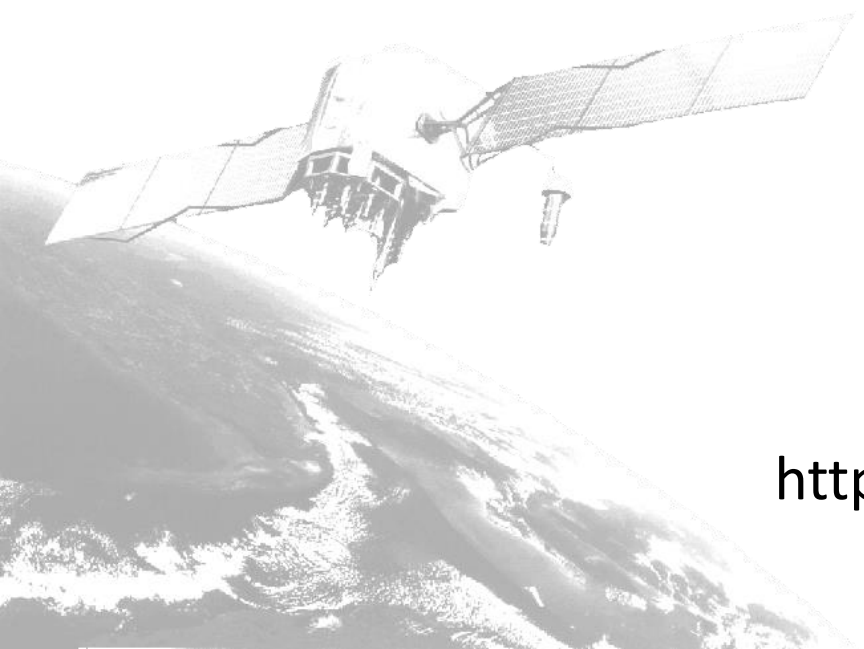


# Low-cost RTK-GNSS for Agriculture

Procedure to set up the RTK-GNSS and its application for agriculture



Yoshihiro Iwaki, TUMSAT

<http://store.shopping.yahoo.co.jp/agrii/>

# Objective

---

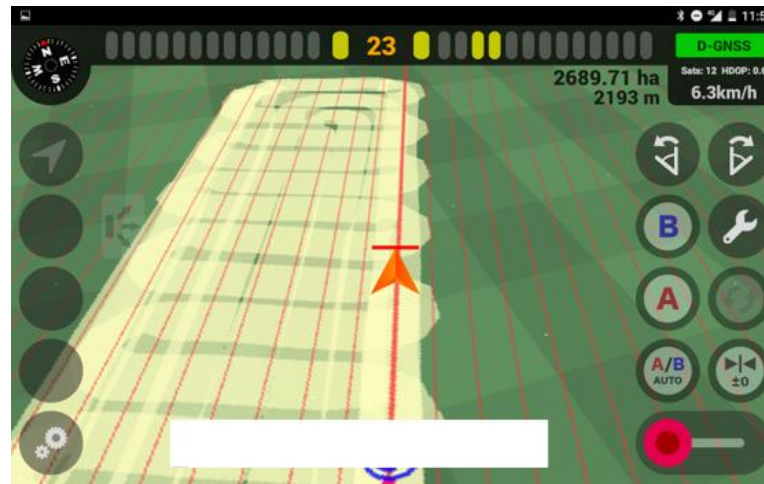
- × Losing sight of work trace for tractor and agricultural machine decrease both the accuracy and efficiency of work
- ✓ Using GNSS for agricultural machine to guide the trace of machine in real-time
  - × The accuracy of normal positioning results by consumer-grade GPS receiver is not enough
  - ✓ **Set up the low-cost RTK-GNSS (cm-level positioning) environment**
- ✓ In the future, cause of agricultural and its machine will be more large-scale cm-level GNSS will be more required.

# Normal positioning results by consumer-grade GPS receiver

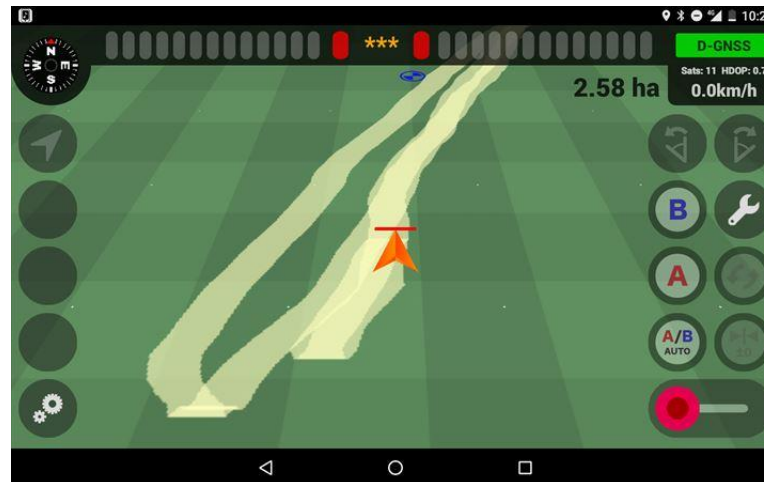


consumer-grade GPS receiver

## Positioning results



Accurate results



Relatively not  
accurate results

**The accuracy is not enough**

# Example case of farming required cm-level positioning

Puddling  
for rice-  
planting



- Before the rice-planting, puddling the soil
- Difficult to confirm the trace of tractor cause of muddy ground
- Over one month for 12ha
- **Under 30cm precision is required**

Spraying  
agrochemical  
with machine



- Arm of machine is 16m
- Difficult to confirm the spread trace cause of wide arm and trace of machine
- 7 times for a year and its takes 2-3days for each. For rice, wheat and soy beans
- **Under 50cm precision is required**

→ **low-cost RTK-GNSS (cm-level positioning)**

# Set up the low-cost RTK-GNSS environment

---

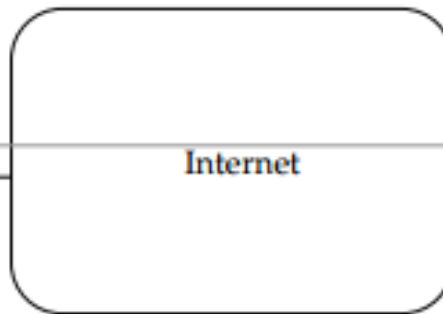
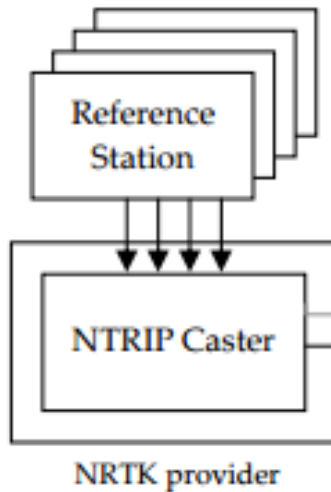
## Equipment

	Base station	Rover	From
PC	Windows VISTA	Windows10	
GNSS receiver	U-blox M8T	U-blox M8T	TUMSAT
Antenna	Tallysman	Tallysman	TUMSAT
Software	RTKLIB ver. 2.4.2 p12	RTKLIB ver. 2.4.2 p12	DL by website <a href="http://www.rtklib.com">http://www.rtklib.com</a>
	u-center_v8.21	u-center_v8.20	
Connection	Wi-Fi	Wi-Fi	

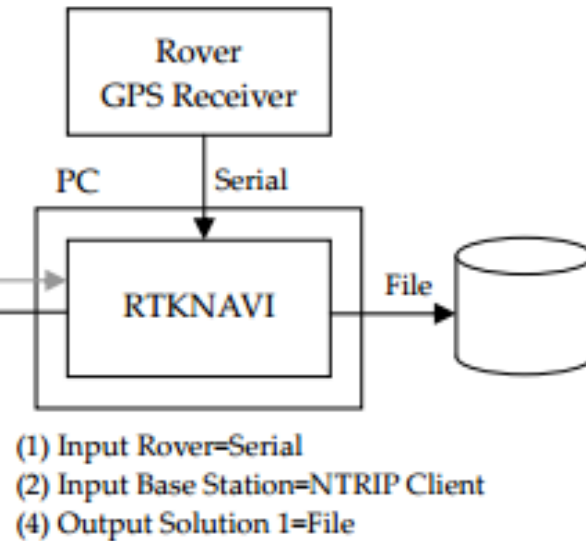
# Set up the low-cost RTK-GNSS environment

- NTRIP caster

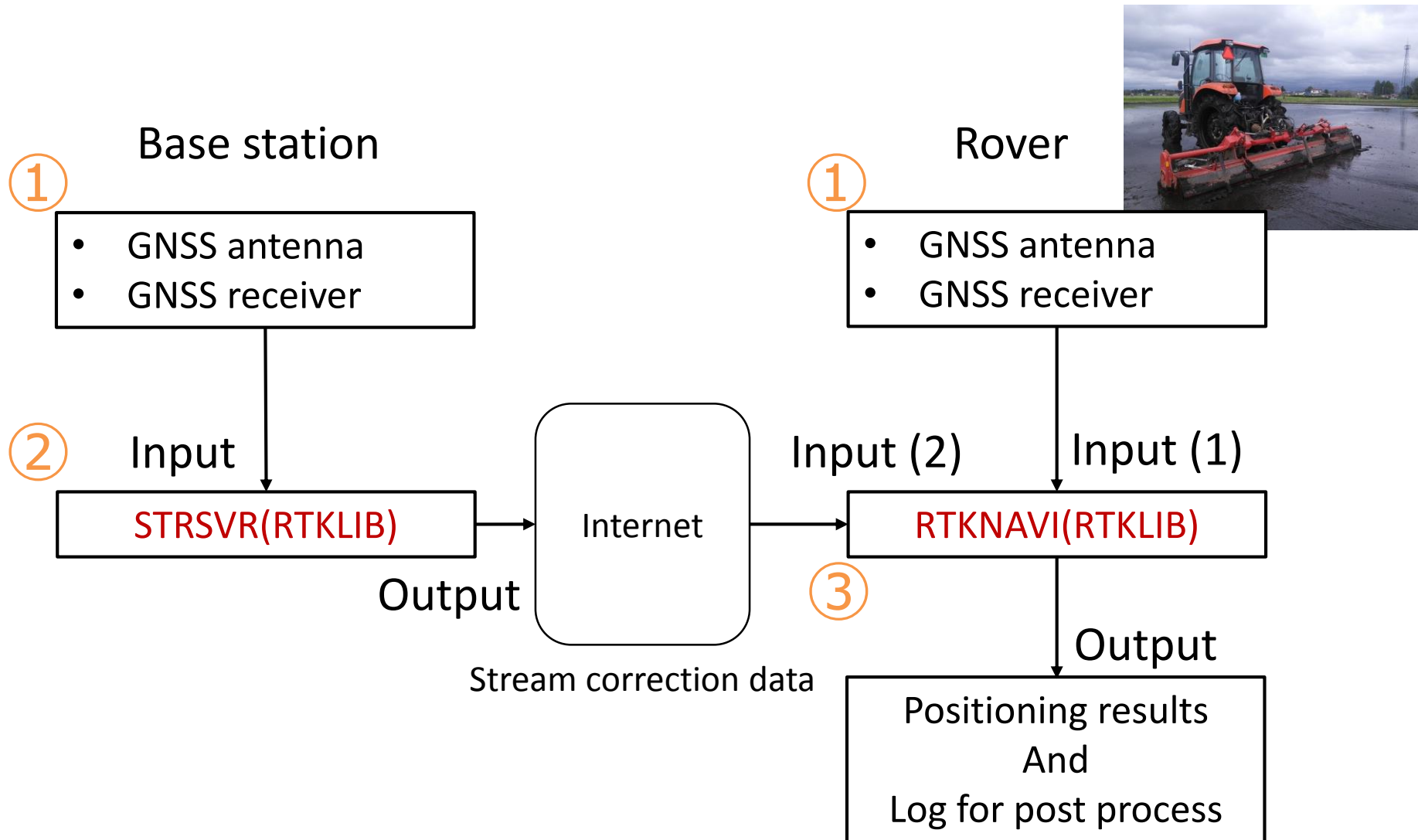
Base station



Rover

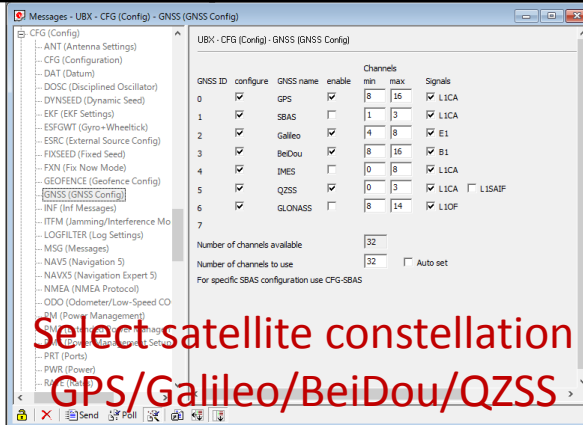


# Set up the low-cost RTK-GNSS environment

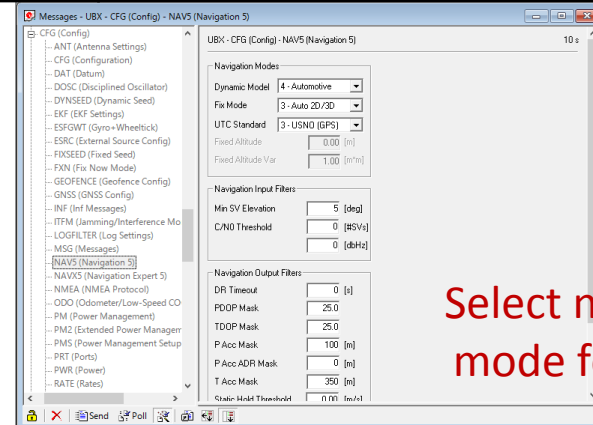


# ① Set up GNSS receiver

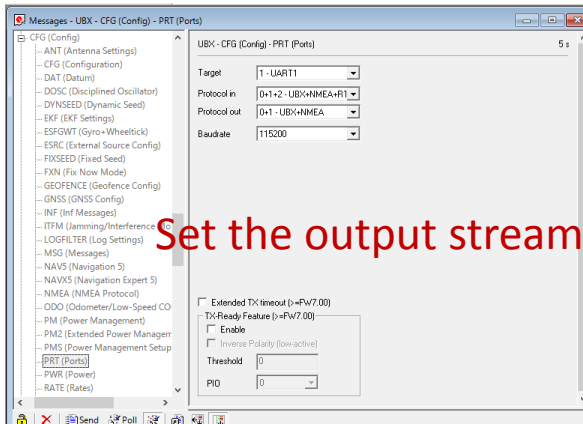
	Base station	Rover
PC	Windows VISTA	Windows10
Receiver	U-blox M8T	U-blox M8T
Software	u-center_v8.21	u-center_v8.20



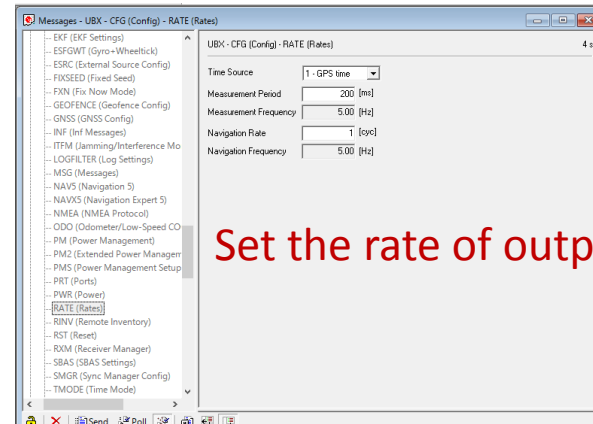
Select satellite constellation  
GPS/Galileo/BeiDou/QZSS



Select navigation mode for NMEA



Set the output stream



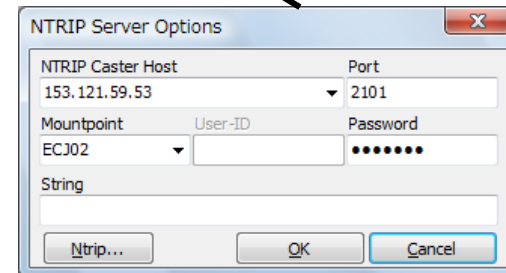
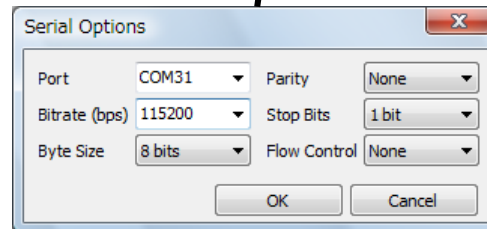
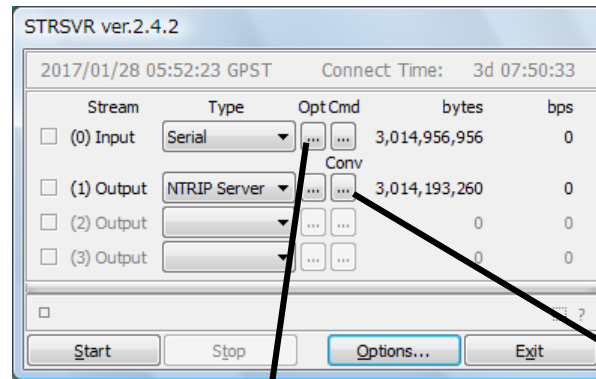
Set the rate of output



## ② Set up STRSVR(RTKLIB) for Base station



Input : GNSS receiver



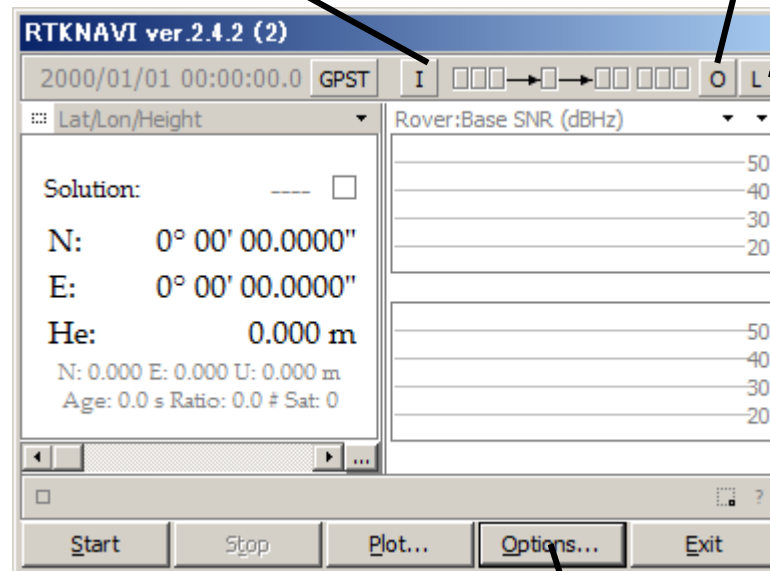
To NTRIP caster setting

### ③ Set up RTKNAVI (RTKLIB) for Rover



Input stream setting

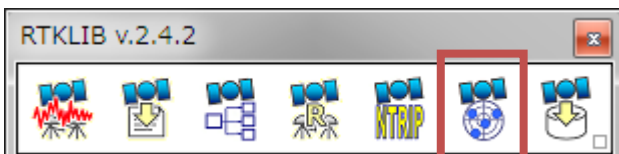
Output stream setting



Log stream setting

RTKNAVI options

# ③ Set up RTKNAVI (RTKLIB) for Rover



## RTKNAVI options

Options

Setting1 Setting2 Output Statistics Positions Files Misc

Positioning Mode: Kinematic

Frequencies / Filter Type: L1 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  Ph-Windup  Reject Ed  RAIM FDE

Excluded Satellites (+PRN: Included):

GPS  GLO  Galileo  QZSS  SBAS  BeiDou

Load Save OK Cancel

Options

Setting1 Setting2 Output Statistics Positions Files Misc

Integer Ambiguity Res (GPS/GLO/BDS): Cont OFF OFF

Min Ratio to Fix Ambiguity: 3.0

Min Confidence / Max FCB to Fix Amb: 0.9999 0.20

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

Number of Filter Iteration: 1

Baseline Length Constraint (m): 0.000 0.000

Load Save OK Cancel

Options

Setting1 Setting2 Output Statistics Positions Files Misc

Solution Format: Lat/Lon/Height

Output Header/Processing Options: ON OFF

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

Latitude / Longitude Format: ddd.dddxxxx

Field Separator:

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: 500.0 100.0

Carrier-Phase Error a+b/sinE (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/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):

36.849283000 140.016611000 256.3125

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

0.0000 0.0000 0.0000

Station Position File:

Load Save OK Cancel

SNR Mask

Rover  Base Station

	Elevation (deg)								(dBHz)
	<5	15	25	35	45	55	65	75	>85
L1	30	32	34	36	36	36	36	36	36
L2	0	0	0	0	0	0	0	0	0
L5	0	0	0	0	0	0	0	0	0

OK Cancel

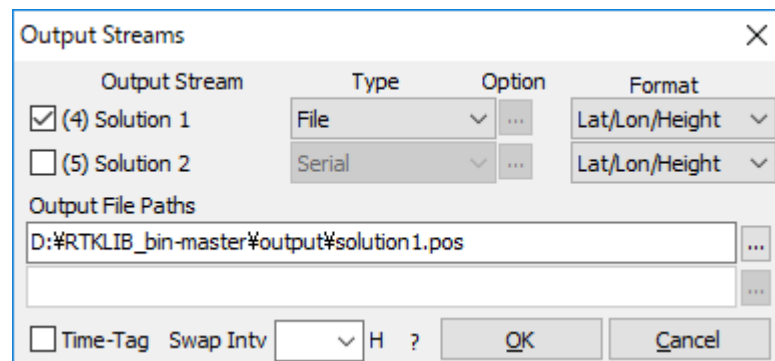
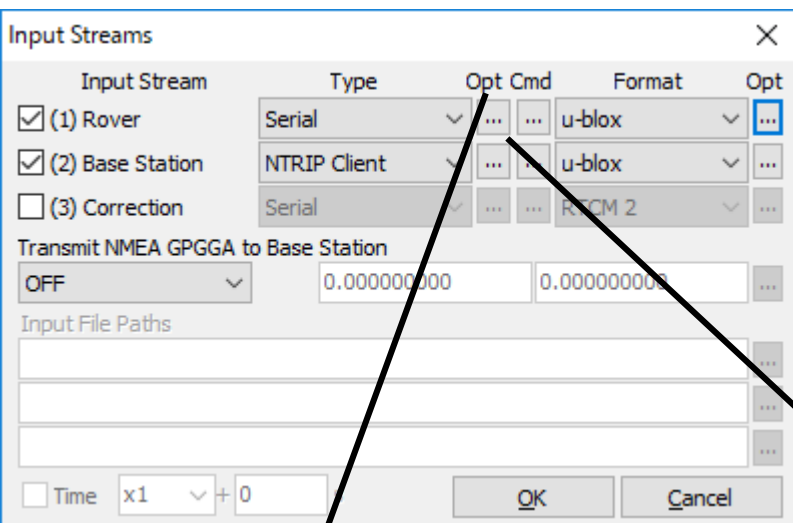
# ③ Set up RTKNAVI (RTKLIB) for Rover



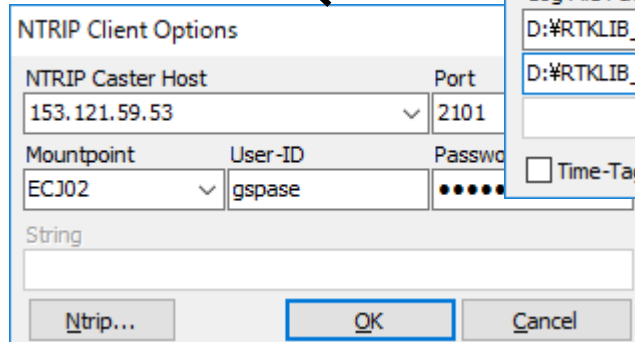
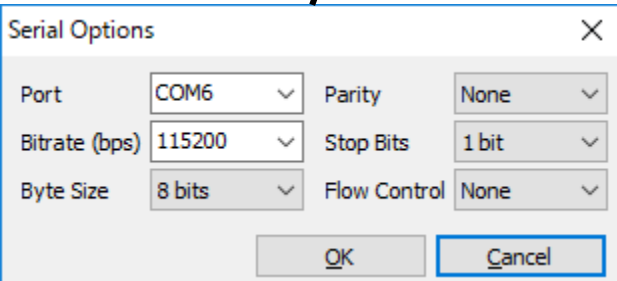
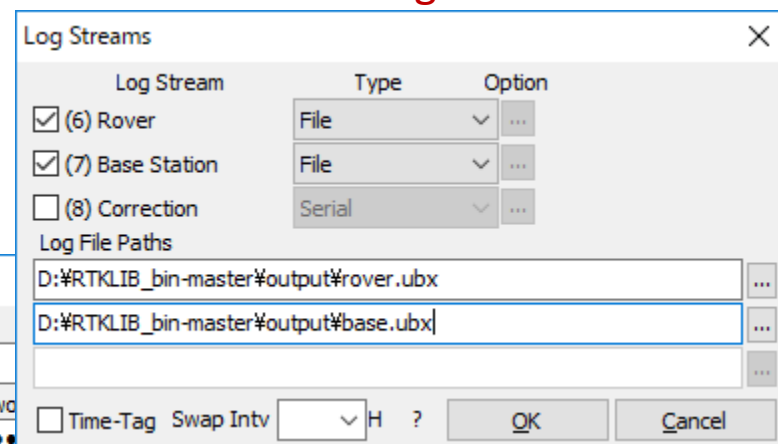
Stream setting

Output

Input



Log



# Setting up antenna for experiments

Base station



Rover  
3 case for  
experiment

Hood (front)



Rotary (back)



Cabin (mid)





# Experiments field



Tochigi pref. Ohtawara  
2017/1/26 AM

# Experiments results

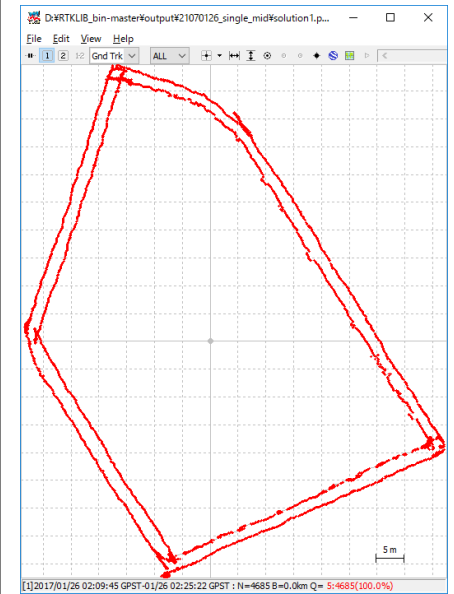
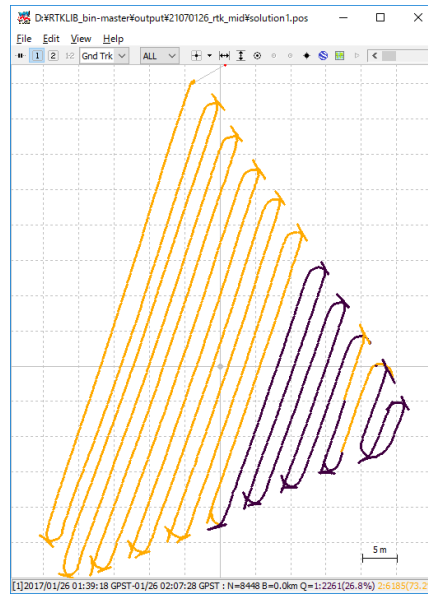
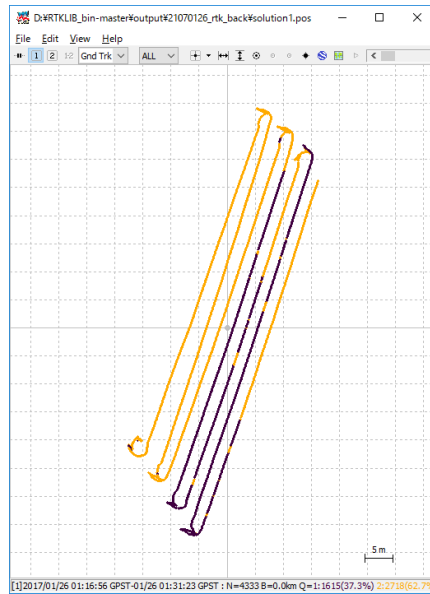
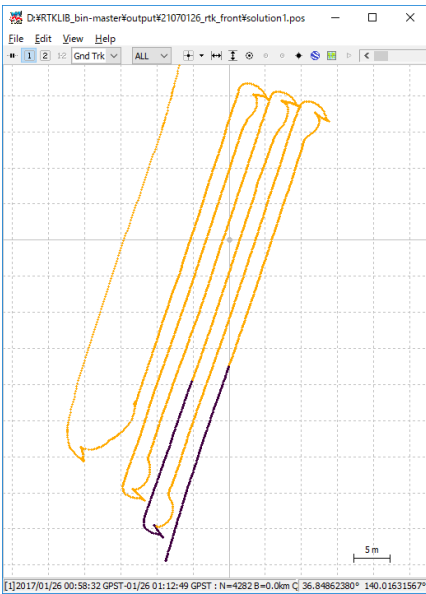
Hood (front)

Rotary (back)

**Cabin (mid)**

RTK-GNSS

Single



- Results seems to accurate enough for farming
- Roof top of cabin is most suitable

## Suggestions by Iwaki-san

---

- Were to buy receivers?
- How to connect Ntrip caster by their own?
- Suitable version of RTKLIB?
- Manuals for tuning options to RTKLIB
- Making applications to navigate tractor easily
- Recommendation for suitable equipment (ex. tablet PC)