Introduction to RTK Data Processing How to get centimeter level accuracy? Part - 1

GNSS Data Processing for High-Accuracy Positioning using
Low-Cost Receiver Systems
19 – 21 JAN 2021

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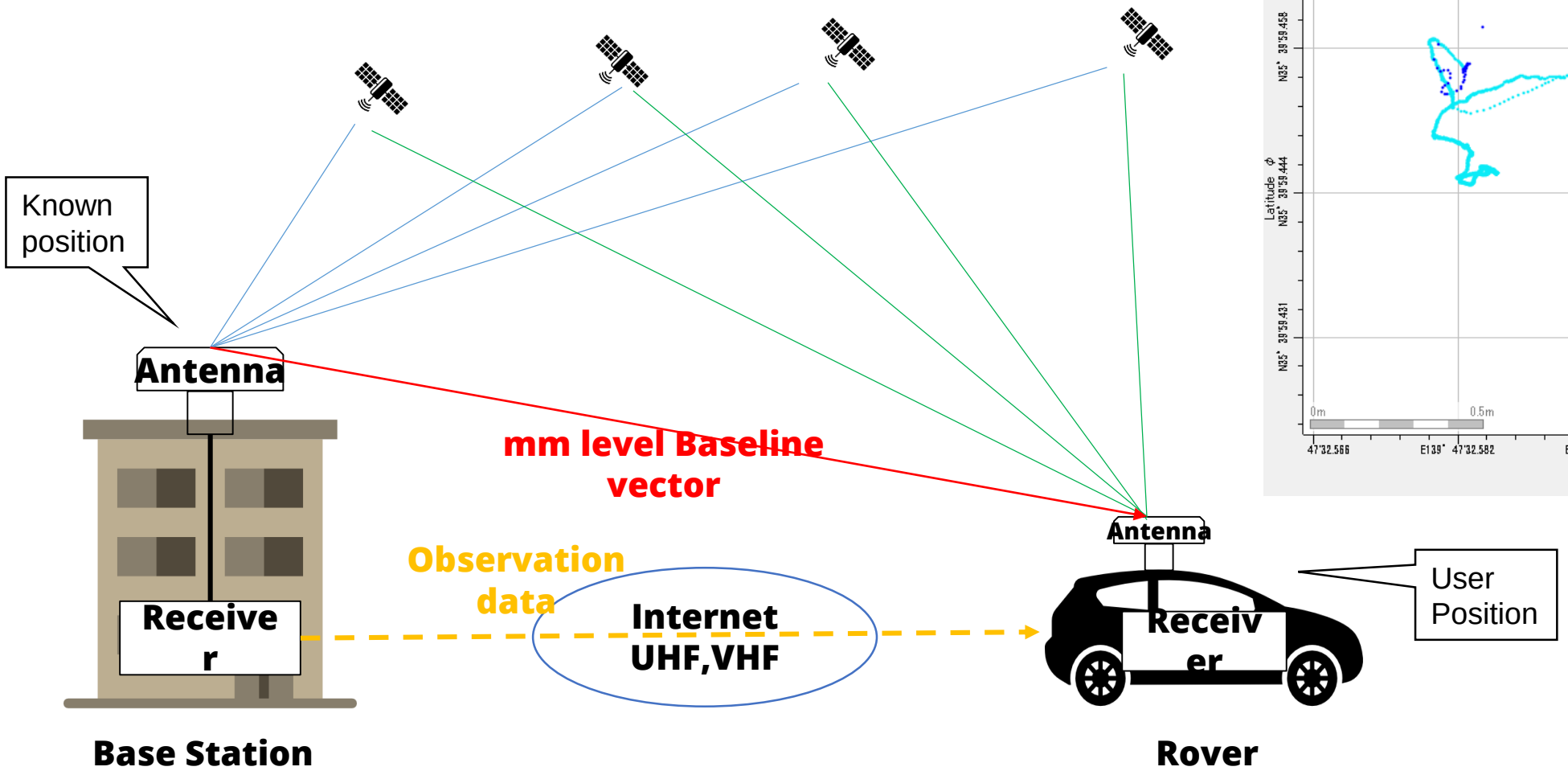
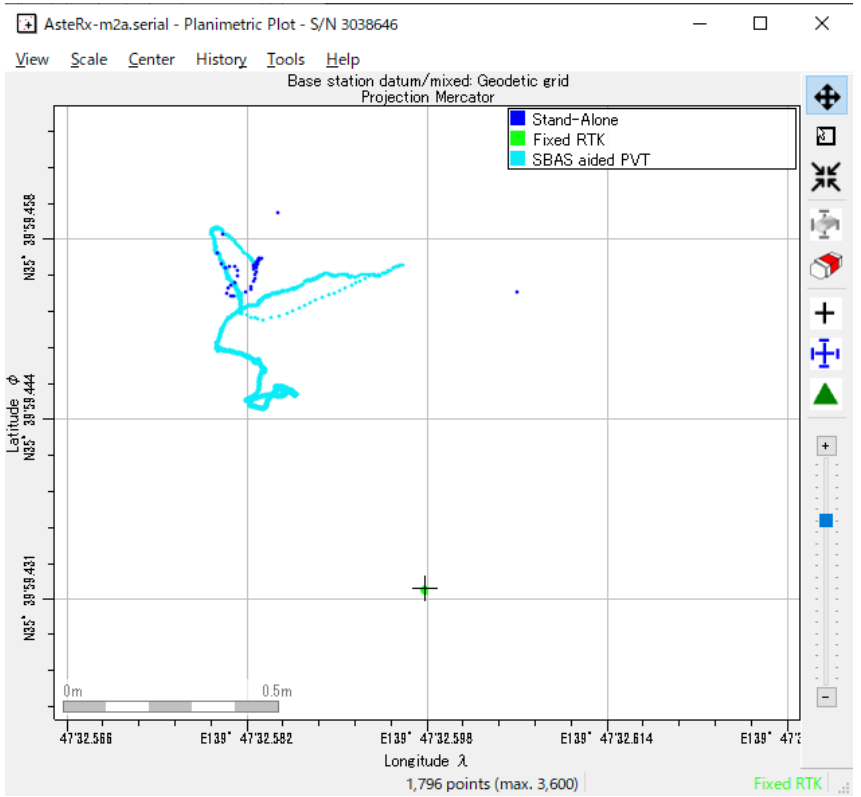
Tokyo University of Marine Science and Technology

Contents

1. What is RTK

RTK is high accuracy positioning method using “Base Station”.

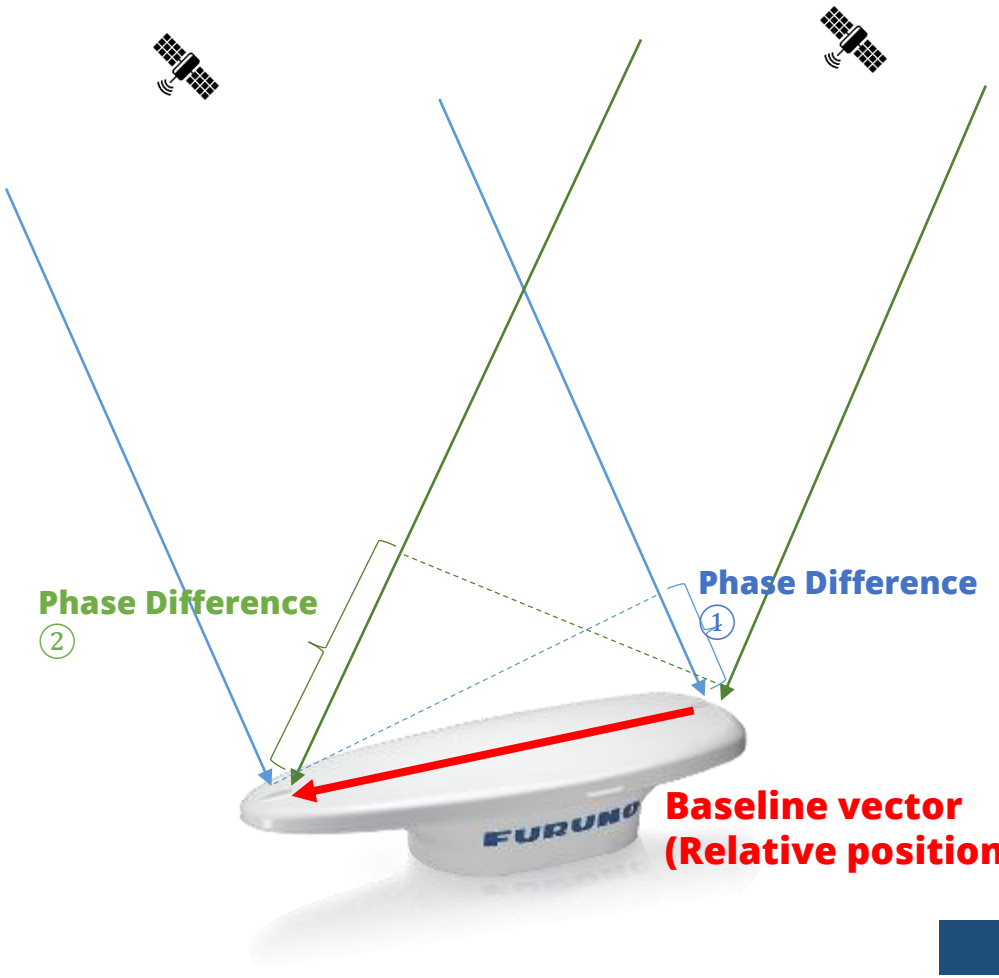


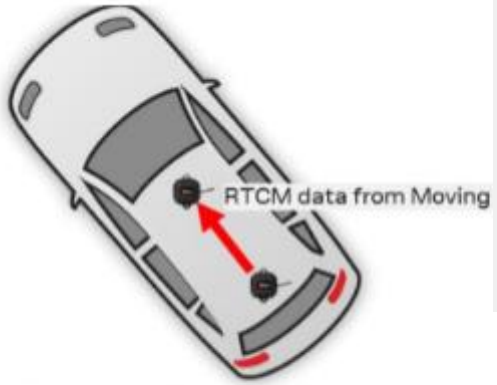


1. What is RTK

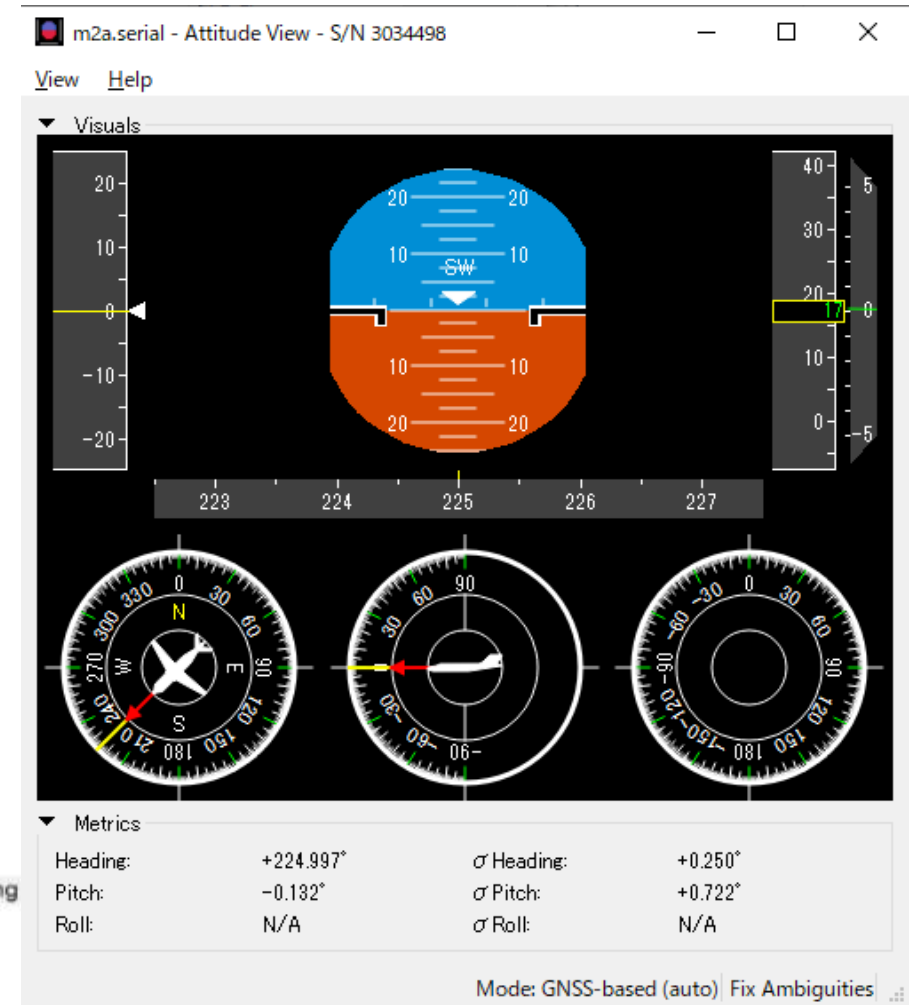
If “Base station” is not fixed → Moving-base RTK

You can get precise relative position, angle between 2 antenna.



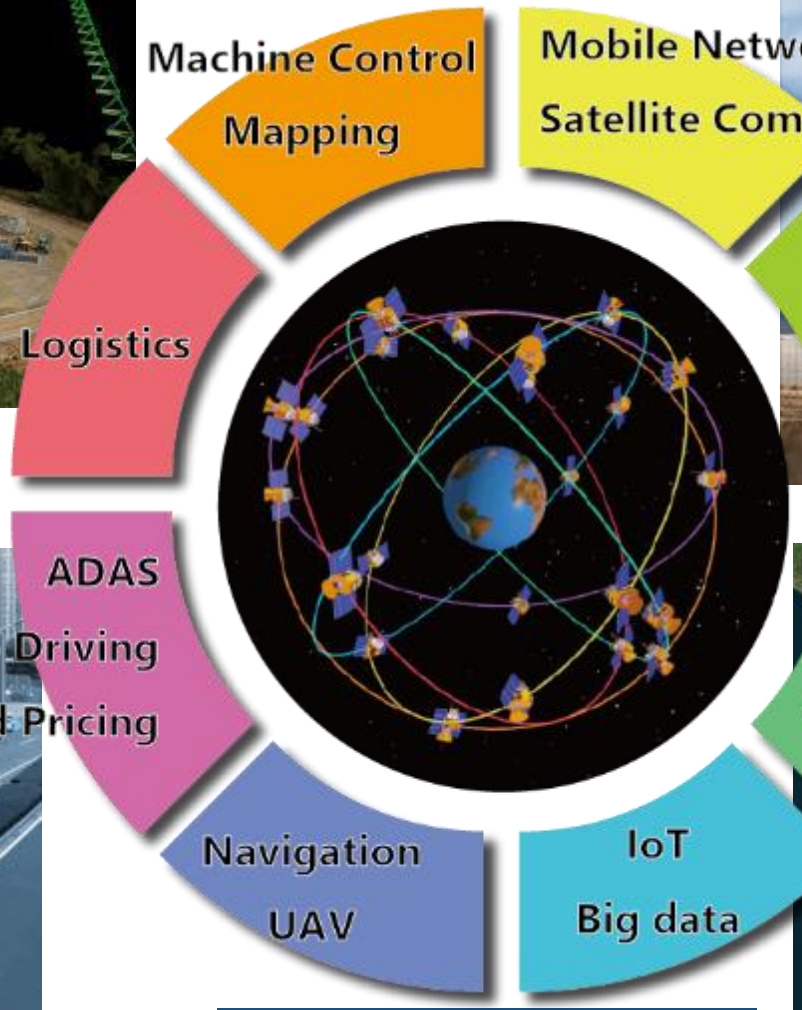


Moving baseline setup for precise heading



2. RTK applications

RTK can expand GNSS use field over traditional PNT (Positioning, Navigation, Timing).

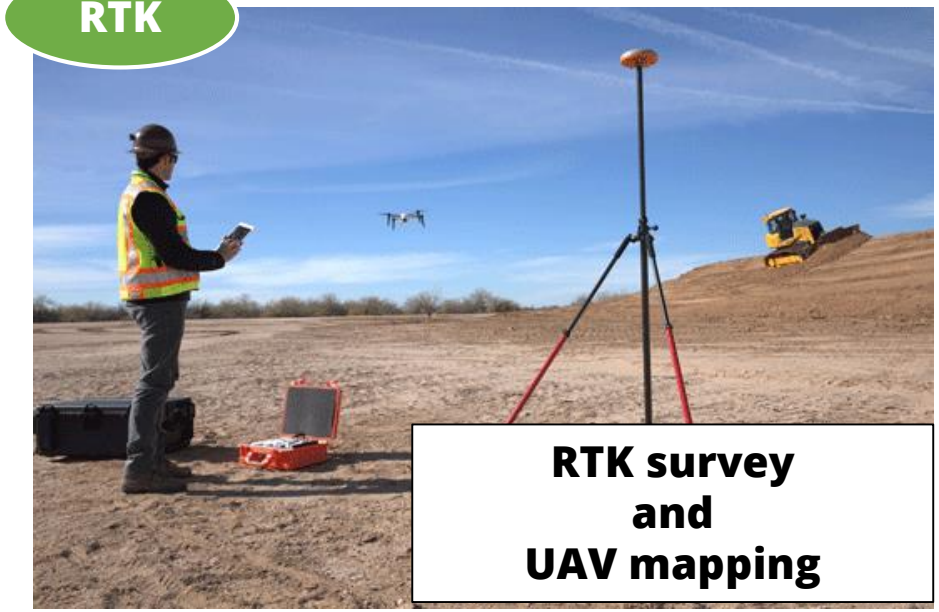


2. RTK applications

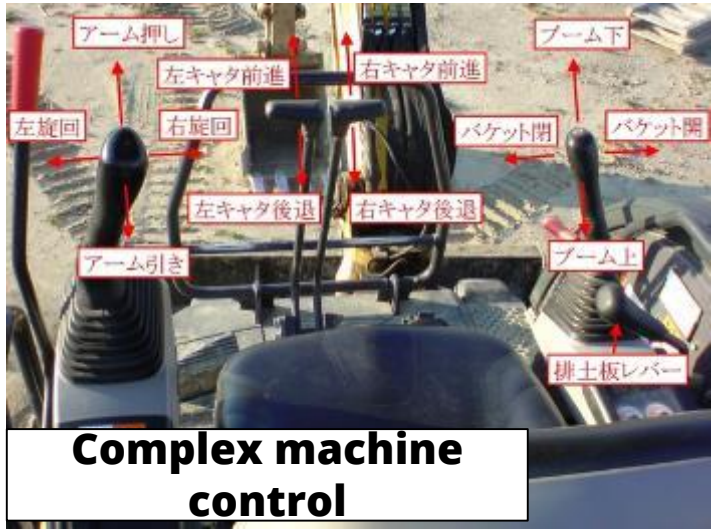
◆Construction

Traditional optical survey

RTK



RTK survey and UAV mapping



Complex machine control

RTK

Moving-base RTK

Machine control using 3D data and Attitude monitoring

2. RTK applications

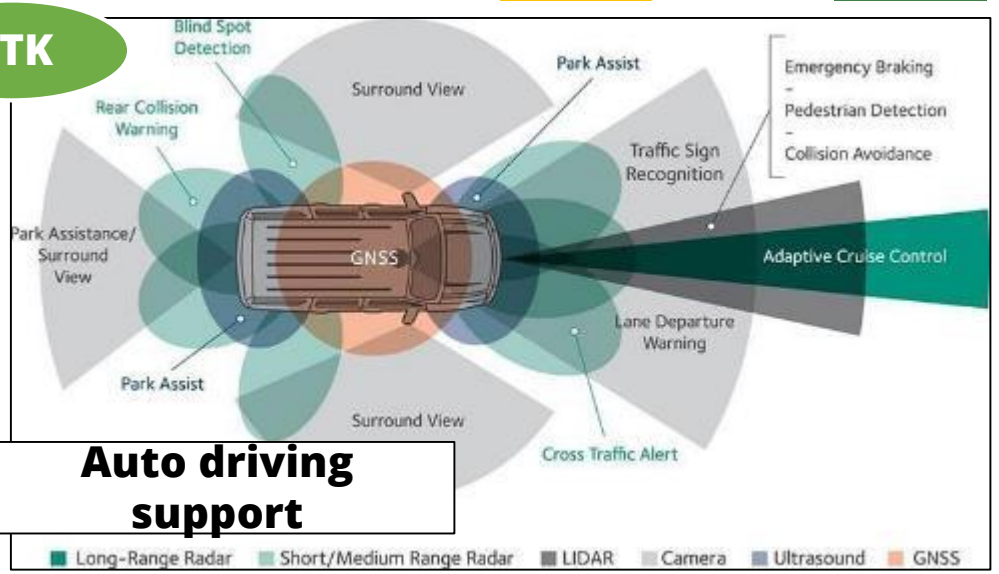
◆ITS (Intelligent Transportation System)

Car navigation

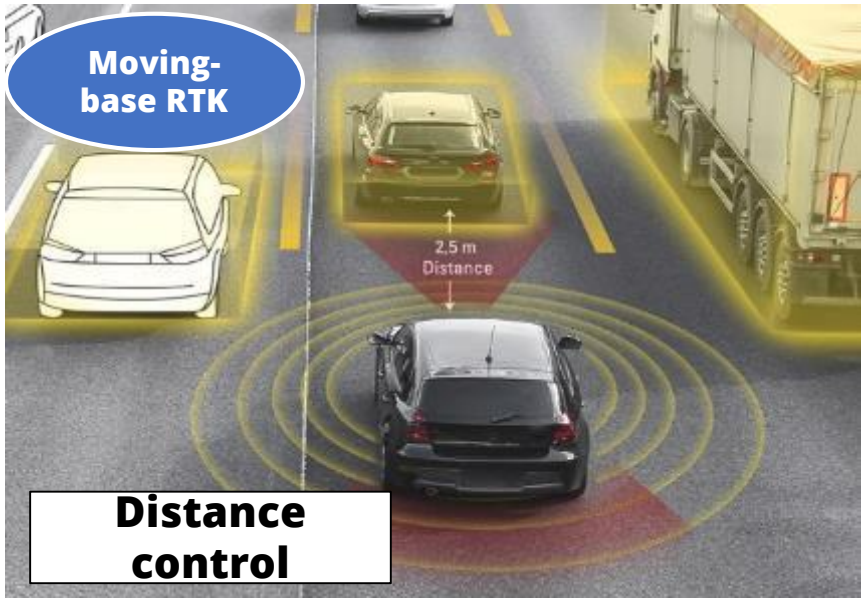
+

Road pricing by lane

RTK



Auto driving support

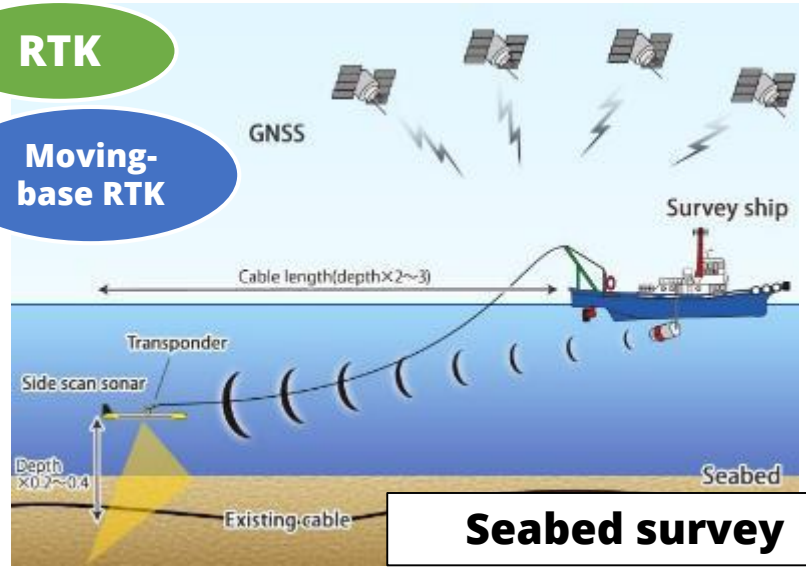


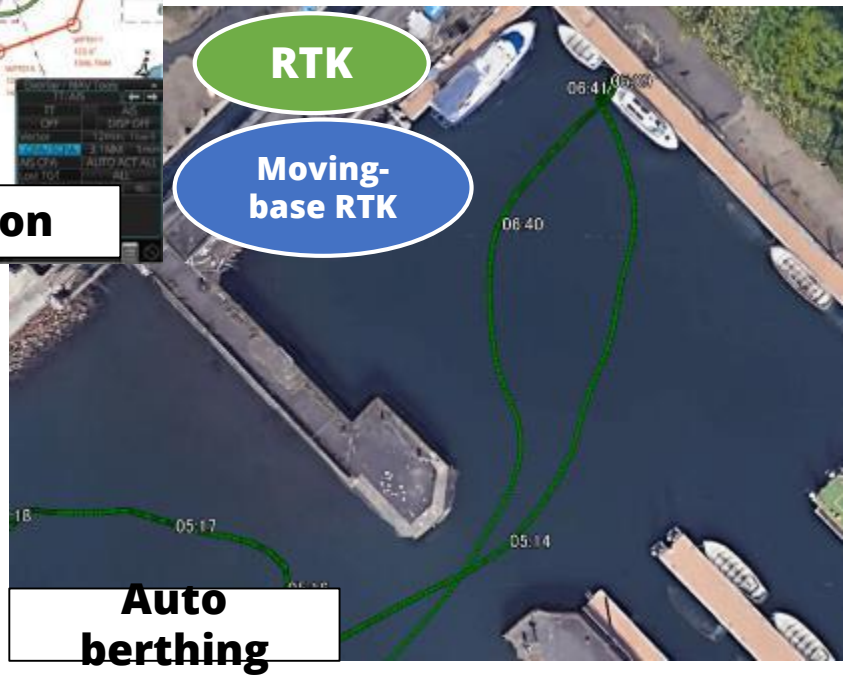
Distance control

2. RTK applications

◆Maritime

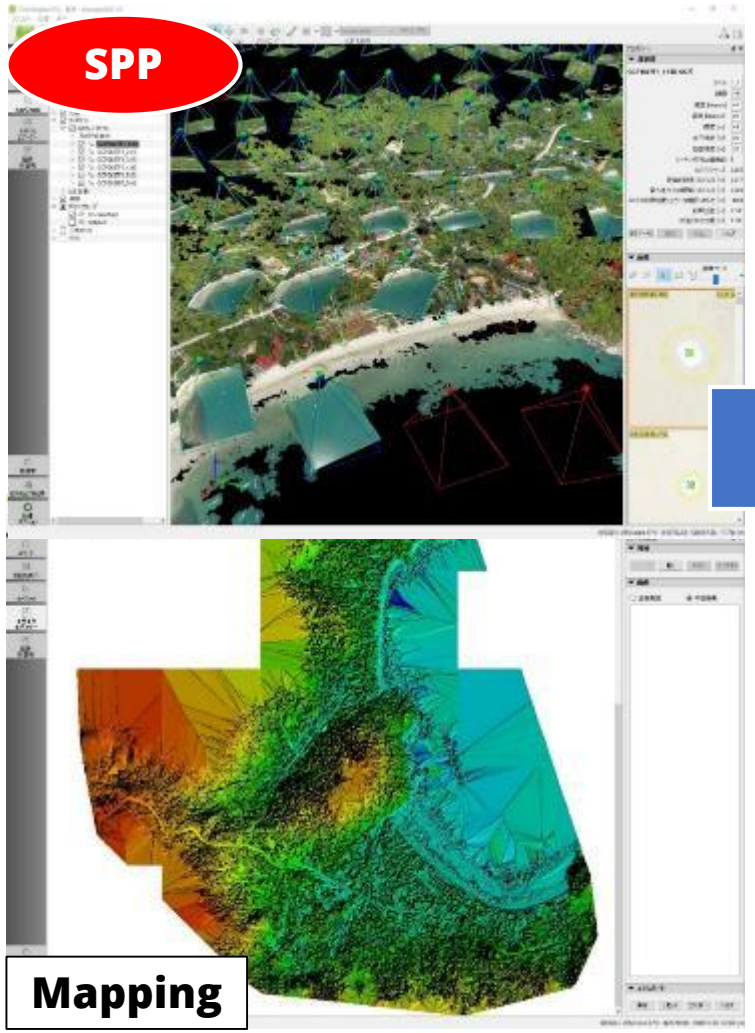
+



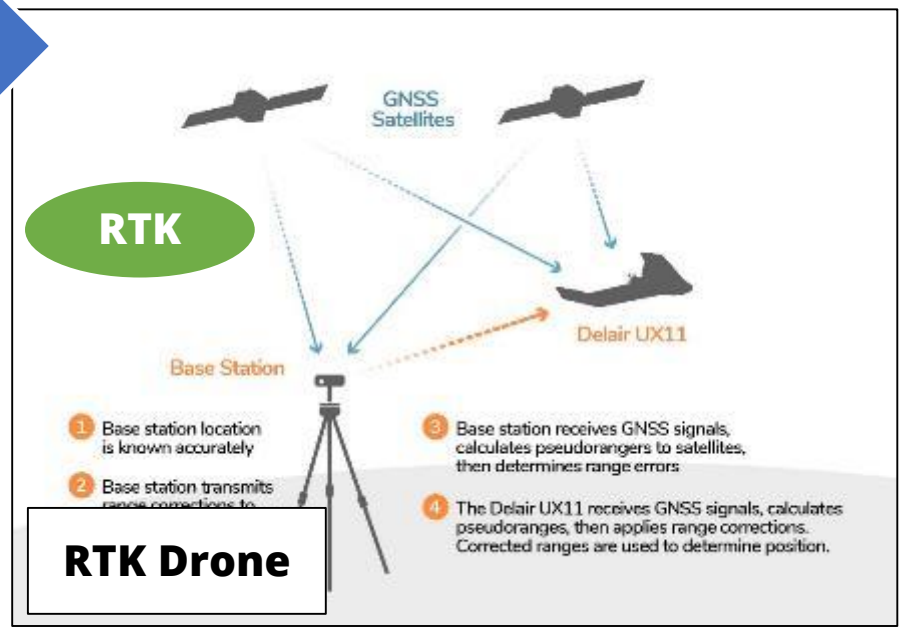


2. RTK applications

◆UAV



More precise map



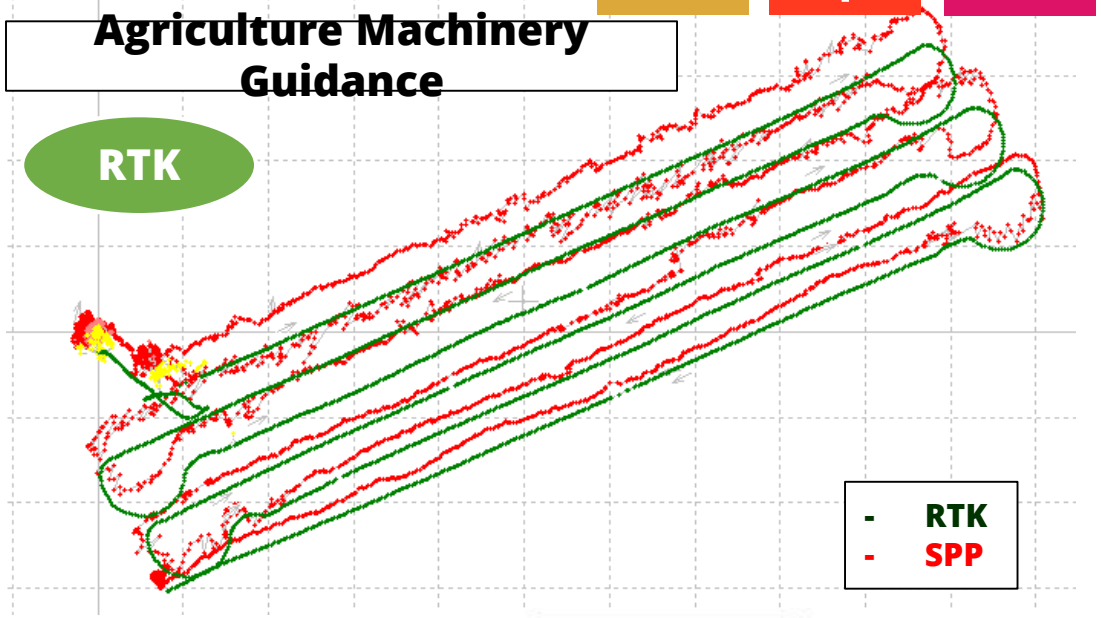
2. RTK applications

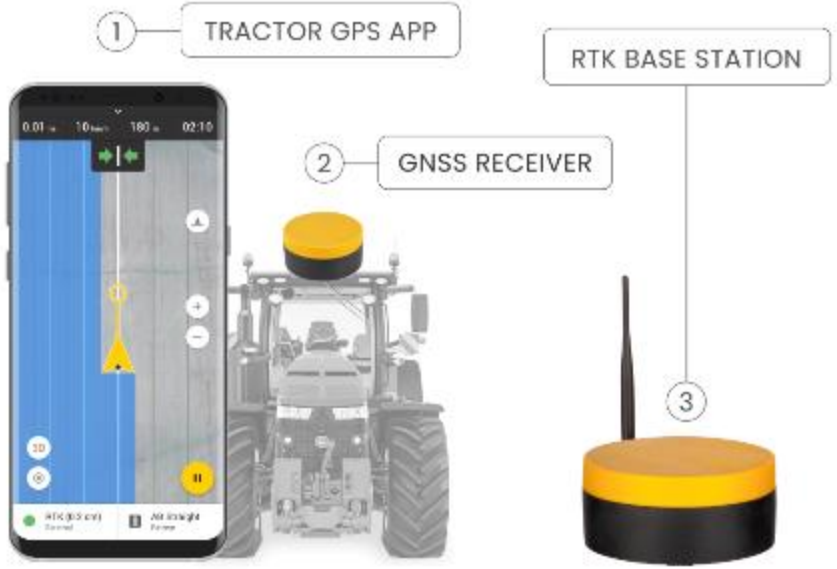
◆Agriculture

Shift to young generation
Effective working

Agriculture Machinery Guidance

RTK



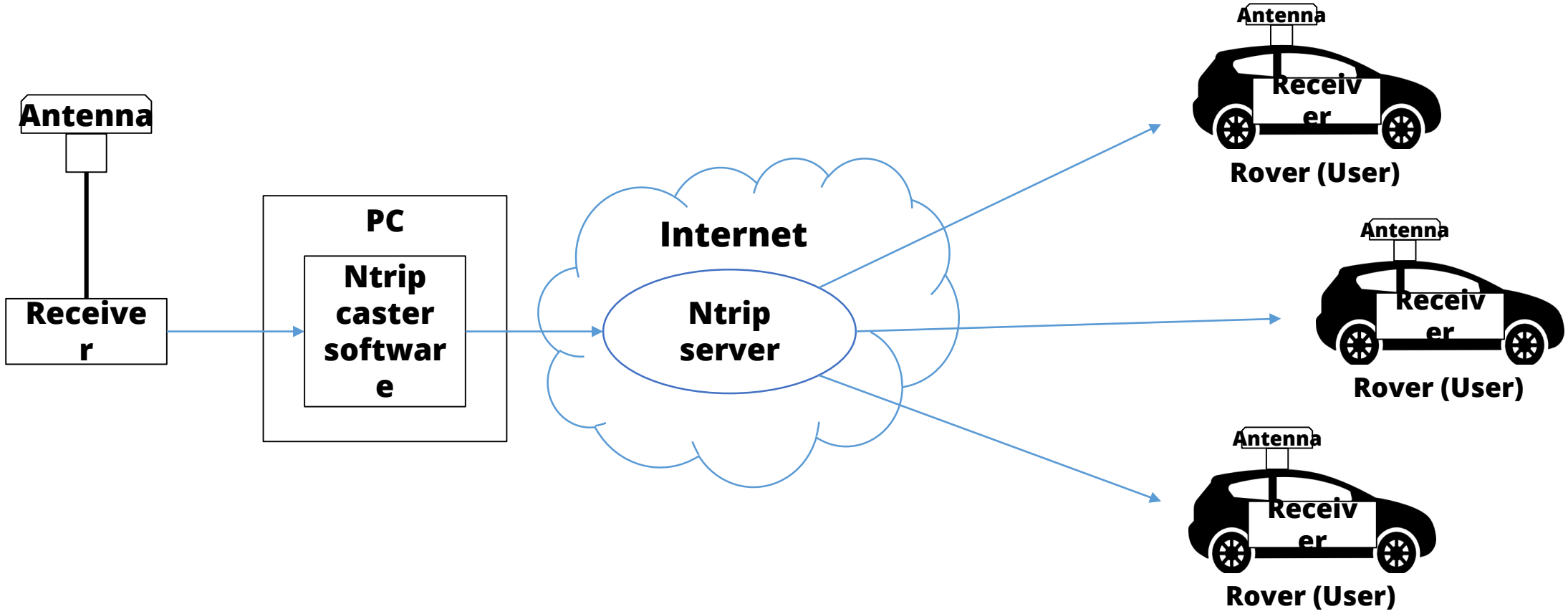


3. How to build RTK environment

◆Base station overview

I explain the most common broadcast way using “Ntrip server”.

However you can also use VHF/UHF radio, Bluetooth, LAN or cable communication to broadcast base station data.



3. How to build RTK environment

◆Base station antenna

Install antenna in open sky & static environment.

Japanese government base station

Our University base station

Temporary base station

3. How to build RTK environment

◆Base station receiver selection

The receiver should support raw data output.

- RTCM3
  Standard format for RTK. Select base station position and observation message is must.
- Receiver manufacturer format
  Binary message.
  Input support is depend on the rover receiver.

RTCM Rev3 Common Message Types

	Most common message used for >90% of all RTK applications
1004	Extended L1&L2 GPS RTK Observables for GPS RTK Use, **the main msg** X
1005	Stationary RTK Reference Station ARP X
1006	Stationary RTK Reference Station ARP plus the Antenna Height X
1007	Antenna Descriptor (msg 1008 (X) is also commonly used) X
1012	Extended L1&L2 GLONASS RTK Observables, **the other main msg** X

https://www.use-snip.com/kb/knowledge-base/an-rtcm-message-cheat-sheet/

septentrio

CHAPTER 4. CONFIGURING THE ASTERX SB AS A ROVER

Configure input of differential corrections

The format of the differential corrections output by the Base station should be compatible with what is accepted by the Rover. In the **Corrections Input** window of the **Corrections** menu, you can configure the AsteRx SB to only accept differential corrections of a particular format. The default 'auto' setting will accept correction data format RTCMv2, RTCMv3 or CMR+.

3.1.5.1 RTCM corrections

RTCM is a binary data protocol for communication of GNSS correction information. The ZED-F9P high precision receiver supports RTCM as specified by RTCM 10403.3, Differential GNSS (Global Navigation Satellite Systems) Services – Version 3 (October 7, 2016).

The RTCM specification is currently at version 3.3 and RTCM version 2 messages are not supported by this standard. Users can download the standard from the RTCM website here.

To modify the RTCM input/output settings, see the configuration section in the u-blox ZED-F9P Interface Description [2].

3. How to build RTK environment

◆Base station receiver setting

Change receiver configuration to output RTCM message from USB port.

Here I will show example using u-blox F9P and Septentrio AtseRx-m2a

3. How to build RTK environment

◆Base station antenna position

You need to know your base station antenna position with cm level accuracy.

・RTK

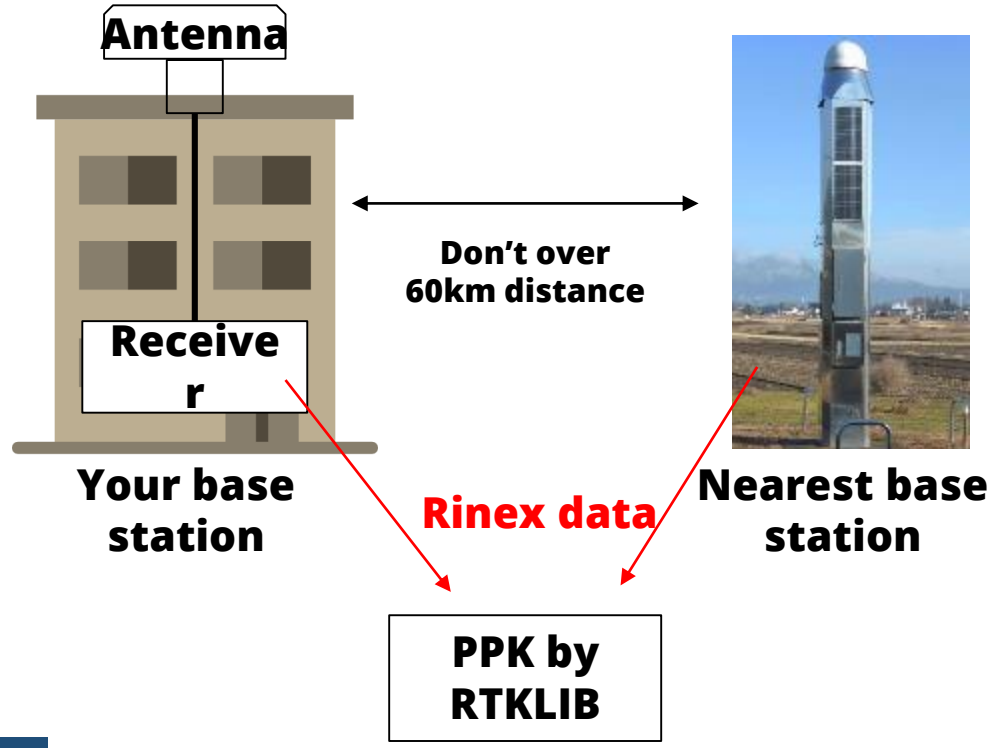
If there is another RTK base station near your base, you can calculate by PPK (Post-Process Kinematic).

Free RTK base stations.

-IGS station http://www.igs.org/network

datalink : ftp://cddis.gsfc.nasa.gov/gnss/data/daily

-Local CORS https://www.chcthailand.com/cors-picture



3. How to build RTK environment

◆Base station antenna position

You need to know your base station antenna position with cm level accuracy.

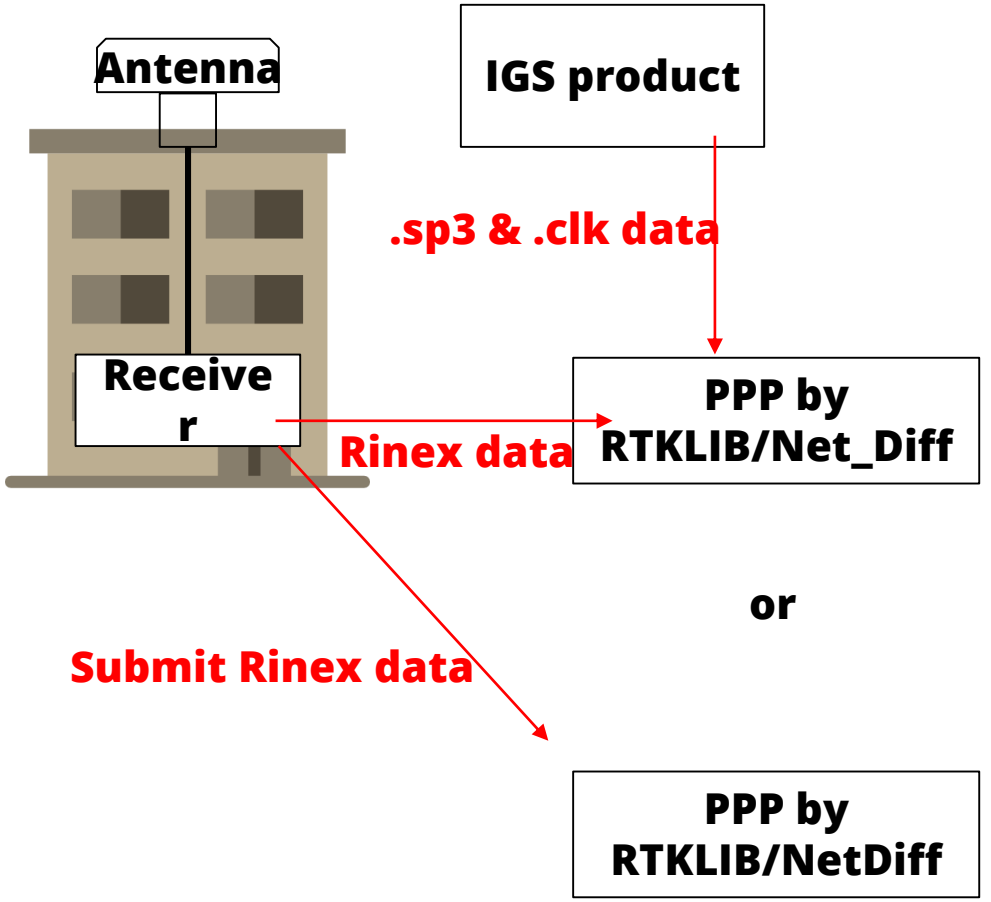
- PPP

If there is no another RTK base station, calculate by PPP.

Free PPP service

- RTKLIB with IGS product (http://www.rtklib.com/)
- Net_Diff with IGS product (https://github.com/YizeZhang/Net_Diff)
- Trimble RTX (https://www.trimblertx.com/UploadForm.aspx)
- CSRS-PPP (https://webapp.geod.nrcan.gc.ca/geod/tools-outils/ppp.php)
- MADOCA-PPP

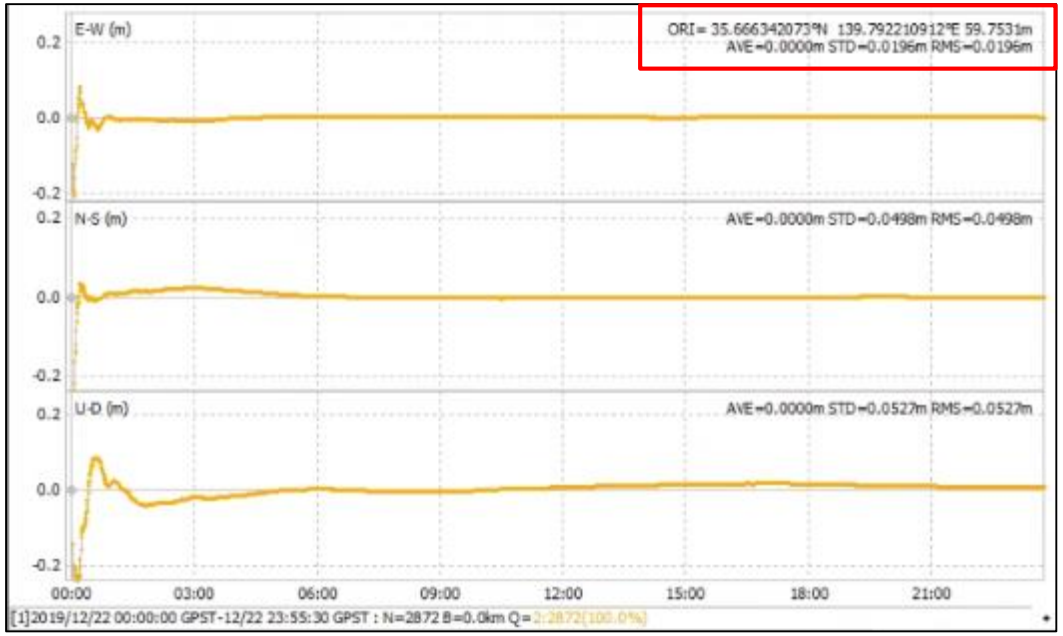
IGS product : (http://mgex.igs.org/IGS_MGEX_Products.php)



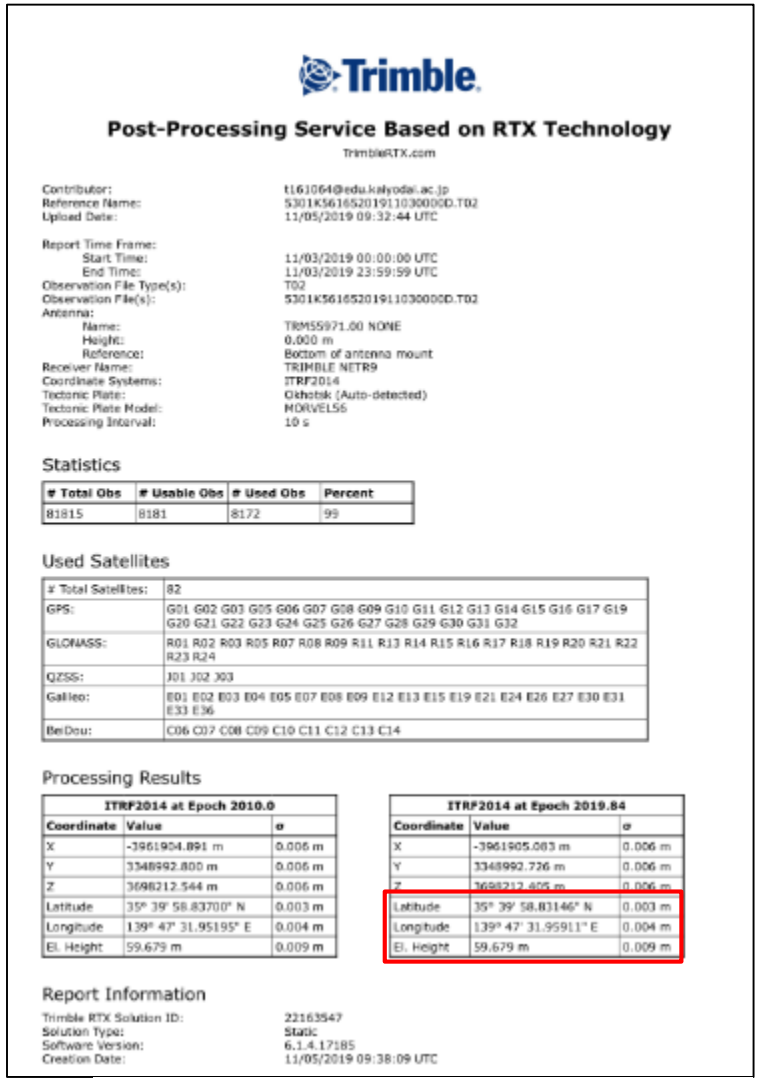
3. How to build RTK environment

◆Base station antenna position

Sample of PPP solution



Net_Diff + MGEX product



Trimble

Post-Processing Service Based on RTX Technology

TrimbleRTX.com

Contributor: t161064@edu.kaiyodai.ac.jp
Reference Name: 5301K561652019110300000.T02
Upload Date: 11/05/2019 09:32:44 UTC

Report Time Frame:
Start Time: 11/03/2019 00:00:00 UTC
End Time: 11/03/2019 23:59:59 UTC
Observation File Type(s): T02
Observation File(s): 5301K561652019110300000.T02
Antenna:
Name: TRM55971.00 NONE
Height: 0.000 m
Reference: Bottom of antenna mount
Receiver Name: TRIMBLE NETR9
Coordinate Systems: ITRF2014
Tectonic Plate: Okhotsk (Auto-detected)
Tectonic Plate Model: MORVEL56
Processing Interval: 10 s

Statistics

# Total Obs	# Usable Obs	# Used Obs	Percent
81815	8181	8172	99

Used Satellites

# Total Satellites:	82
GPS:	G01 G02 G03 G05 G06 G07 G08 G09 G10 G11 G12 G13 G14 G15 G16 G17 G19 G20 G21 G22 G23 G24 G25 G26 G27 G28 G29 G30 G31 G32
GLONASS:	R01 R02 R03 R05 R07 R08 R09 R11 R13 R14 R15 R16 R17 R18 R19 R20 R21 R22 R23 R24
QZSS:	J01 J02 J03
Galileo:	E01 E02 E03 E04 E05 E07 E08 E09 E12 E13 E15 E19 E21 E24 E26 E27 E30 E31 E33 E36
BeiDou:	C06 C07 C08 C09 C10 C11 C12 C13 C14

Processing Results

ITRF2014 at Epoch 2010.0		
Coordinate	Value	σ
X	-3961904.891 m	0.006 m
Y	3348992.800 m	0.006 m
Z	3698212.544 m	0.006 m
Latitude	35° 39' 58.83700" N	0.003 m
Longitude	139° 47' 31.95195" E	0.004 m
El. Height	59.679 m	0.009 m

ITRF2014 at Epoch 2019.84		
Coordinate	Value	σ
X	-3961905.083 m	0.006 m
Y	3348992.726 m	0.006 m
Z	3698212.405 m	0.006 m
Latitude	35° 39' 58.83146" N	0.003 m
Longitude	139° 47' 31.95911" E	0.004 m
El. Height	59.679 m	0.009 m

Report Information

Trimble RTX Solution ID: 22163547
Solution Type: Static
Software Version: 6.1.4.17185
Creation Date: 11/05/2019 09:38:09 UTC

Trimble RTX service

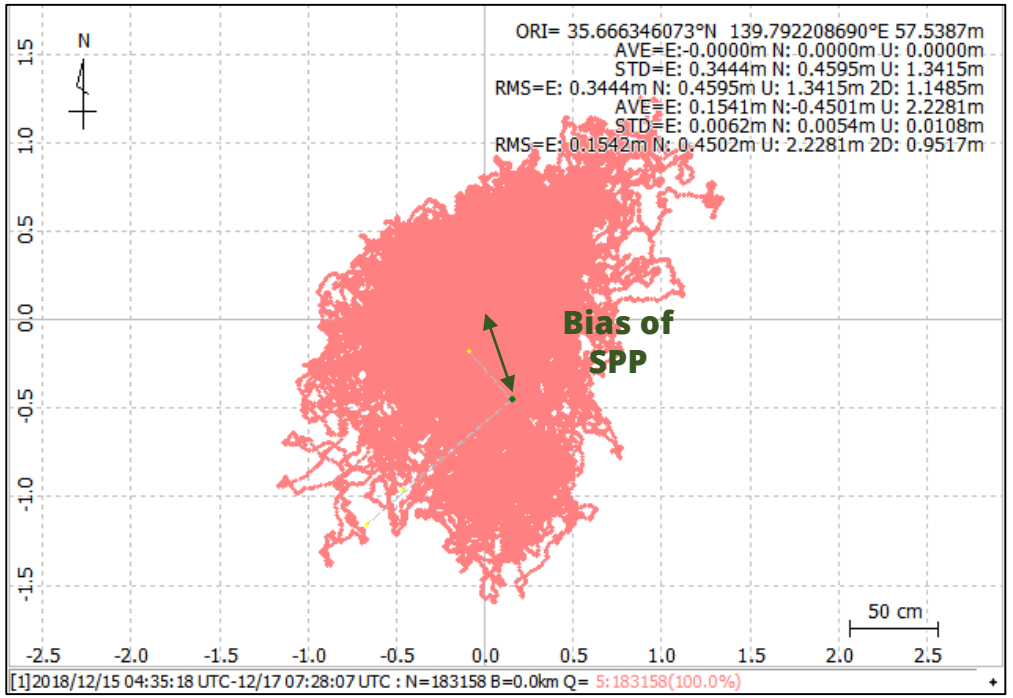
Use this position as your base station position.

3. How to build RTK environment

◆Base station antenna position

Unless there is a special reason, I don't recommend to use optical survey position or SPP average position for the base station position.

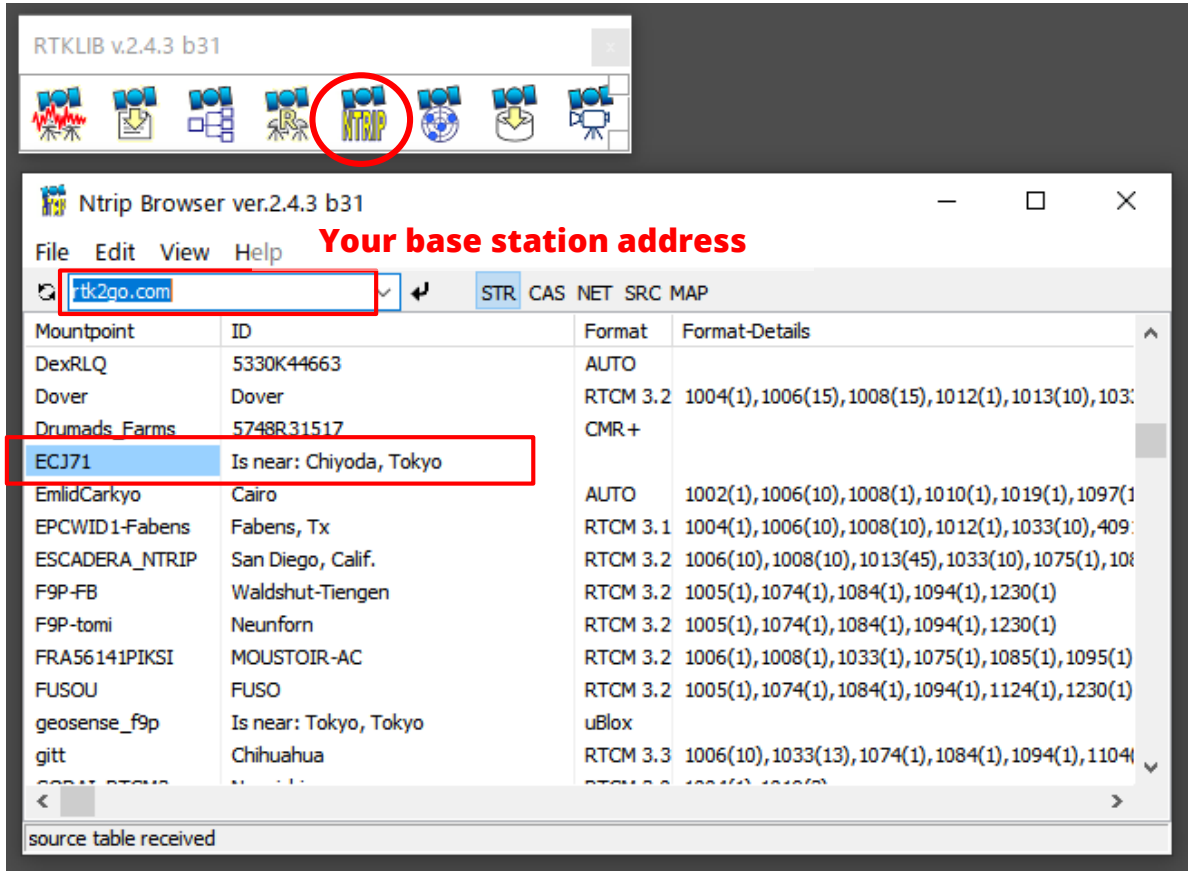
Local survey coordinate has a gap with GNSS coordinate (ITRF).



3. How to build RTK environment

◆Push out data to Ntrip server

You can check your Mount Point from “NTRIP Browser” in RTKLIB.



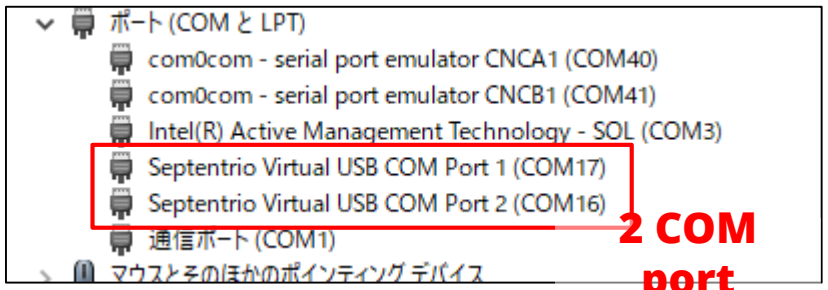
4. RTK configuration on rover

◆RTK (Septentrio with PC)

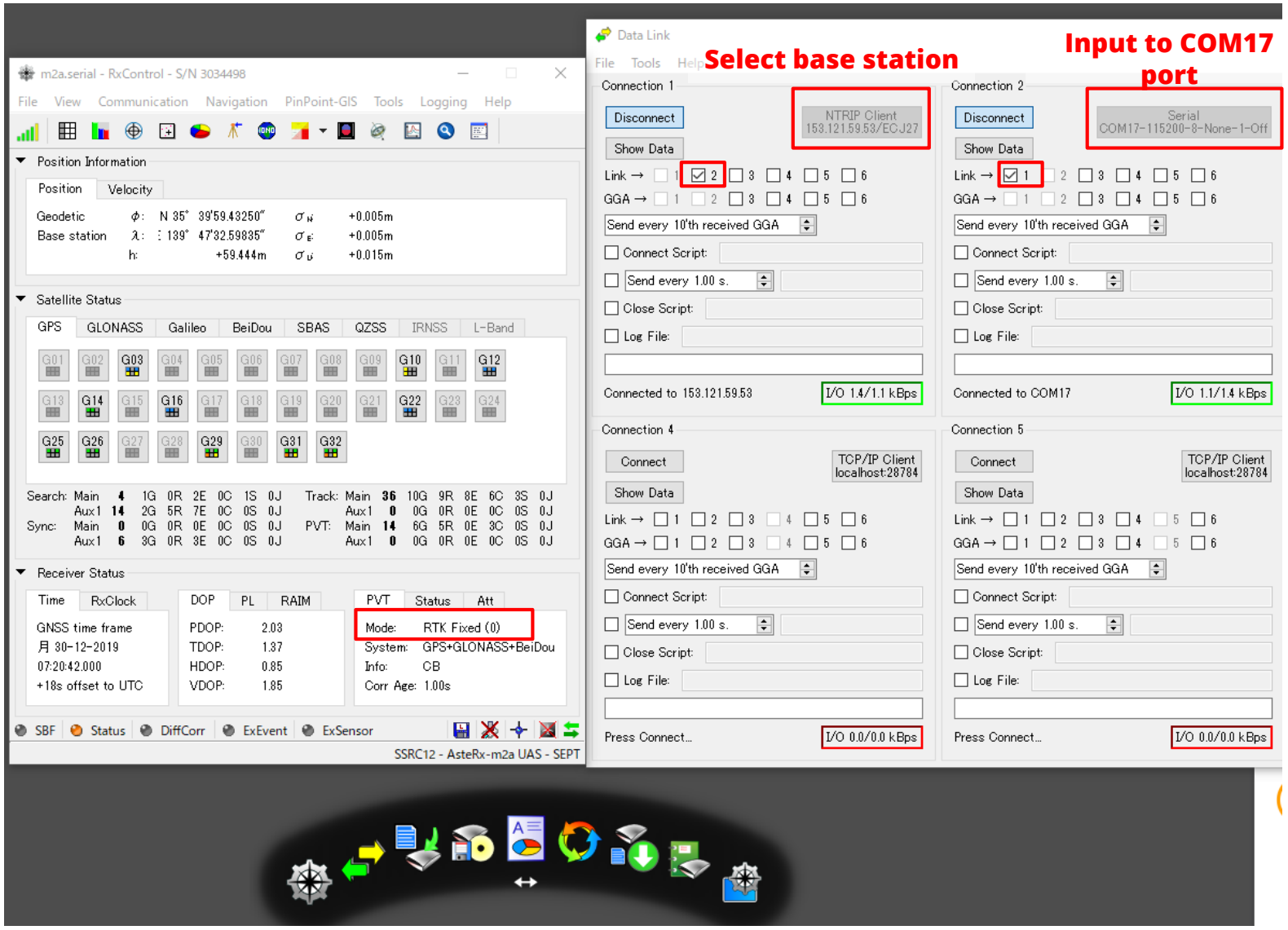
Use Ntrip client function of “Data Link” in “RxTools”

https://www.septentrio.com/en/products/software/rxtools

Downloand link
https://www.septentrio.com/en/support/software/rxtools



2 COM port



4. RTK configuration on rover

◆RTK (ublox with PC)

Use Ntrip client setting in u-center.

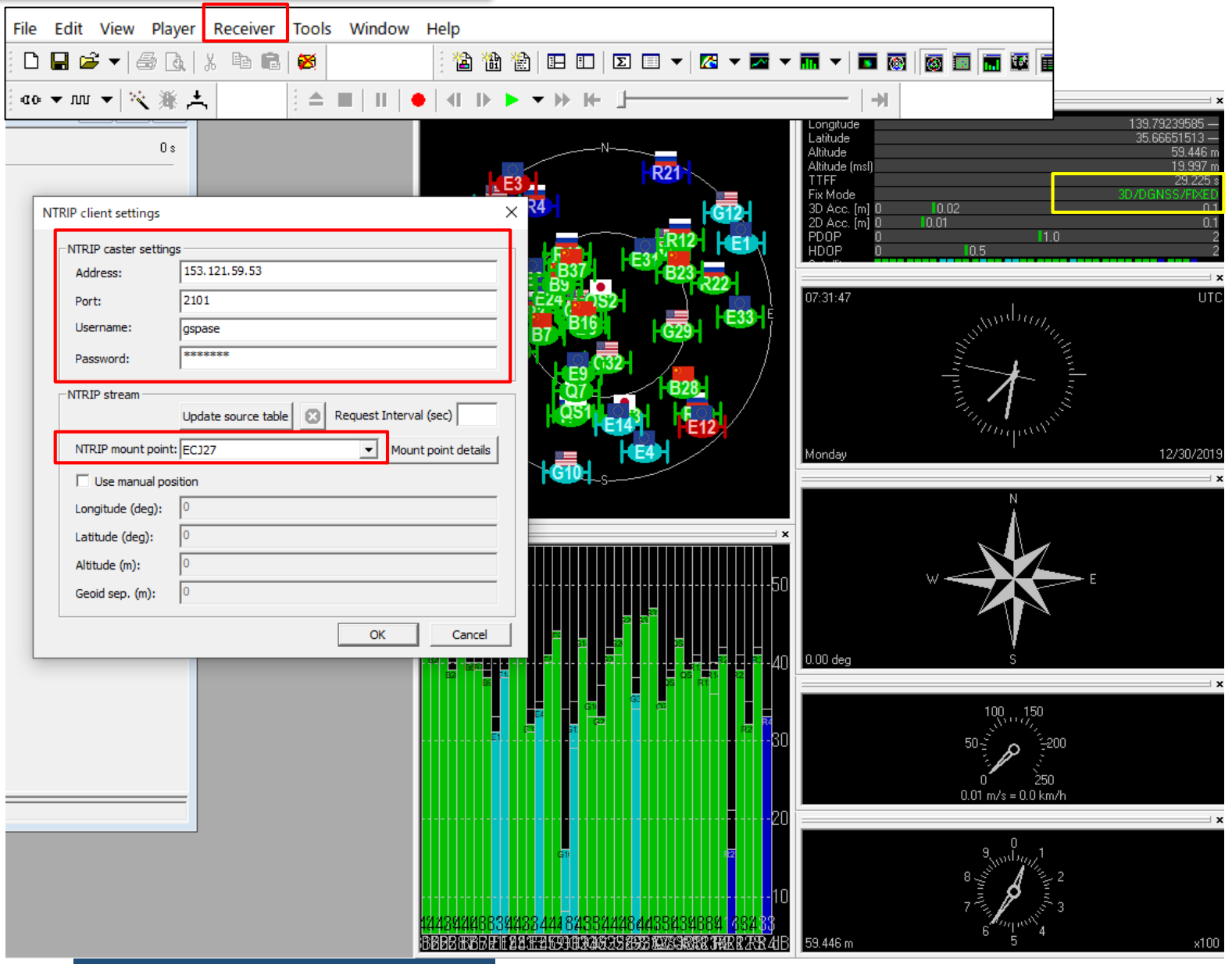
https://www.u-blox.com/en/product/u-center

NTRIP client setting

Receiver>NTRIP Client

Select mount point and click "OK".

RTK support is M8P and F9P



4. RTK configuration on rover

◆RTK (RTKNAVI)

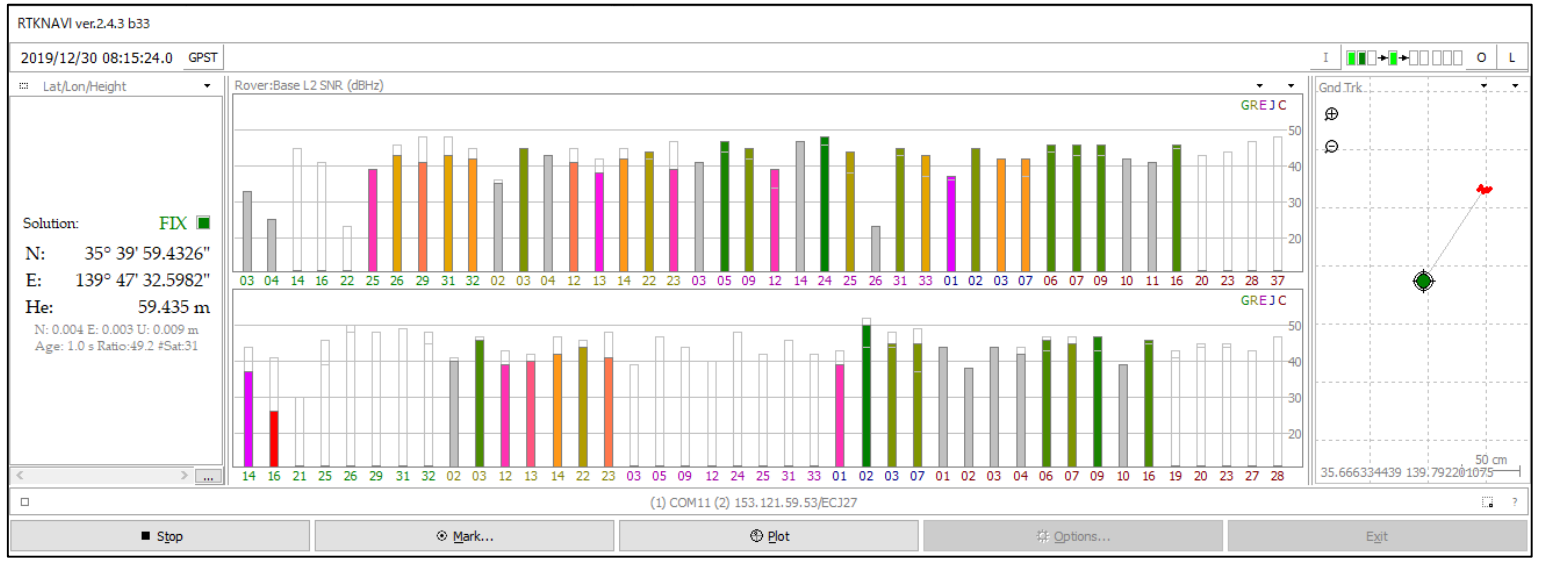
Real time RTK engine that supports many receivers.

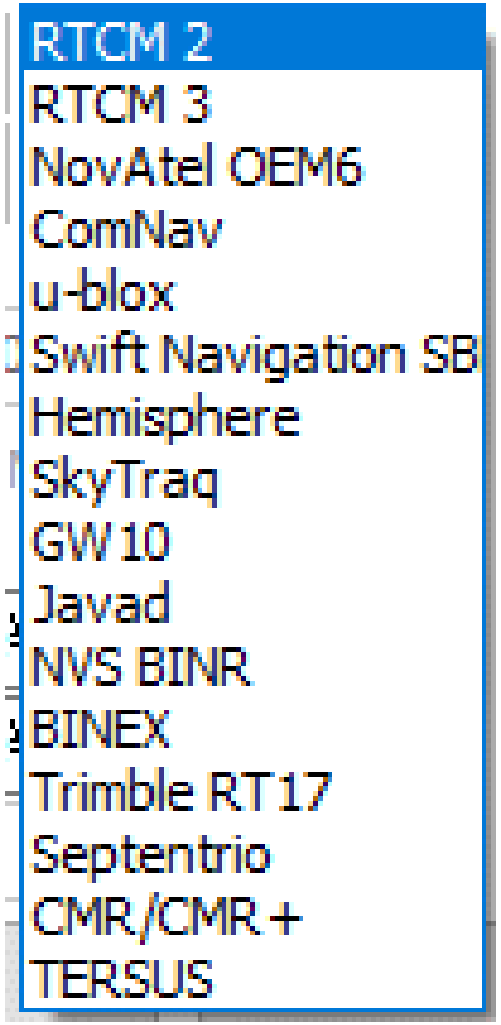
To use RTKNAVI, first you should set receiver to output “raw data”.

“raw data” means binary observation message include RTCM.

RTKNAVI decodes this “raw data” and calculate RTK solution.

Here, I show the example using u-blox receiver.





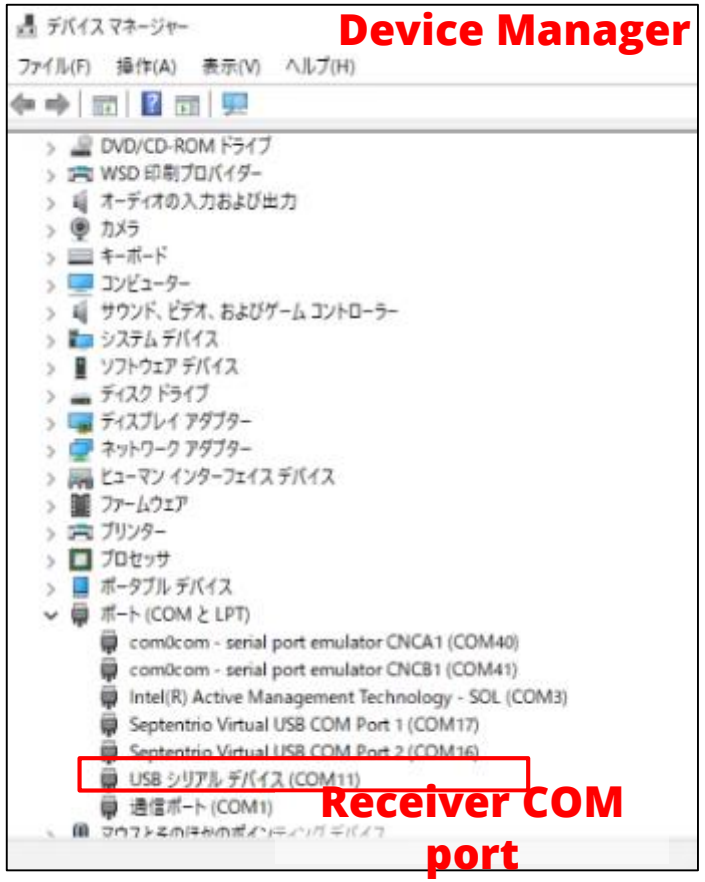
Supported “raw data” formats

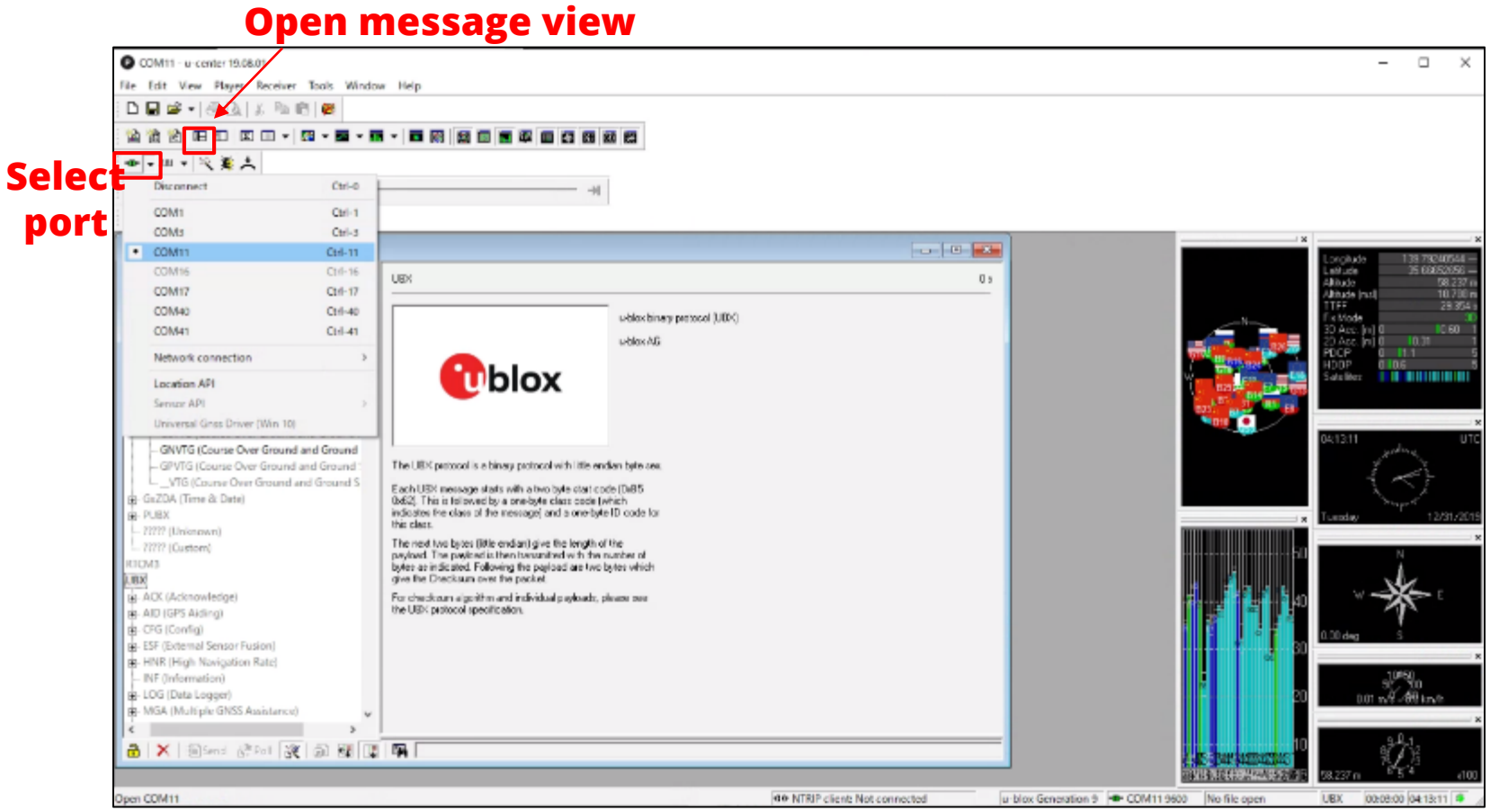
4. RTK configuration on rover

◆RTK (RTKNAVI)

Receiver configuration on u-center.

First, select COM port of the receiver and connect. Then open “message view”.



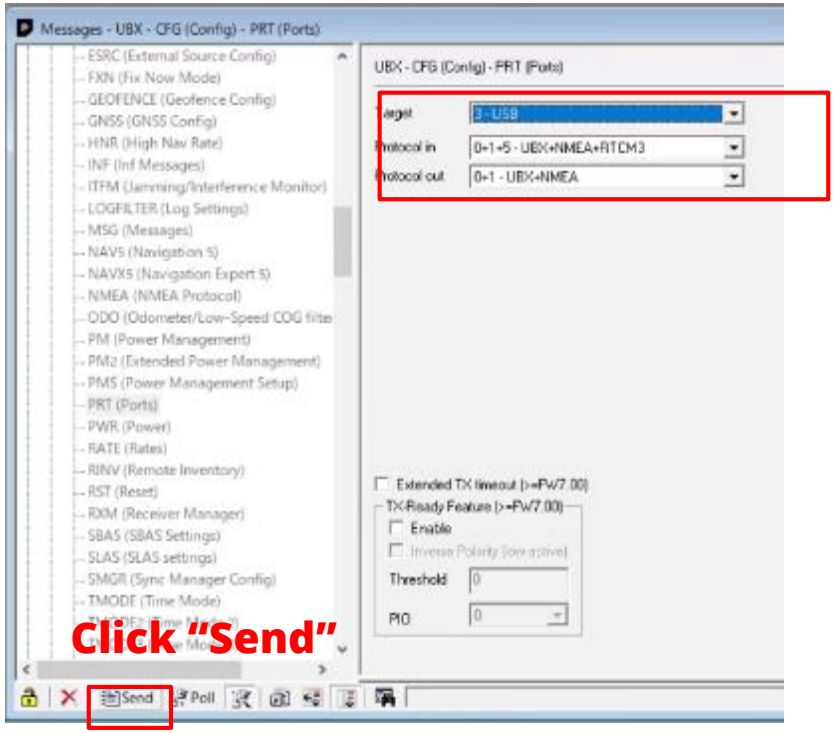


4. RTK configuration on rover

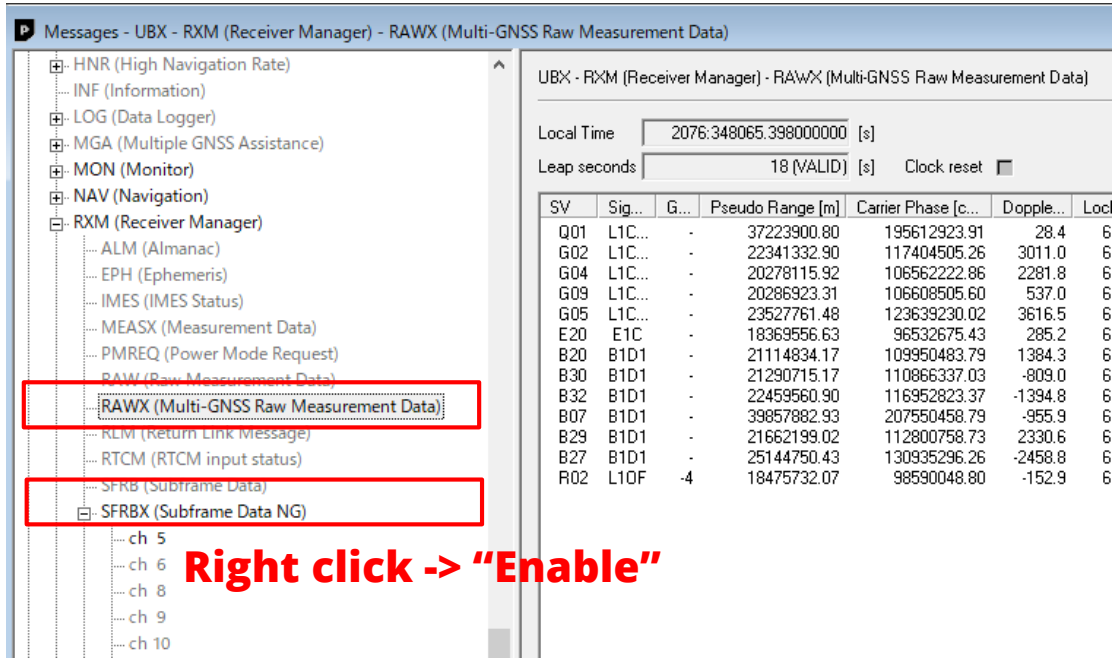
◆RTK (RTKNAVI)

Receiver configuration on u-center. Open message view from View>Message View.

You need to click “send” after change configuration.



Setting to output UBX format (UBX-CFG-PRT)



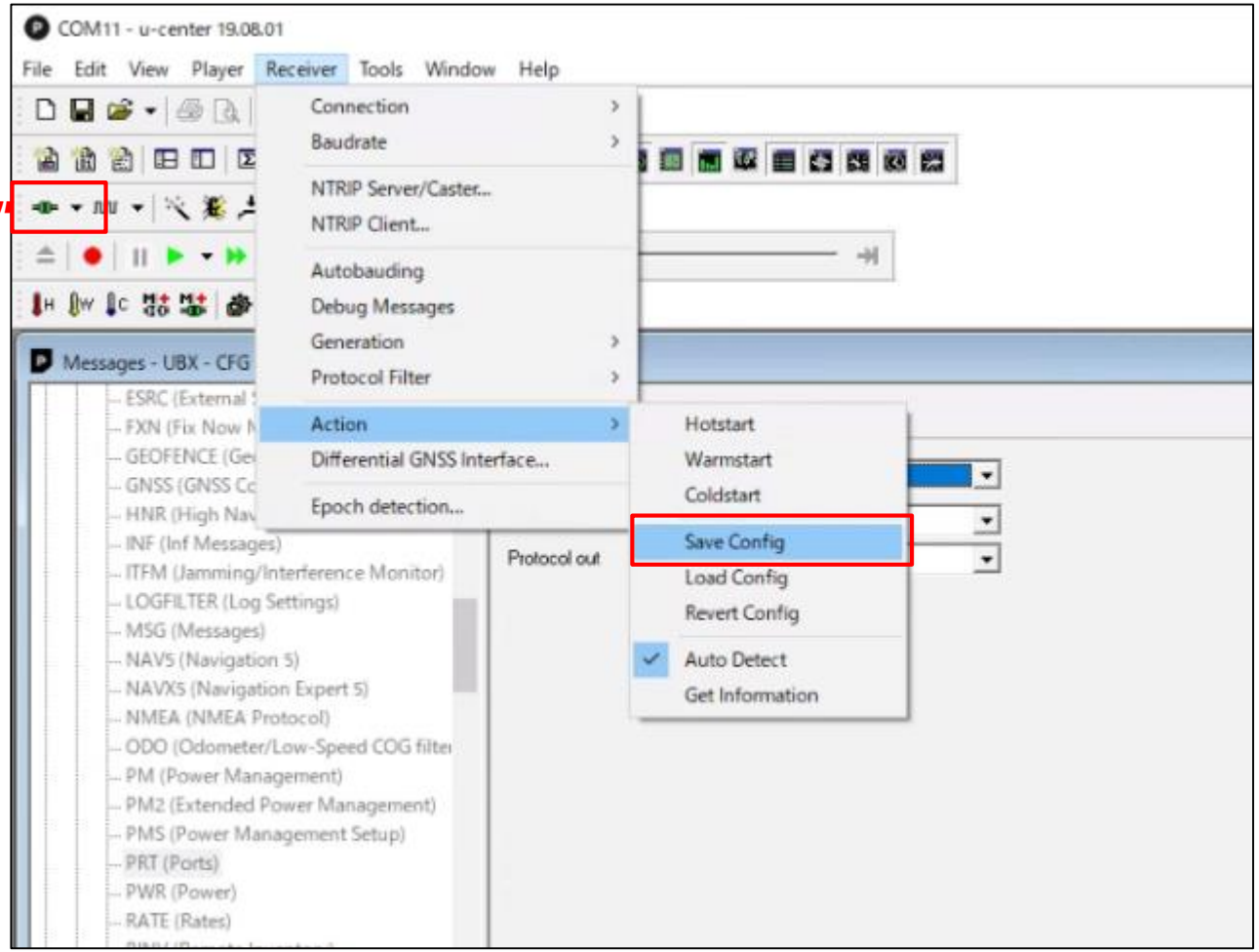
Enable output of RAWX & SFRBX (UBX-RXM)

4. RTK configuration on rover

◆RTK (RTKNAVI)

After receiver configuration was completed, save it and disconnect receiver.

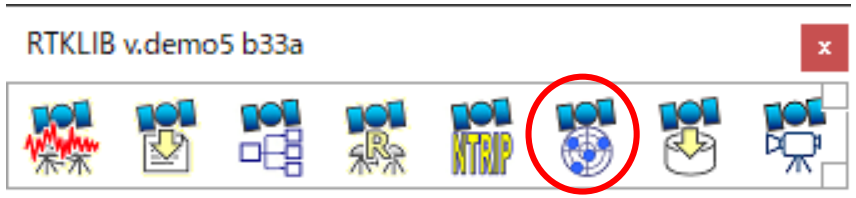
"Disconnect"

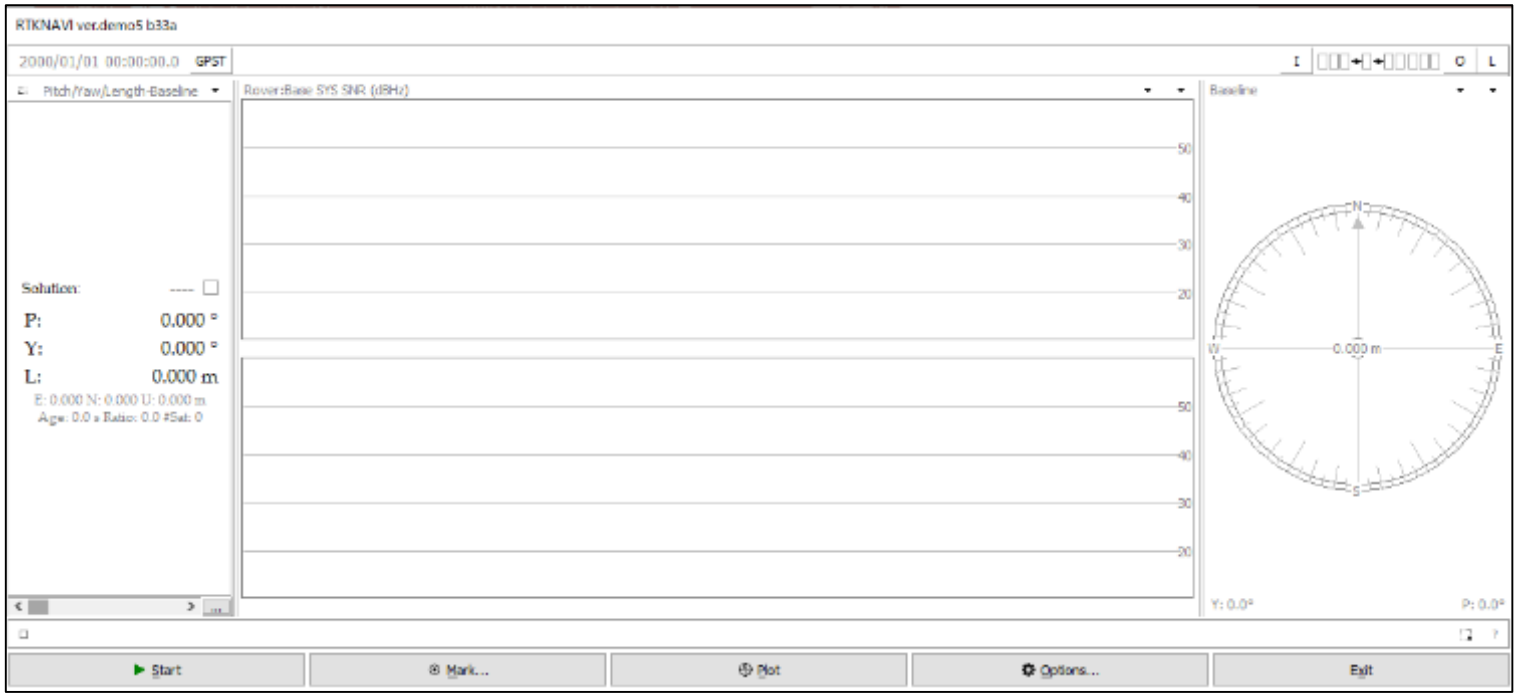


4. RTK configuration on rover

◆RTK (RTKNAVI)

Open RTKNAVI.

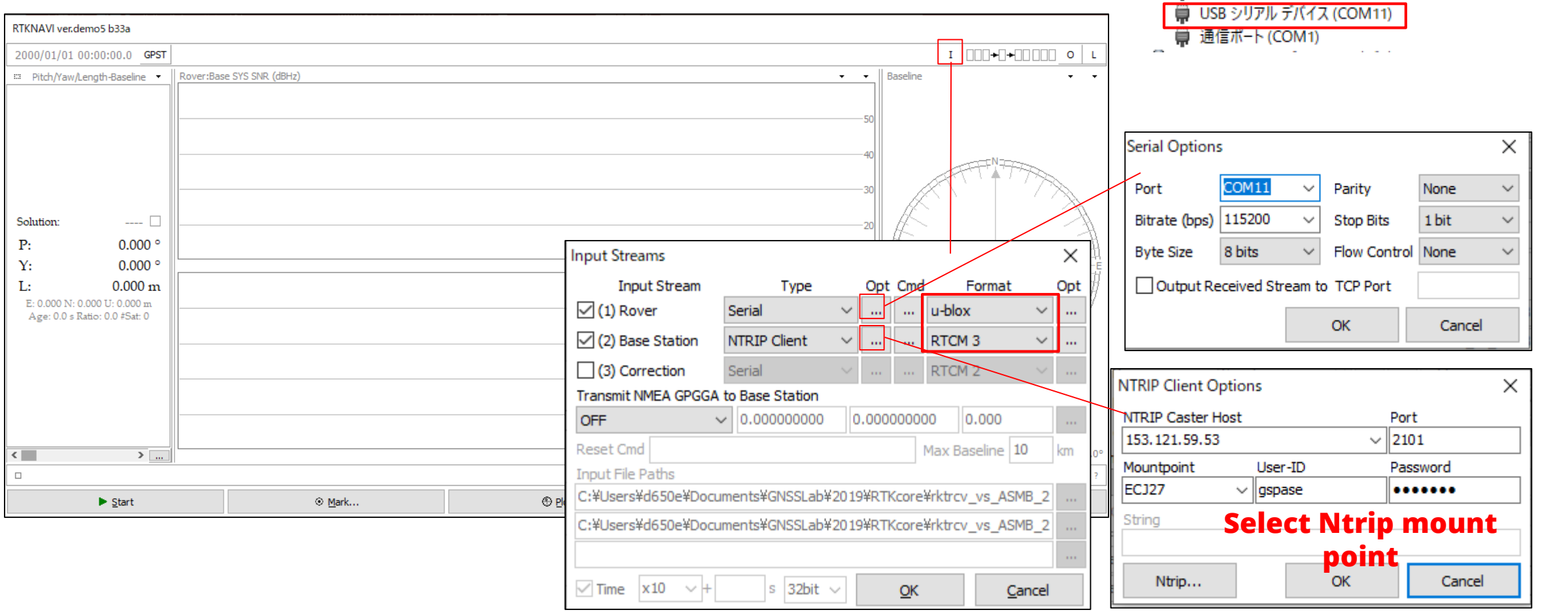




4. RTK configuration on rover

◆RTK (RTKNAVI)

Set input stream.

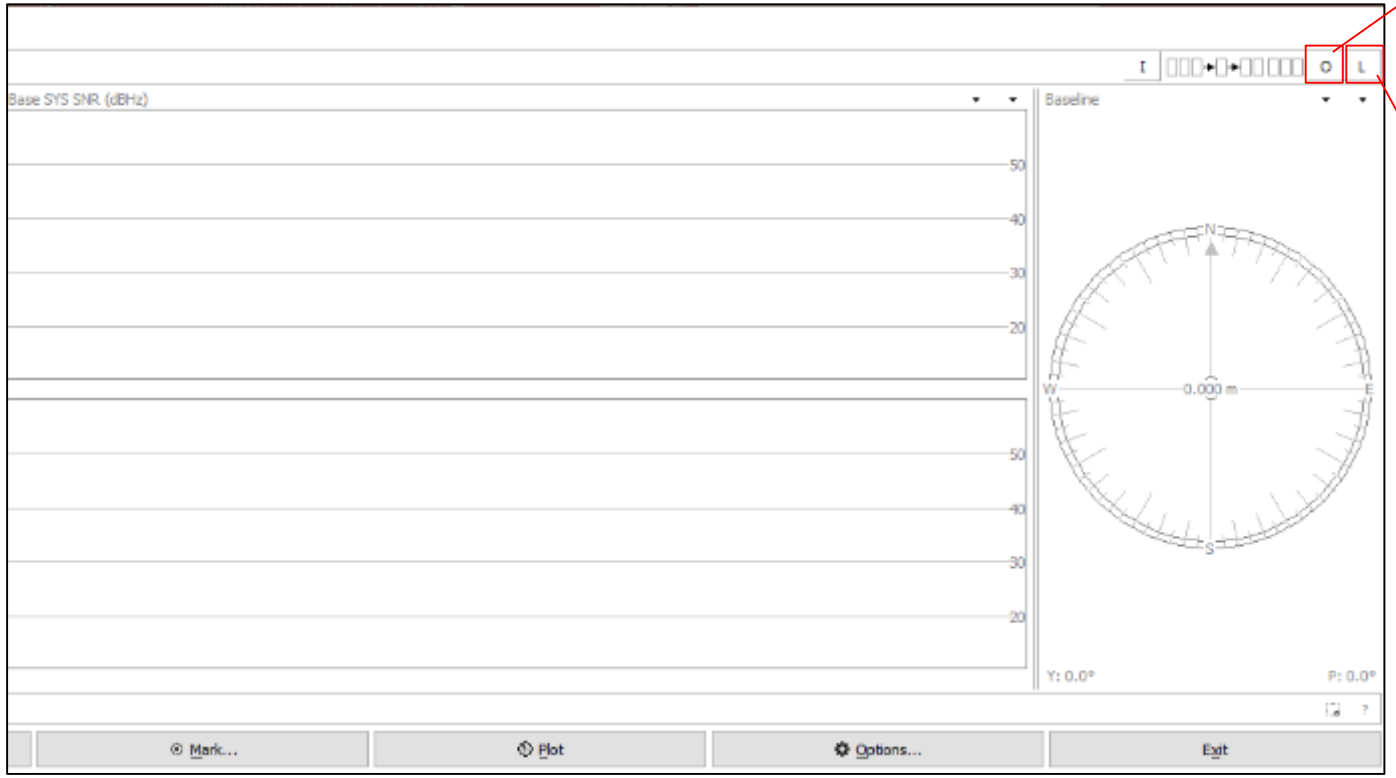


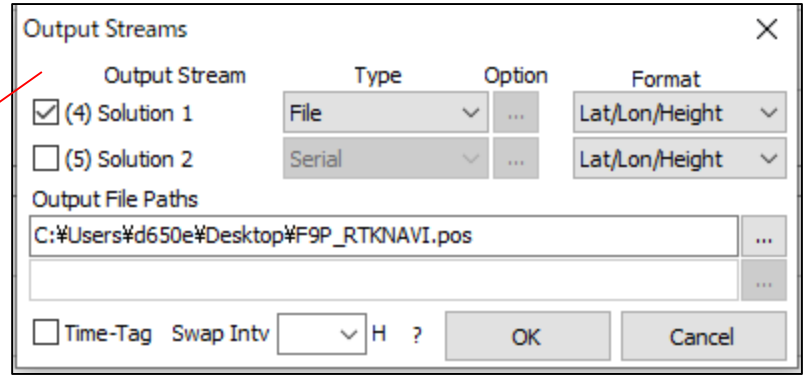
4. RTK configuration on rover

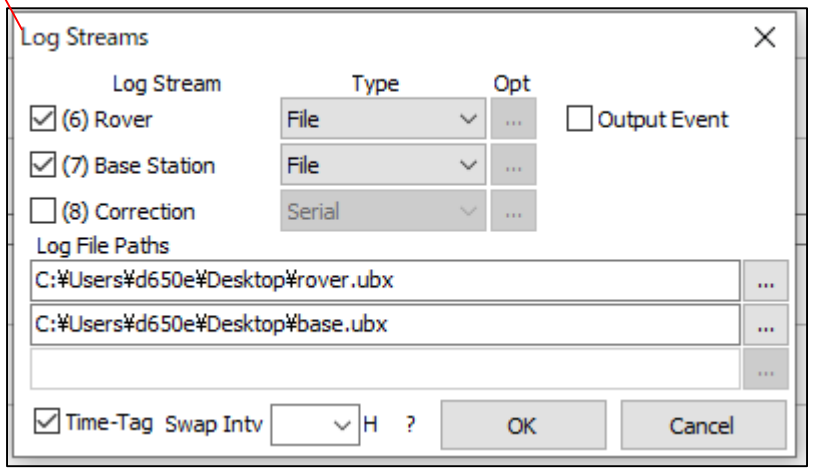
◆RTK (RTKNAVI)

Set output stream & log stream.

Here the RTK position will be written to the file.
Also you can choose other option (TCP, Serial)
according to your use case



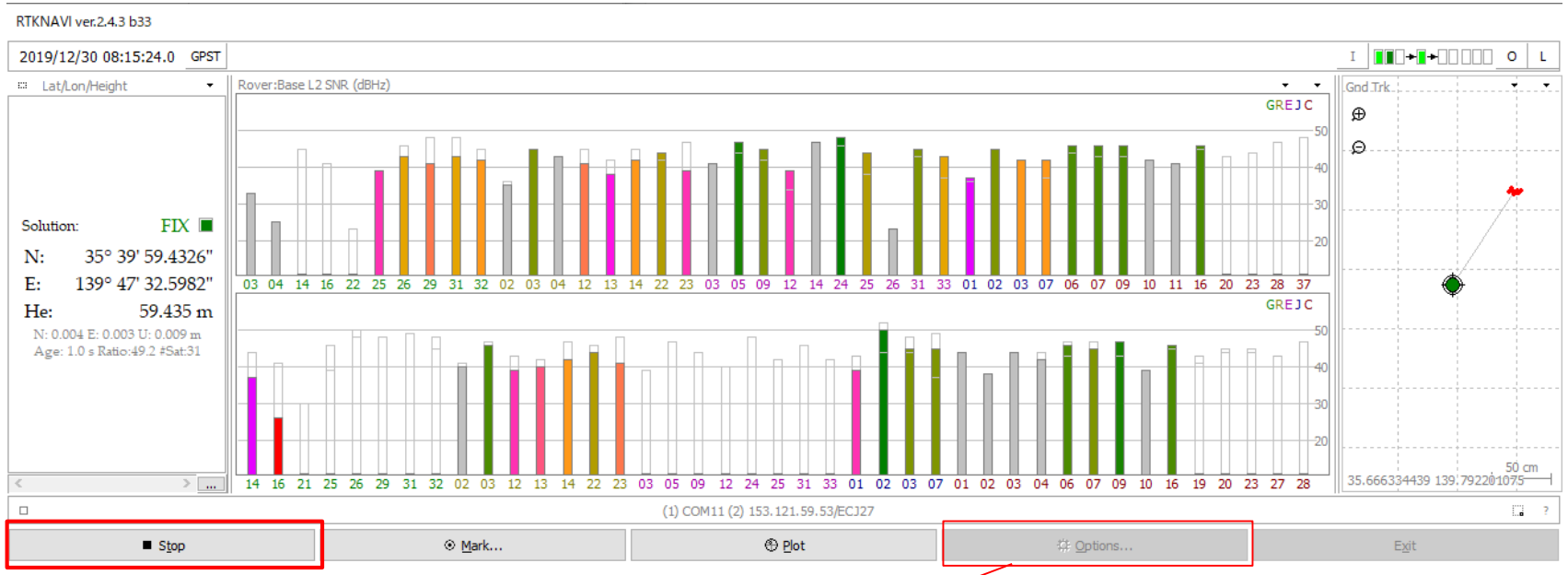


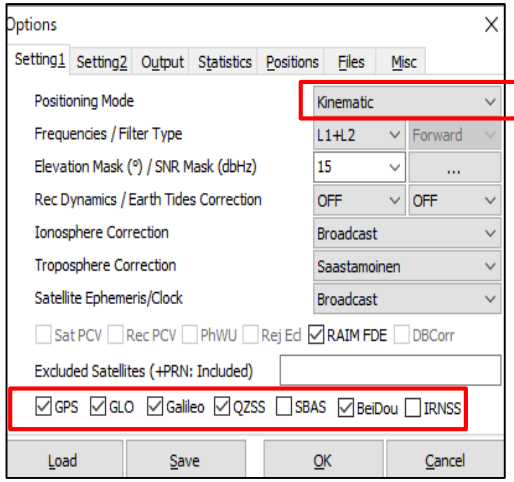


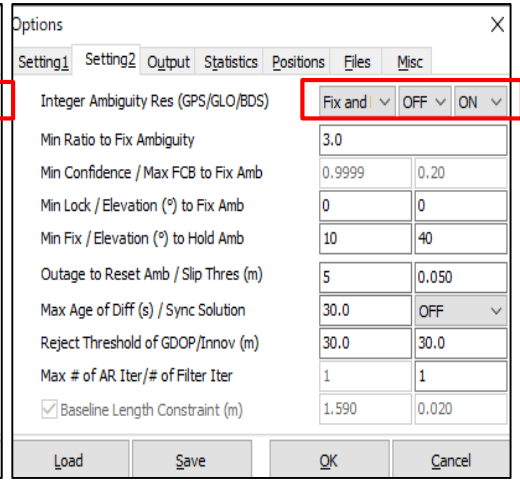
4. RTK configuration on rover

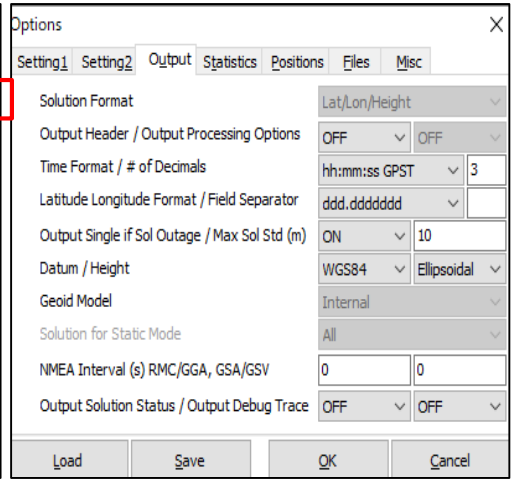
◆RTK (RTKNAVI)

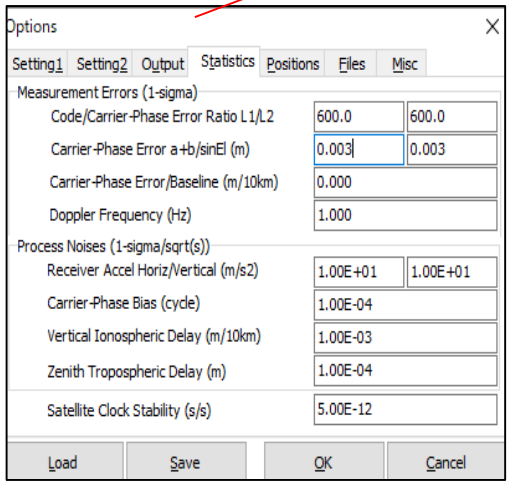
Set option to calculate RTK.
After option setting, click
“Start” and then RTK starts.

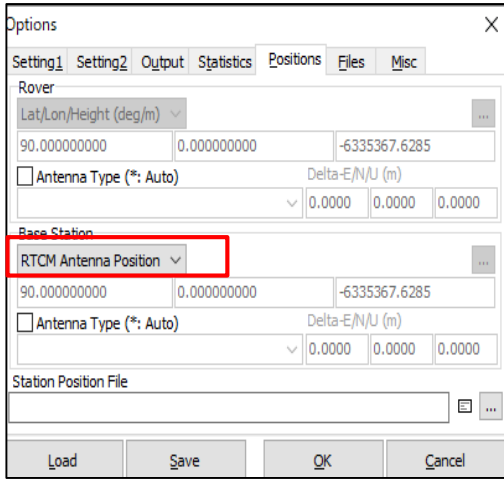






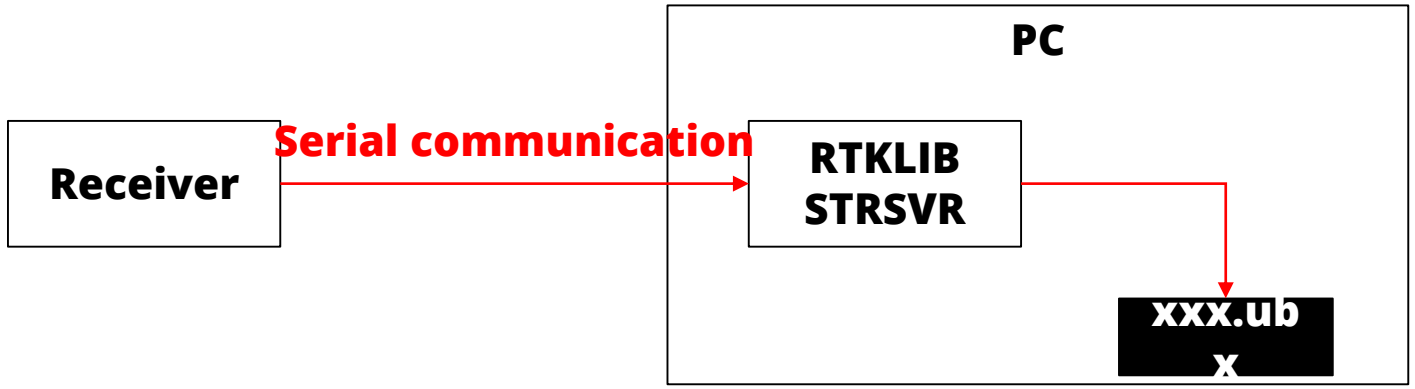






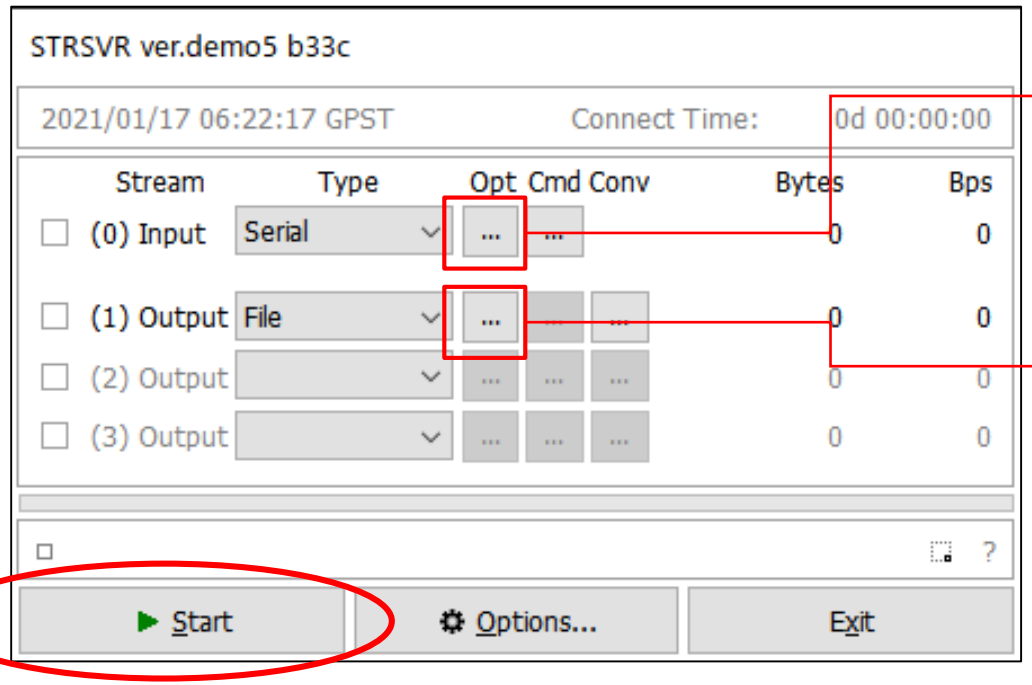
5. GNSS raw data recording

- ◆RTK post processing need GNSS raw data.
- ◆After change the configuration of the receiver to output raw observation, you need to record it.
- ◆Most of the receivers output its data stream by serial communication.
- ◆Easy way to record the data on PC is use RTKLIB.

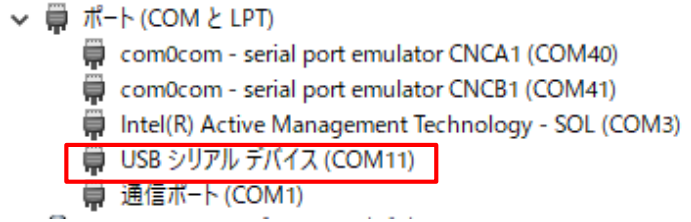


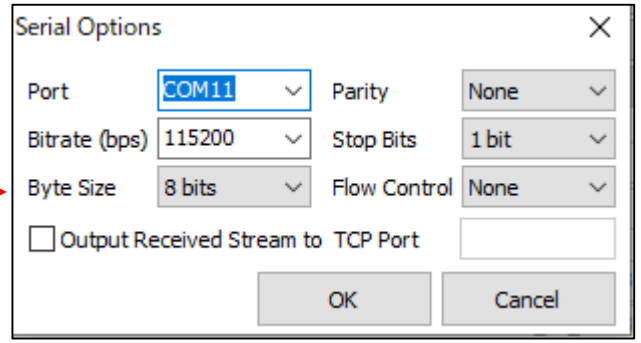
5. GNSS raw data recording

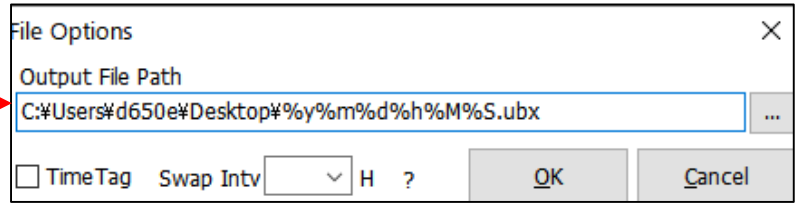
◆Data recording (STRSVR)

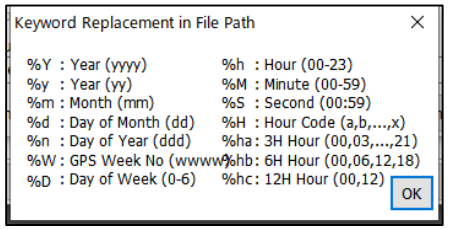


Start recording







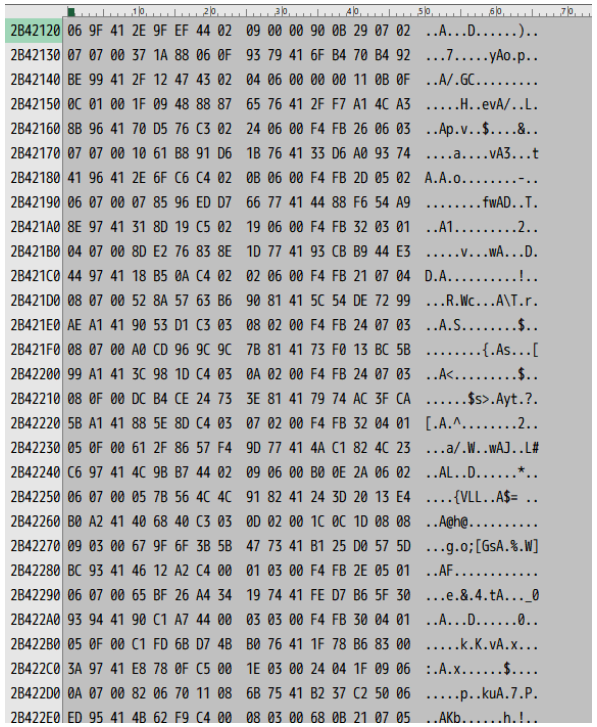


File name Tips

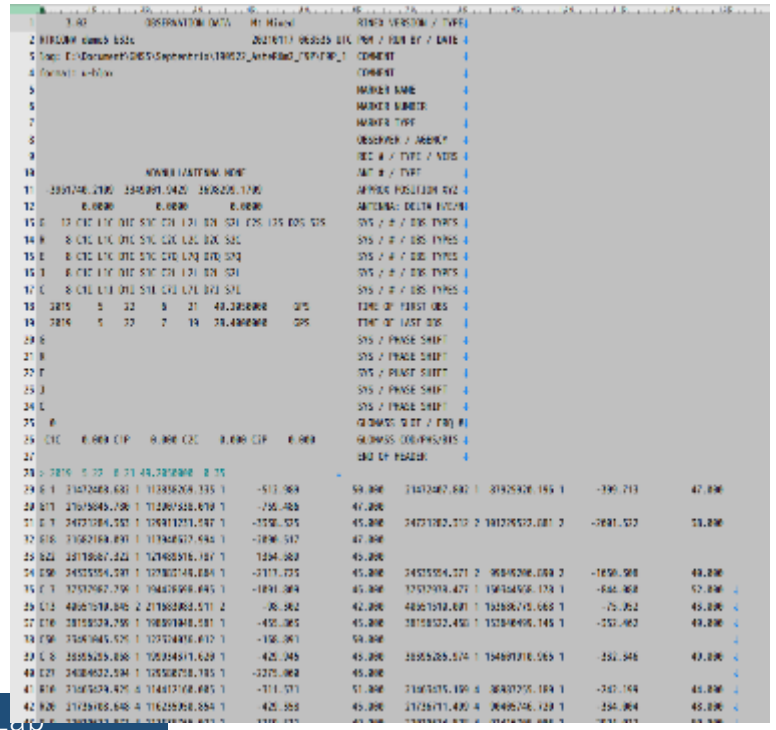
6. GNSS raw data convert

- ◆GNSS raw data is normally original binary format by receiver manufacturer.
- ◆To use raw data on third party RTK software, we need to convert it to **RINEX** format.
- ◆RTKCONV on RTKLIB can convert several manufacturer's receiver data.
- ◆About RINEX format > https://www.igs.org/wg/rinex/

xxx.ubx **original format (Binary)**

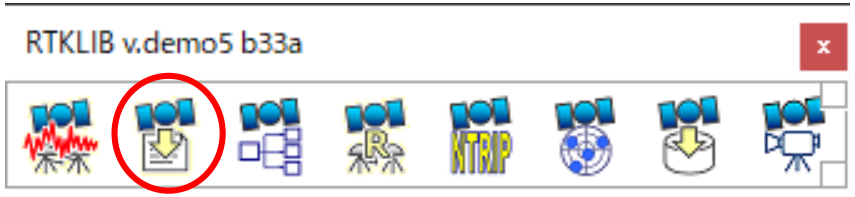


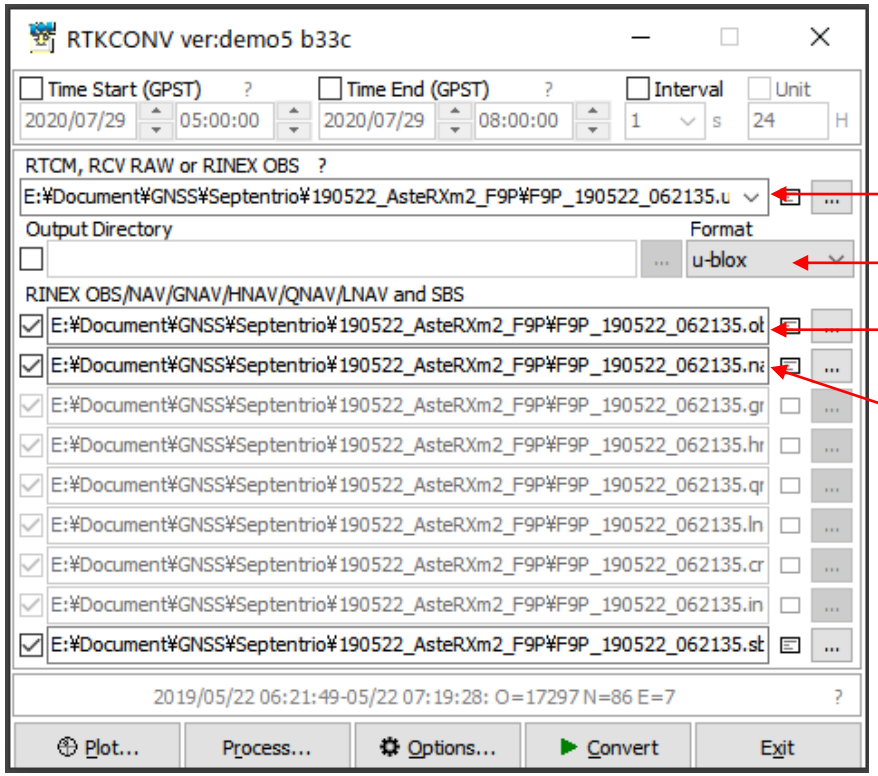
xxx.obs **RINEX format (ASCII)**



6. GNSS raw data convert

◆Data conversion (RTKCONV)





GNSS raw data

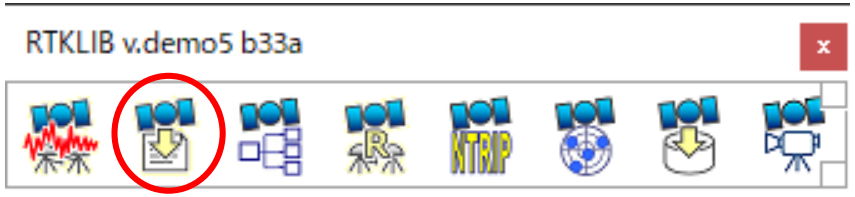
Select receiver manufacturer

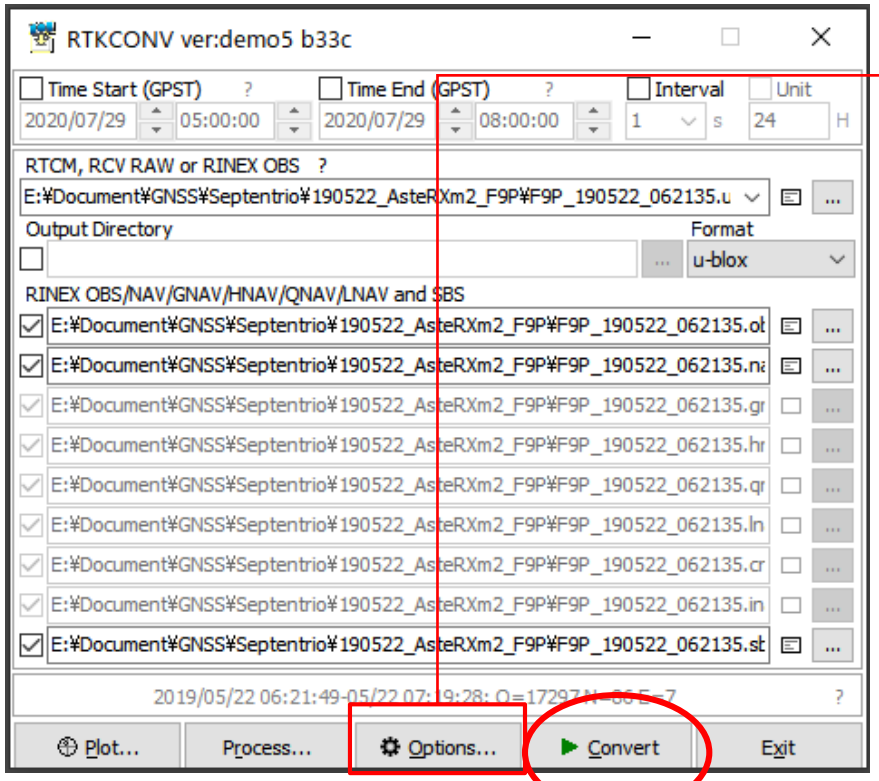
.obs is observation file with RINEX format

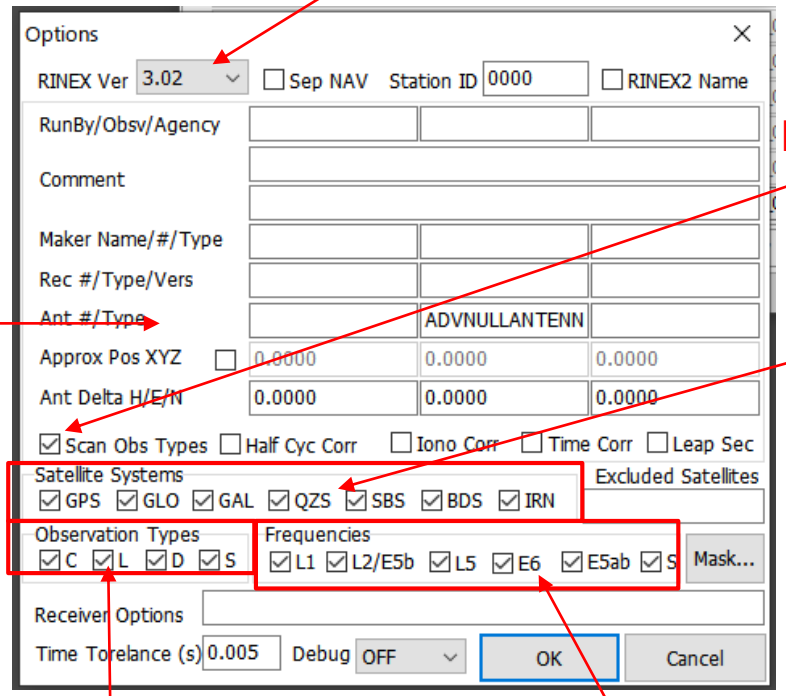
.nav is ephemeris file with RINEX format

6. GNSS raw data convert

◆Data conversion (RTKCONV)







Output RINEX version. Recommend upper 3.02

Recommend check "Scan Obs Types"

Satellite constellations you want to output

Recommend check all
C: Code range
L: Carrier phase
D: Doppler shift
S: SNR

GNSS frequencies you want to use
Recommend check all for general purpose

Start conversion

6. GNSS raw data convert

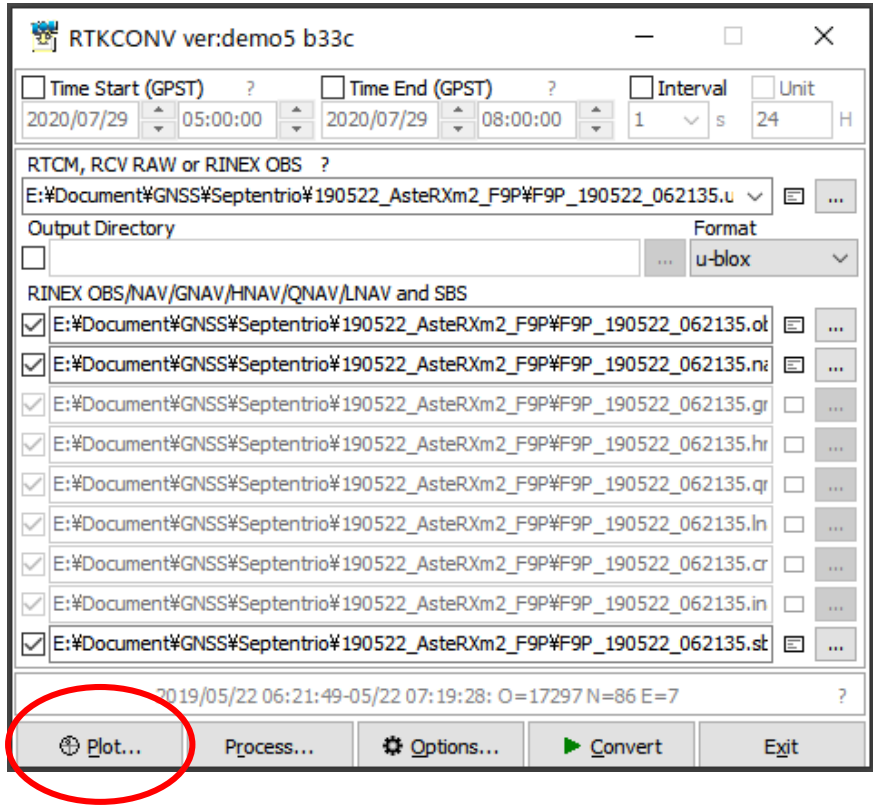
◆Data conversion (RTKCONV)

After conversion you can find .obs file and .nav file which can open with text editor.

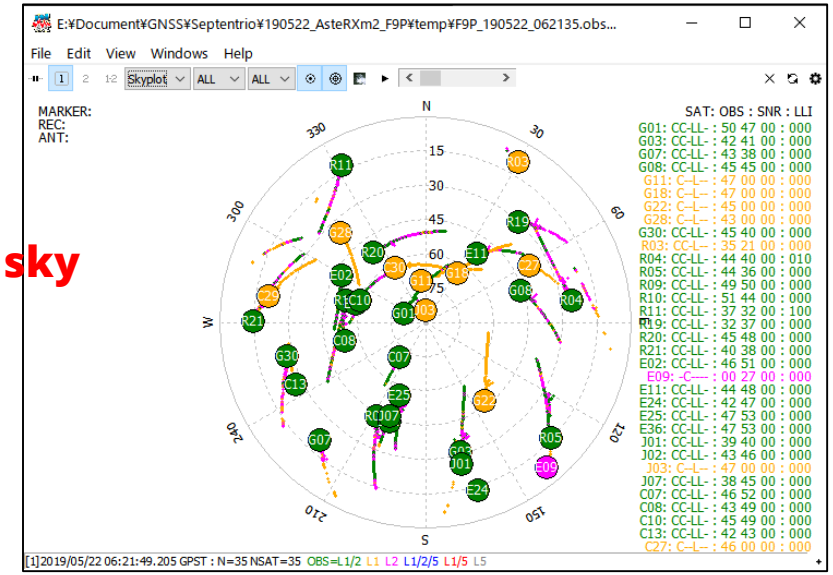
6. GNSS raw data convert

◆Data conversion (RTKCONV)

You can also check RINEX format data graphically by RTKPLOT.



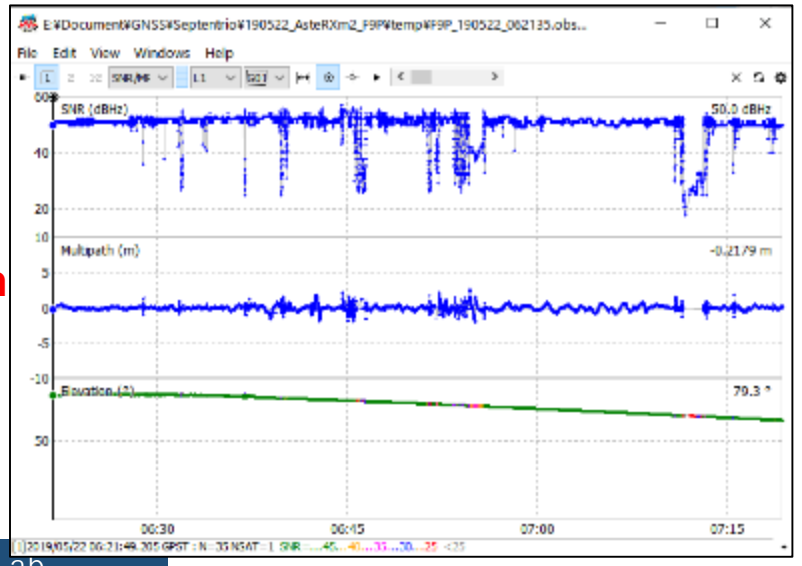
Satellite sky plot



SNR

Multipath

Elevation



7. Useful web sites

◆Useful web sites for your RTK experiment

- http://www.denshi.e.kaiyodai.ac.jp/gnss_tutor/base_station.html
- https://home.csis.u-tokyo.ac.jp/~dinesh/
- http://www.rtklib.com/