



# GNSS analysis software “GSILIB” for utilizing Multi- GNSS data

\*Satoshi Kawamoto, Naofumi Takamatsu

Geospatial Information Authority of Japan

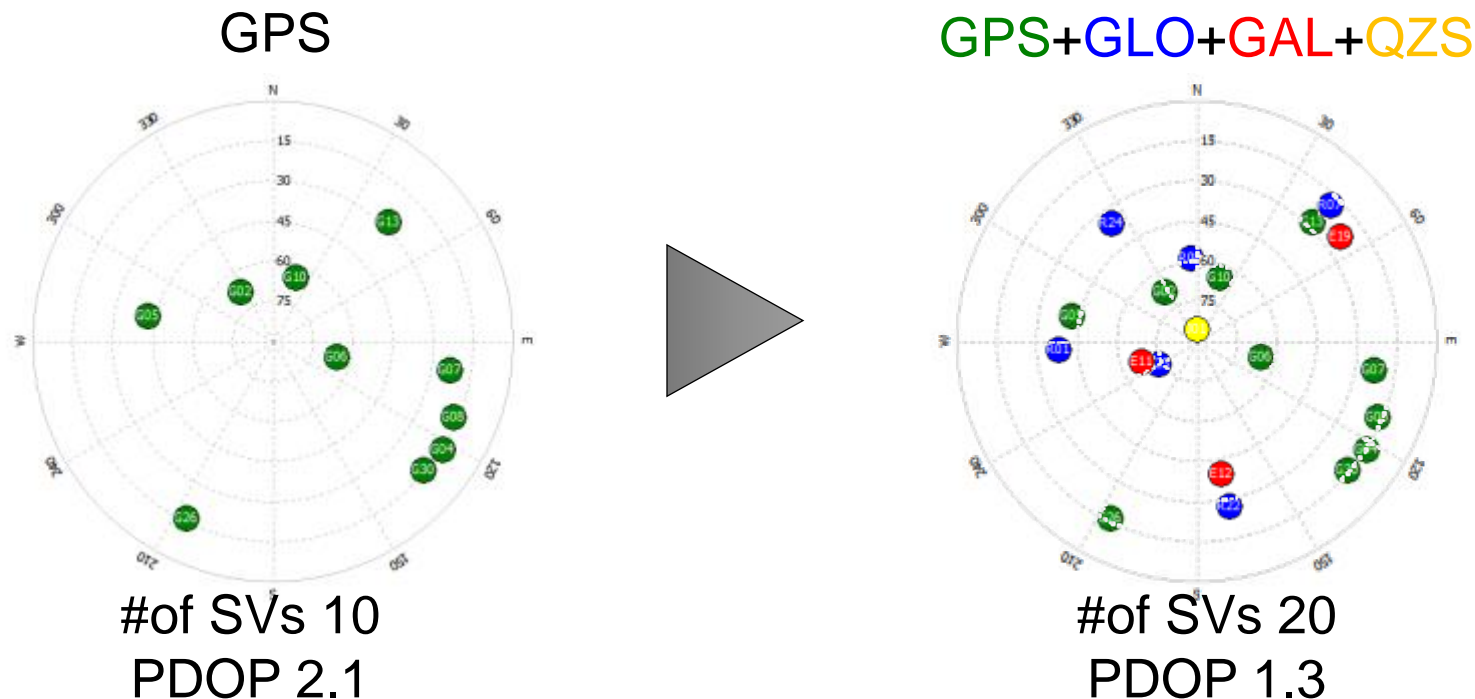
- Benefits of Multi-GNSS constellation
- Biases in Multi GNSS observations
- What is GSILIB?
- Demonstration of GSILIB



# Benefits of Multi-GNSS constellation

# Benefits of Multi-GNSS

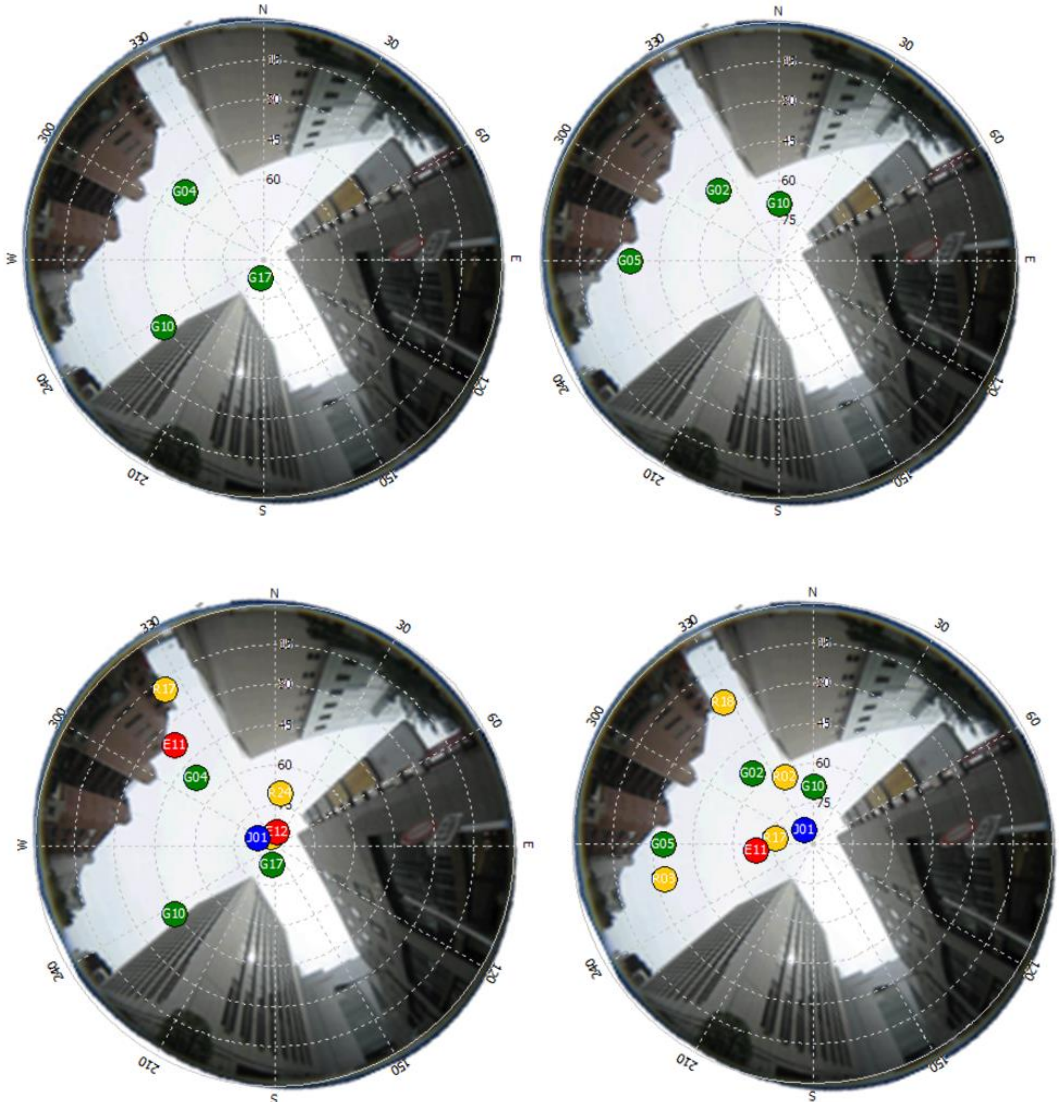
- Significant improvement of number of visible satellites, accuracy, convergence time



2014/08/09 12:00:00 <GPST> Tokyo Japan  
Elevation mask is 15deg  
Plotted by GSI PLOT

# Improvement of satellite visibility

Nov. 13, 2013 at Ginza, Tokyo

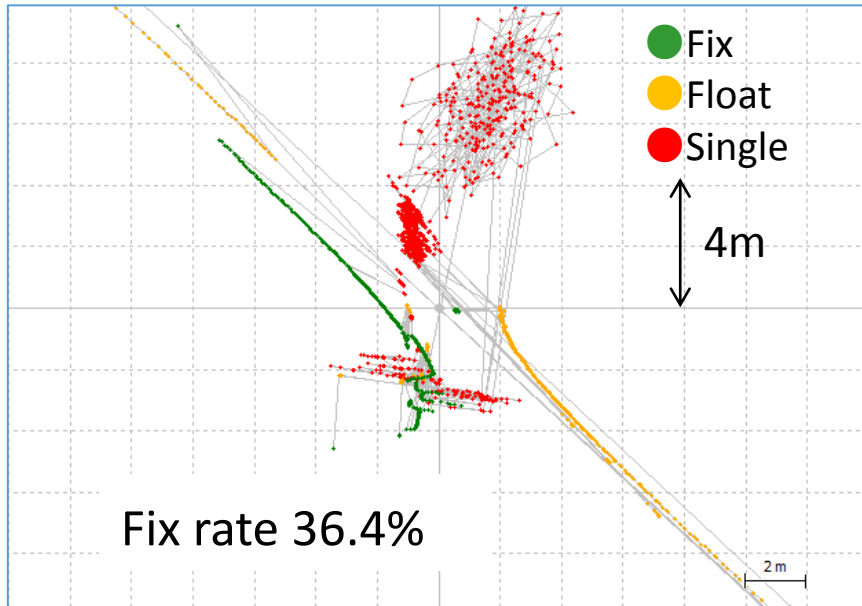


- GPS only:
  - 3 satellites
  - positioning impossible
- Multi-GNSS:
  - **8-9 satellites**
  - enables positioning in urban areas

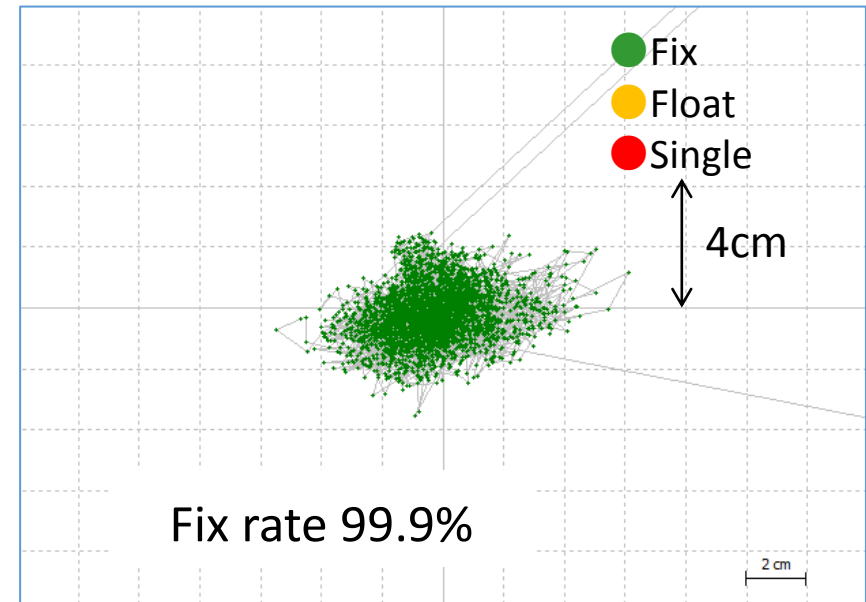


# Improvement of accuracy in urban area

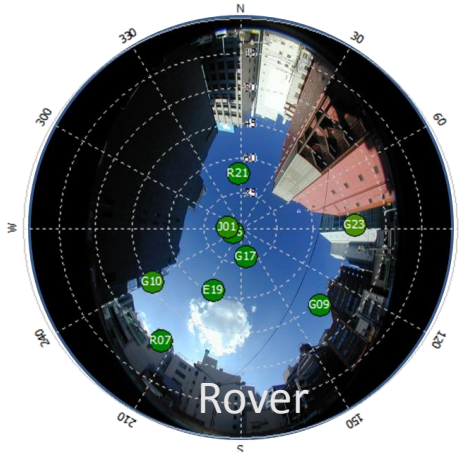
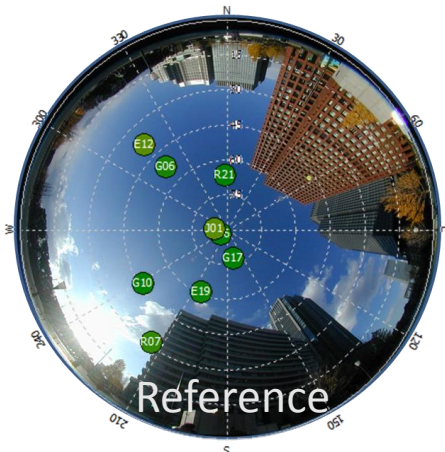
## GPS



## GPS+GLONASS+QZSS+Galileo



## Skyview



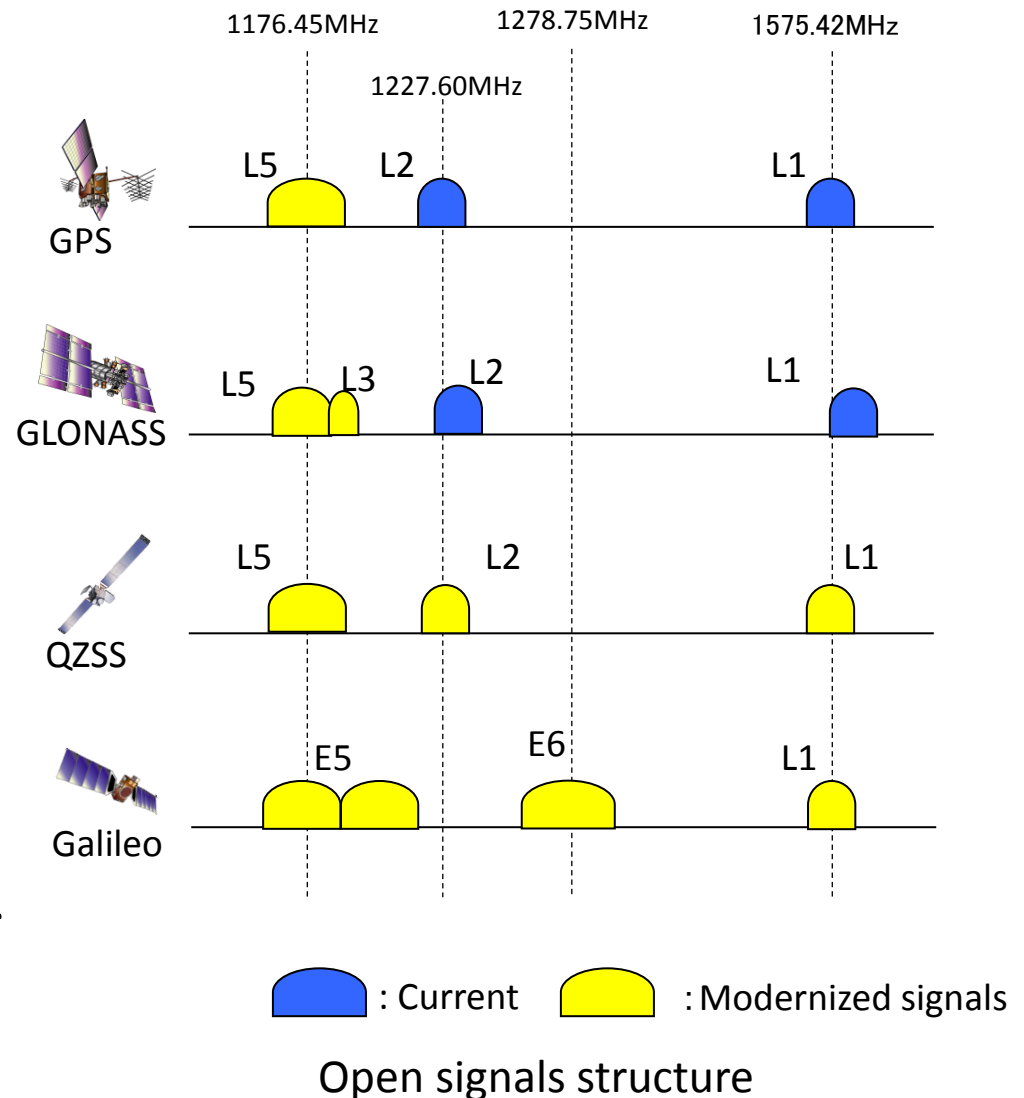
- Positions with GPS only largely degraded in urban area
- Multi-GNSS observation dramatically improved the performance to the cm-level accuracy

# Fast convergence using Multiple frequencies

- Dual frequency (L1 + L2)



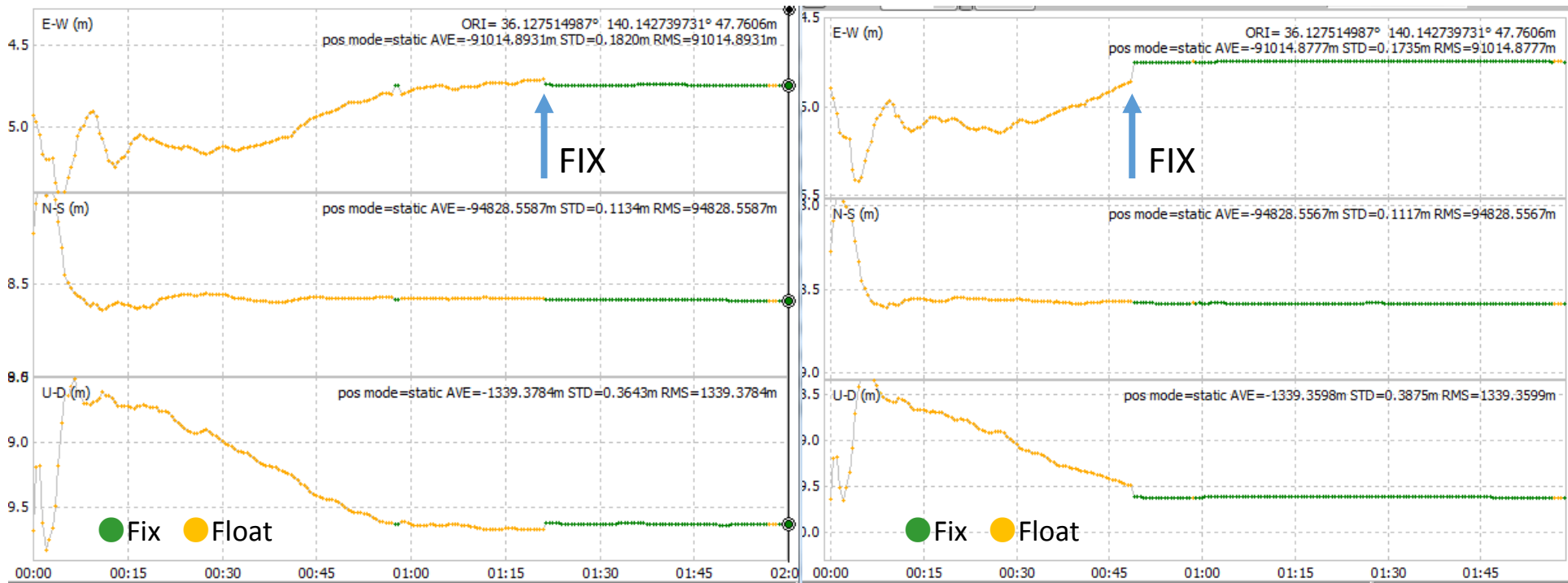
- Triple, Quadruple frequencies (L1+L2+L5+E6)
- Enables fast convergence because of increased number of observables



# Positioning with triple frequencies

**L1+L2**  
(Convergence: 82 min.)

**L1+L2+L5**  
(Convergence: 49 min.)



Jan. 1, 2013 0:00~2:00 (UTC)  
mode: Static baseline:126.3km

- Triple frequency (L1+L2+L5) accelerate the convergence time (TTF: Time to fix)



# Benefits of Multi-GNSS

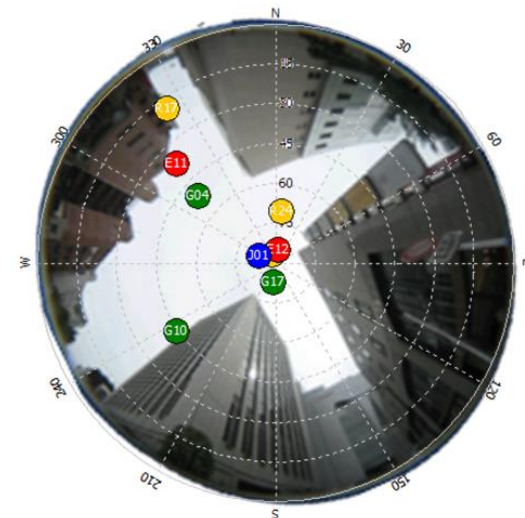
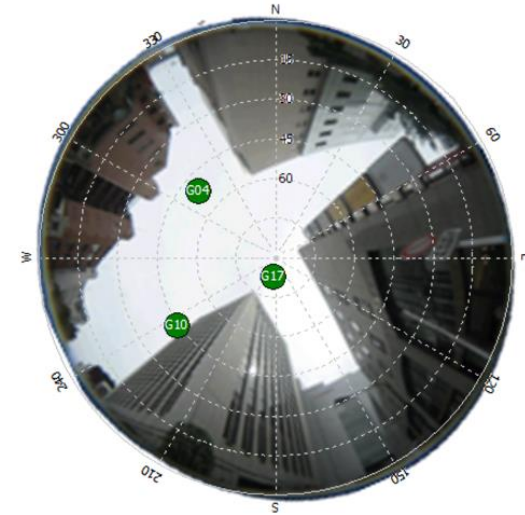
- Increased visible satellites



- Improvement of:
  1. Availability
  2. positioning accuracy
  3. convergence time



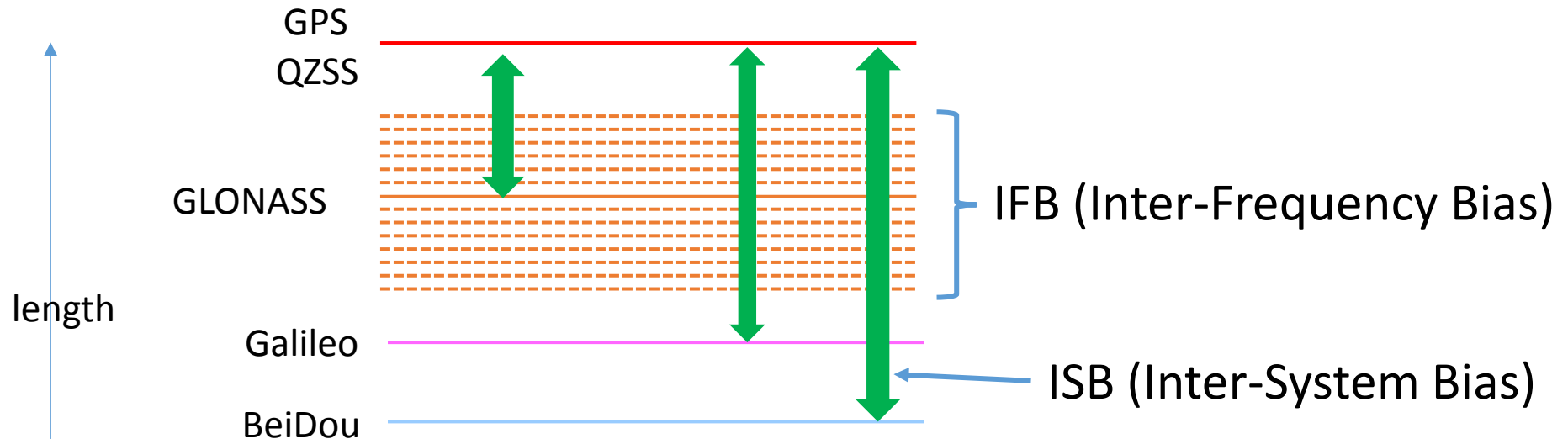
- Efficient, accurate, reliable positionings





# Biases in Multi-GNSS positioning

- Small delays between the signal transmission and reception of the signal in the GNSS receiver
- Major biases:
  1. Inter-System Bias (ISB)
  2. Inter-Frequency Bias (IFB)
  3. Quarter cycle shift between L2P(Y) and L2C signals

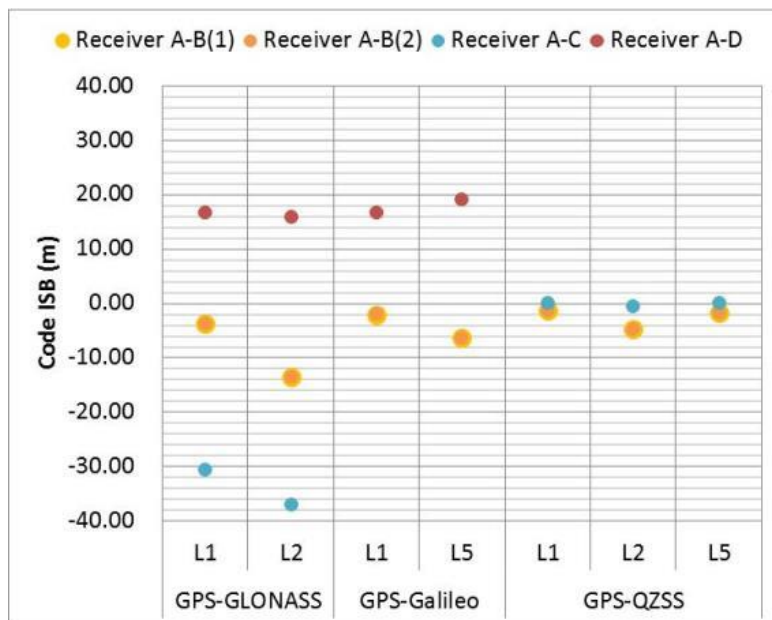


- **Inter-System Bias (ISB)**  
Inter-system delay due to receiver and satellite hardwares
- **Inter-Frequency Bias (IFB)**  
caused by carrier frequency differences, especially due to FDMA of GLONASS

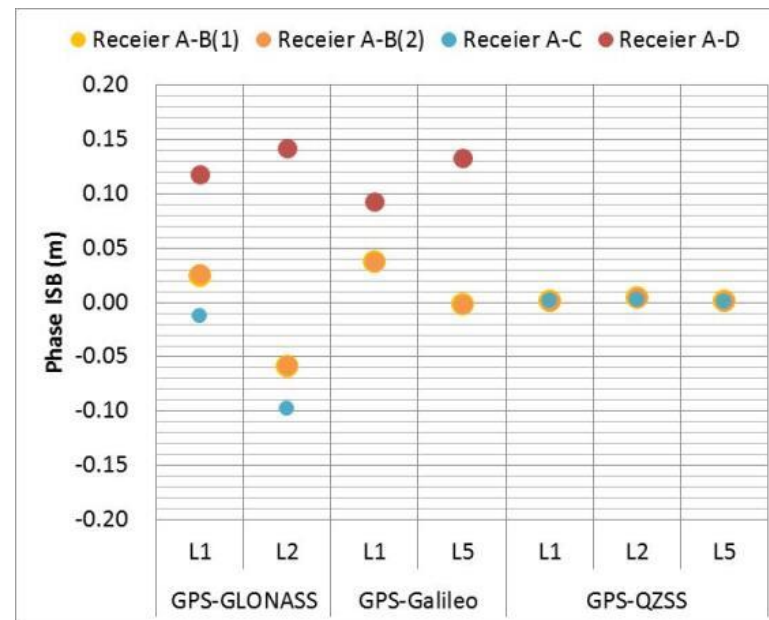
**Correction is required for relative positioning using different types of receivers**

# Inter-System Bias (ISB)

## Code ISB

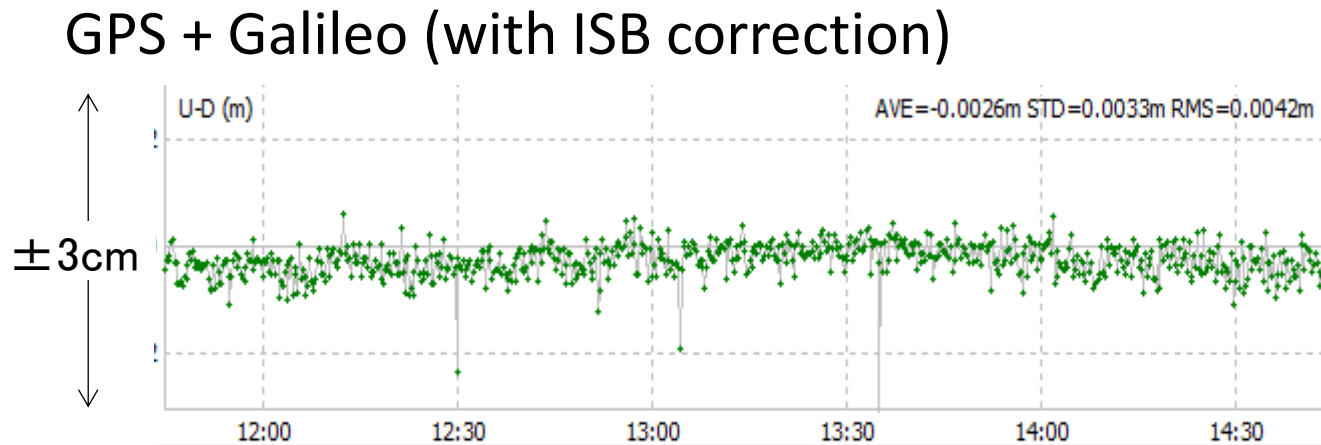
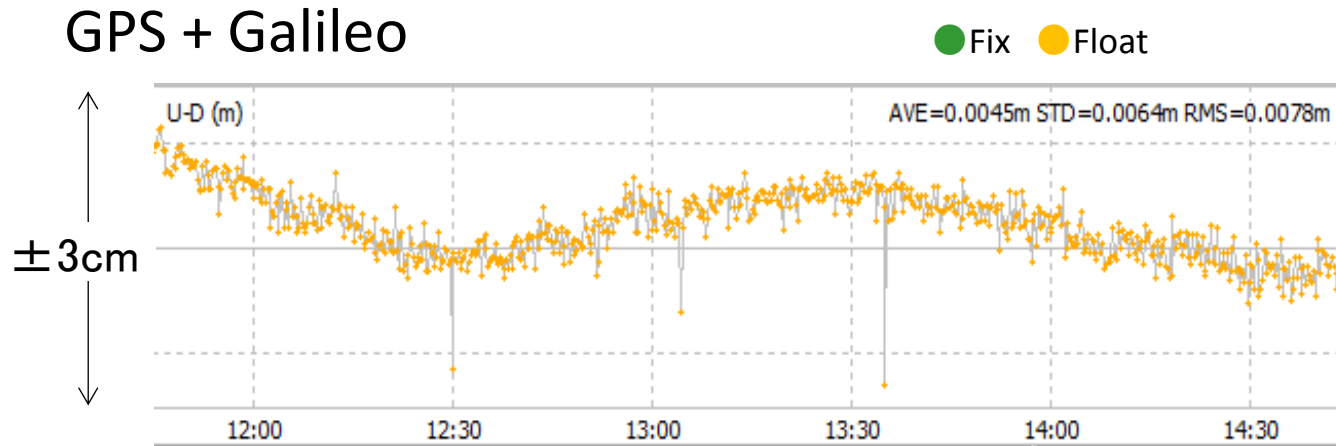


## Phase ISB



- Found in GPS vs GLONASS vs Galileo data
- Depends on the types of receiver

# Inter-System Bias (ISB)



mode: kinematic, baseline: 0m, 3hrs

## IFB model

$$f_{L2,k} = f_{0,L2} + k * df_{L2}$$

$$f_{L1,k} = f_{0,L1} + k * df_{L1}$$

*k: slot number*



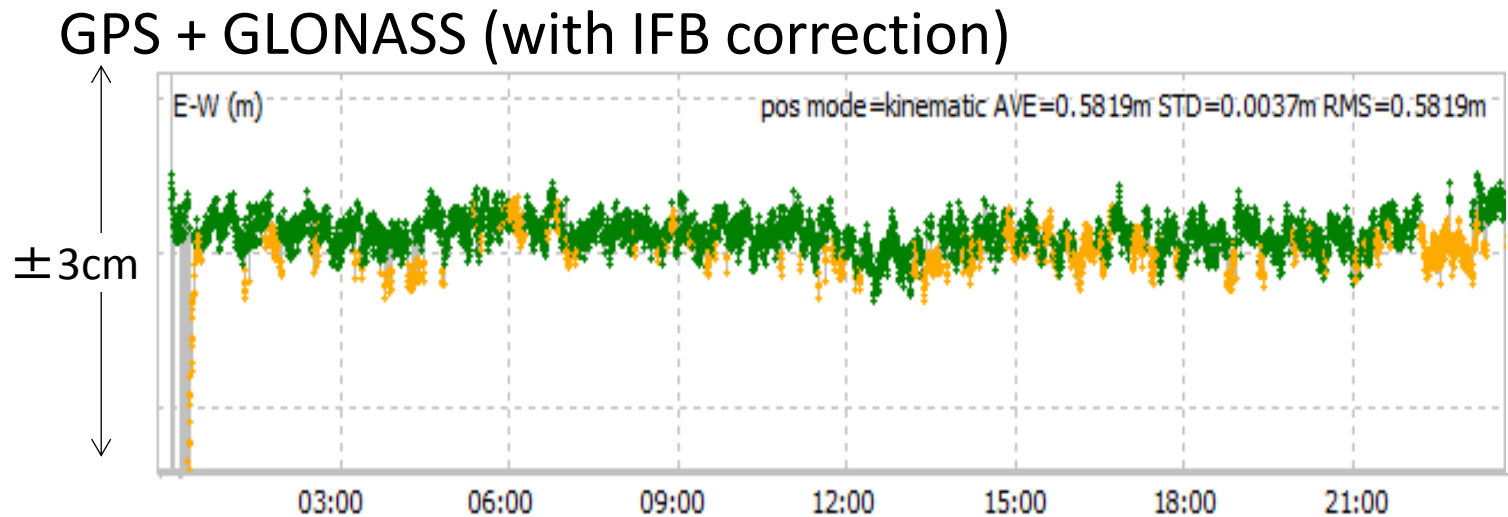
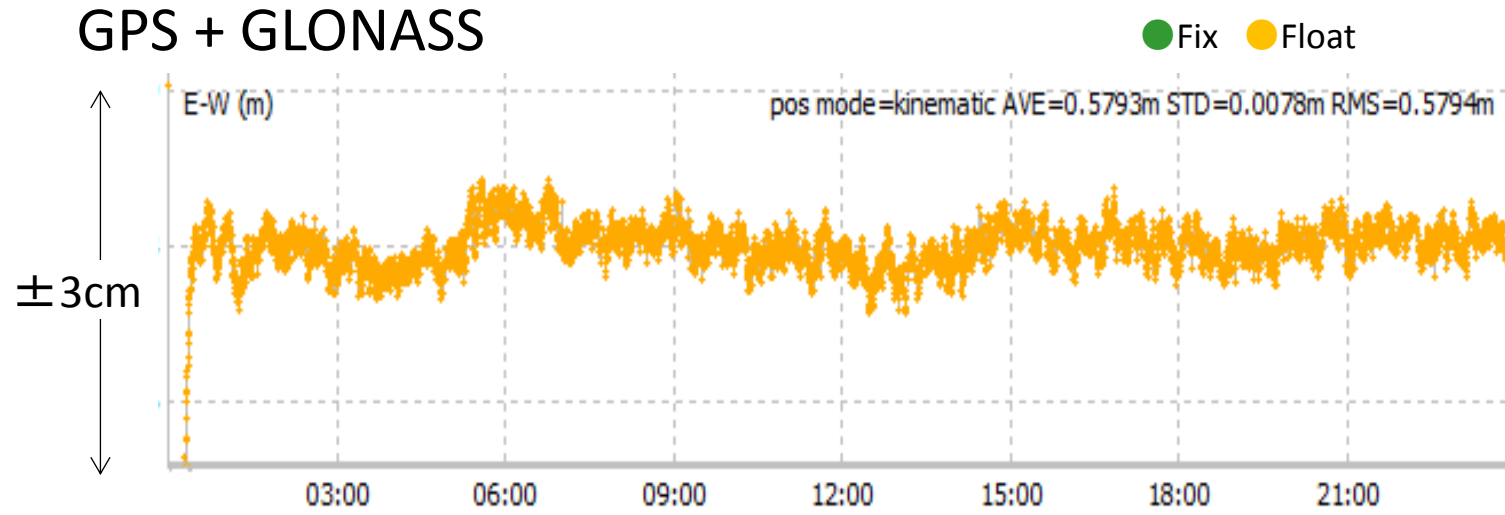
$$IFB = A * k$$

Estimated IFB with respect to receiver A(S/N1) (cm/channel)

	receiver A (S/N2)	receiver B (S/N1)	receiver B (S/N2)	receiver C	receive D
L1	0.03	-0.72	-0.74	-0.50	2.98
L2	-0.04	-1.04	-1.02	-0.49	2.93

- IFB is frequency dependent hardware-induced bias, especially for the FDMA of GLONASS signals.
- IFB (cm/channel) are consistent between same receiver types.

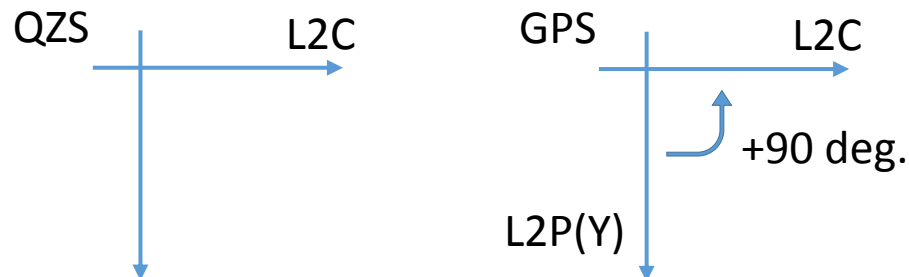
# Inter-Frequency Bias (IFB)



mode: kinematic, baseline: 1m, 24hrs



# Quarter-cycle shift for L2C signal

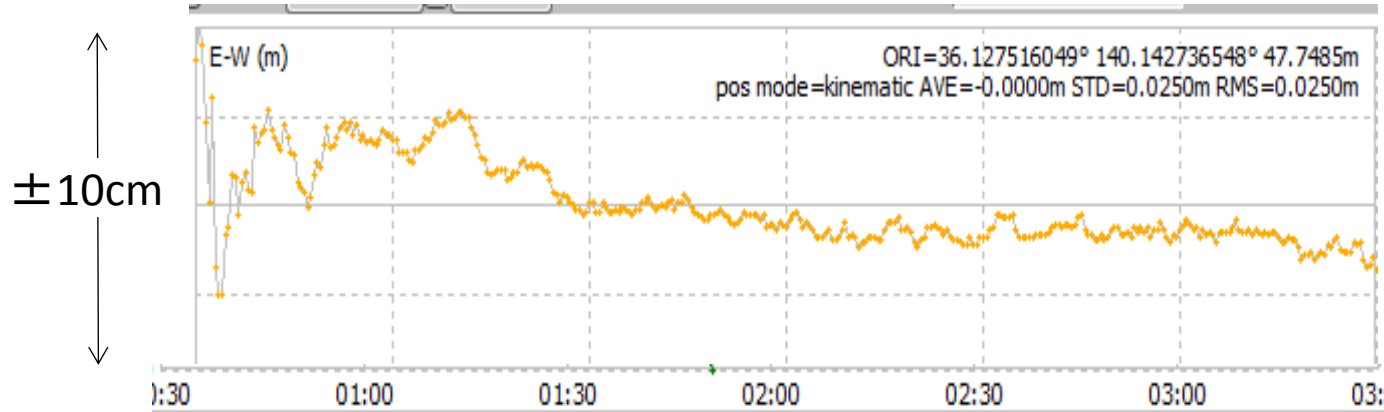


	Receiver A	Receiver B	Receiver C
GPS L2C	$L2P(Y) + 1/4$ cycle	0 (aligned by receiver)	$L2P(Y) - 1/4$ cycle
QZSS L2C	$L2P(Y) + 1/4$ cycle	0 (aligned by receiver)	$L2P(Y) - 1/4$ cycle

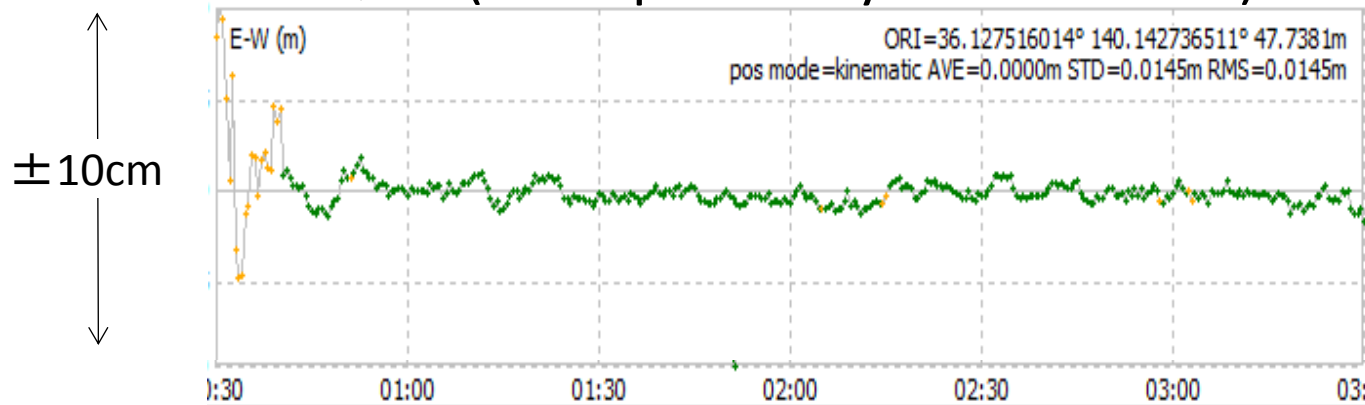
- The difference in the alignment of L2C signal vs L2P(Y)
- Bias arises in the double-differenced observable between L2C and L2P(Y) using different types of receivers

# Quarter-cycle shift for L2C signals of GPS and QZSS

## GPS + QZSS



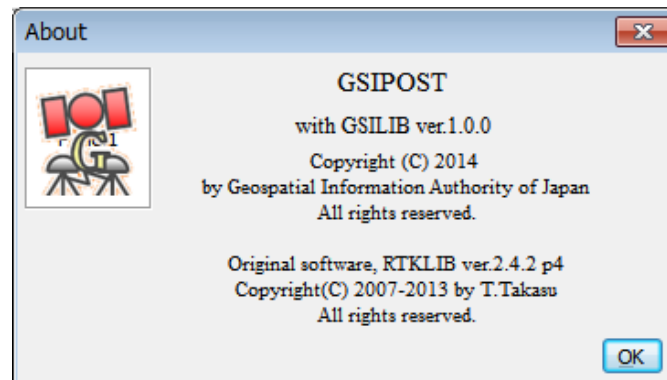
## GPS + QZSS (with quarter-cycle correction)





# GSILIB (GNSS Survey Implementation Library)

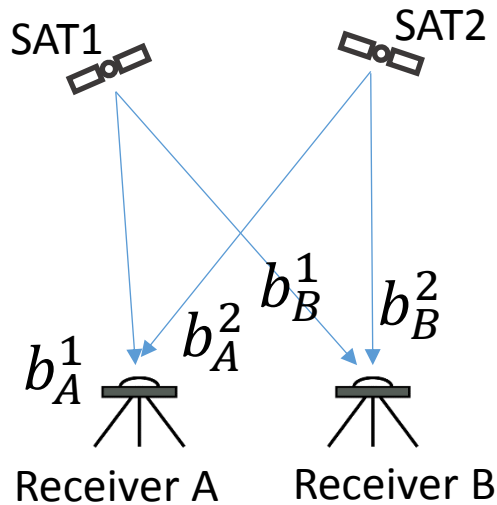
- Open source software package for GNSS positioning developed by GSI
- Fork of the RTKLIB software (by T. Takasu) with handling of multi-GNSS-related biases



GSILIB: GNSS Surveying Implementation  
([http://datahouse1.gsi.go.jp/gsilib/gsilib\\_download\\_eng.html](http://datahouse1.gsi.go.jp/gsilib/gsilib_download_eng.html))  
Library

- Corrections of biases in multi-GNSS data
  - Quarter-cycle biases
  - Inter frequency bias (IFB)
  - Inter system bias (ISB)
- Inherit all the functions of RTKLIB
  - Multi-GNSS data support: GPS, GLONASS, QZSS, Galileo, SBAS
  - Various positioning modes: RTK, Static, PPP, etc.
- Simple GUI (Windows) and CUI (Windows, Linux) interfaces

# The effect of hardware dependent biases



- DD bias:

$$(b_A^{Sat1} - b_B^{Sat1}) - (b_A^{Sat2} - b_B^{Sat2})$$

		ISB	IFB	L2C 1/4 cycle
Sat Sys	1 – 1	Canceled	Canceled	–
Rec Type	A – A			
Sat Sys	1 – 1	Canceled	<b>Arise</b>	<b>Arise</b>
Rec Type	A – B			
Sat Sys	1 – 2	Canceled	–	–
Rec Type	A – A			
Sat Sys	1 – 2	<b>Arise</b>	–	<b>Arise</b>
Rec Type	A – B			

## 1. Calibration of biases in multi-GNSS data

- Inter system bias (ISB)
- Inter frequency bias (IFB)
- Quarter-cycle shift



## 2. Save the biases to table files



## 3. Import pre-determined tables in positioning



# Demonstration of GSILIB

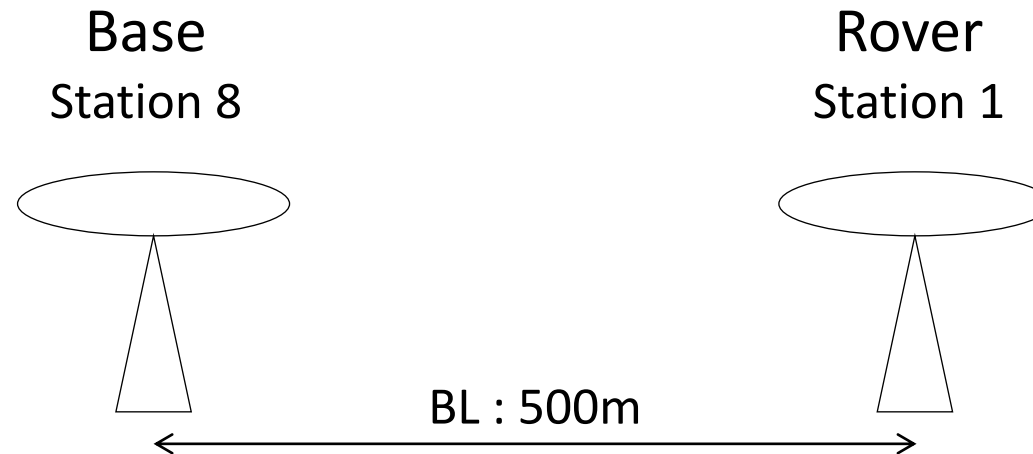


- Multi-GNSS environment improves availability, accuracy, reliability, convergence of GNSS positioning
- However, some biases have to be considered
  - IFB, ISB, quarter-cycle shift
- **GSILIB is an open-source software**, which offers the **table-based corrections of IFB, ISB and quarter-cycle shift** to utilize multi-GNSS data

[http://datahouse1.gsi.go.jp/gsilib/gsilib\\_download\\_eng.html](http://datahouse1.gsi.go.jp/gsilib/gsilib_download_eng.html)

1. RTK using GPS (No bias)
2. RTK using GPS + GLONASS (IFB correction)
3. RTK using GPS + QZSS (L2C quarter cycle shift)
4. RTK using GPS + Galileo (ISB correction)
5. RTK using GPS + GLONASS + QZSS + Galileo (all corrections)

- RTK using GPS

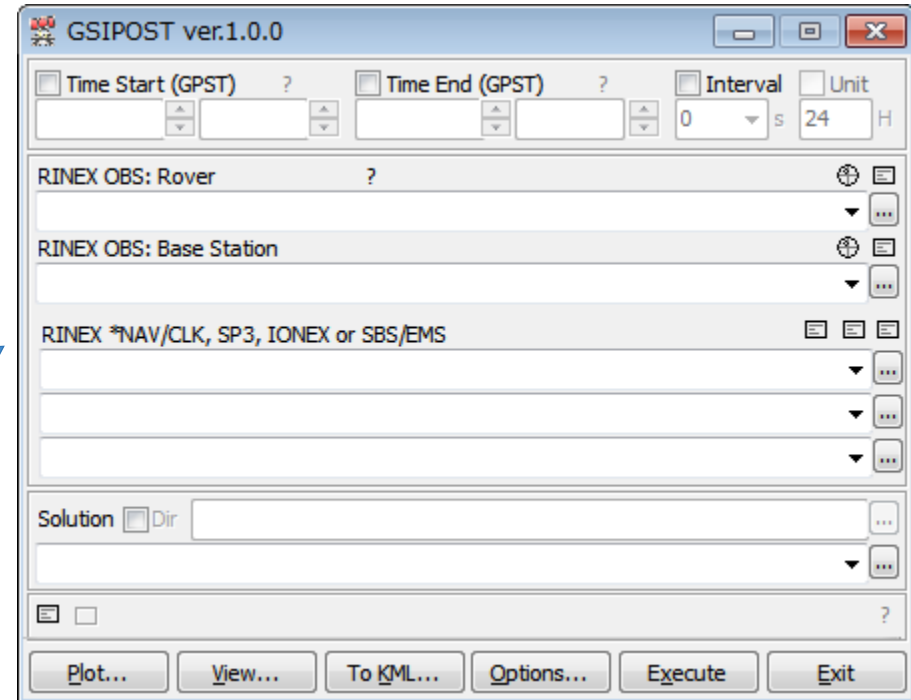
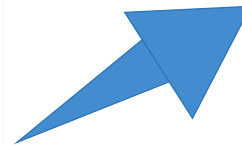


Antenna : JAV\_GRANT-G3T  
Receiver : JAVAD TRE\_G3T DELTA

1. Configuration of positioning options
2. Setting of input RINEX files, output directory
3. Start processing
4. Show the result

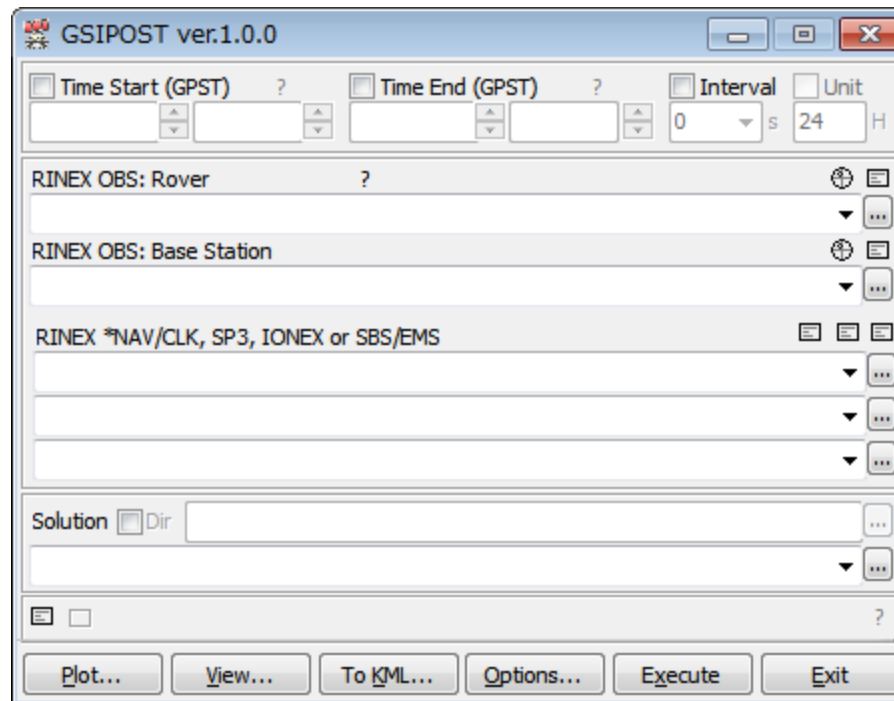
# Launch gsipost\_gui.exe

gsilib/bin/



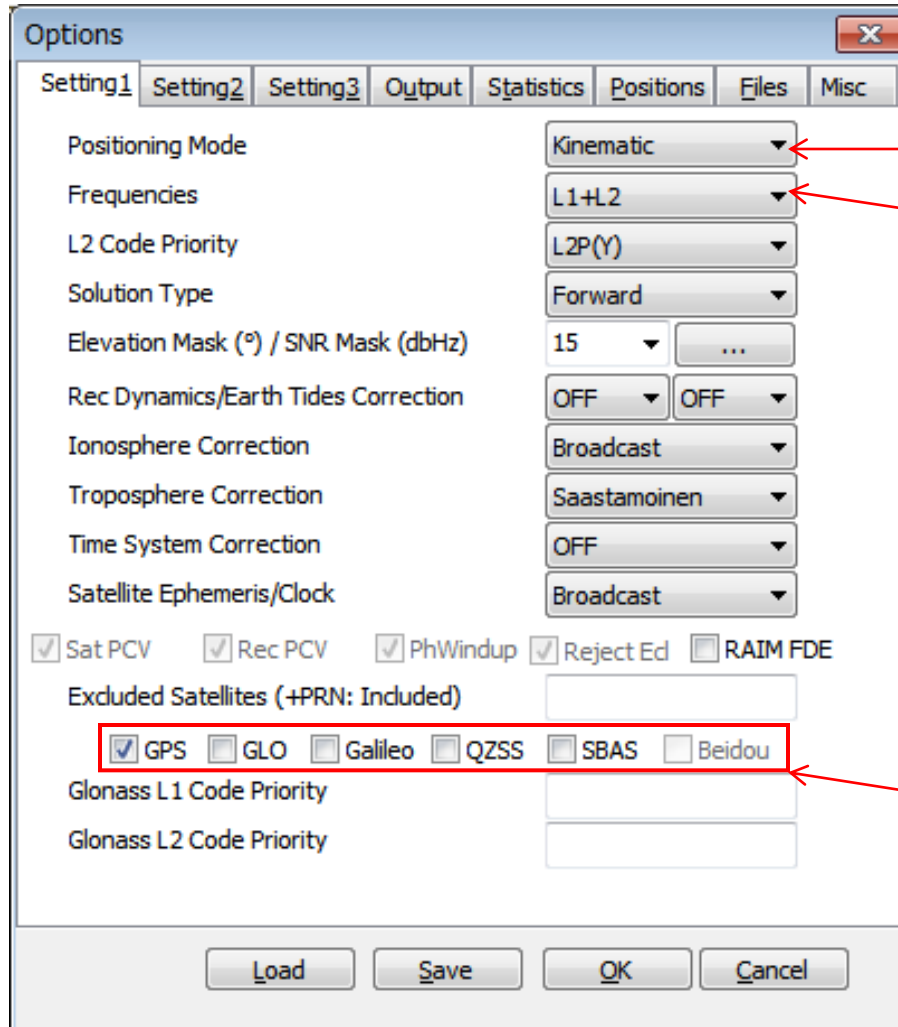
Post Processing tool of GSILIB

# 1: Configuration



← Configure positioning options

# (1-1) Positioning options: Setting 1



Positioning Mode "Kinematic"

Frequencies "L1+L2"

Satellite types (GPS)

# (1-2) Positioning options: Setting 2



The screenshot shows a software dialog box titled "Options" with a close button (X) in the top right corner. The "Setting2" tab is selected, and the "Positions" sub-tab is active. The dialog contains the following settings:

Integer Ambiguity Resolution Method	LAMBDA	
Integer Ambiguity Resolution Strategy	Continuous	
GLONASS Ambiguity Resolution	ON	
PPP Ambiguity Resolution	OFF	
Min Ratio to Fix Ambiguity	3	
Min Confidence / Max FCB to Fix Amb	0.9999	0.2
Min Lock / Elevation (°) to Fix Ambiguity	0	0
Min Fix / Elevation (°) to Hold Ambiguity	10	0
Outage to Reset Amb/Slip Thres (m)	5	0.500
Phase Cycle Shift	OFF	
L2C-L2P Bias	OFF	
Max Age of Differential (s)	30.0	
Reject Threshold of GDOP/Innov (m)	30.0	30.0
Number of Filter Iteration	1	
<input type="checkbox"/> Baseline Length Constraint (m)	0.000	0.000
Inter System Bias	OFF	
Analysys Method in Double Differencing	exc. glonass	

At the bottom of the dialog are four buttons: Load, Save, OK, and Cancel.

← Phase Cycle Shift "OFF"

← Inter System Bias "OFF"



# (1-3) Positioning options: Output



Options

Setting1 Setting2 Setting3 **Output** Statistics Positions Files Misc

Solution Format	X/Y/Z-ECEF
Output Header/Processing Options	ON ON
Time Format / # of Decimals	hh:mm:ss GPST 3
Latitude / Longitude Format	ddd.dddddd
Field Separator	
Datum/Height	WGS84 Ellipsoi
Geoid Model	Internal
Solution for Static Mode	All
NMEA Interval (s) RMC/GGA, GSA/GSV	0 0
Output Solution Status / Debug Trace	Residu OFF
Output ISB Data	OFF
Output L2P-L2C Data	OFF
Output Position in SINEX	OFF
Output Ion/Trop	OFF OFF
Output Receiver/Satellite Clock	OFF OFF
Output Baseline	OFF
Output FCB	OFF

Solution Format

Debug Trace

Solution Status

# (1-4) Positioning options: Positions

Rover:  
 Antenna type  
 Receiver type

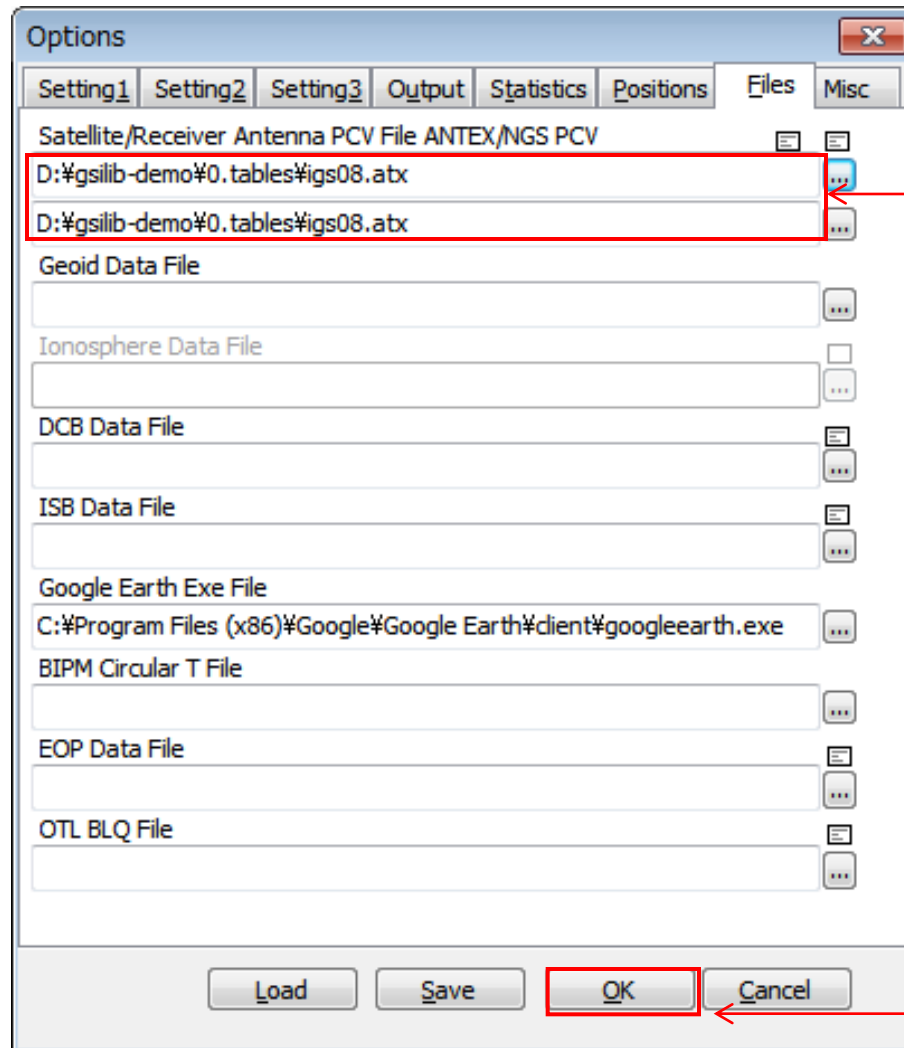
Base:  
 Position  
 Antenna type  
 Receiver type

Position file

```

$ latitude longitude height(ellipsoidal) id name
$-----
36.130349273 140.138352074 48.5321 Sta8 Base
36.127346662 140.143000323 47.7168 Sta1 Rover
    
```

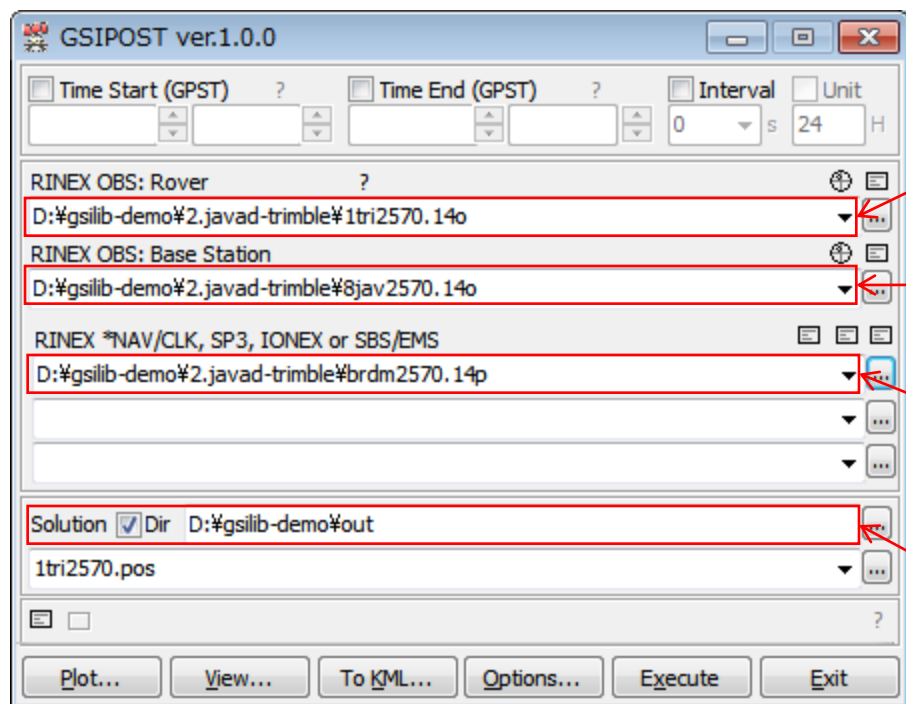
# (1-5) Positioning options: Files



Satellite/Receiver  
Antenna PCV File

Click

# (2) RINEX file selection



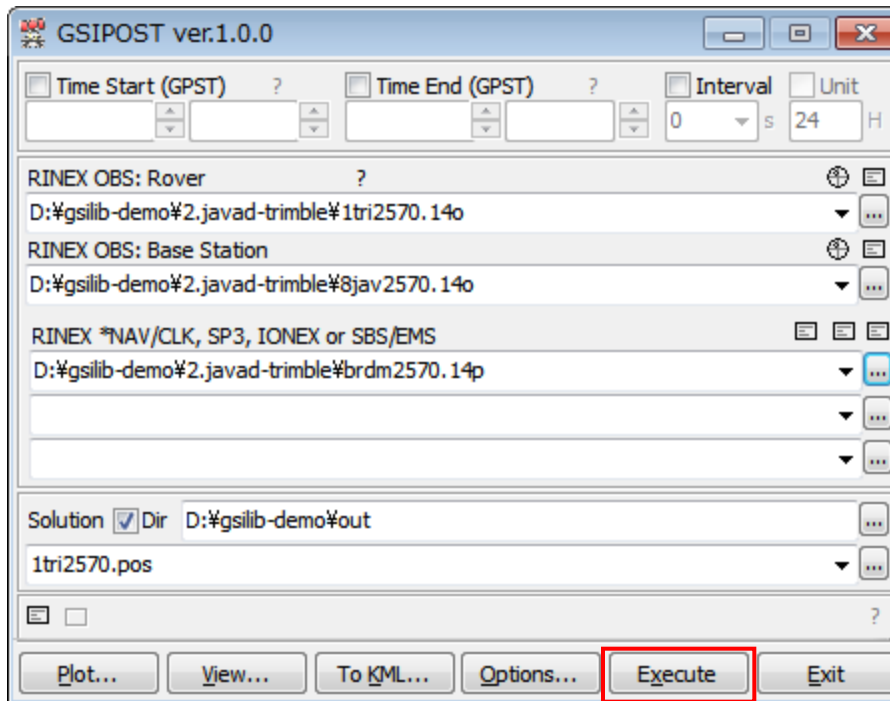
RINEX OBS of rover station  
(\*\*\*\*.yyo)

RINEX OBS of base station  
(\*\*\*\*.yyo)

RINEX NAV  
(\*\*\*\*.yy\*)

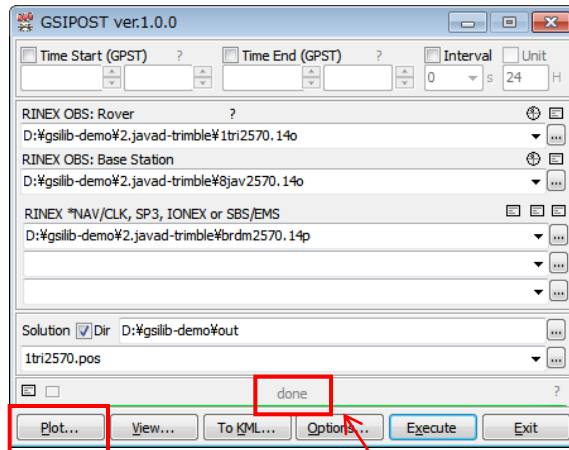
Solution directory for the  
solution file (\*\*\*\*.pos)

# (3) Processing



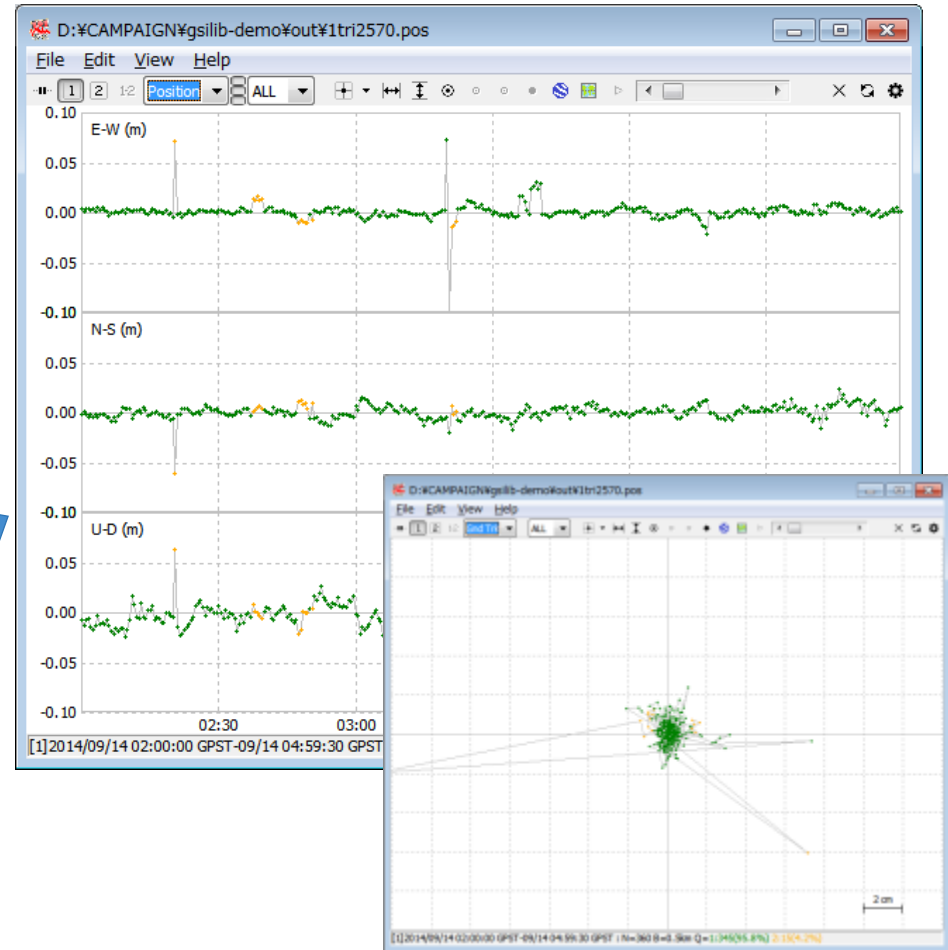
Start processing

# (4) Show result



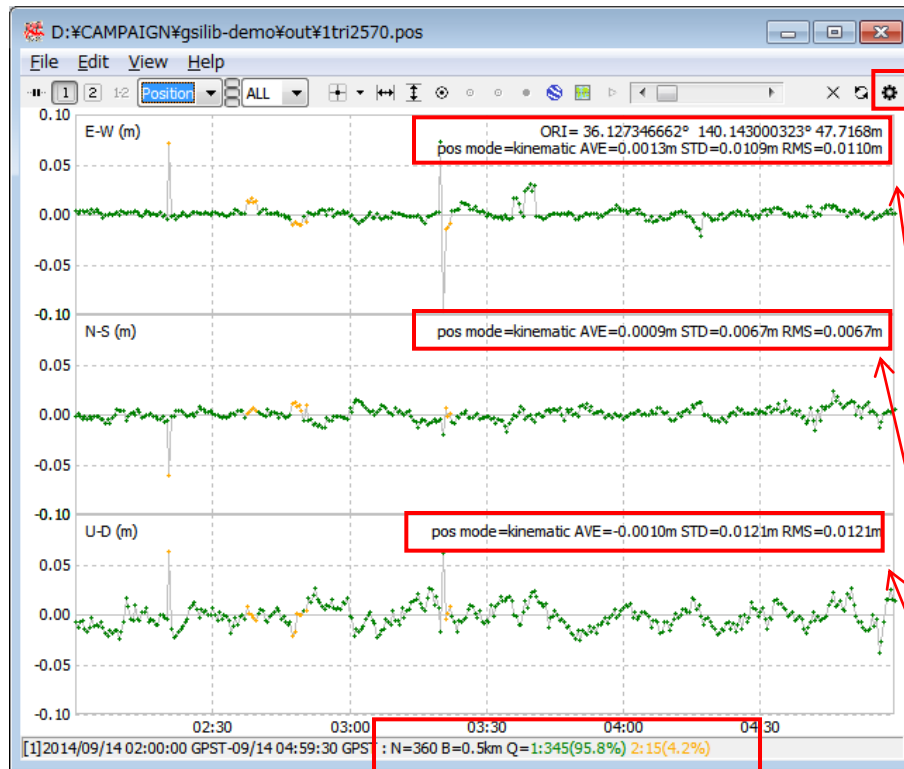
Processing is done

Plot results



# (4-2) Plot options

Show Statistics



Options

Time Format: h:m:s GPST  
 Lat/Lon Format: ddd.ddddd  
 Show Statistics: ON  
 Cycle-Slip: OFF  
 Parity Unknown: OFF  
 Ephemeris: OFF  
 Elevation Mask (°): 15  
 Elev Mask Pattern: OFF  
 Hide Low Satellite: ON  
 Max DOP: 30  
 Max Multipath: 10  
 Receiver Position: Single Solut  
 Satellite System:  GPS  GLO  Galileo  QZSS  SBAS  BeiDou  
 Excluded Sats (+Sn: Included)

Satellite System

Baseline length  
 Fix rate

Average,  
 Standard deviation,  
 RMS

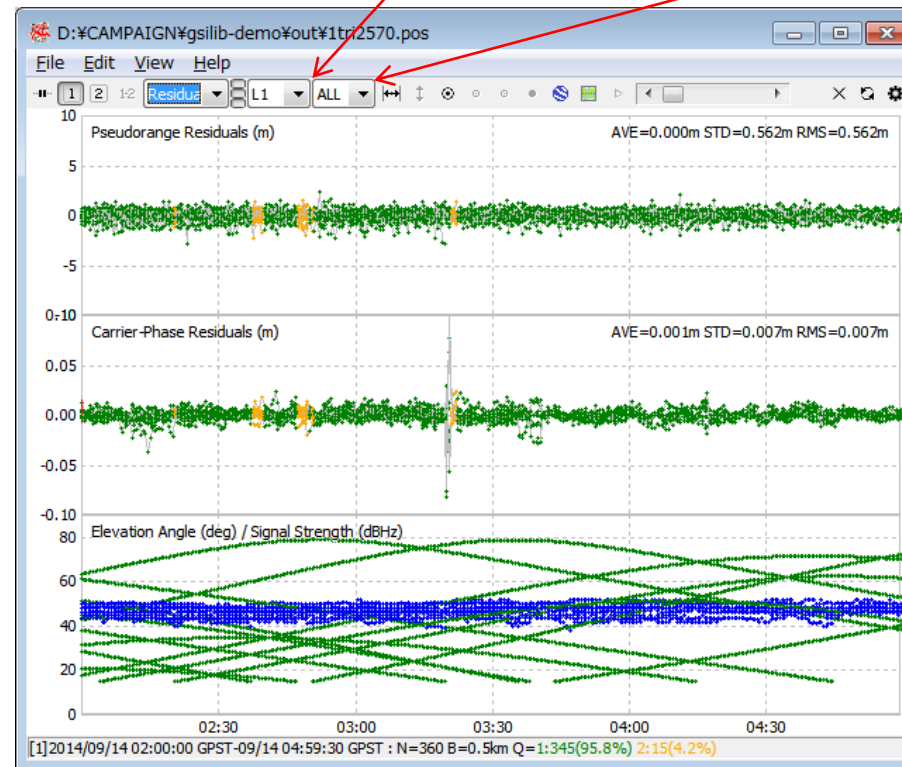
# (4-3) Show residuals

Residuals                      Frequency                      Satellite

Code

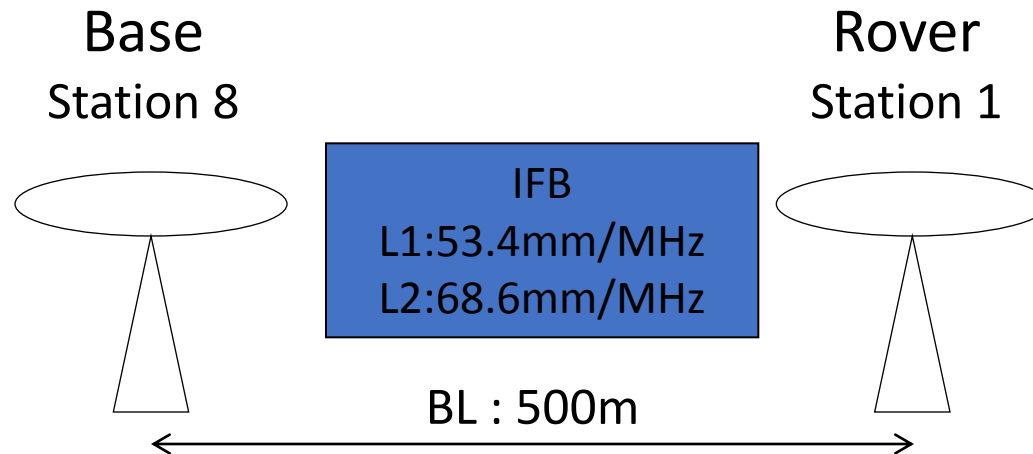
Phase

Elevation  
SNR





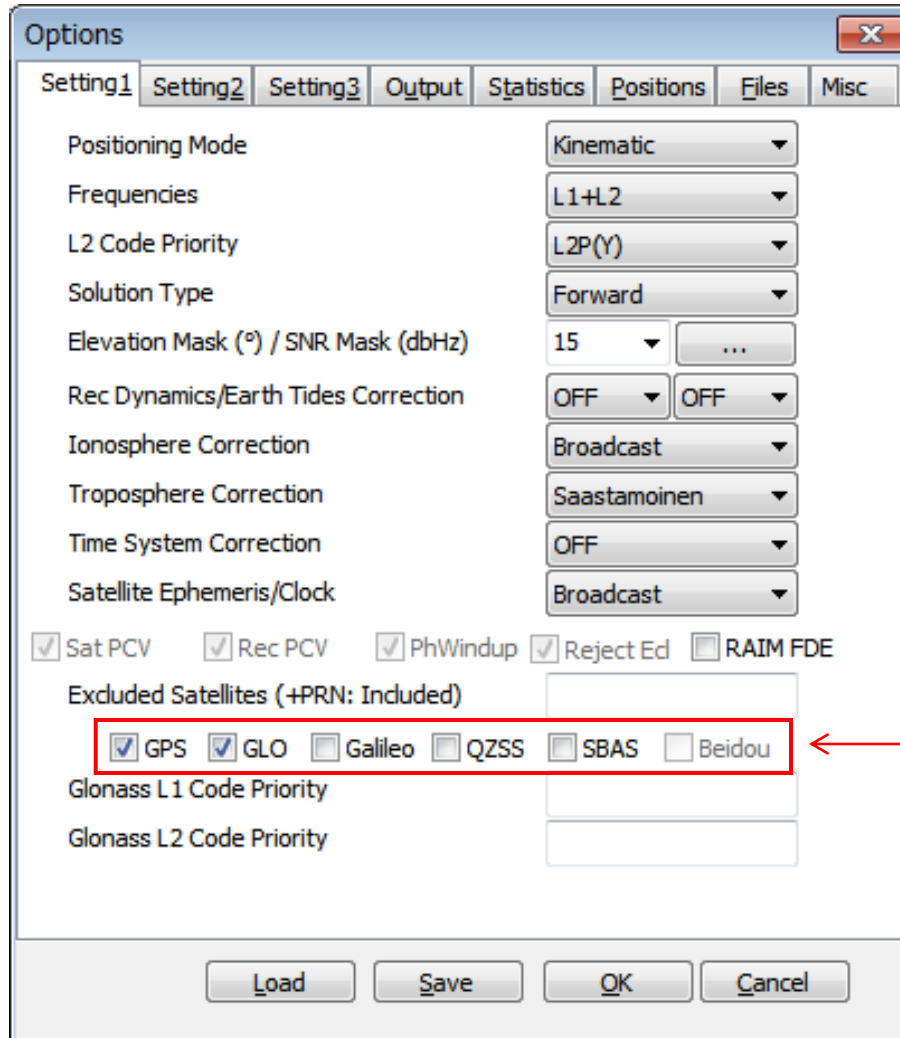
- RTK using GPS + GLONASS (IFB correction)



Antenna : JAV\_GRANT-G3T  
Receiver : TRIMBLE NetR9

GLONASS  
L1 :  $1602 \text{ MHz} + 0.5625 \text{ MHz} * k$   
L2 :  $1246 \text{ MHz} + 0.4375 \text{ MHz} * k$  ( $k=-7,-6,\dots,5,6$ )

# (1-1) Positioning options: Setting 1



Options

Setting1 Setting2 Setting3 Output Statistics Positions Files Misc

Positioning Mode Kinematic

Frequencies L1+L2

L2 Code Priority L2P(Y)

Solution Type Forward

Elevation Mask (°) / SNR Mask (dbHz) 15 ...

Rec Dynamics/Earth Tides Correction OFF OFF

Ionosphere Correction Broadcast

Troposphere Correction Saastamoinen

Time System Correction OFF

Satellite Ephemeris/Clock Broadcast

Sat PCV  Rec PCV  PhWindup  Reject Ed  RAIM FDE

Excluded Satellites (+PRN: Included)

GPS  GLO  Galileo  QZSS  SBAS  Beidou

Glonass L1 Code Priority

Glonass L2 Code Priority

Load Save OK Cancel

Satellite types (GPS, GLO)

# (1-2) Positioning options: Setting 2



The screenshot shows a software dialog box titled 'Options' with a close button (X) in the top right corner. The 'Setting2' tab is selected, and the 'GLONASS Ambiguity Resolution' dropdown menu is set to 'Use IFB Table'. A red arrow points from the text 'GLONASS Ambiguity Resolution "USE IFB Table"' to this dropdown menu. Other settings include 'Integer Ambiguity Resolution Method' (LAMBDA), 'Integer Ambiguity Resolution Strategy' (Continuous), 'PPP Ambiguity Resolution' (OFF), 'Min Ratio to Fix Ambiguity' (3), 'Min Confidence / Max FCB to Fix Amb' (0.9999 / 0.2), 'Min Lock / Elevation (°) to Fix Ambiguity' (0 / 0), 'Min Fix / Elevation (°) to Hold Ambiguity' (10 / 0), 'Outage to Reset Amb/Slip Thres (m)' (5 / 0.500), 'Phase Cycle Shift' (OFF), 'L2C-L2P Bias' (OFF), 'Max Age of Differential (s)' (30.0), 'Reject Threshold of GDOP/Innov (m)' (30.0 / 30.0), 'Number of Filter Iteration' (1), 'Baseline Length Constraint (m)' (0.000 / 0.000), 'Inter System Bias' (OFF), and 'Analysys Method in Double Differencing' (exc. glonass). Buttons for 'Load', 'Save', 'OK', and 'Cancel' are at the bottom.

Integer Ambiguity Resolution Method	LAMBDA
Integer Ambiguity Resolution Strategy	Continuous
GLONASS Ambiguity Resolution	Use IFB Table
PPP Ambiguity Resolution	OFF
Min Ratio to Fix Ambiguity	3
Min Confidence / Max FCB to Fix Amb	0.9999 / 0.2
Min Lock / Elevation (°) to Fix Ambiguity	0 / 0
Min Fix / Elevation (°) to Hold Ambiguity	10 / 0
Outage to Reset Amb/Slip Thres (m)	5 / 0.500
Phase Cycle Shift	OFF
L2C-L2P Bias	OFF
Max Age of Differential (s)	30.0
Reject Threshold of GDOP/Innov (m)	30.0 / 30.0
Number of Filter Iteration	1
<input type="checkbox"/> Baseline Length Constraint (m)	0.000 / 0.000
Inter System Bias	OFF
Analysys Method in Double Differencing	exc. glonass

GLONASS Ambiguity Resolution  
"USE IFB Table"

# (1-3) Positioning options: Setting 3



Options

Setting1 Setting2 **Setting3** Output Statistics Positions Files Misc

Phase Cycle Shift, GLONASS IFB, Error Model

D:\%gsilib-demo%0.tables%gloifb.tbl

Multi Baseline Static

Estimate Satellite Clock/FCB OFF OFF

Semi-Dynamic Correction Parameter

Solution Directory

Est. Interval of ZTD (s) 7200

Est. Interval of Trop. Gradient (s) 43200

Trop. Process Noise Zen/EW/NS 1.00E-1 1.00E-1 1.00E-1

O-C Reject Phase/Code (sigma) 1.0 5.0

Fixing Probability WL/NL 1.00000 0.00000

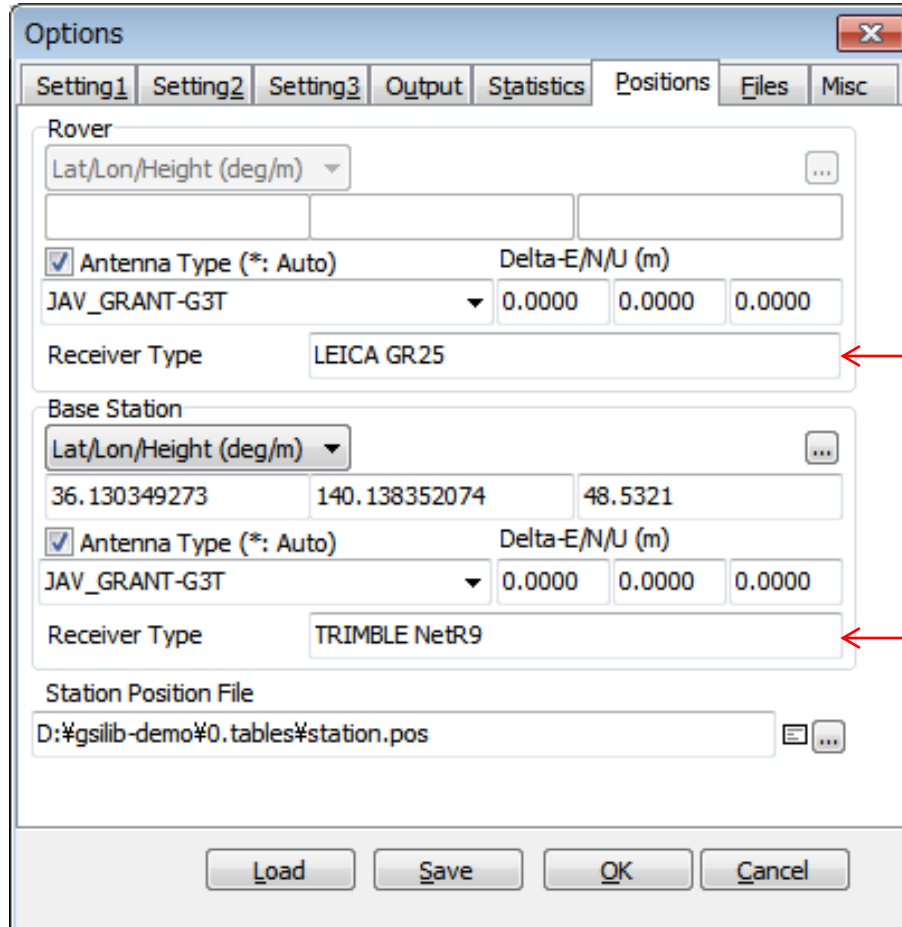
Load Save OK Cancel

IFB table file

GLONASS IFB TABLE 2014/09/29

RECEIVER TYPE 1	RECEIVER TYPE 2	FREQ L*	BIAS (m/MHz)	FLAG
JAVAD TRE_G3T DELTA	TRIMBLE NetR9	1	-0.0082	*
		2	-0.0106	
LEICA GR25	TRIMBLE NetR9	1	-0.0534	*
		2	-0.0686	

# (1-4) Positioning options: Positions



Options

Setting<sub>1</sub> Setting<sub>2</sub> Setting<sub>3</sub> Output Statistics **Positions** Files Misc

Rover

Lat/Lon/Height (deg/m) ...

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

JAV\_GRANT-G3T 0.0000 0.0000 0.0000

Receiver Type LEICA GR.25

Base Station

Lat/Lon/Height (deg/m) ...

36.130349273 140.138352074 48.5321

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

JAV\_GRANT-G3T 0.0000 0.0000 0.0000

Receiver Type TRIMBLE NetR9

Station Position File

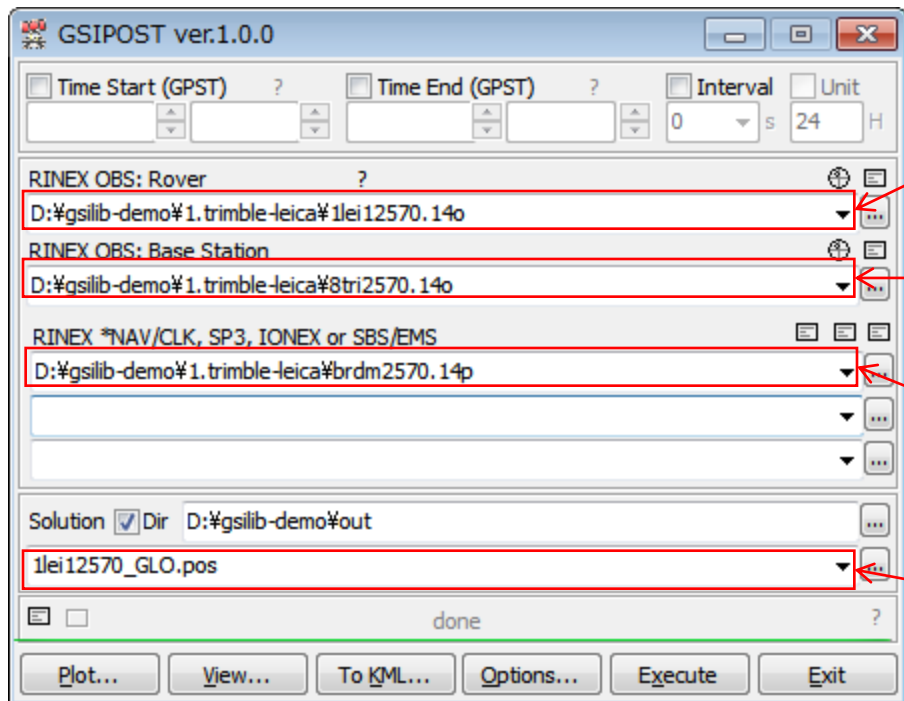
D:%gsilib-demo#0.tables#station.pos

Load Save OK Cancel

Rover Receiver Type

Base Receiver Type

# RINEX file selection



RINEX OBS of rover station  
(\*\*\*\*.yyo)

RINEX OBS of base station  
(\*\*\*\*.yyo)

RINEX NAV  
(\*\*\*\*.yy\*)

Solution file (\*\*\*\*.pos)

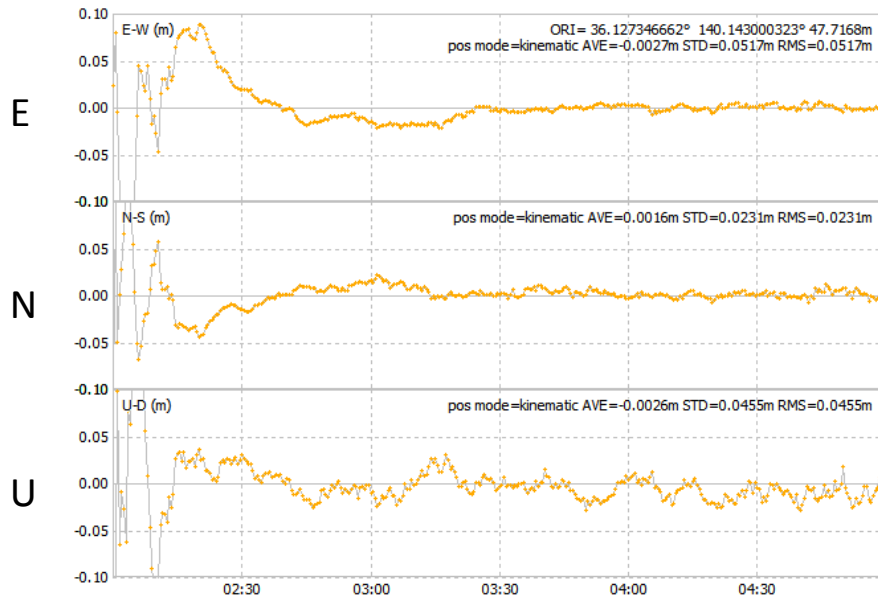
# IFB correction result

## GPS + GLONASS

### No IFB correction

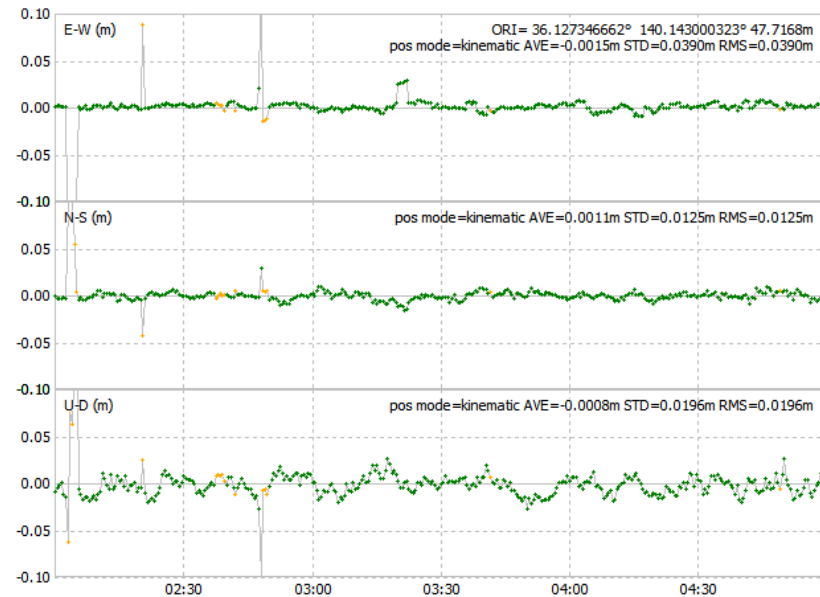
Fix 0.0%

● Fix ● Float



### IFB correction

Fix 95.3%

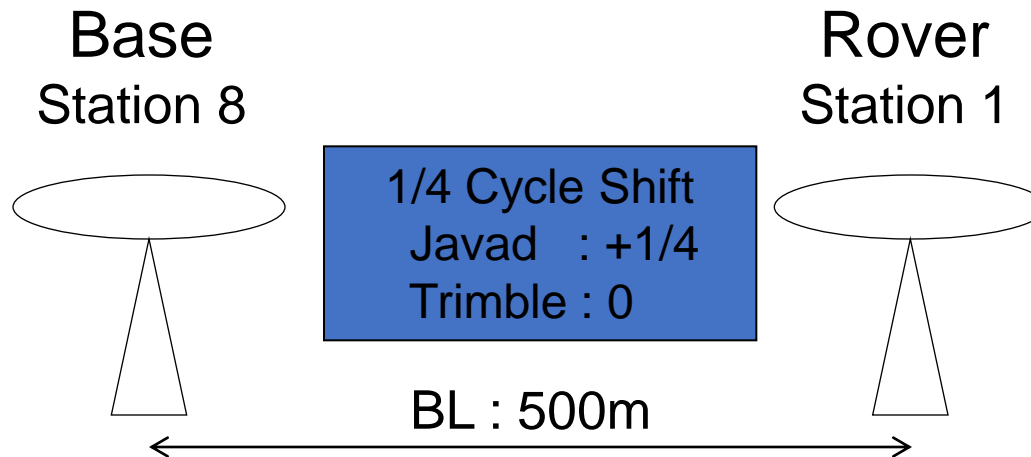


± 10cm

# GSILIB Demonstration 3

## quarter cycle shift correction

### RTK using GPS+QZSS w/wo L2C quarter cycle bias correction



Antenna : JAV\_GRANT-G3T  
Receiver : JAVAD TRE\_G3T DELTA



# (1-1) Positioning options: Setting 1



Options

Setting1 Setting2 Setting3 Output Statistics Positions Files Misc

Positioning Mode Kinematic

Frequencies L1+L2

L2 Code Priority L2P(Y)

Solution Type Forward

Elevation Mask (°) / SNR Mask (dbHz) 15 ...

Rec Dynamics/Earth Tides Correction OFF OFF

Ionosphere Correction Broadcast

Troposphere Correction Saastamoinen

Time System Correction OFF

Satellite Ephemeris/Clock Broadcast

Sat PCV  Rec PCV  PhWindup  Reject Ed  RAIM FDE

Excluded Satellites (+PRN: Included)

GPS  GLO  Galileo  QZSS  SBAS  Beidou

Glonass L1 Code Priority

Glonass L2 Code Priority

Load Save OK Cancel

Satellite types (GPS, QZSS)

# (1-2) Positioning options: Setting 2



Options

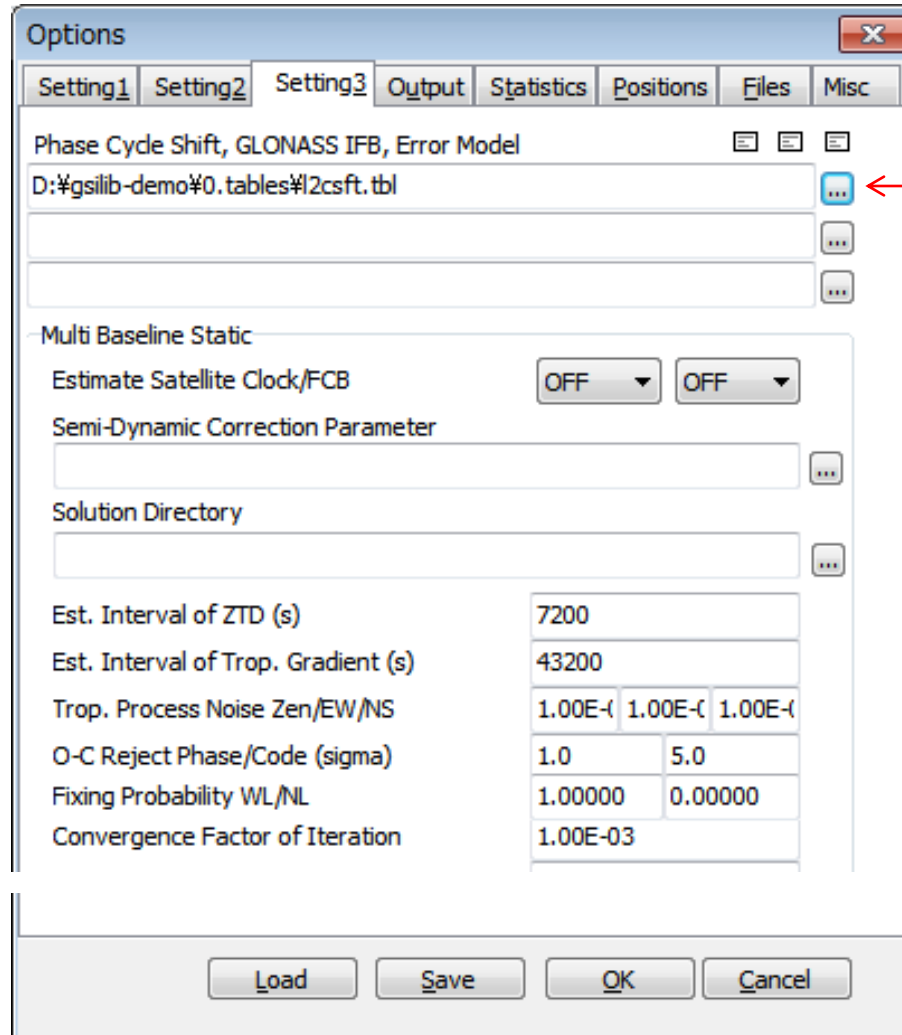
Setting1 Setting2 Setting3 Output Statistics Positions Files Misc

Integer Ambiguity Resolution Method	LAMBDA
Integer Ambiguity Resolution Strategy	Continuous
GLONASS Ambiguity Resolution	ON
PPP Ambiguity Resolution	OFF
Min Ratio to Fix Ambiguity	3
Min Confidence / Max FCB to Fix Amb	0.9999 0.2
Min Lock / Elevation (°) to Fix Ambiguity	0 0
Min Fix / Elevation (°) to Hold Ambiguity	10 0
Outage to Reset Amb/Slip Thres (m)	5 0.500
Phase Cycle Shift	Table
L2C-L2P Bias	OFF
Max Age of Differential (s)	30.0
Reject Threshold of GDOP/Innov (m)	30.0 30.0
Number of Filter Iteration	1
<input type="checkbox"/> Baseline Length Constraint (m)	0.000 0.000
Inter System Bias	OFF
Analysys Method in Double Differencing	exc. glonass

Load Save OK Cancel

← Phase Cycle Shift “Table”

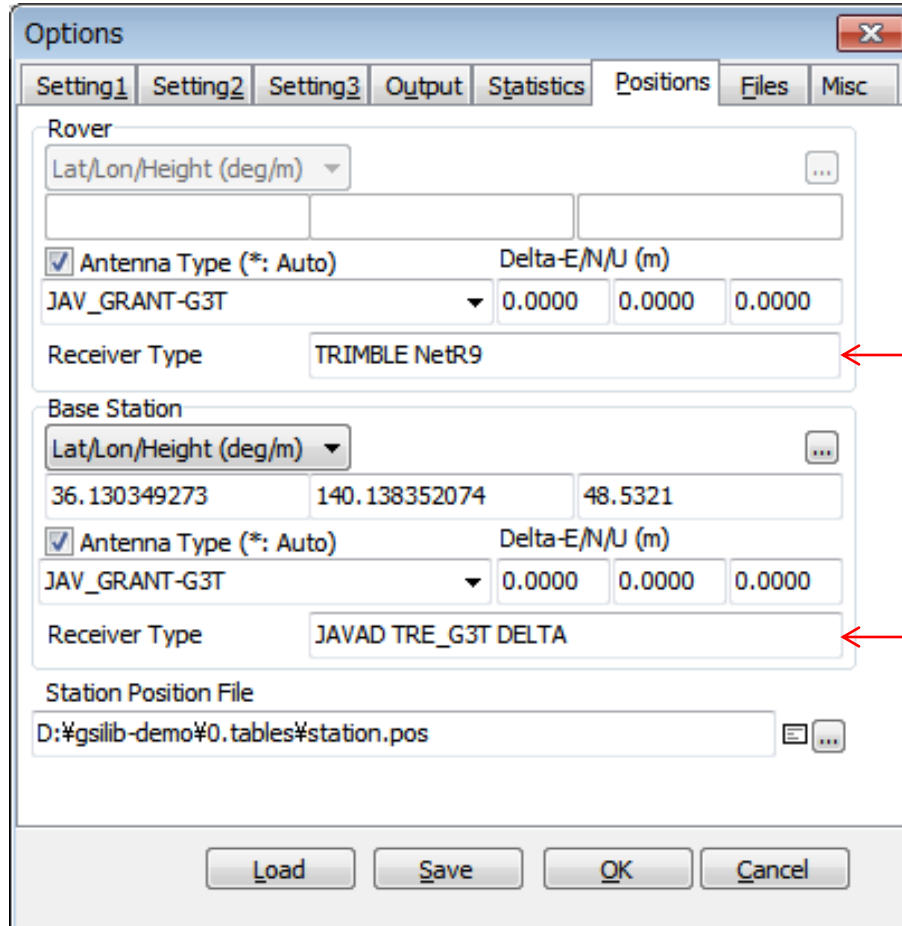
# (1-3) Positioning options: Setting 3



Phase Cycle Shift file

```
Quarter-Cycle Phase Shifts Table
-----
RECEIVER TYPE      BIAS
*****
JAVAD TRE_G3T DELTA      -0.25
```

# (1-4) Positioning options: Positions



Options

Setting<sub>1</sub> Setting<sub>2</sub> Setting<sub>3</sub> Output Statistics **Positions** Files Misc

Rover

Lat/Lon/Height (deg/m) ...

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

JAV\_GRANT-G3T 0.0000 0.0000 0.0000

Receiver Type TRIMBLE NetR9

Base Station

Lat/Lon/Height (deg/m) ...

36.130349273 140.138352074 48.5321

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

JAV\_GRANT-G3T 0.0000 0.0000 0.0000

Receiver Type JAVAD TRE\_G3T DELTA

Station Position File

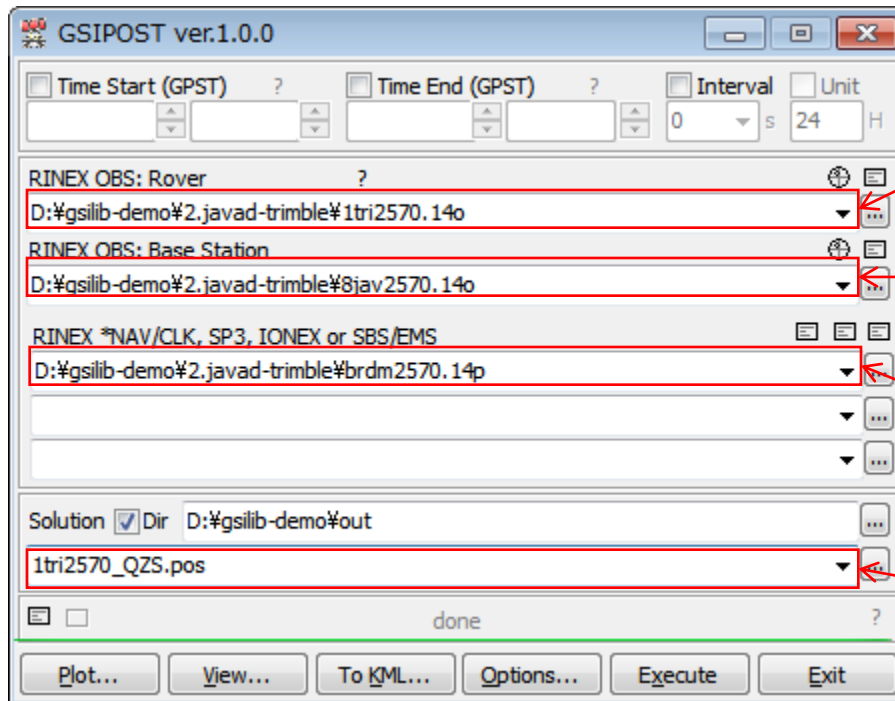
D:%gsilib-demo#0.tables#station.pos

Load Save OK Cancel

Rover Receiver Type

Base Receiver Type

# RINEX file selection



RINEX OBS of rover station  
(\*\*\*\*.yyo)

RINEX OBS of base station  
(\*\*\*\*.yyo)

RINEX NAV  
(\*\*\*\*.yy\*)

Solution file (\*\*\*\*.pos)

# Quarter cycle shift correction result

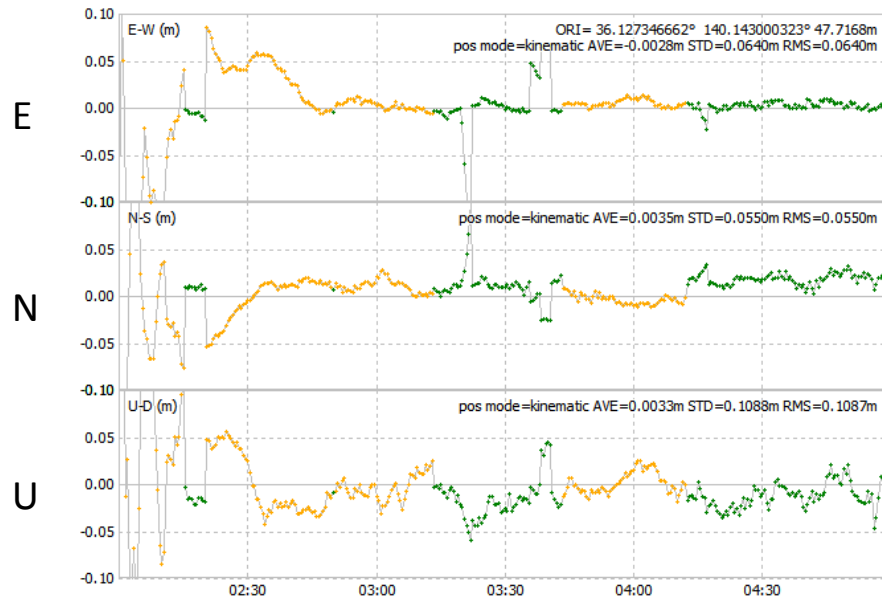


## GPS + QZSS

No correction

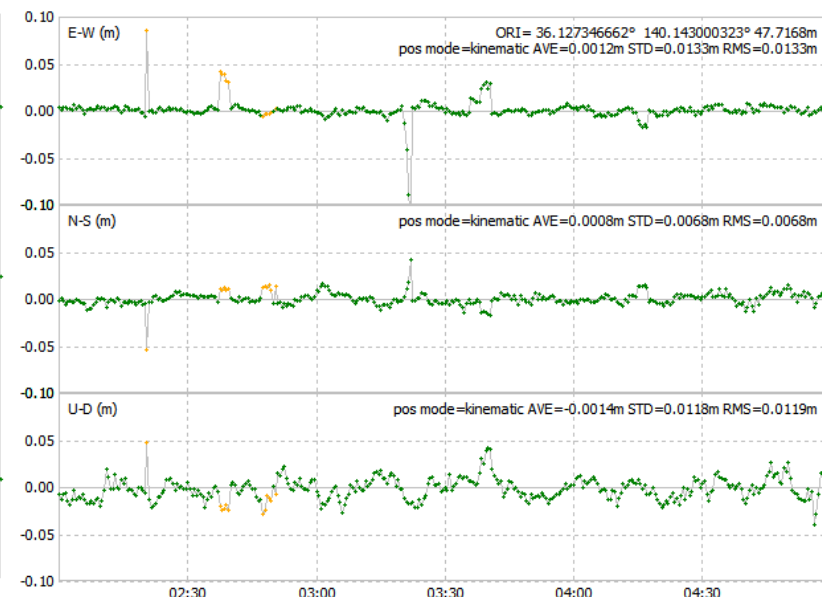
Fix 46.1%

● Fix ● Float



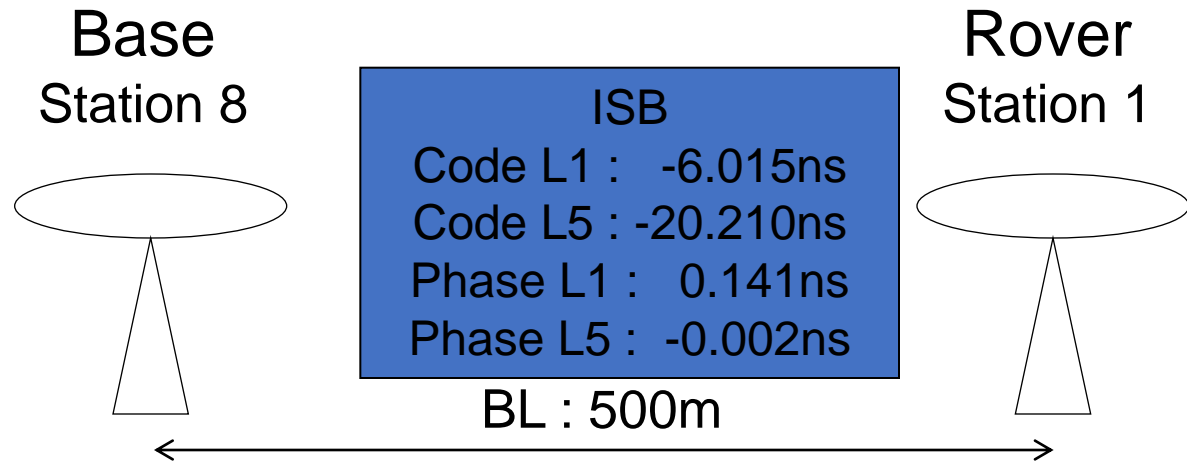
Quarter cycle shift correction

Fix 96.7%



± 10cm

- RTK using GPS+Galileo  
w/wo ISB correction

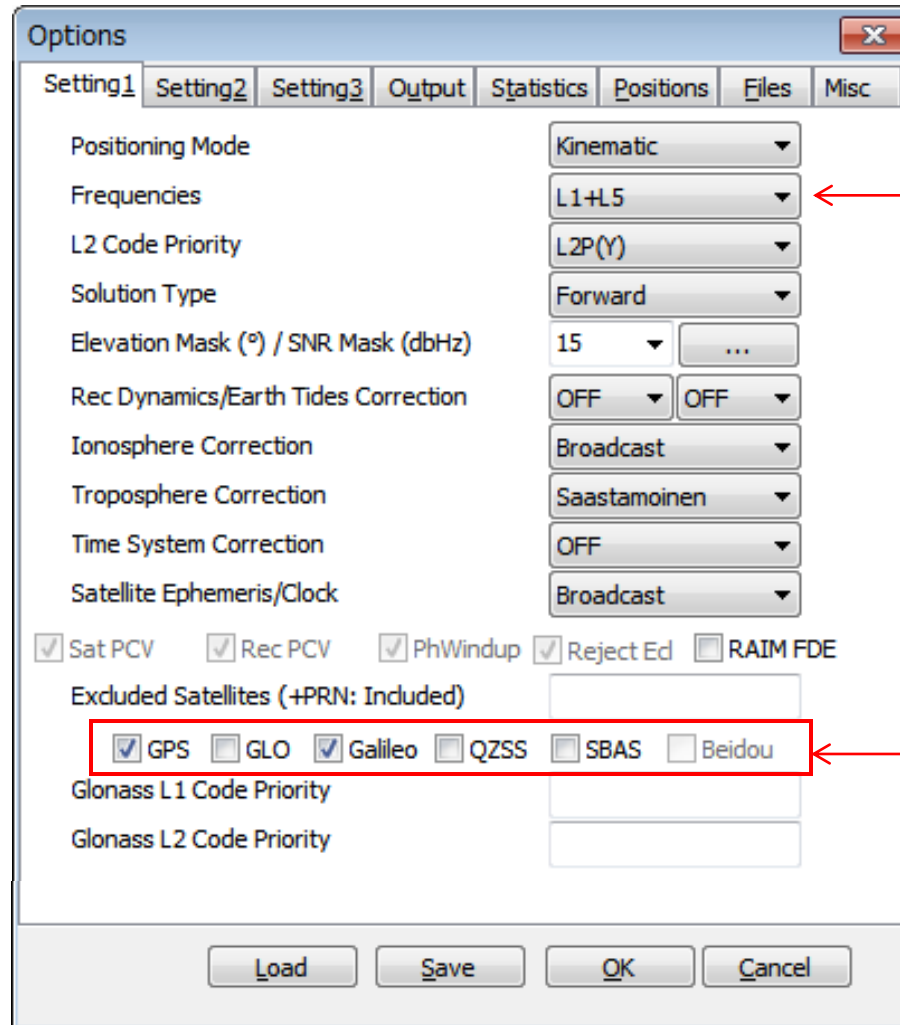


Antenna : JAV\_GRANT-G3T  
Receiver : JAVAD TRE\_G3T DELTA

Antenna : JAV\_GRANT-G3T  
Receiver : TRIMBLE NetR9

Speed of Light : 0.29979 m / ns

# (1-1) Positioning options: Setting 1



Frequencies "L1+L5"

Satellite types (GPS, Galileo)



# (1-2) Positioning options: Setting 2



The screenshot shows a software dialog box titled 'Options' with a close button (X) in the top right corner. The 'Setting2' tab is selected. The dialog contains various configuration options for positioning, including ambiguity resolution methods, confidence thresholds, and filter settings. At the bottom, there are buttons for 'Load', 'Save', 'OK', and 'Cancel'.

Option	Value
Integer Ambiguity Resolution Method	LAMBDA
Integer Ambiguity Resolution Strategy	Continuous
GLONASS Ambiguity Resolution	ON
PPP Ambiguity Resolution	OFF
Min Ratio to Fix Ambiguity	3
Min Confidence / Max FCB to Fix Amb	0.9999   0.2
Min Lock / Elevation (°) to Fix Ambiguity	0   0
Min Fix / Elevation (°) to Hold Ambiguity	10   0
Outage to Reset Amb/Slip Thres (m)	5   0.500
Phase Cycle Shift	OFF
L2C-L2P Bias	OFF
Max Age of Differential (s)	30.0
Reject Threshold of GDOP/Innov (m)	30.0   30.0
Number of Filter Iteration	1
<input type="checkbox"/> Baseline Length Constraint (m)	0.000   0.000
Inter System Bias	Table
Analysys Method in Double Differencing	exc. glonass

Inter System Bias "Table"

# (1-3) Positioning options: Positions



Options

Setting<sub>1</sub> Setting<sub>2</sub> Setting<sub>3</sub> Output Statistics **Positions** Files Misc

Rover

Lat/Lon/Height (deg/m) ...

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

JAV\_GRANT-G3T 0.0000 0.0000 0.0000

Receiver Type TRIMBLE NetR9

Base Station

Lat/Lon/Height (deg/m) ...

36.130349273 140.138352074 48.5321

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

JAV\_GRANT-G3T 0.0000 0.0000 0.0000

Receiver Type JAVAD TRE\_G3T DELTA

Station Position File

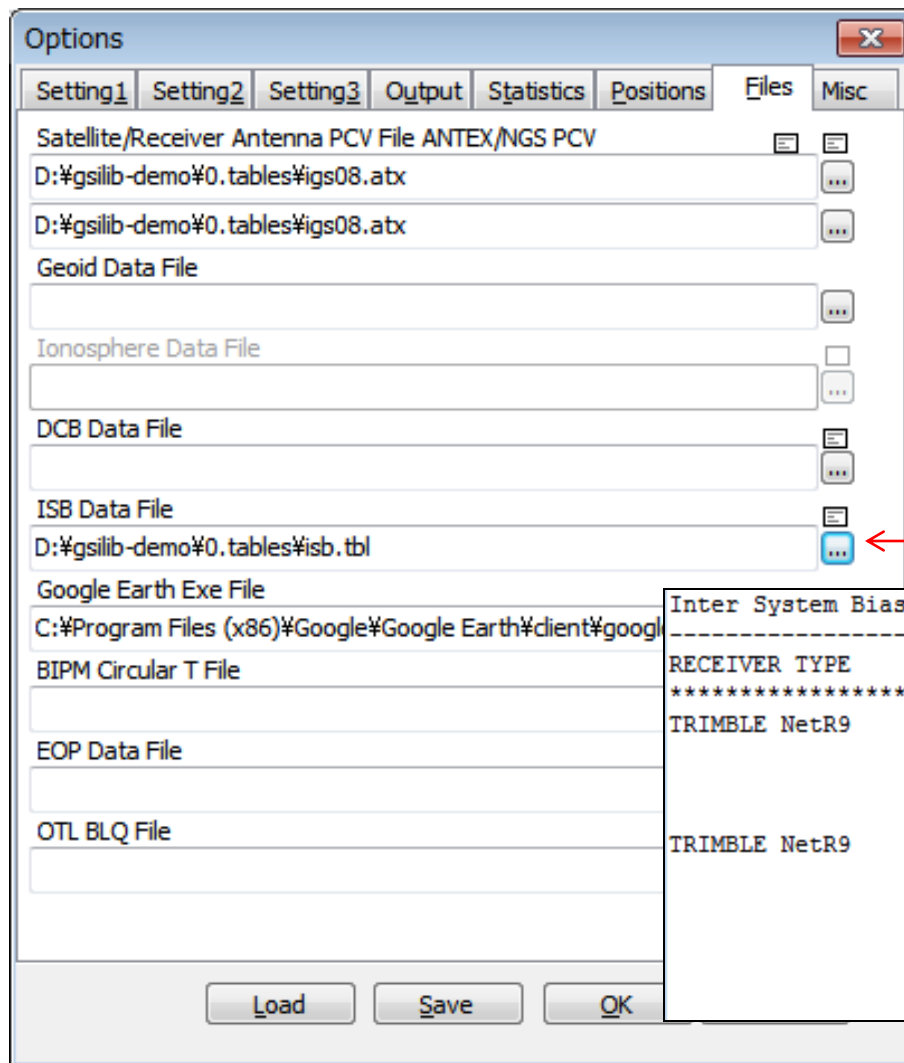
D:%gsilib-demo#0.tables#station.pos

Load Save OK Cancel

Rover Receiver Type

Base Receiver Type

# (1-4) Positioning options: Files

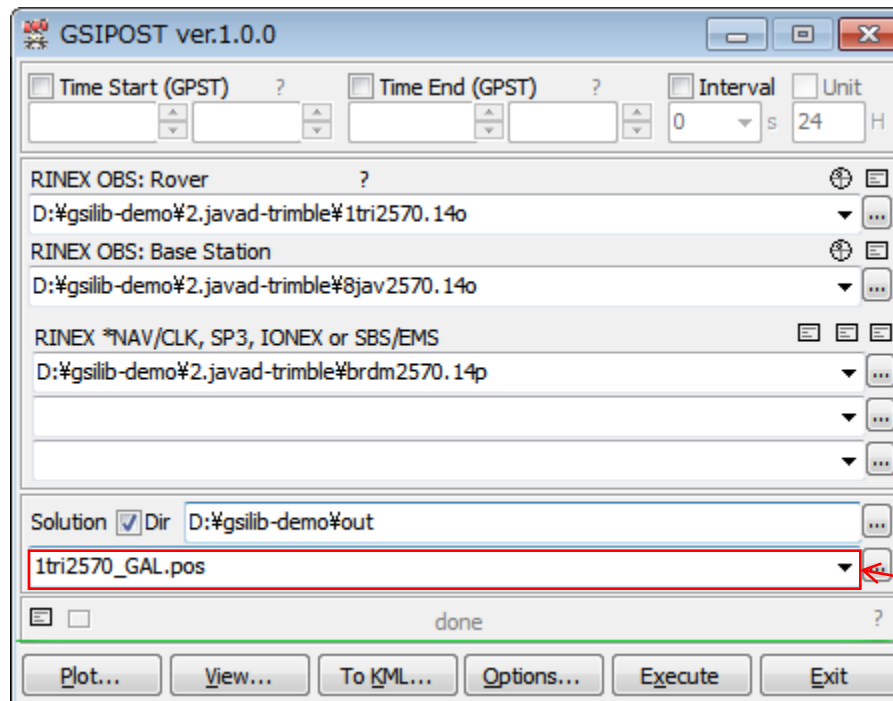


ISB Data File

Inter System Bias Table

RECEIVER TYPE	RECEIVER TYPE (BASE)	S	F	O	BIAS (ns)
TRIMBLE NetR9	JAVAD TRE_G3T DELTA	E	1	L	0.140597108
	JAVAD TRE_G3T DELTA	E	5	L	-0.002028744
	JAVAD TRE_G3T DELTA	E	1	P	-6.014535971
	JAVAD TRE_G3T DELTA	E	5	P	-20.210058998
TRIMBLE NetR9	JAVAD TRE_G3T DELTA	J	1	L	-0.006256701
	JAVAD TRE_G3T DELTA	J	2	L	0.013422874
	JAVAD TRE_G3T DELTA	J	5	L	0.002776976
	JAVAD TRE_G3T DELTA	J	1	P	-3.393992703
	JAVAD TRE_G3T DELTA	J	2	P	-11.247084528
	JAVAD TRE_G3T DELTA	J	5	P	-4.957847311

# RINEX file selection



Solution file (\*\*\*\*.pos)

# ISB correction result

## GPS + Galileo

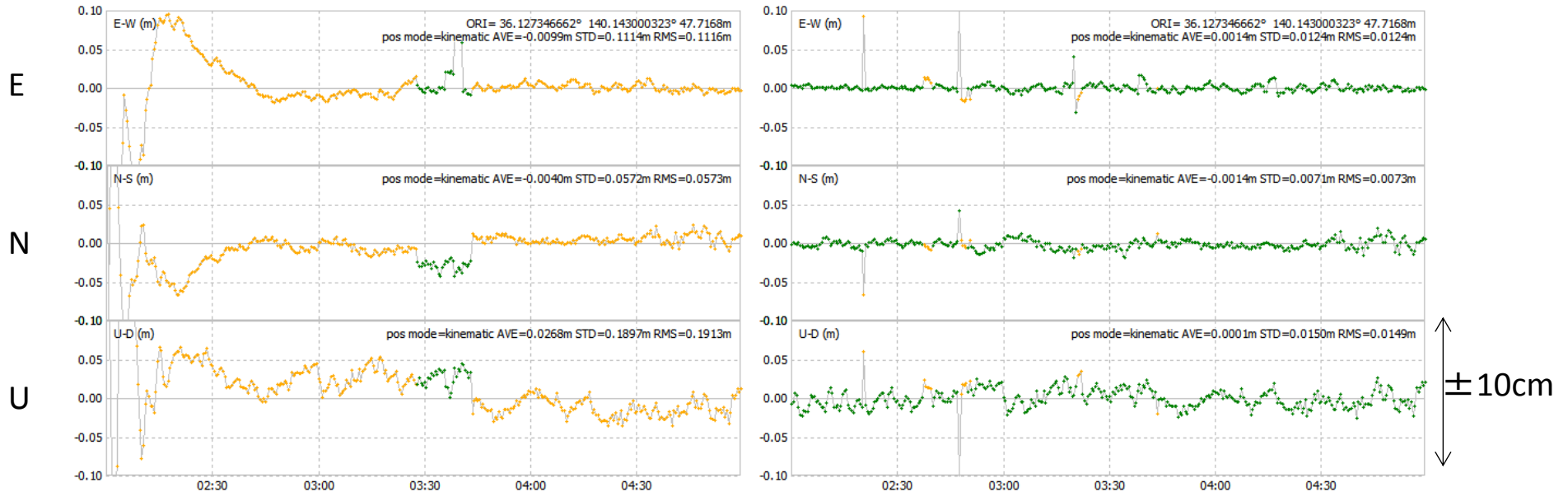
No correction

Fix 8.6%

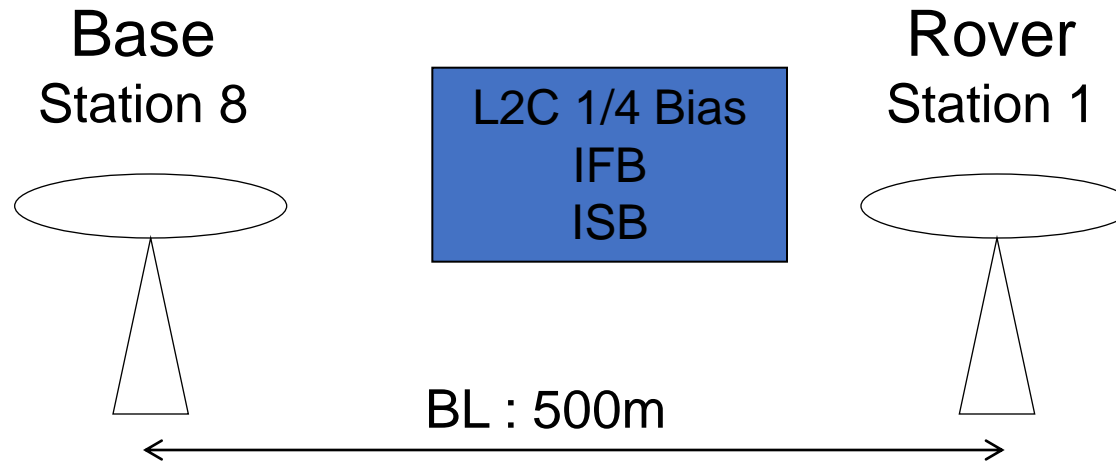
● Fix ● Float

ISB correction

Fix 95.8%

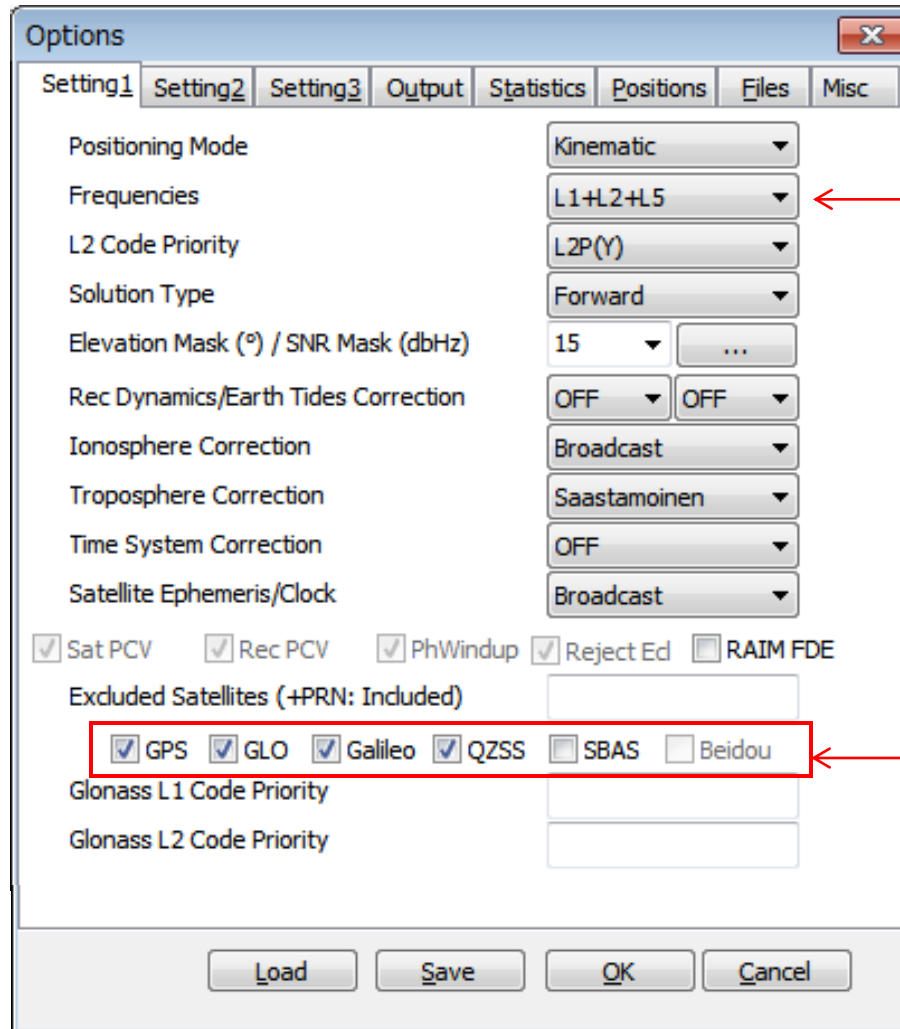


- RTK using GPS+GLONASS+QZSS+Galileo with all corrections



Antenna : JAV\_GRANT-G3T  
Receiver : JAVAD TRE\_G3T DELTA

# (1-1) Positioning options: Setting 1



Frequencies "L1+L2+L5"

Satellite types  
(GPS, GLO, GAL, QZS)

# (1-2) Positioning options: Setting 2



Options

Setting1 Setting2 Setting3 Output Statistics Positions Files Misc

Integer Ambiguity Resolution Method	LAMBDA
Integer Ambiguity Resolution Strategy	Continuous
GLONASS Ambiguity Resolution	Use IFB Table
PPP Ambiguity Resolution	OFF
Min Ratio to Fix Ambiguity	3
Min Confidence / Max FCB to Fix Amb	0.9999 0.2
Min Lock / Elevation (°) to Fix Ambiguity	0 0
Min Fix / Elevation (°) to Hold Ambiguity	10 0
Outage to Reset Amb/Slip Thres (m)	5 0.500
Phase Cycle Shift	Table
L2C-L2P Bias	OFF
Max Age of Differential (s)	30.0
Reject Threshold of GDOP/Innov (m)	30.0 30.0
Number of Filter Iteration	1
<input type="checkbox"/> Baseline Length Constraint (m)	0.000 0.000
Inter System Bias	Table
Analysys Method in Double Differencing	exc. glonass

Load Save OK Cancel

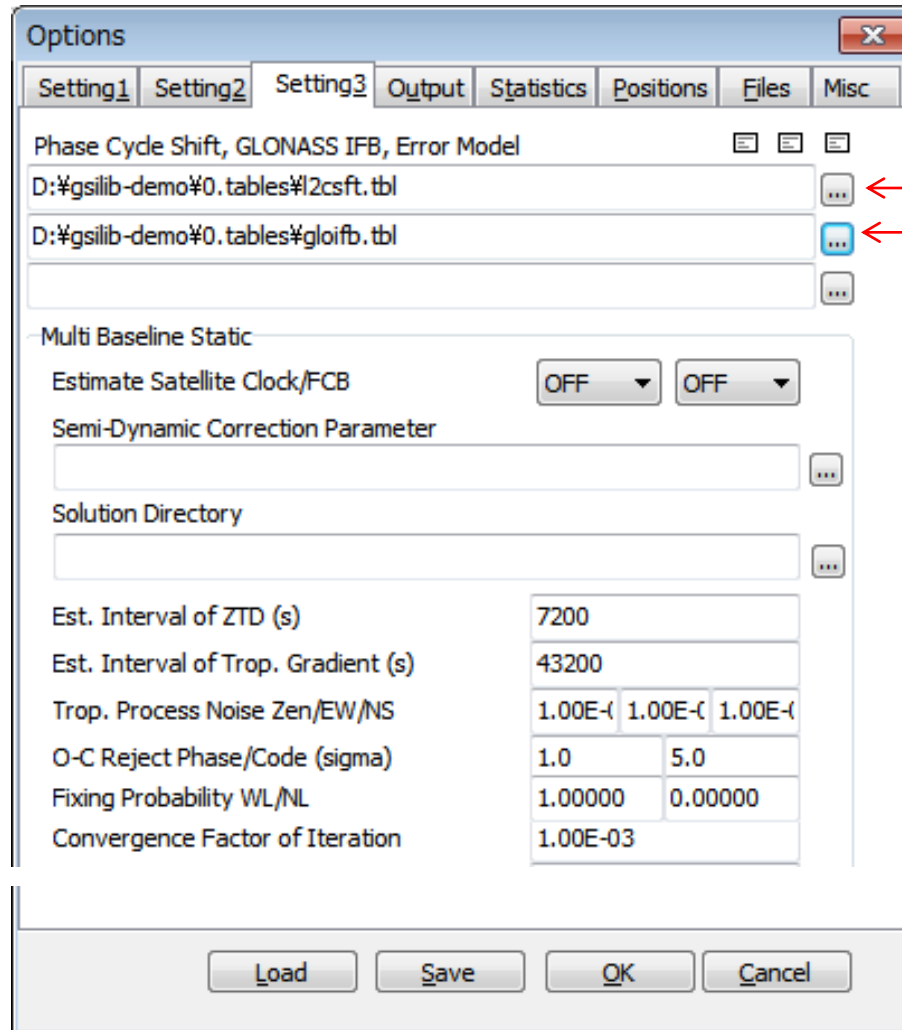
GLONASS Ambiguity Resolution "Use IFB Table"

Phase Cycle Shift "Table"

Inter System Bias "Table"

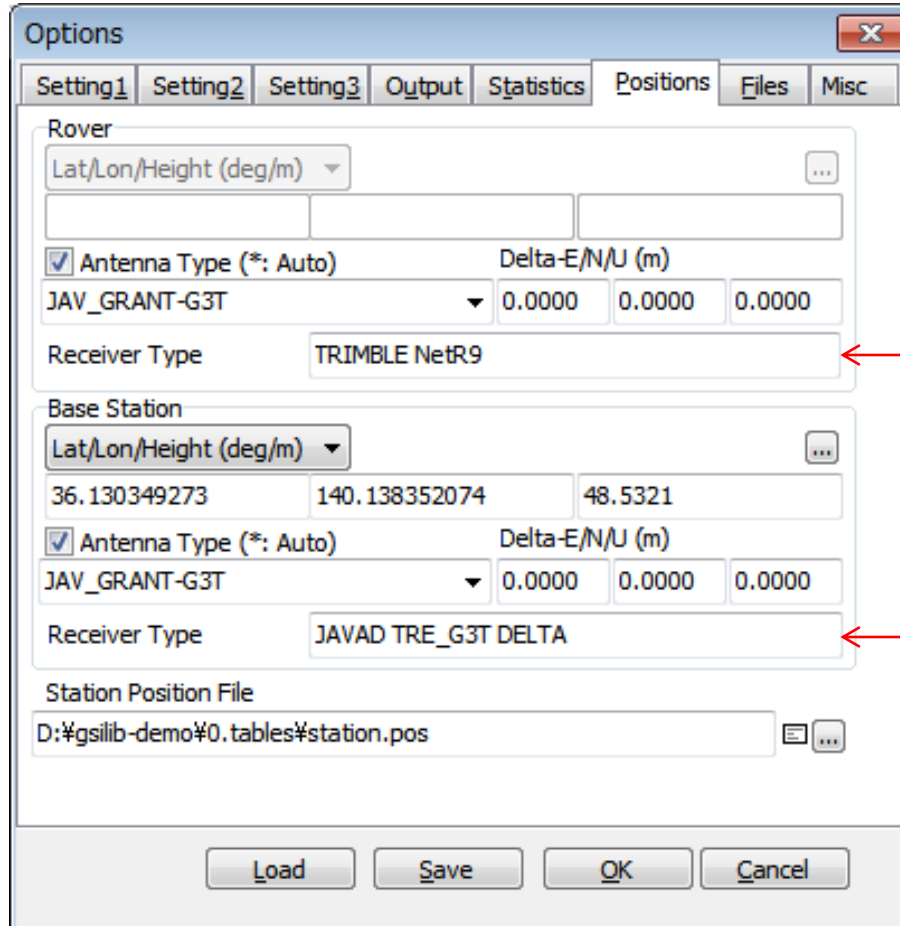


# (1-2) Positioning options: Setting 3



Phase Cycle Shift file  
GLONASS IFB file

# (1-4) Positioning options: Positions



Options

Setting<sub>1</sub> Setting<sub>2</sub> Setting<sub>3</sub> Output Statistics **Positions** Files Misc

Rover

Lat/Lon/Height (deg/m) ...

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

JAV\_GRANT-G3T 0.0000 0.0000 0.0000

Receiver Type TRIMBLE NetR9

Base Station

Lat/Lon/Height (deg/m) ...

36.130349273 140.138352074 48.5321

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

JAV\_GRANT-G3T 0.0000 0.0000 0.0000

Receiver Type JAVAD TRE\_G3T DELTA

Station Position File

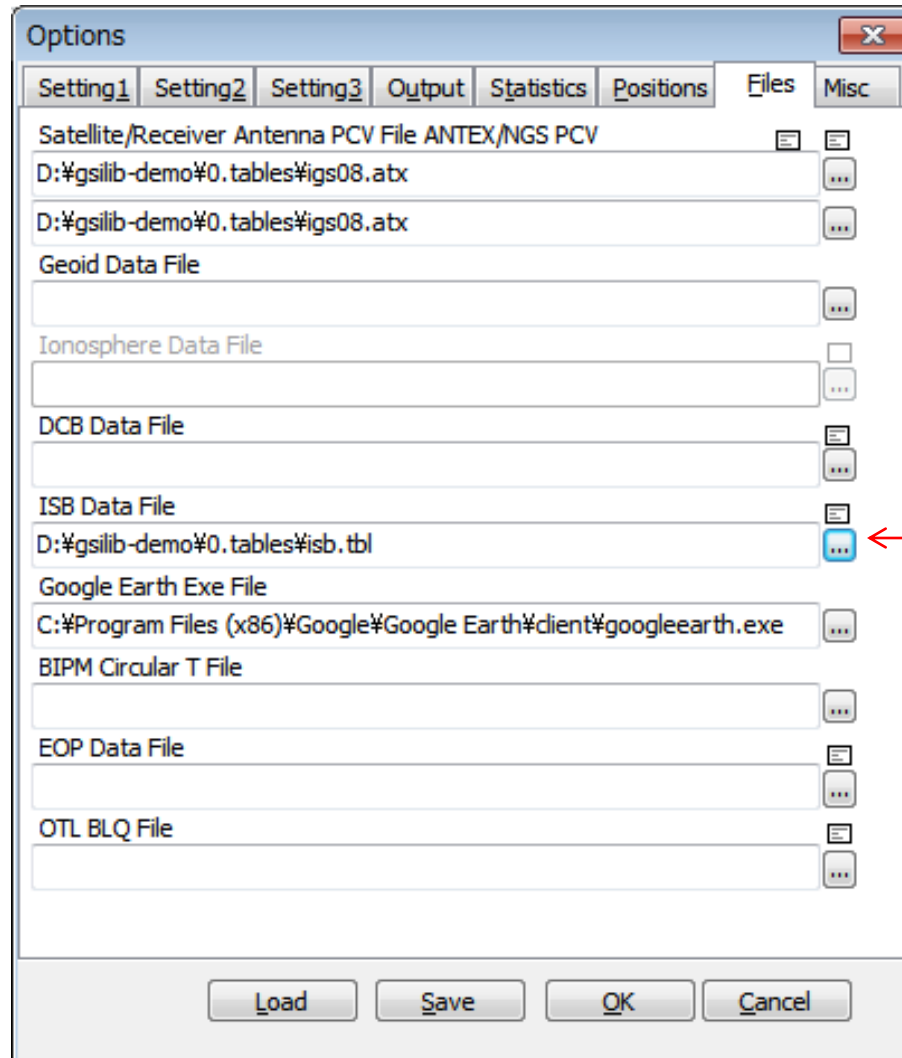
D:\%gsilib-demo%0.tables#station.pos

Load Save OK Cancel

Rover Receiver Type

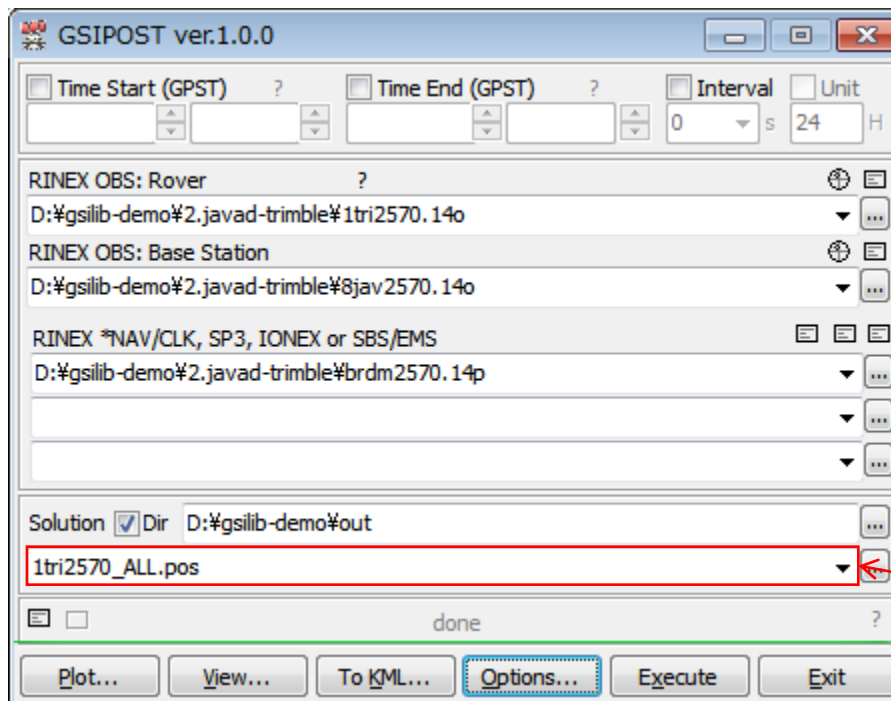
Base Receiver Type

# (1-5) Positioning options: Files



ISB Data File

# RINEX file selection



Solution file (\*.\*\*\*.pos)

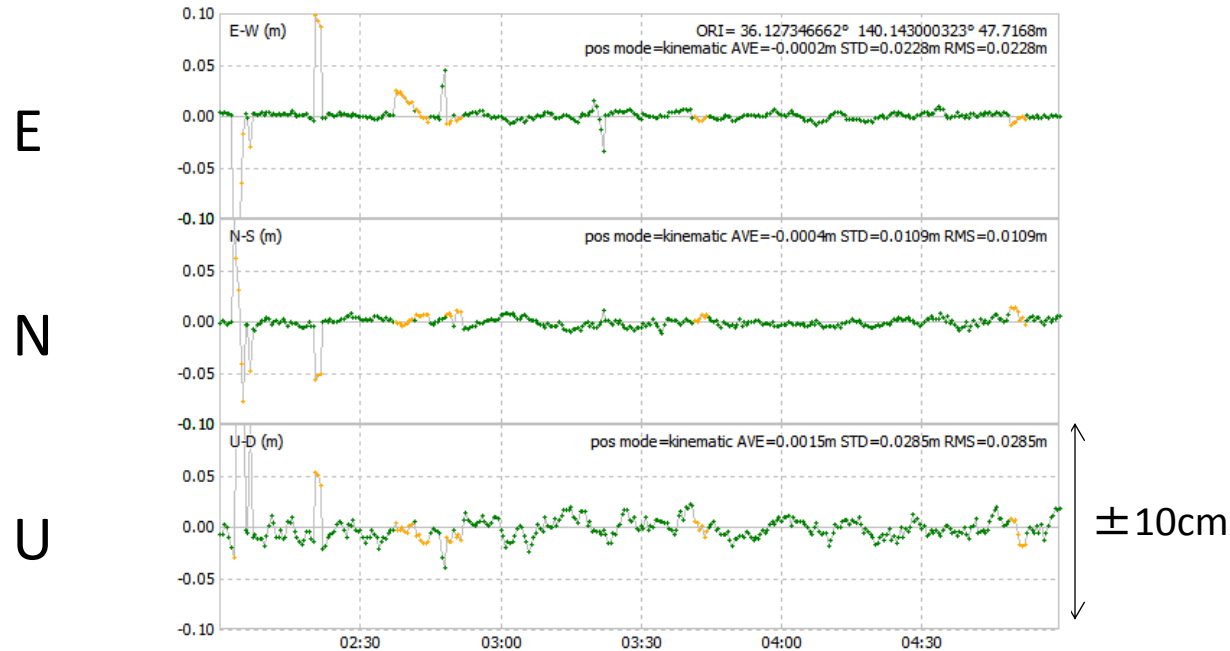
# Results with all corrections



## GPS + GLONASS + QZSS + Galileo

Fix 88.3%

● Fix ● Float



Fix solution

RMS E: 4.9mm N: 3.8mm U: 9.4mm

- Multi-GNSS environment improves availability, accuracy, reliability, convergence of GNSS positioning
- However, some biases have to be considered
  - IFB, ISB, quarter-cycle shift
- **GSILIB is an open-source software**, which offers the **table-based corrections of IFB, ISB and quarter-cycle shift** to utilize multi-GNSS data

[http://datahouse1.gsi.go.jp/gsilib/gsilib\\_download\\_eng.html](http://datahouse1.gsi.go.jp/gsilib/gsilib_download_eng.html)