS is several meters

1.2 Your task

- How about the low-cost receiver data?
- How about the kinematic data?
- If we choose different GNSS systems...
- If we change elevation mask...

Try it by yourself!

2.1 DGNSS 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 ?

RINEX OBS: Base Station

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

Solution Dir

?

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

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

Options

Setting1 Setting2 Output Statistics Positions Files Misc

Positioning Mode DGPS/DGNSS

Frequencies / Filter Type ? Single

Elevation Mask (°) / SNR Mask (dBHz) DGPS/DGNSS

Rec Dynamics / Earth Tides Correction Kinematic

Ionosphere Correction Static

Troposphere Correction Moving-Base

Satellite Ephemeris/Clock Fixed

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

DGNSS 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: Rover ?

G:\data\2021_GNSSTraining_DataSet\RTKdata\base_ubx.obs

RINEX OBS: Base Station

G:\data\2021_GNSSTraining_DataSet\RTKdata\base_NetR9.20o

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

G:\data\2021_GNSSTraining_DataSet\RTKdata\base.nav

Solution Dir

G:\data\2021_GNSSTraining_DataSet\RTKdata\base_ubx.pos

?

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

Input files:

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

We need to change some settings for DGNSS mode

Settings of DGNSS

Options

Setting1 Setting2 Output Statistics Positions Files Misc

Positioning Mode **DGPS/DGNSS**

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

Rover

Lat/Lon/Height (deg/m)

90.000000000 0.000000000 -6335367.6285

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

0.0000 0.0000 0.0000

Base Station

Lat/Lon/Height (deg/m) Datum ITRF2014

35.666342070 139.792210860 59.6790

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

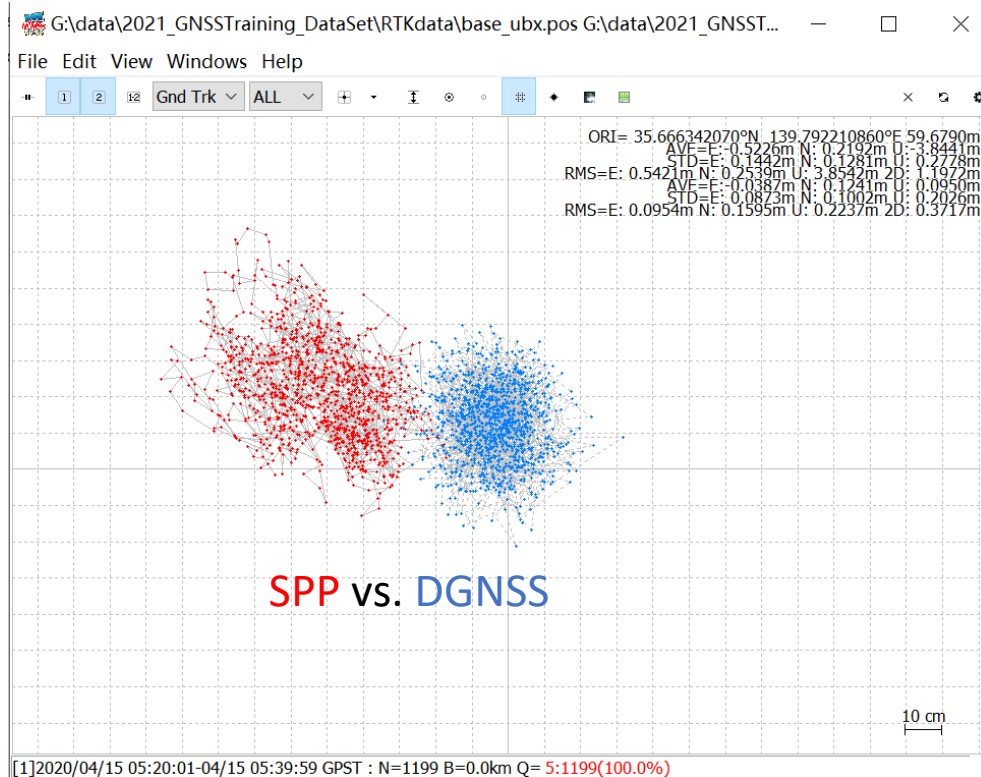
0.0000 0.0000 0.0000

Station Position File

Load... Save... **OK** Cancel

Should set the coordinate of the base station

DGNSS result in RTKPLOTT



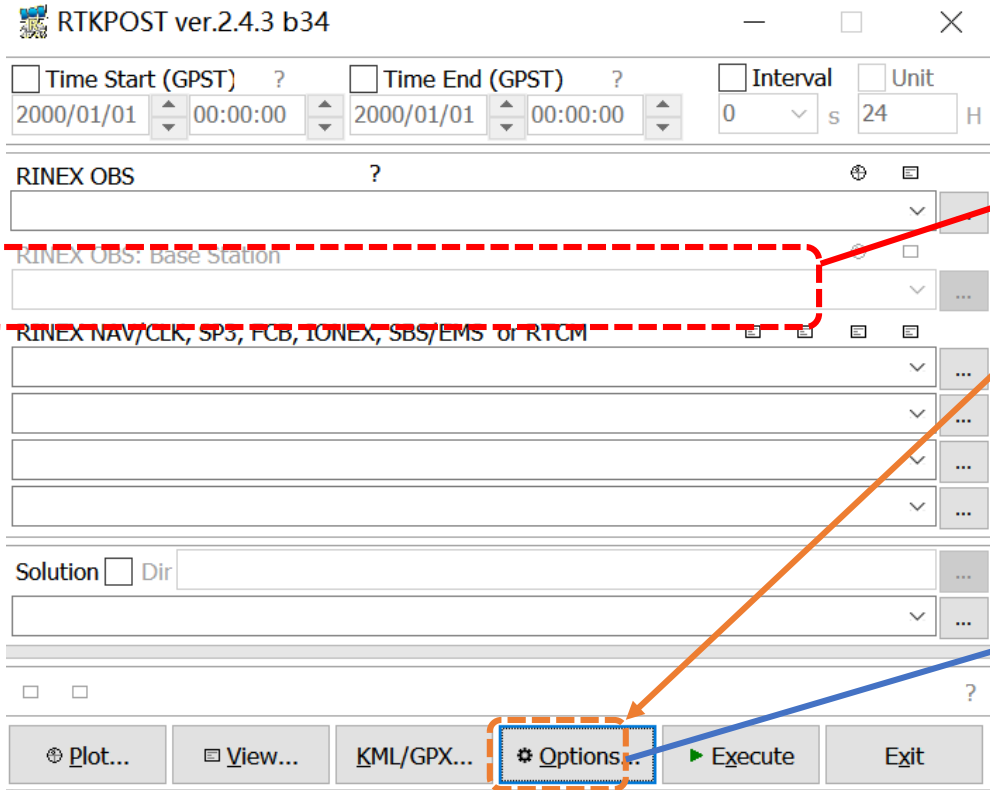
What is the benefit of DGNSS?

2.2 Your task

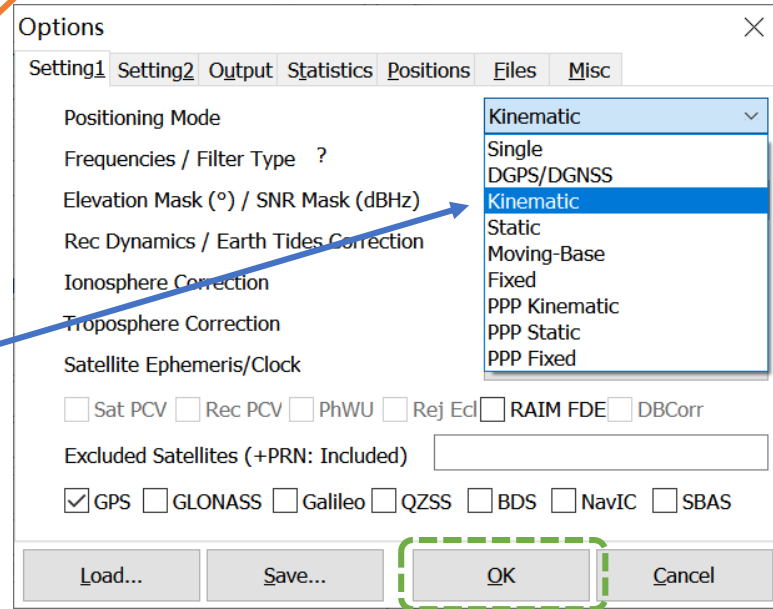
- How about the high-end receiver data?
- How about the kinematic data?
- If we choose different GNSS systems...

Try it by yourself!

3.1 RTK processing using static data



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



3.1 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: Rover ?

G:\data\2021_GNSSTraining_DataSet\RTKdata\base_ubx.obs

RINEX OBS: Base Station

G:\data\2021_GNSSTraining_DataSet\RTKdata\base_NetR9.20o

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

G:\data\2021_GNSSTraining_DataSet\RTKdata\base.nav

Solution Dir

G:\data\2021_GNSSTraining_DataSet\RTKdata\base_ubx.pos

?

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

Input files:

- Obs. file of rover station
- 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/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/U (m): 0.0000 0.0000 0.0000

Base Station

Lat/Lon/Height (deg/m) Datum: ITRF2014

35.666334713 139.792200636 59.9920

Antenna Type (*: Auto) Delta-E/N/U (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 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: Rover ?

G:\data\2021_GNSSTraining_DataSet\RTKdata\rover_NetR9.20o

RINEX OBS: Base Station

G:\data\2021_GNSSTraining_DataSet\RTKdata\base_NetR9.20o

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

G:\data\2021_GNSSTraining_DataSet\RTKdata\base.nav

Solution Dir

G:\data\2021_GNSSTraining_DataSet\RTKdata\rover_NetR9.pos

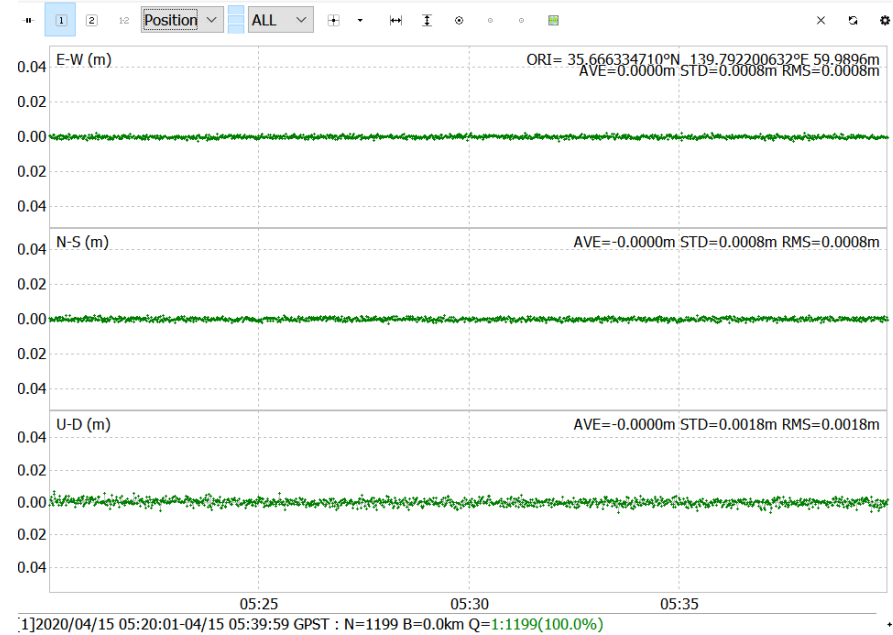
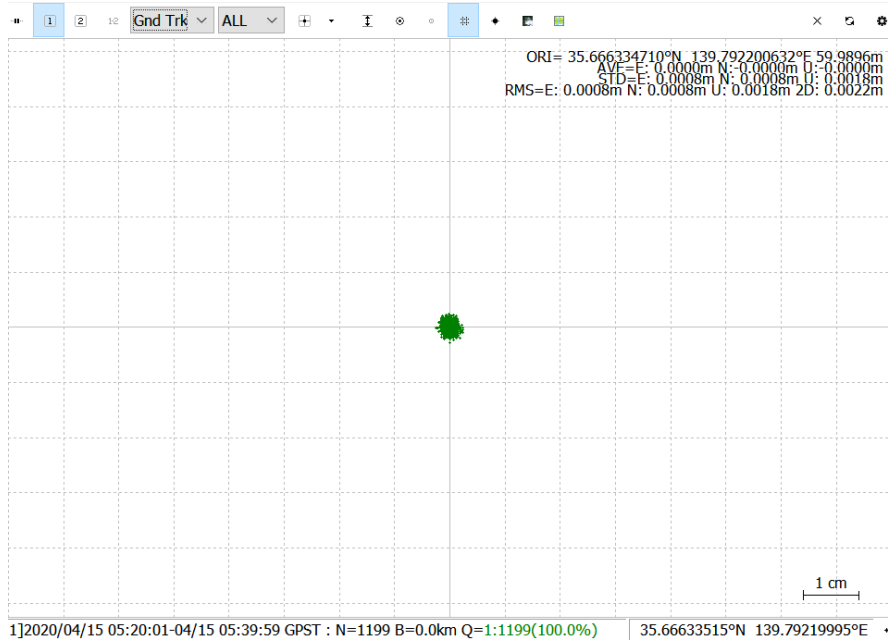
?

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

If settings are finished,
execute!

Then Plot...

RTK result in RTKPLOTT



Fix rate is 100%

Precision is within 2mm (this is a zero baseline)

3.2 If we use kinematic 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: Rover ?

G:\data\2021_GNSSTraining_DataSet\RTKdata\rover_NetR9.20o

RINEX OBS: Base Station

G:\data\2021_GNSSTraining_DataSet\RTKdata\base_NetR9.20o

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

G:\data\2021_GNSSTraining_DataSet\RTKdata\base.nav

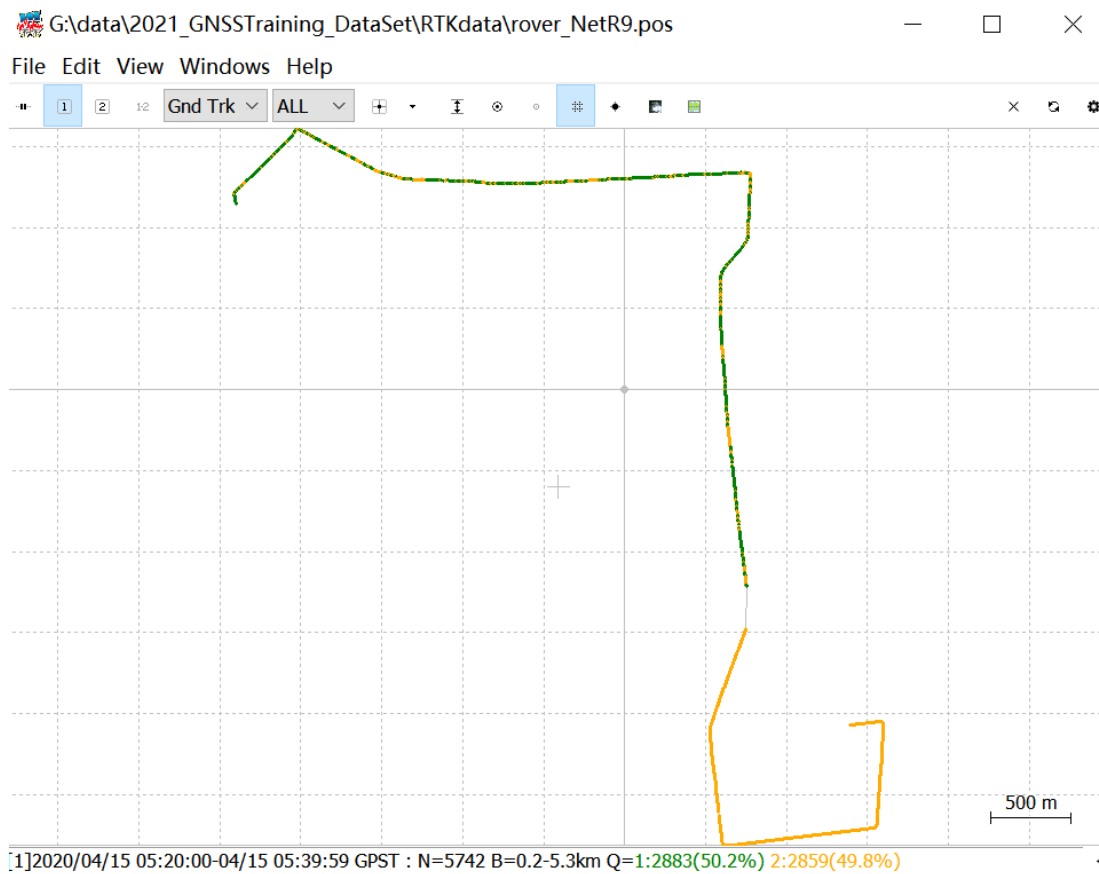
Solution Dir

G:\data\2021_GNSSTraining_DataSet\RTKdata\rover_NetR9.pos

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

Change the data of the rover station, then execute.

RTK result of the kinematic data

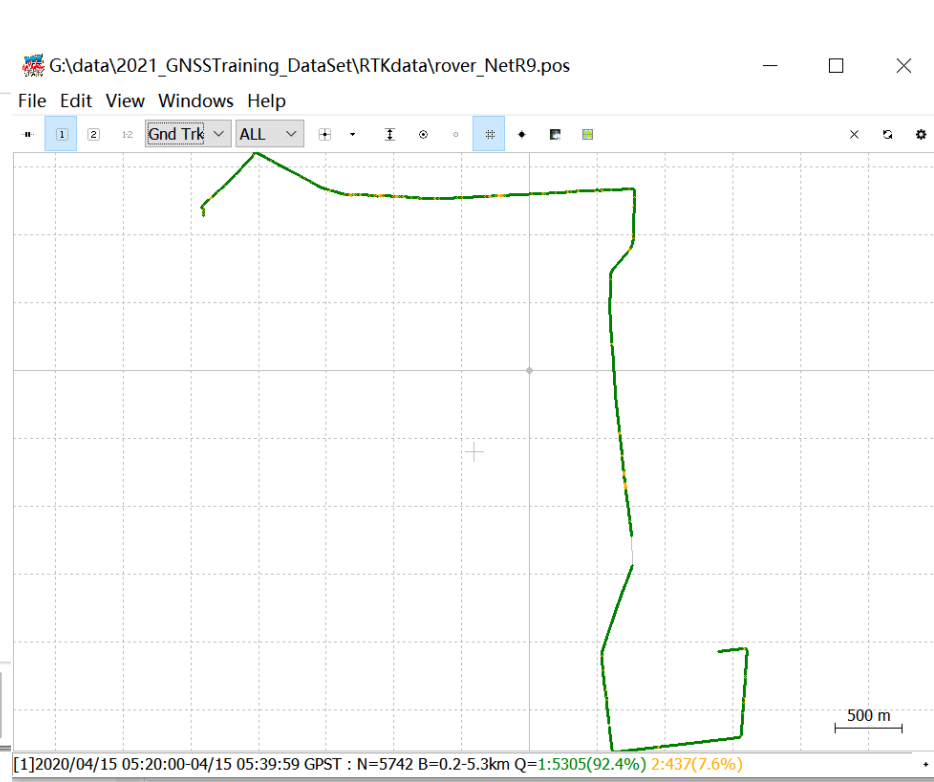


If we use the instantaneous mode

Options

Setting1	Setting2	Output	Statistics	Positions	Files	Misc
Integer Ambiguity Res (GPS/GLO/BDS)	Instanta	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				
<input type="checkbox"/> Baseline Length Constraint (m)	0.000	0.000				

Load... Save... OK Cancel



Fix rate will improve from 50.2% to 92.4%

If we set SNR Mask

Options

Setting1 Setting2 Output Statistics Positions Files Misc

Positioning Mode: Kinematic

Frequencies / Filter Type: L1+L2 Forward

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

Rec Dynamics / Earth Tides Correction: OFF OFF

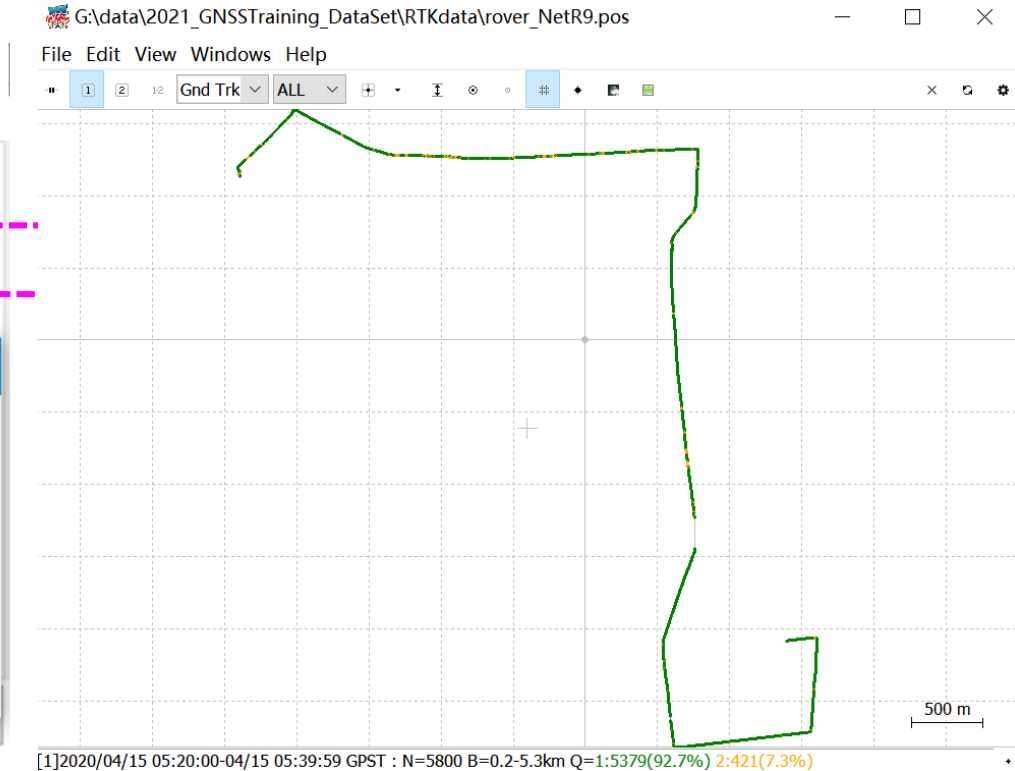
SNR Mask

Rover Base Station

	Elevation (deg)								
	<5	15	25	35	45	55	65	75	>85
L1	30	30	30	30	30	30	30	30	30
L2	30	30	30	30	30	30	30	30	30
L5	0	0	0	0	0	0	0	0	0

OK Cancel

X



Fix rate will improve from 92.4% to 92.7%

3.3 Your task

- 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!