



# An Introduction to RTKLIB open source GNSS processing software

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# Overview

- Introduction and Installation of RTKLIB.

## Post-Processing Tutorial

- Observation Data Quality.
- Single Point Post-Processing.
- Precise Post-Positioning.



## What is RTKLIB?

- An open source package for GNSS Positioning.
- Developed by Mr Tomoji Takasu of the Tokyo University of Marine Science and Technology.
- Support for multi-GNSS.
- Positioning modes for both real-time and post-processing.
- Supports standard formats and protocols.
- GUI and CUI Aps on Windows and CUI Aps on Linux.
- Freely distributed from [www.rtklib.com](http://www.rtklib.com) under a BSD license.

# Potential Uses of RTKLIB



...?



## Installation of RTKLIB

- The current release is v2.4.3 (*rtklib\_2.4.3.zip*)
- Copy file from provided thumb-drive or from github and unzip to a directory (eg. *Program Files*).
- Double click the *rtklib\_2.4.3* directory and you will find:
  - bin\* (contains the executables)
  - doc\* (contains the user manual)
- To begin, double click the executable *rtklaunch.exe*.



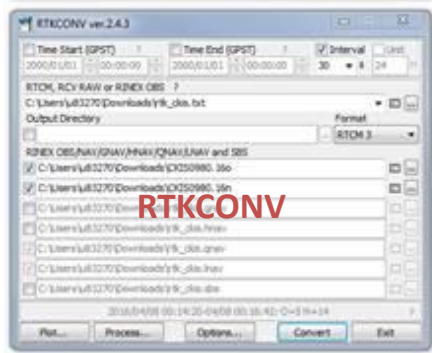
# RTKLIB Apps



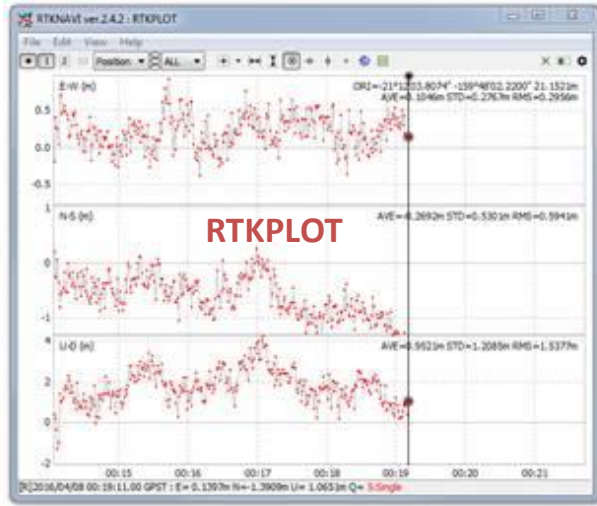
**STRSRV**



**RTKPLLOT**



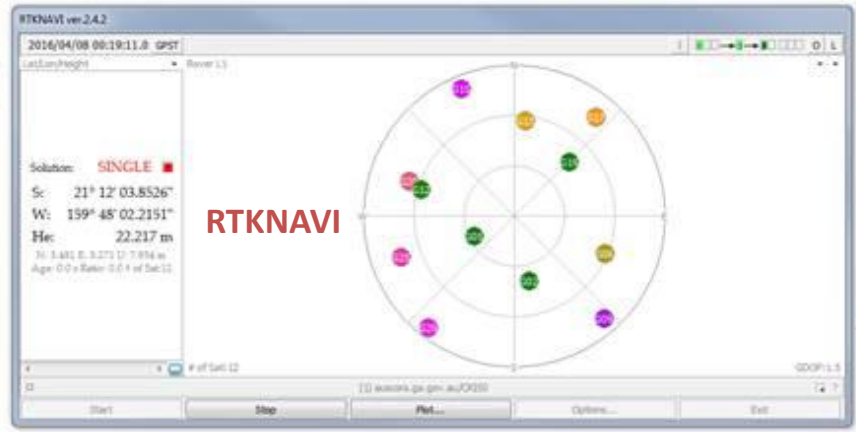
**RTKCONV**



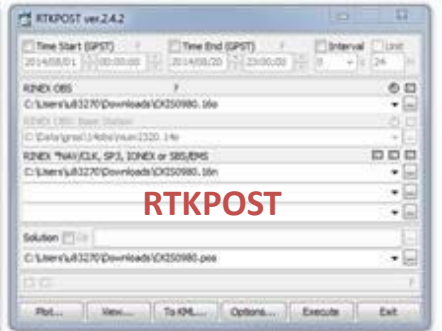
**RTKNAVI**

Mountpoint	ID	Format	Format Details	Ca Nav-System	Network	Country	Latitude
AUS10	Albany (WA)	RTCM 3.1	300C(1), 1009E(1S), 1008N(1S), 10 12Z(1), 10 19W(0), VC 2	GPS+GLD	AUSCOPE	AUS	-34.95
AUS20	Alice Springs (NT)	RTCM 3.1	300C(1), 1009E(1S), 1008N(1S), 10 12Z(1), 10 19W(0), VC 2	GPS+GLD	AUSCOPE	AUS	-23.670
AUS30	Alice Springs (NT)	RTCM 3.2	300E(1S), 1009E(1S), 1008N(1S), 10 19W(0), 10 13Z(1S), 10 13Z(1S)	GPS+GLD	AUSCOPE	AUS	-23.670
AUS40	Andromeda (SA)	RTCM 3.1	300E(1), 1009E(1S), 1008N(1S), 10 12Z(1), 10 19W(0), VC 2	GPS+GLD	AUSCOPE	AUS	-35.45
AUS50	Armidale (NSW)	RTCM 3.1	300E(1), 10 12Z(1)	GPS+GLD	ARRF	AUS	-30.52
AUS60	Aramac (QLD)	RTCM 3.1	300E(1), 1009E(1S), 1008N(1S), 10 12Z(1), 10 13Z(1S), VC 2	GPS+GLD	AUSCOPE	AUS	-23.95
AUS70	Aramac (QLD)	RTCM 3.2	300E(1S), 1009E(1S), 10 19W(0), 10 13Z(1S), 10 13Z(1S)	GPS+GLD	AUSCOPE	AUS	-23.95
AUS80	Aratuddy (WA)	RTCM 3.1	300E(1), 1009E(1S), 1008N(1S), 10 12Z(1), 10 19W(0), VC 2	GPS+GLD	AUSCOPE	AUS	-31.80
AUS90	Aratuddy (WA)	RTCM 3.2	300E(1S), 1009E(1S), 10 19W(0), 10 13Z(1S), 10 13Z(1S)	GPS+GLD	AUSCOPE	AUS	-31.80
AUS00	Australian	RTCM 3.0	300E(1), 1009E(1S), 1008N(1S), 10 12Z(1), 10 13Z(1S), VC 2	GPS+GLD	10S	NL	-36.60
BALA0	Baladonia (WA)	RTCM 3.1	300E(1), 1009E(1S), 1008N(1S), 10 12Z(1), 10 19W(0), VC 2	GPS+GLD	AUSCOPE	AUS	-32.46
BALA4	Baladonia (WA)	RTCM 3.2	300E(1S), 1009E(1S), 10 19W(0), 10 13Z(1S), 10 13Z(1S)	GPS+GLD	AUSCOPE	AUS	-32.46
BARR0	Barrack Heights (NSW)	RTCM 3.1	300E(1), 10 12Z(1)	GPS+GLD	ARRF	AUS	-34.53
BEC00	Bucklebo (SA)	RTCM 3.1	300E(1), 1009E(1S), 1008N(1S), 10 12Z(1), 10 19W(0), VC 2	GPS+GLD	AUSCOPE	AUS	-32.81
BOLD0	Barradale (VIC)	RTCM 3.1	300E(1), 1009E(1S), 1008N(1S), 10 12Z(1), 10 13Z(1S)	GPS+GLD	AUSCOPE	AUS	-37.76
BOSV0	Briveville (QLD)	RTCM 3.1	300E(1), 1009E(1S), 1008N(1S), 10 12Z(1), 10 13Z(1S), VC 2	GPS+GLD	AUSCOPE	AUS	-25.90
BOSV4	Briveville (QLD)	RTCM 3.2	300E(1S), 1009E(1S), 10 19W(0), 10 13Z(1S), 10 13Z(1S)	GPS+GLD	AUSCOPE	AUS	-25.90
BEEC0	Beechworth (VIC)	RTCM 3.1	300E(1), 1009E(1S), 1008N(1S), 10 12Z(1), 10 13Z(1S)	GPS+GLD	AUSCOPE	AUS	-36.30
BENG0	Bengalla (NSW)	RTCM 3.1	300E(1), 10 12Z(1)	GPS+GLD	AUSCOPE	AUS	-32.41
BHNL0	Broken Hill (NSW)	RTCM 3.1	300E(1), 10 12Z(1)	GPS+GLD	AUSCOPE	AUS	-31.99
BMAN0	Brimman (SA)	RTCM 3.1	300E(1), 1009E(1S), 1008N(1S), 10 12Z(1), 10 13Z(1S), VC 2	GPS+GLD	AUSCOPE	AUS	-31.13
BMAN4	Brimman (SA)	RTCM 3.2	300E(1S), 1009E(1S), 10 13Z(1S), 10 13Z(1S)	GPS+GLD	AUSCOPE	AUS	-31.13
BREY0	Burdleberg (QLD)	RTCM 3.0	300E(1), 1009E(1S), 1008N(1S), 10 12Z(1), 10 19W(0), VC 2	GPS+GLD	ARGN	AUS	-24.81
BRLD0	Burrolake (NT)	RTCM 3.1	300E(1), 1009E(1S), 1008N(1S), 10 12Z(1), 10 13Z(1S)	GPS+GLD	AUSCOPE	AUS	-16.05

**NTRIP Browser**



**RTKNAVI**



**RTKPOST**



**RTKLAUNCH**



# Post-Processing Tutorial

## Example Data

- Niue Tide Gauge
- 24 hours static observation
- GPS L1+L2
- niut0880.16o
- niut0880.16n



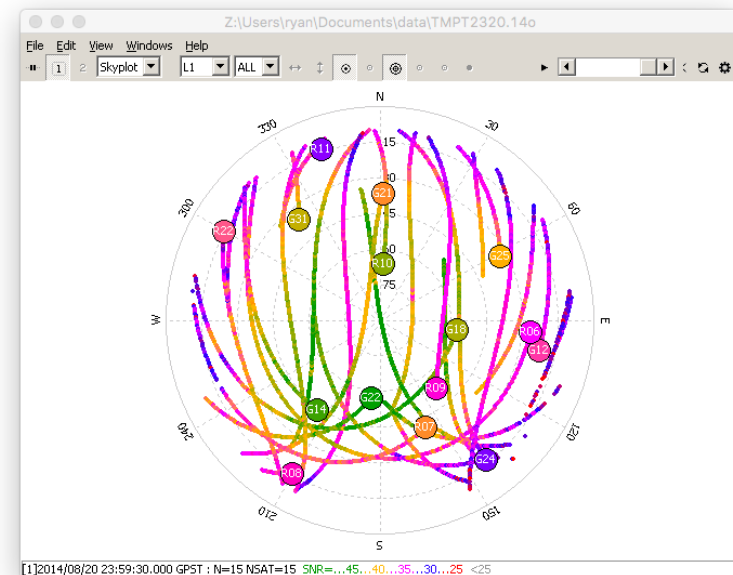


## Observation Data Quality (RTKPLOT) (1)

RTKPLOT can be used to assess the quality of RINEX observation data and to assist in planning the ideal time to undertake a GNSS occupation.

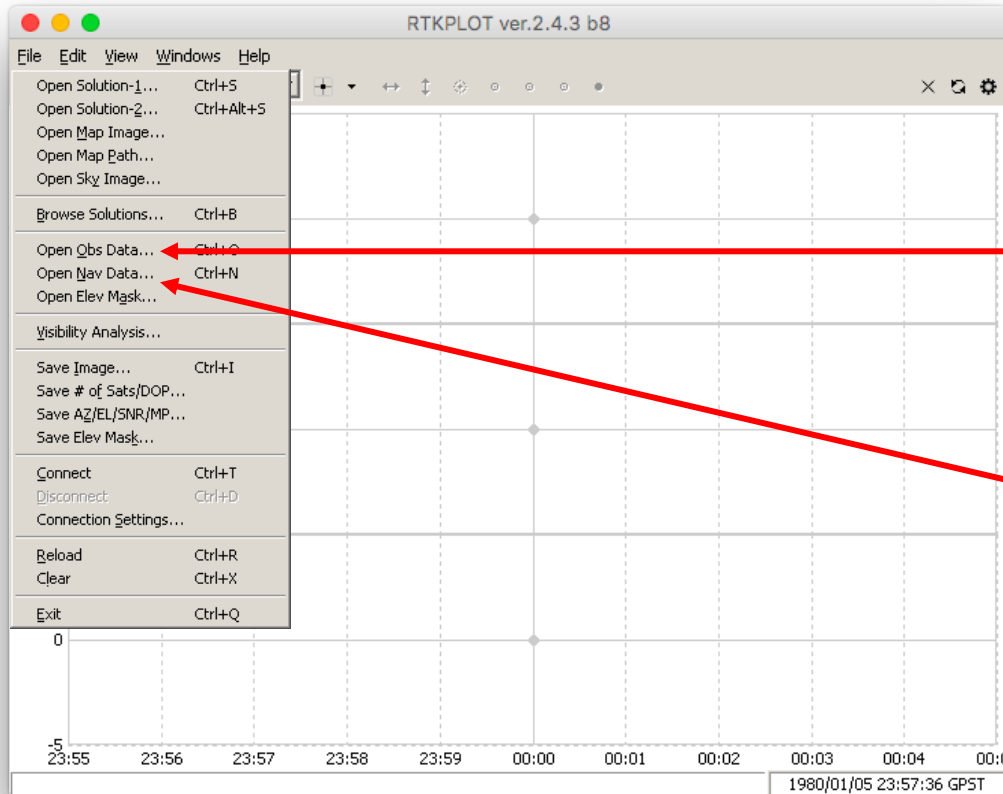
### Visual Analysis Includes:

- Satellite Availability
- Dilution of Precision (DOP)
- Signal to Noise Ratio (SNR)
- Multipath



A QC summary file is also available through a TEQC analysis.

# Observation Data Quality (RTKPLOT) (2)



niut0880.16o

Observation data

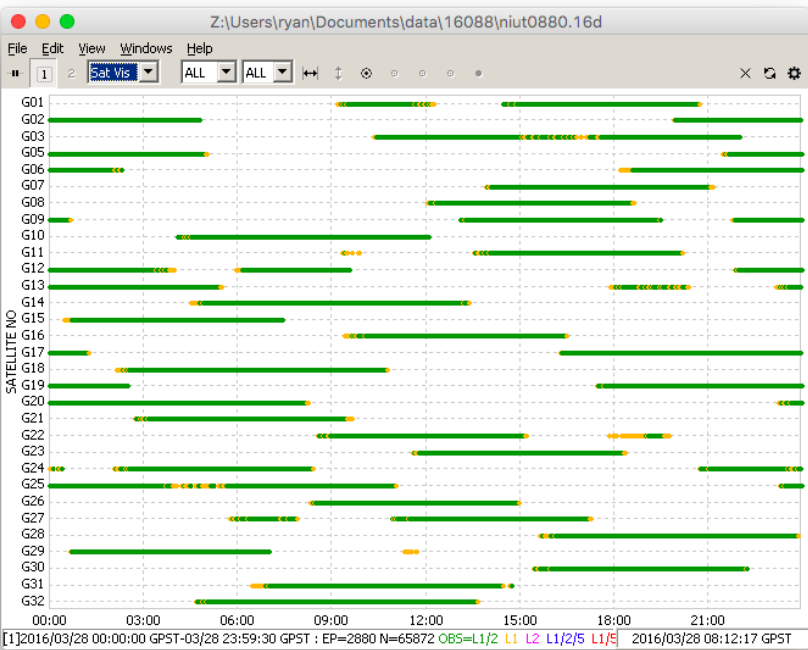
niut0880.16n

Navigation data

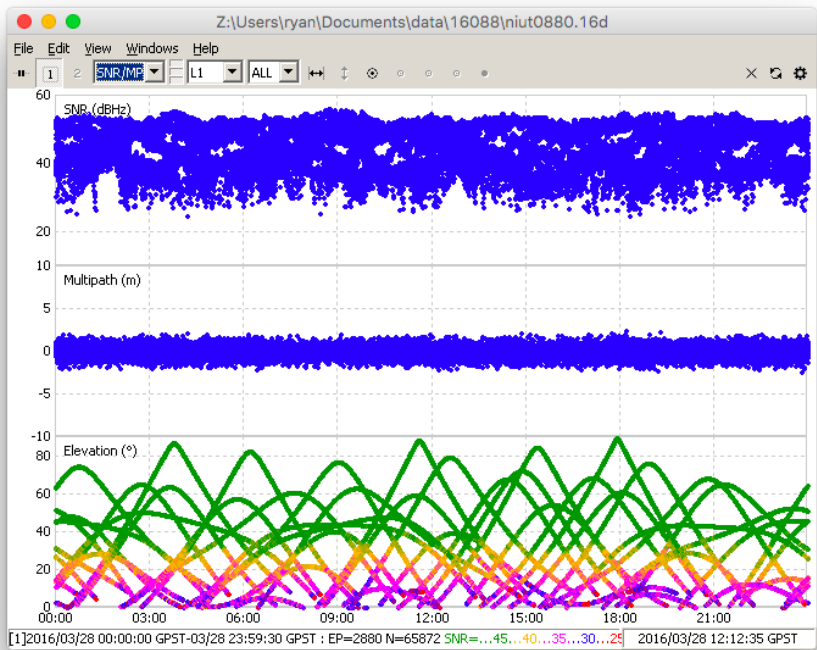


# Observation Data Quality (RTKPLLOT) (3)

Satellite Availability



SNR and Multipath (L1)





# RTKPOST

RTKPOST is a post-processing application that computes positioning solutions by various modes including single-point, DGNSS, kinematic, static and PPP.

## Single-Point Positioning Example

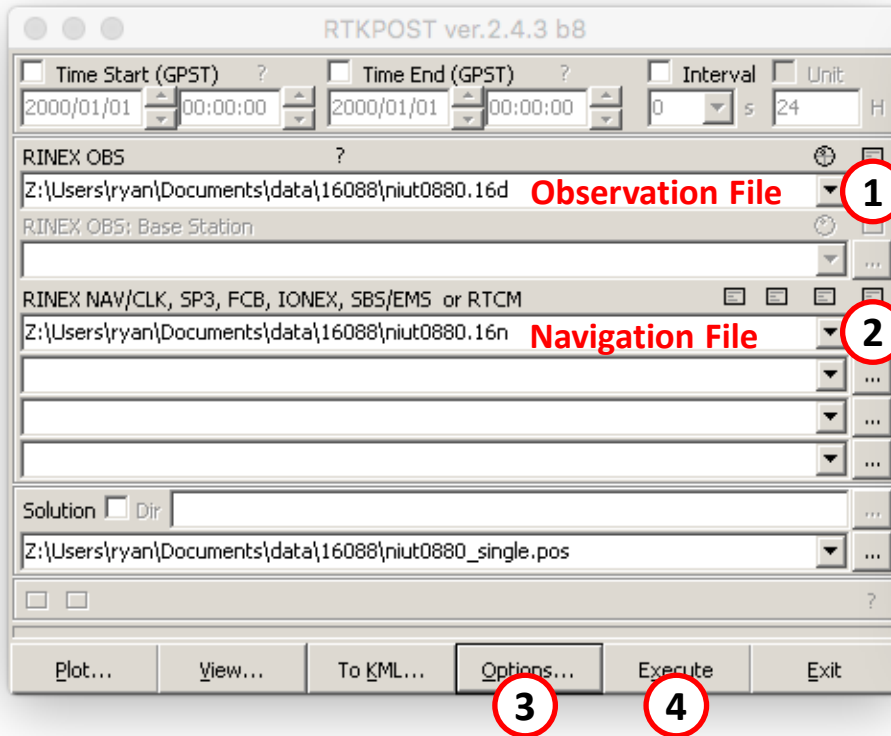
- Standard positioning mode using L1 Pseudorange only.

## Objectives

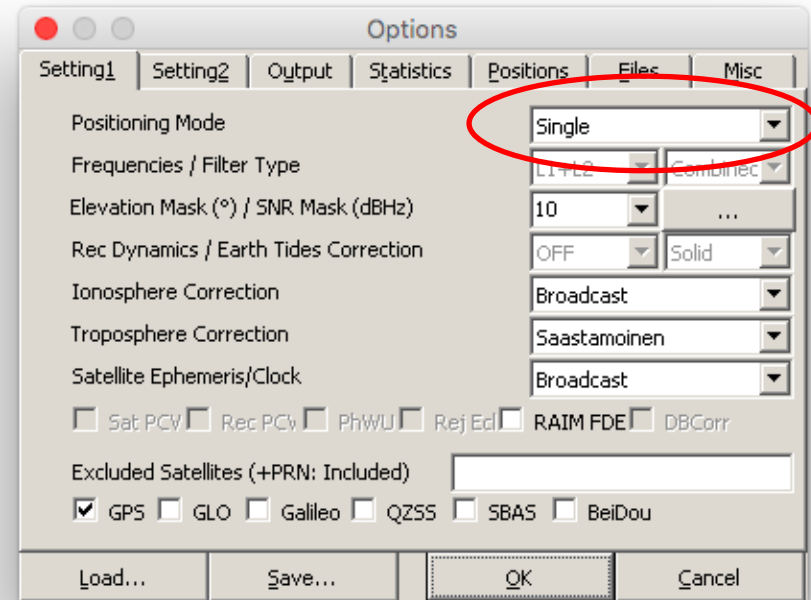
- Introduce GNSS post-processing using RTKPOST.
- Plot the results using RTKPLOT.

# Single Point Positioning – Options (RTKPOST)

- Import data and execute processing.



## Setting 1



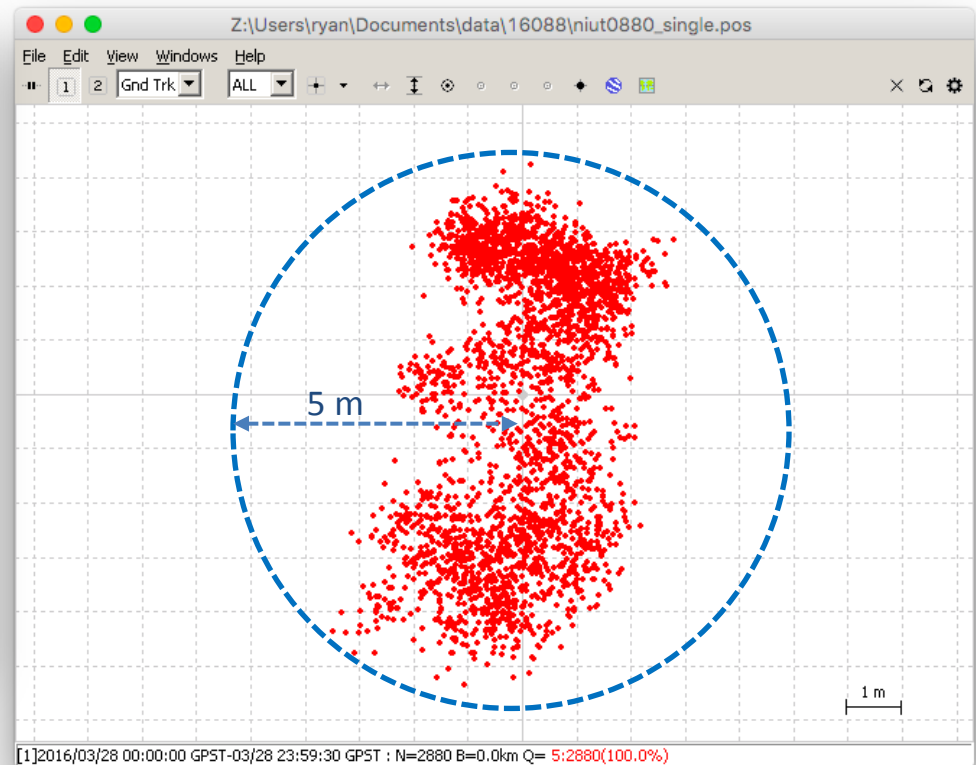
# Single Point Positioning – Plotting Results (RTKPLOT)

- RTKPLOT can be used to display the solution per epoch.

```

Z:\Users\ryan\Documents\data\16088\niut0880_L1.pos
Find Read... Option... Close

% program : RTKPOST ver.2.4.3 b8
% inp file : Z:\Users\ryan\Documents\data\16088\niut0880.16d
% inp file : Z:\Users\ryan\Documents\data\16088\niut0880.16n
% obs start : 2016/03/28 00:00:00.0 GPST (week1890 86400.0s)
% obs end : 2016/03/28 23:59:30.0 GPST (week1890 172770.0s)
% pos mode : single
% elev mask : 10.0 deg
% ionos opt : broadcast
% tropo opt : saastamoinen
% ephemeris : broadcast
%
% (lat/lon/height=WGS84/ellipsoidal,Q=1:fix,2:float,3:sbas,4:dgps,5:single,6:ppp,ns=#
% GPST latitude(d'') longitude(d'') height(m) Q ns sdn(m)
2016/03/28 00:00:00.000 -19 03 10.97845 -169 55 14.31895 41.7279 5 10 3.5082
2016/03/28 00:00:30.000 -19 03 10.97041 -169 55 14.31620 41.2188 5 10 3.5108
2016/03/28 00:01:00.000 -19 03 10.96182 -169 55 14.32376 40.7426 5 10 3.5135
2016/03/28 00:01:30.000 -19 03 10.98085 -169 55 14.32642 40.2948 5 10 3.5161
2016/03/28 00:02:00.000 -19 03 10.96608 -169 55 14.31260 41.3207 5 10 3.5187
2016/03/28 00:02:30.000 -19 03 10.96779 -169 55 14.32320 40.7788 5 10 3.5212
2016/03/28 00:03:00.000 -19 03 10.98283 -169 55 14.31291 41.5010 5 10 3.5238
2016/03/28 00:03:30.000 -19 03 10.96841 -169 55 14.30076 42.9595 5 10 3.5264
2016/03/28 00:04:00.000 -19 03 10.99227 -169 55 14.33142 41.8662 5 10 3.5289
2016/03/28 00:04:30.000 -19 03 10.97354 -169 55 14.33392 41.1253 5 10 3.5314
2016/03/28 00:05:00.000 -19 03 10.97997 -169 55 14.30762 41.1892 5 10 3.5339
2016/03/28 00:05:30.000 -19 03 10.98362 -169 55 14.33030 40.4177 5 10 3.5364
2016/03/28 00:06:00.000 -19 03 10.97031 -169 55 14.33254 41.4383 5 10 3.5389
2016/03/28 00:06:30.000 -19 03 10.96438 -169 55 14.32813 40.2563 5 10 3.5413
2016/03/28 00:07:00.000 -19 03 10.97472 -169 55 14.32589 41.4575 5 10 3.5437
2016/03/28 00:07:30.000 -19 03 10.97057 -169 55 14.32013 41.3052 5 10 3.5461
2016/03/28 00:08:00.000 -19 03 10.98224 -169 55 14.32967 41.9397 5 10 3.5485
    
```



[1]2016/03/28 00:00:00 GPST-03/28 23:59:30 GPST : N=2880 B=0.0km Q= 5:2880(100.0%)



## Standard Positioning v Precise Positioning

	Standard Positioning (code based)	Precise Positioning (carrier based)
Observables	Pseudorange	Carrier + Pseudorange
Receiver Noise	30 cm	3 mm
Multipath	30 cm to 30 m	1 to 3 cm
Sensitivity	High	Low
Discontinuity	No Slip	Cycle-Slip
Ambiguity	-	Estimated / Resolved
Receiver	Low Cost (Single Freq.)	Expensive (Dual Freq.)
Accuracy (RMS)	3 m (Horizontal) 5 m (Vertical)	5 mm (Horizontal) 10 mm (Vertical)
Application	Navigation, Timing ...	Surveying, Mapping ...

Table adapted from GNSS Precise Positioning with RTKLIB: Part 2, IPNT-J Seminar, Tokyo, April 26, 2011



## Static Post-Processing (RTKPOST)

The static positioning mode processes a baseline between a known reference point (base) and a static antenna (rover).

### Requires:

- Reference station data with reliable coordinates.
- Precise satellite orbits.
- Antenna information.

### Objectives

- Configure RTKPOST for precise positioning.
- Find reference station data and coordinates from a global data centre.
- Download precise satellite orbits (RTKGET).

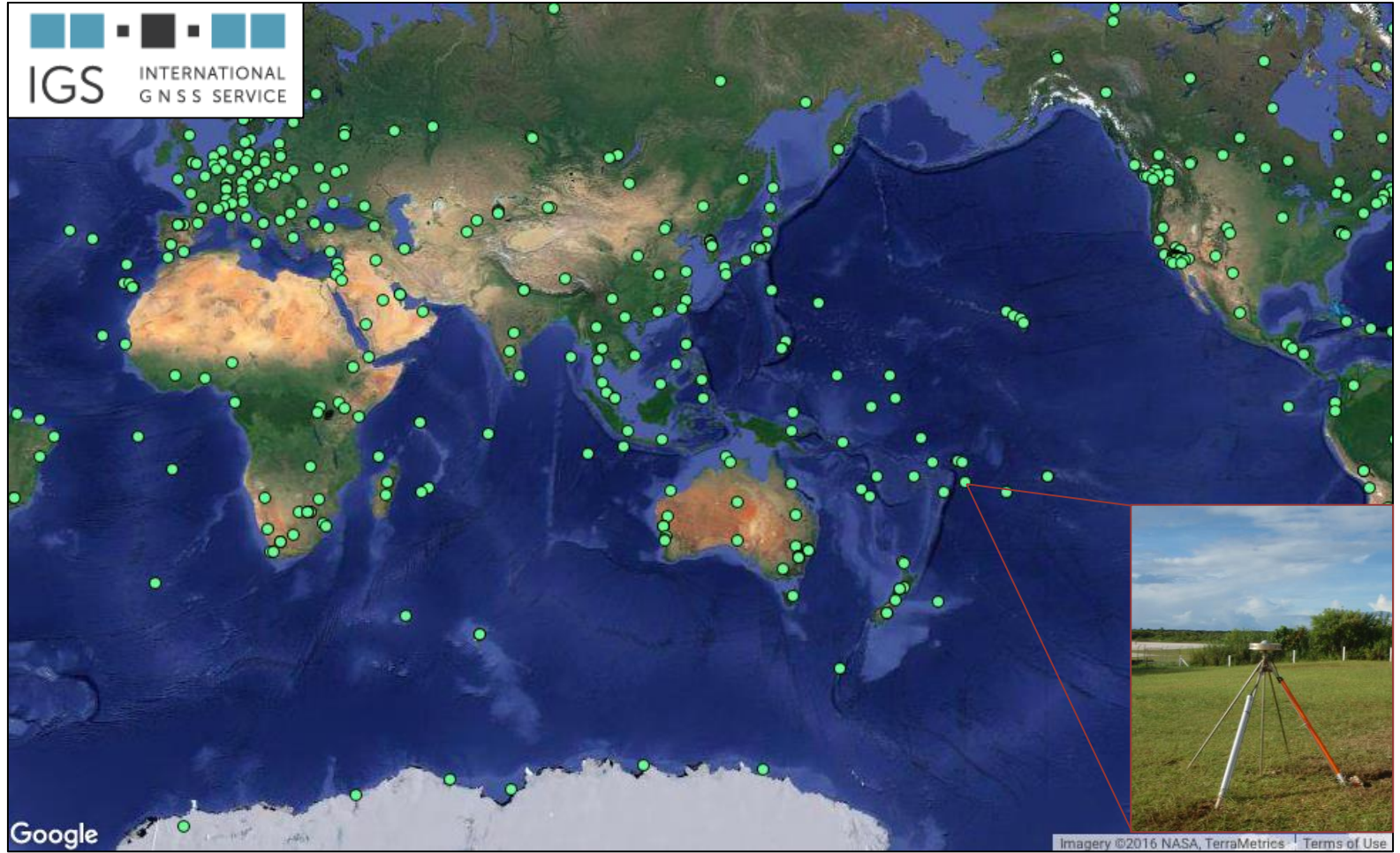




# Reference Station Data

<http://www.igs.org>

<ftp://ftp.ga.gov.au>



Sponsors:





# Precise Satellite Orbits

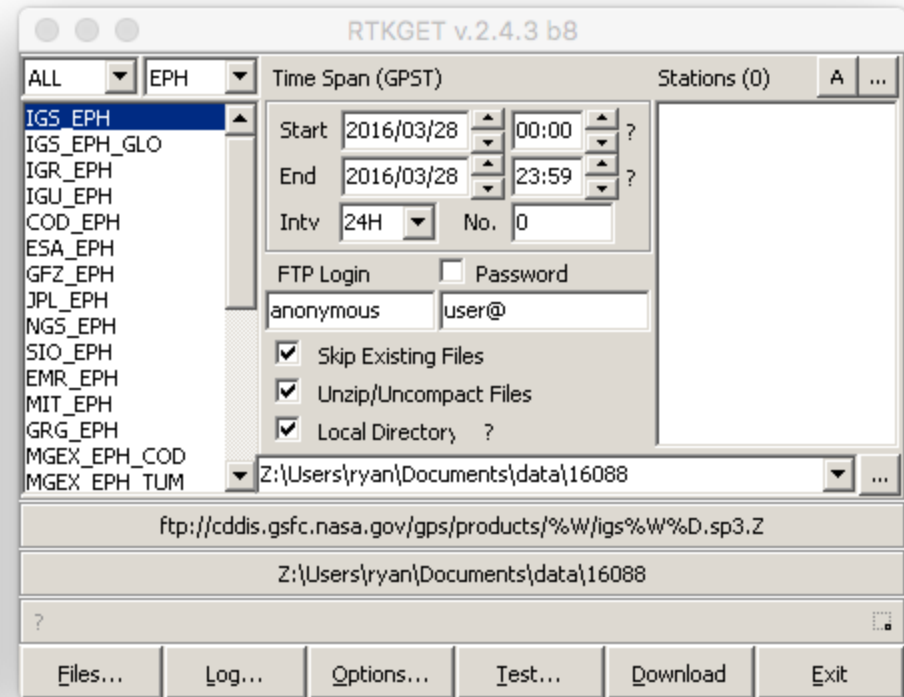
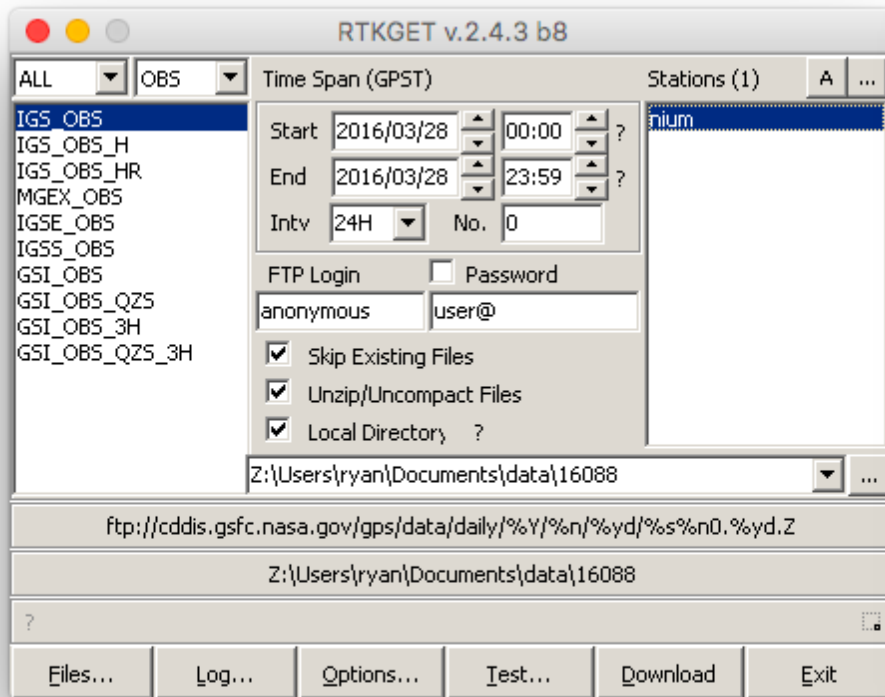
Type	Accuracy	Latency	Updates	Sample Interval
Broadcast	~100 cm	Real-time	-	daily
Ultra-Rapid (predicted half)	~5 cm	Real-time	at 03,09,15,21 UTC	15 min
Ultra-Rapid (observed half)	~3 cm	3 – 9 hours	at 03,09,15,21 UTC	15 min
Rapid	~2.5 cm	17 – 41 hours	at 17 UTC daily	15 min
Final	~2.5 cm	12 – 18 days	every Thursday	15 min

- <ftp://cddis.gsfc.nasa.gov/gps/products/>



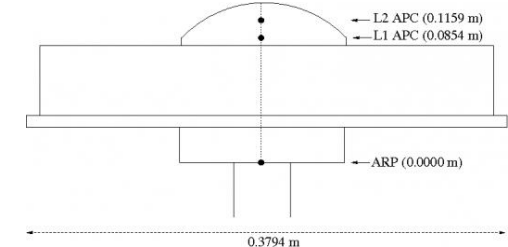
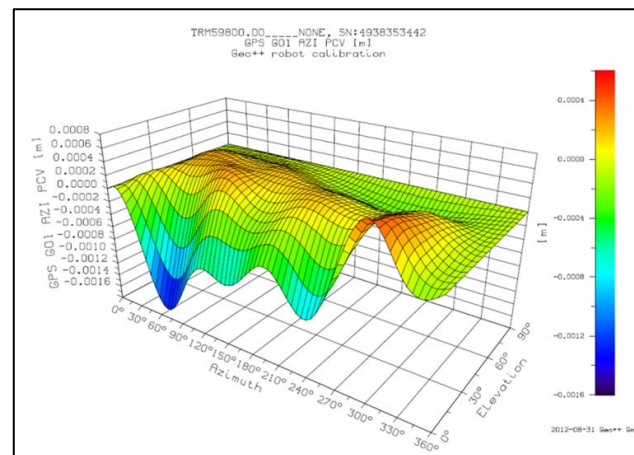
# RTKGET

- Used to download IGS products, such as satellite and clock information as well as observation data.



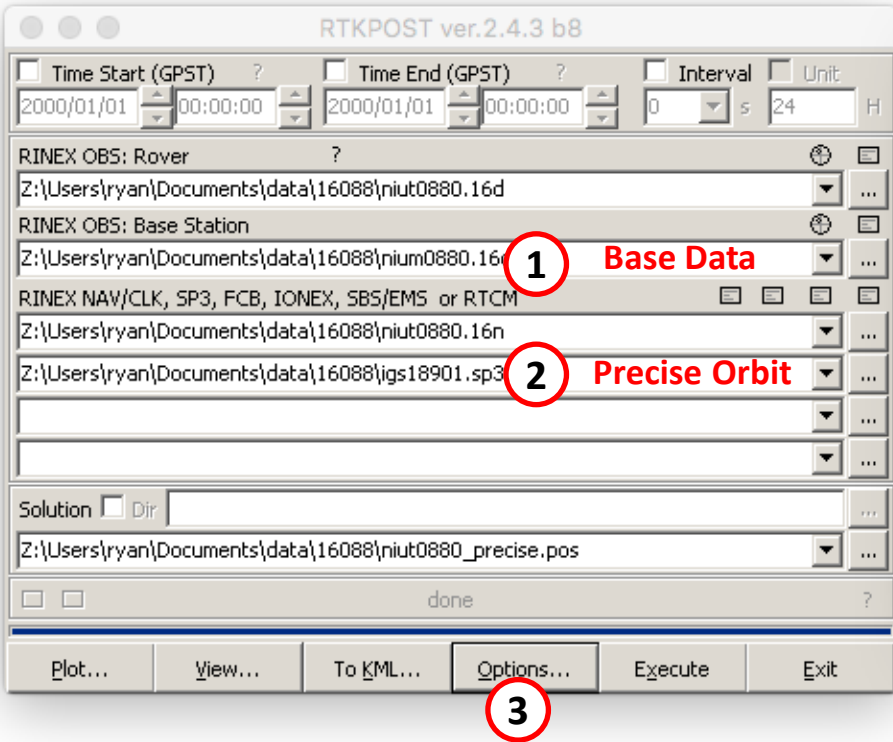
# Antenna Phase Centre Variation Models

- The antenna PC is the part of the antenna that receives the signal.
- Due to manufacturing differences and satellite geometry PC's vary between antennas.
- Robotic antenna calibrations are available that provide models to correct for the PC variation.
- <ftp.igs.org/pub/station/general/igs08.atx>

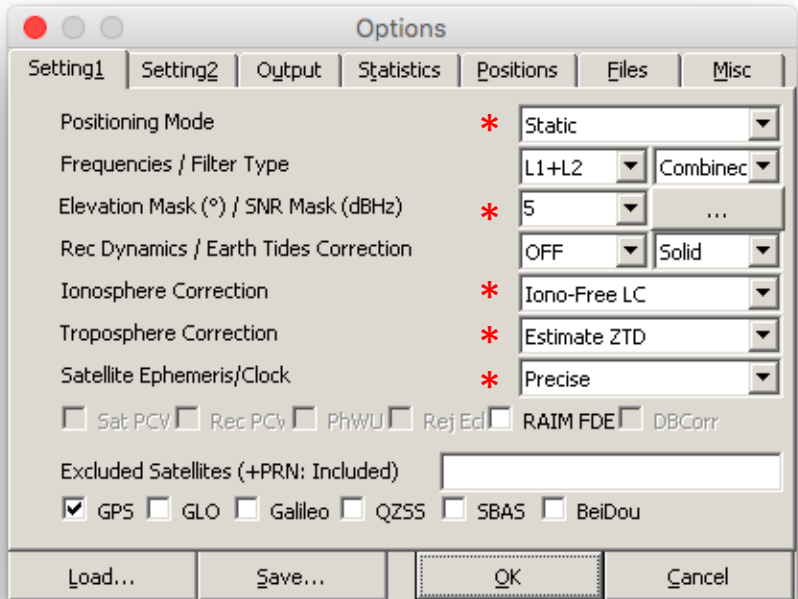




# Static Post-Processing – Options (RTKPOST)



## Setting 1





# Static Post-Processing - Options (RTKPOST)

**Setting 2**

Options dialog box, Setting2 tab. Settings include:

- Integer Ambiguity Res (GPS/GLO/BDS): Contini, 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

**Output**

Options dialog box, Output tab. Settings include:

- Solution Format: Lat/Lon/Height
- Output Header/Processing Options: ON, ON
- Time Format / # of Decimals: hh:mm:ss GPST, 3
- Latitude / Longitude Format: ddd mm ss.sss
- Field Separator: (empty)
- Datum/Height: WGS84, Ellipsoidal
- Geoid Model: Internal
- Solution for Static Mode: \* Single
- NMEA Interval (s) RMC/GGA, GSA/GSV: 0, 0
- Output Solution Status / Debug Trace: OFF, OFF

**Positions**

Options dialog box, Positions tab. Settings include:

- Rover: Lat/Lon/Height (deg/m) [90.000000000, 0.000000000, -6335367.6285]
- Antenna Type (\*: Auto): \* (marked with \*)
- Delta-E/N/U (m): 0.0000, 0.0000, 0.0000
- Base Station: Lat/Lon/Height (dms/m) [-19 04 35.487760, -169 55 37.458620, 89.6991]
- Antenna Type (\*: Auto): TRM59800.00 NONE (marked with \*)
- Delta-E/N/U (m): 0.0000, 0.0000, 0.0000

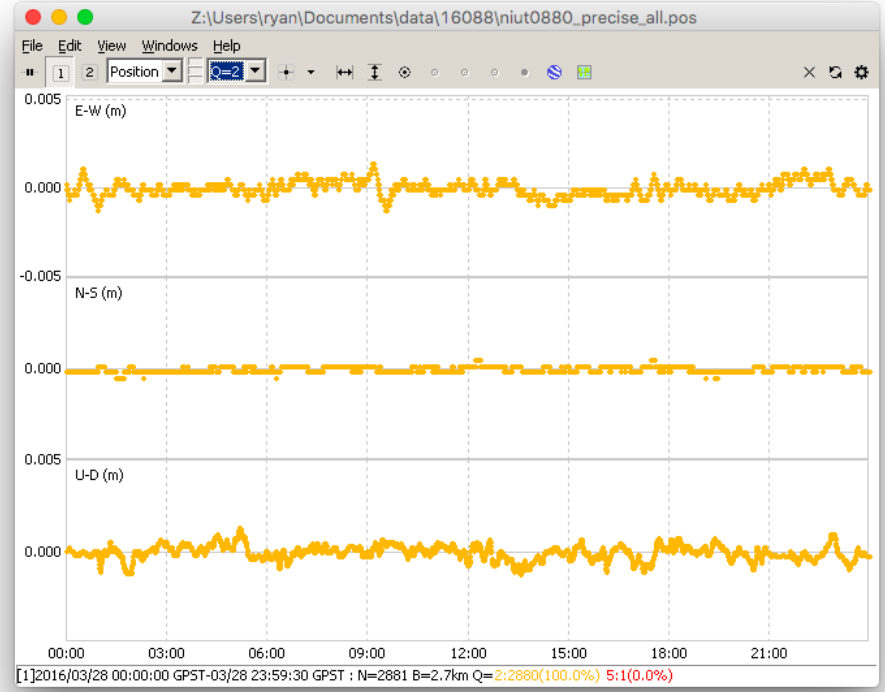
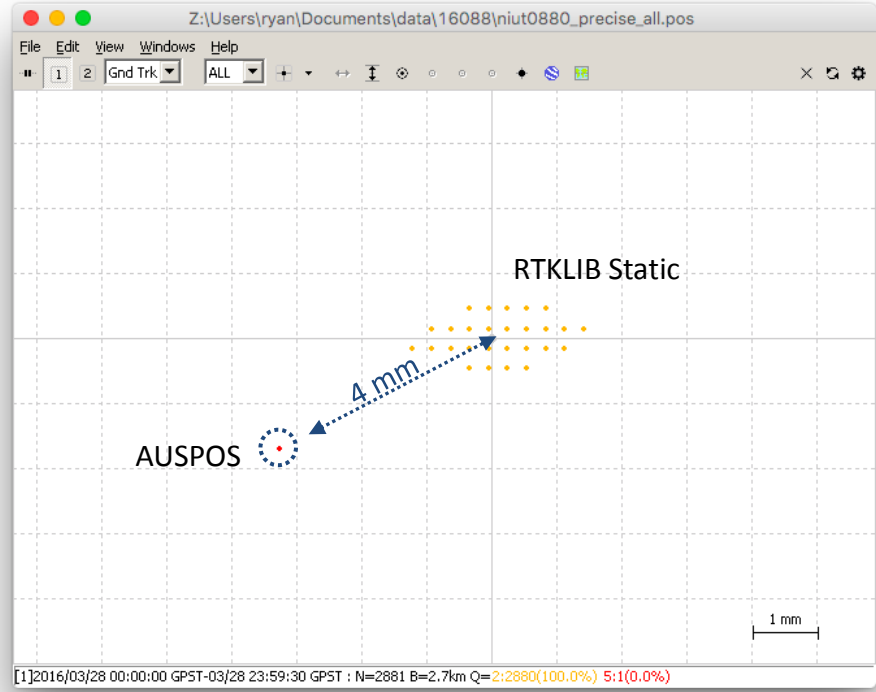
**Files**

Options dialog box, Files tab. Settings include:

- Satellite/Receiver Antenna PCV File ANTEX/NGS PCV: \* Z:\Users\ryan\Documents\data\igs08.atx
- Geoid Data File: (empty)
- DCB Data File: (empty)
- EOP Data File: (empty)
- OTL BLQ File: (empty)
- Ionosphere Data File: (empty)



# Comparison of Solutions (RTKPLOT)



Point	Latitude	Longitude	Height
NIUT (RTKLIB)	-19°03'10.79414" ± 1 mm	-169°55'14.34912" ± 3 mm	37.6594 m ± 3 mm
NIUT (AUSPOS)	-19°03'10.79419" ± 6 mm	-169°55'14.34923" ± 5 mm	37.6515 m ± 11 mm
	ΔN 3 mm	ΔE 2 mm	ΔU 8 mm



## Questions