



FIG References Frame in Practice Seminar
Operational Aspects of GNSS CORS
Holiday Inn, Suva – Fiji (18-20 September 2018)

RTK Lib

Open source GNSS Software for GNSS Solutions

Ryan Ruddick & Bart Thomas (Geoscience Australia)

Andrick Lal (Pacific Community)



Resources

- RTKLIB homepage <http://www.rtklib.com>
- GIT repository <https://github.com/tomojitakasu/RTKLIB/>
- Windows binaries https://github.com/tomojitakasu/RTKLIB_bin
- Tutorial files ftp://ftp.ga.gov.au/geodesyoutgoing/gnss/pub/RFIP_2018/



GNSS Analysis Software

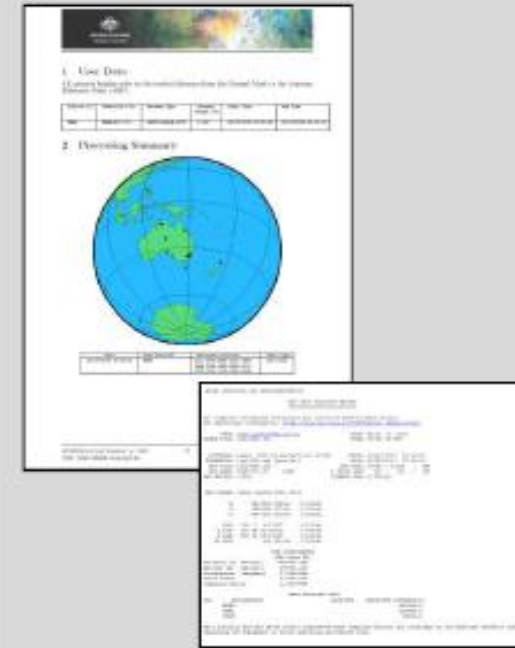
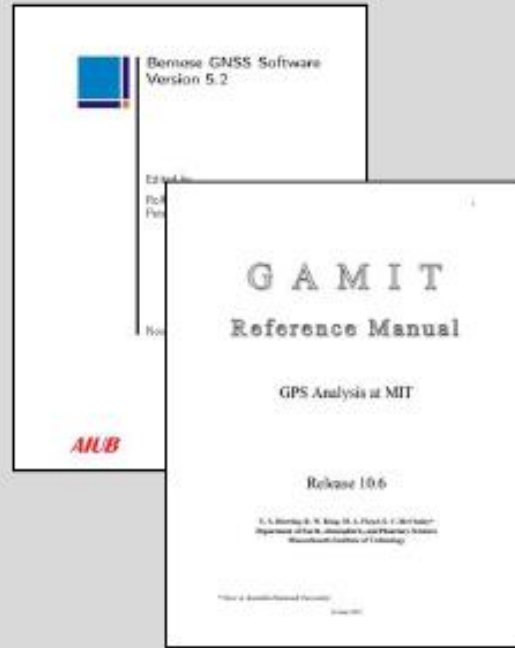




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What is RTKLIB?

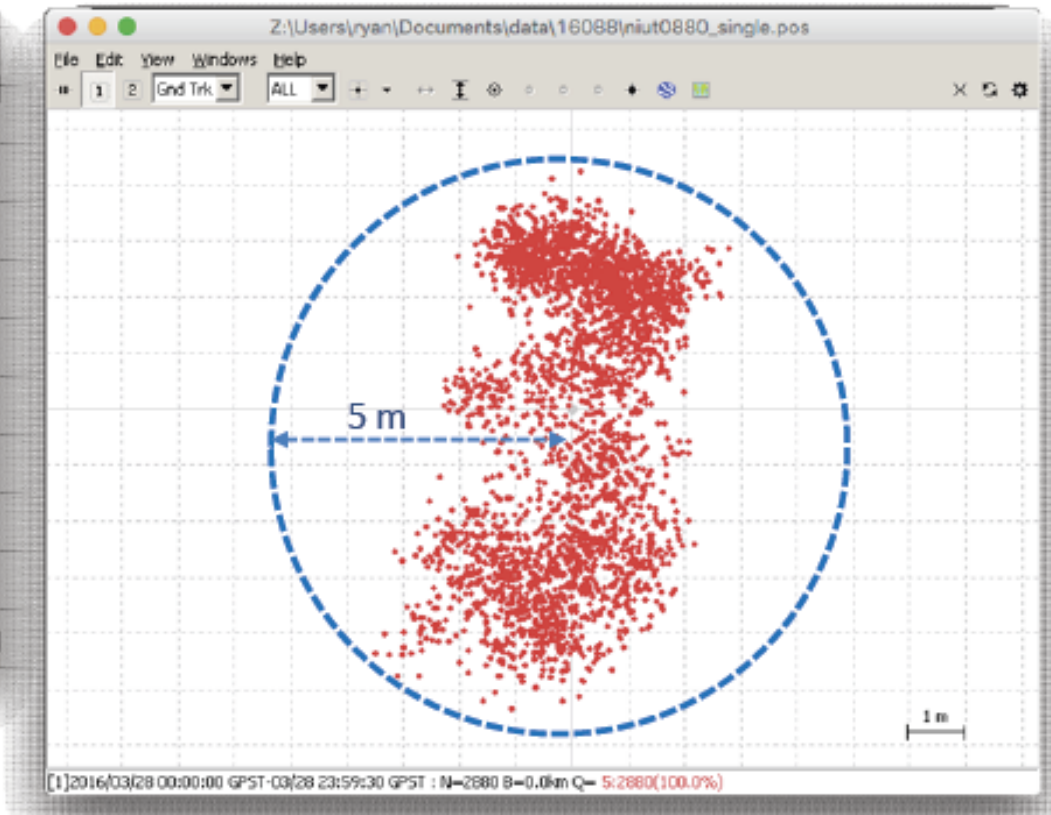
- An open source package for GNSS positioning and analysis.
- Developed by Mr Tomoji Takasu of the Tokyo University of Marine Science and Technology.
- Support for multi-GNSS.
- Positioning modes for both real-time and post-processing.
- Supports standard formats and protocols.
- GUI and CUI on Windows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

Use Case – Static Post-Processing

- RTKPOST
- RTKPLOTT

```

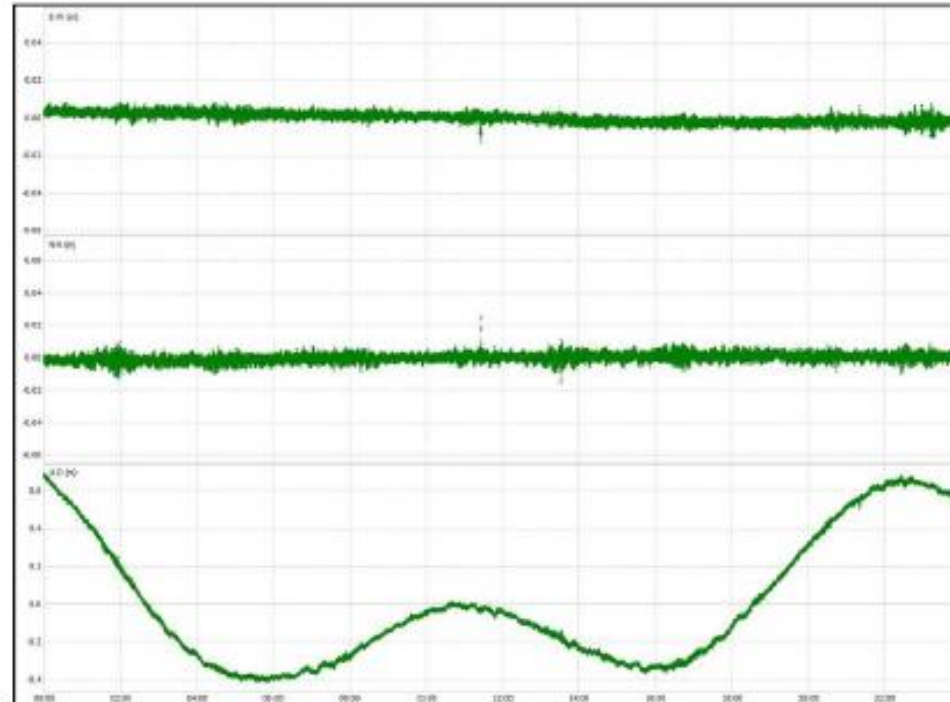
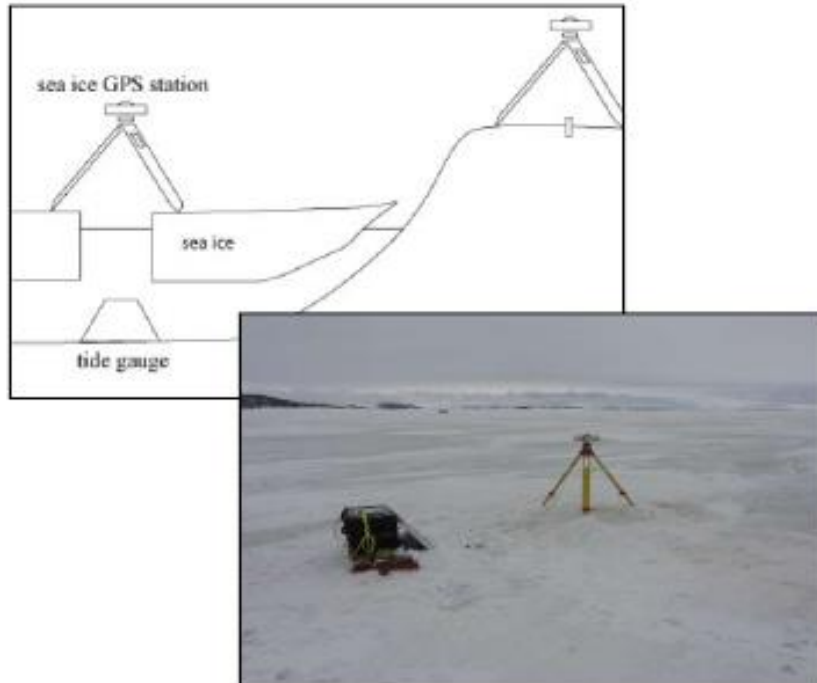
Z:\Users\ryan\Documents\data\16088\niut0880_L1.pos
Find Bead... Option... Close
^ program : RTKPOST ver.2.4.3 b0
^ inp file : Z:\Users\ryan\Documents\data\16088\niut0880.16d
^ inp file : Z:\Users\ryan\Documents\data\16088\niut0880.16n
^ obs start : 2016/03/28 00:00:00.0 073T (week1890 06400.0a)
^ obs end : 2016/03/28 23:59:30.0 073T (week1890 172770.0a)
^ pos mode : single
^ elev mask : 10.0 deg
^ ionos opt : broadcast
^ tropo opt : Saastamoinen
^ ephemeris : broadcast
^
^ (lat/lon/height=WGS84/ellipsoidal,@=1:fix,2:float,3:stas,4:dpps,5:single,6:rppp,ns=#
^ 073T latitude(d'') longitude(d'') height(m) 0 ns edn(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 40.7700 5 10 3.5213
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 41.0662 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 10.96430 -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 10.98774 -169 55 14.37467 41.9227 5 10 3.5485
    
```



Use Case – Kinematic Processing

Floating Tide Gauge

- RTKPOST in Kinematic mode.
- RTKPLOT to view the results.

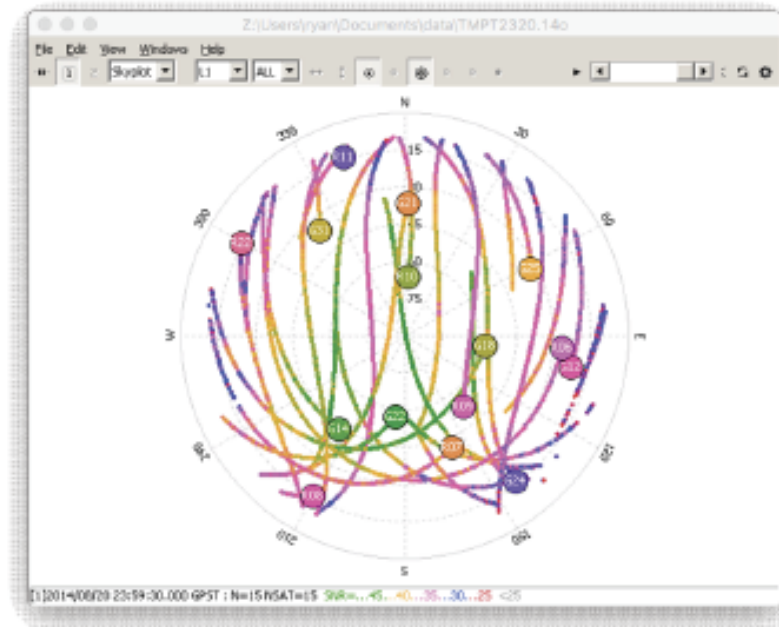


Use Case – Observation Data Quality

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





Installation of RTKLib (Windows)

If you would like to follow the tutorial please download the latest RTKLib Windows binary files from:

https://github.com/tomojitakasu/RTKLIB_bin/archive/master.zip

To open unzip and open the **RTKLIB_bin-master** directory.

bin (contains the executables)

To begin, double click on the executable **rtklaunch.exe**.



RTKLib Applications (Windows GUI)

The image displays seven screenshots of RTKLib software applications:

- STRSRV**: A window for configuring data streams, showing input and output ports and file paths.
- RTKPLLOT**: A window showing three stacked plots of position error (E, N, U) over time, with a Google Map view below.
- NTRIP Browser**: A window displaying a list of CORS stations with columns for Station ID, Format, Details, Ca, Network, and Location.
- RTKCONV**: A window for converting data files, showing time start/end, interval, and file paths.
- RTKNAVI**: A window showing a circular constellation diagram of GNSS satellites with their status (e.g., visible, tracked).
- RTKPOST**: A window for post-processing data, showing time start/end, interval, and file paths.
- RTKLAUNCH**: A small utility window for launching the RTKLib applications.



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Post processing tutorial



Tutorial Scenario (1)

Task: Generate Geocentric Datum of Australia 2020 (GDA2020) coordinates for the survey mark CA16.

Steps

- 1) Using **RTKLib** process a short baseline between CA16 and the Continuously Operating Reference Station *MENA*.



Tutorial Scenario (2)





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Required Files

Observation Data (*.o)

- ca160670.17o (campaign/rover station)
- mena0670.17o (reference/base station)

Navigation Data (*.n)

- brdc0670.17n (broadcast)

Precise Satellite Orbits (*.sp3)

- igs19393.sp3

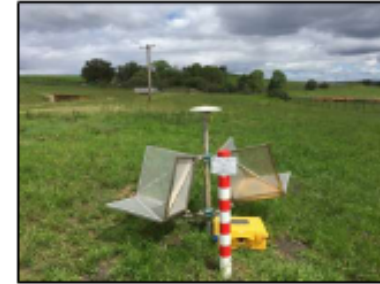
Antenna Phase Centre Model (*.atx)

- igs14.atx



Data

- Rover station: CA16
- Base station: MENA
- Dates: 08/03/2017 (DOY067, GPS Week 19393)
07/03/2018 (DOY066, GPS Week 19913)
- 24 hours static observation
- GPS L1+L2



Base Station Coordinates

Point (GDA 2020)	X (m)	Y (m)	Z (m)
MENA (DOY 067 2017)	-4611310.958 ± 11 mm	2583118.192 ± 11 mm	-3558095.376 ± 14 mm
MENA (DOY 066 2018)	-4611310.955 ± 11 mm	2583118.193 ± 11 mm	-3558095.379 ± 13 mm



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Reference Station Data

<http://www.igs.org>





Precise Satellite Orbits

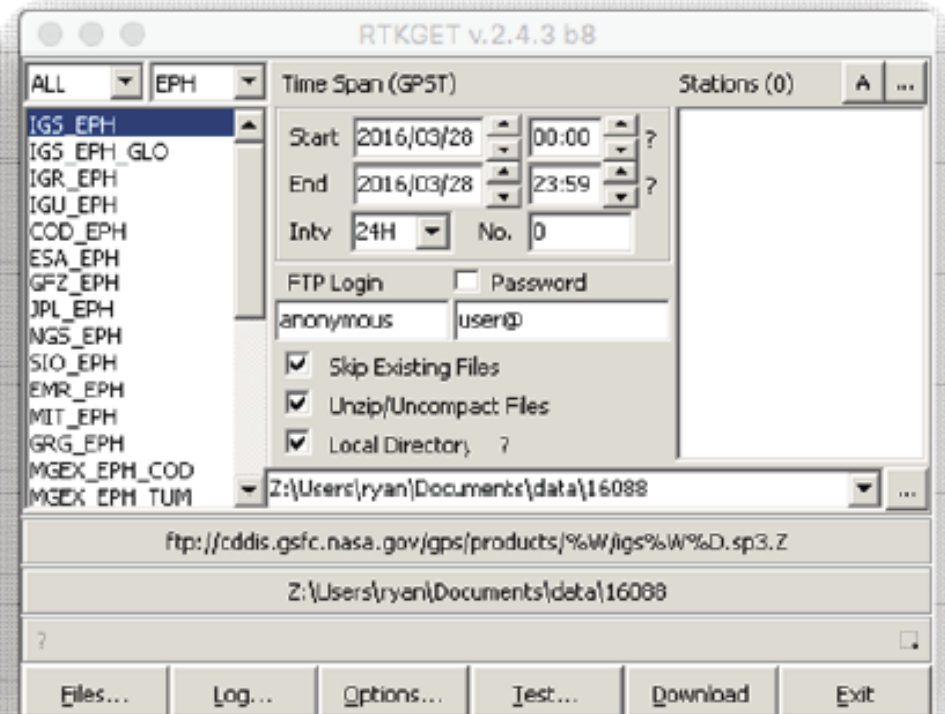
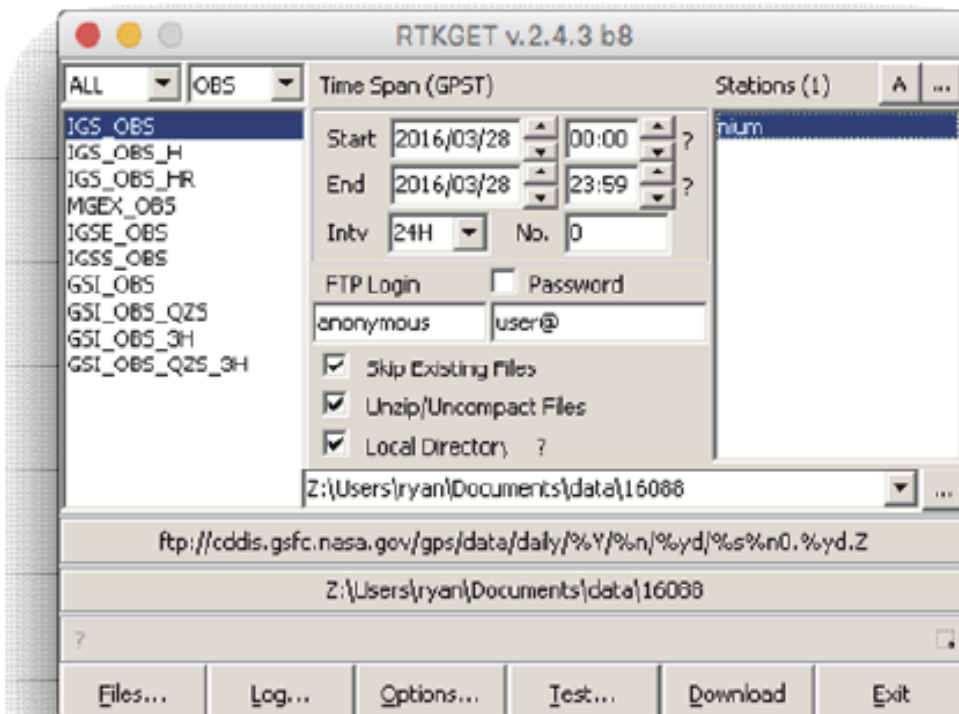
Type	Accuracy	Latency	Updates	Sample Interval
Broadcast	~100 cm	Real-time	-	daily
Ultra-Rapid (predicted half)	~5 cm	Real-time	at 03,09,15,21 UTC	15 min
Ultra-Rapid (observed half)	~3 cm	3 – 9 hours	at 03,09,15,21 UTC	15 min
Rapid	~2.5 cm	17 – 41 hours	at 17 UTC daily	15 min
Final	~2.5 cm	12 – 18 days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

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



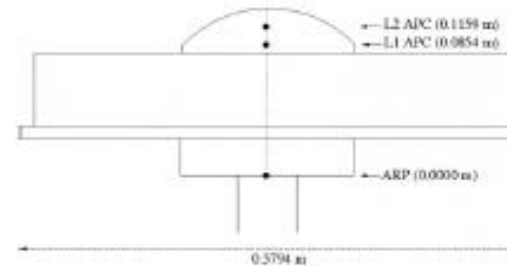
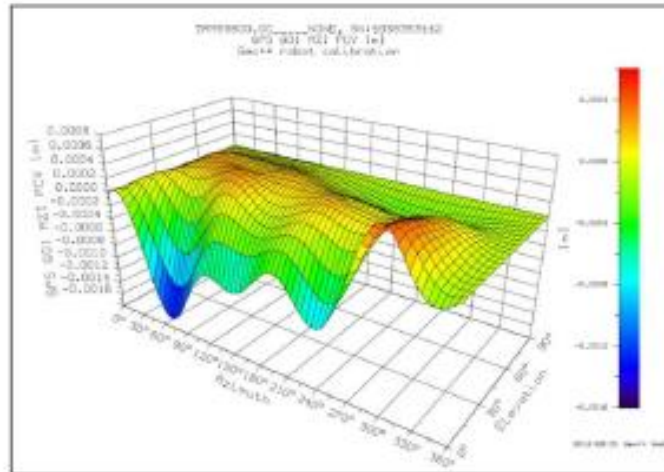
RTKGET

RTKGET can be used to download IGS products, such as reference station data, satellite orbits, clock files and Earth orientation parameters.



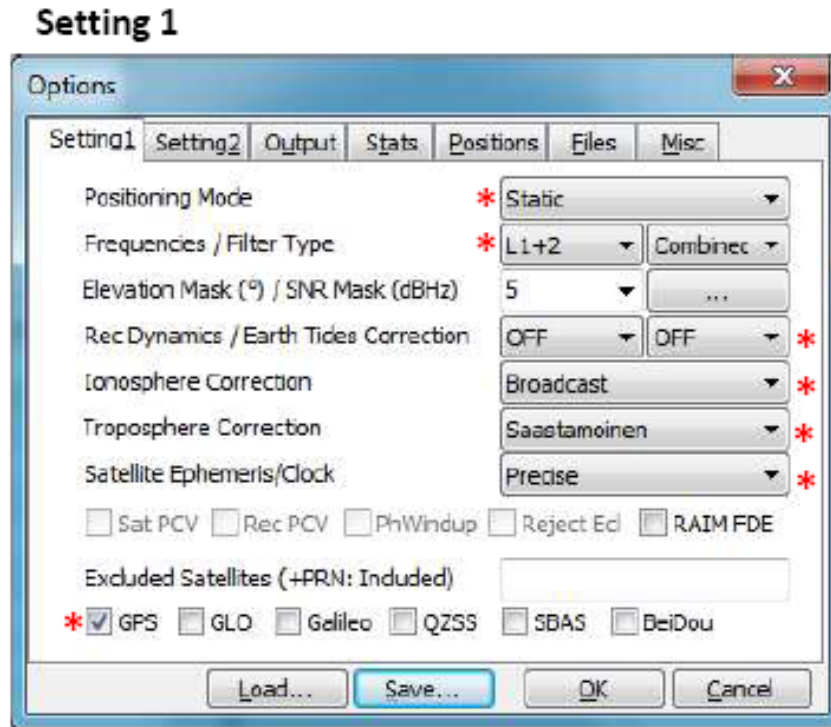
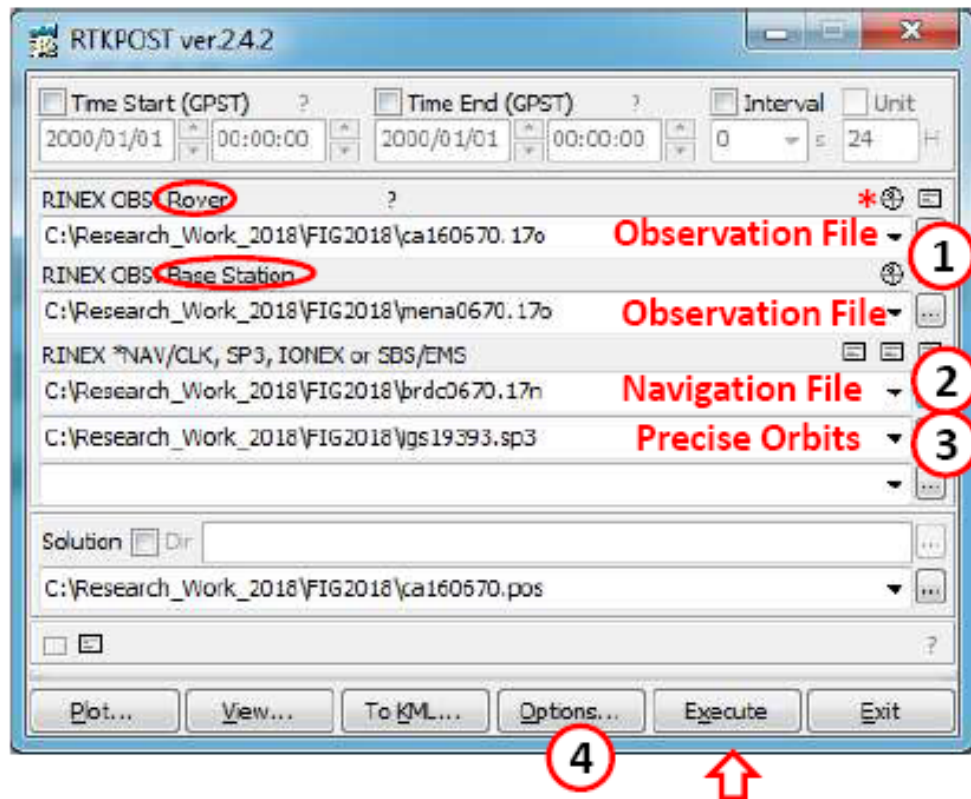
Antenna Phase Centre Variation Models

- 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://ftp.igs.org/pub/station/general/igs14.atx>



Static Post-Processing – Options (RTKPOST)

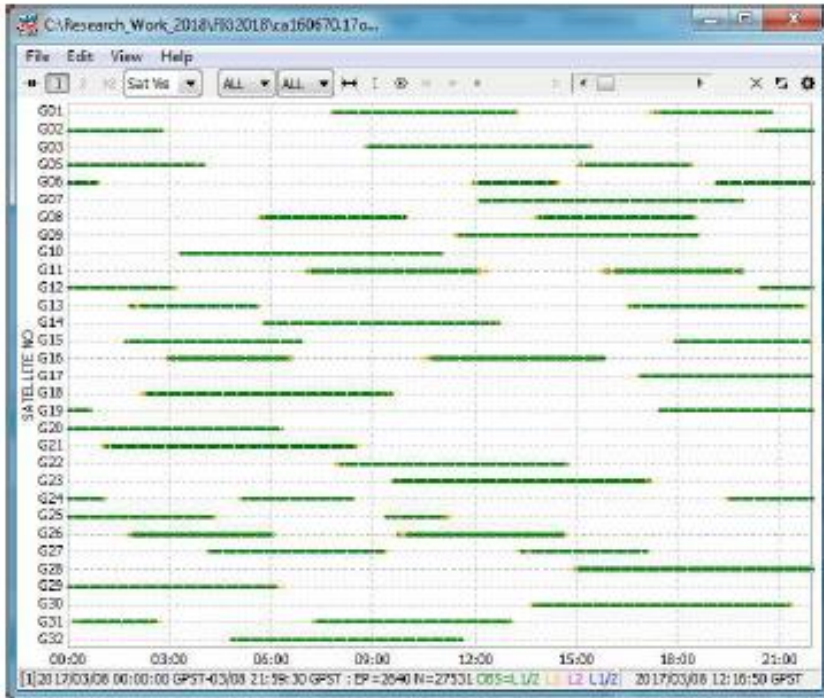
- Import data, set up processing configuration and execute processing.



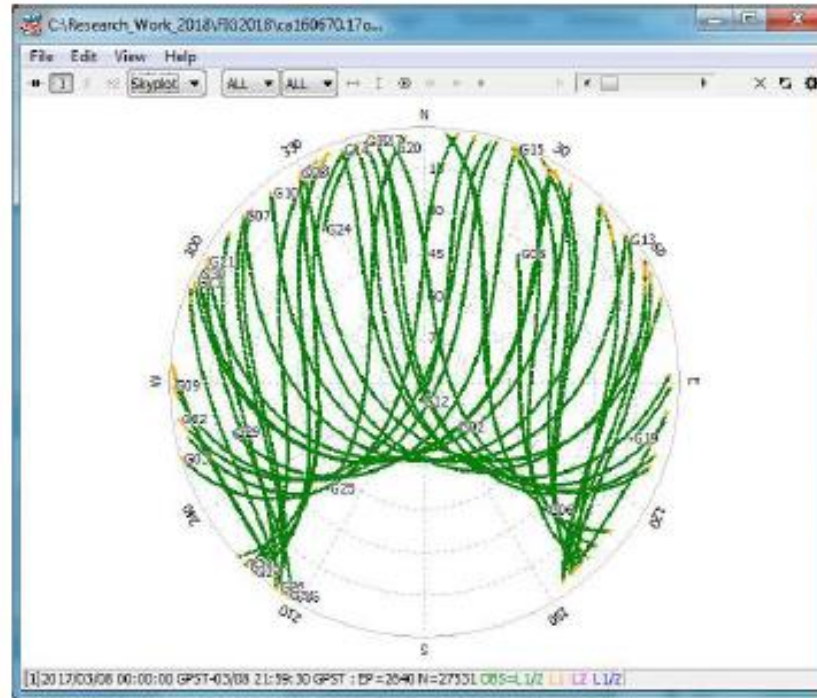


Observation Data Quality

Satellite Visibility

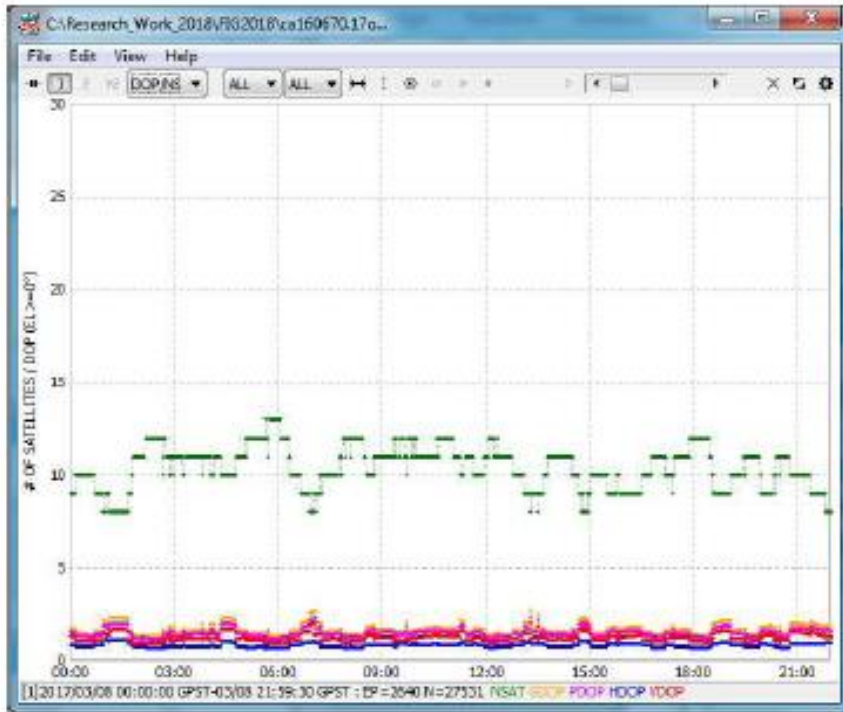


Skyplot

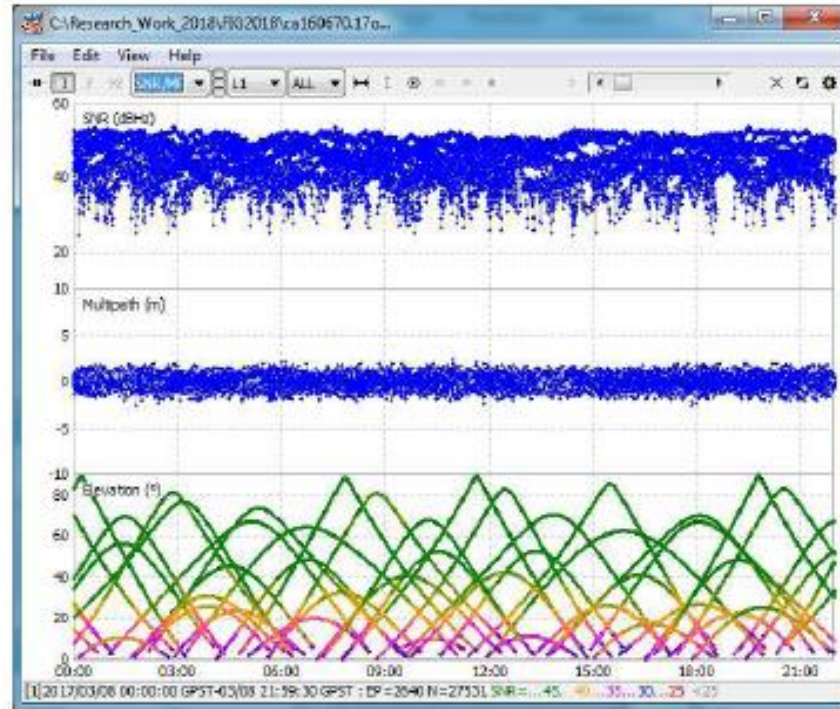


Observation Data Quality

Number of Satellites and DOP



SNR, Multipath, Elevation



Static Post-Processing – Options (RTKPOST)

Setting 2

Options dialog, Setting 2 tab. The 'Integer Ambiguity Res (GPS/GLO/BDS)' is set to 'Cont'd'. Other parameters include 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 (30 / 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), and Baseline Length Constraint (m) (0.000 / 0.000).

Output

Options dialog, Output tab. The 'Solution Format' is 'E/N/U-Baseline'. 'Output Header/Processing Options' are 'GN' and 'GN'. 'Time Format / # of Decimals' is 'hh:mm:ss GPST' with 3 decimals. 'Latitude / Longitude Format' is 'ddd.dddddd'. 'Field Separator' is empty. 'Datum/Height' is 'WGS84' and 'Ellipsoidal'. 'Geoid Model' is 'Internal'. 'Solution for Static Mode' is 'All'. 'NMEA Interval (s) RMC/GGA, GSA/GSV' is '0' and '0'. 'Output Solution Status / Debug Trace' is 'OFF' and 'OFF'.

Stats

Options dialog, Stats tab. 'Measurement Errors (1-sigma)' table:

Code/Carrier-Phase Error Ratio L1/L2	100.0	100.0
Carrier-Phase Error a+b/sinE (m)	0.003	0.003
Carrier-Phase Error/Baseline (m/10km)	0.000	
Doppler Frequency (Hz)	10.000	

'Process Noises (1-sigma/sqrt(s))' table:

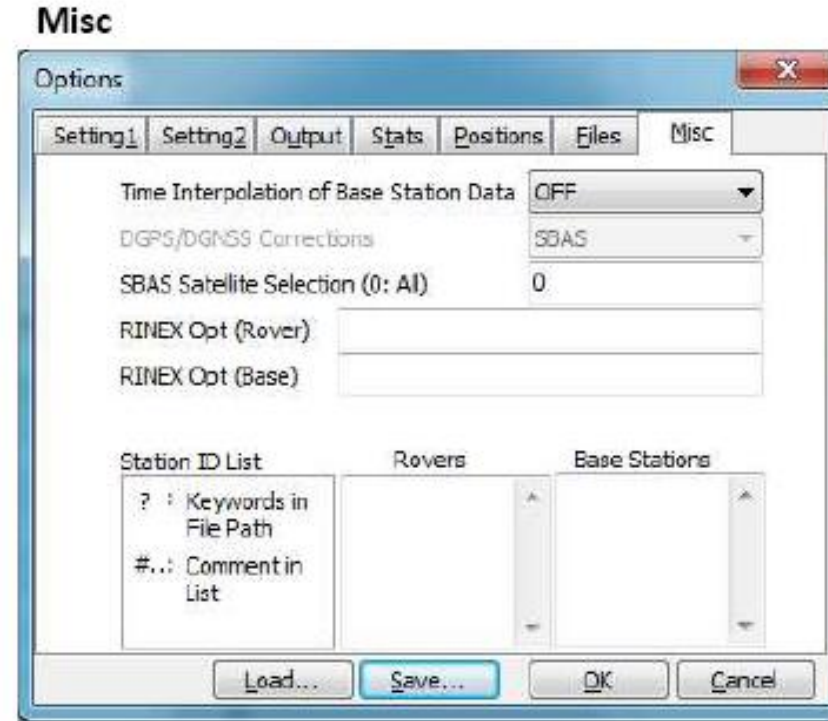
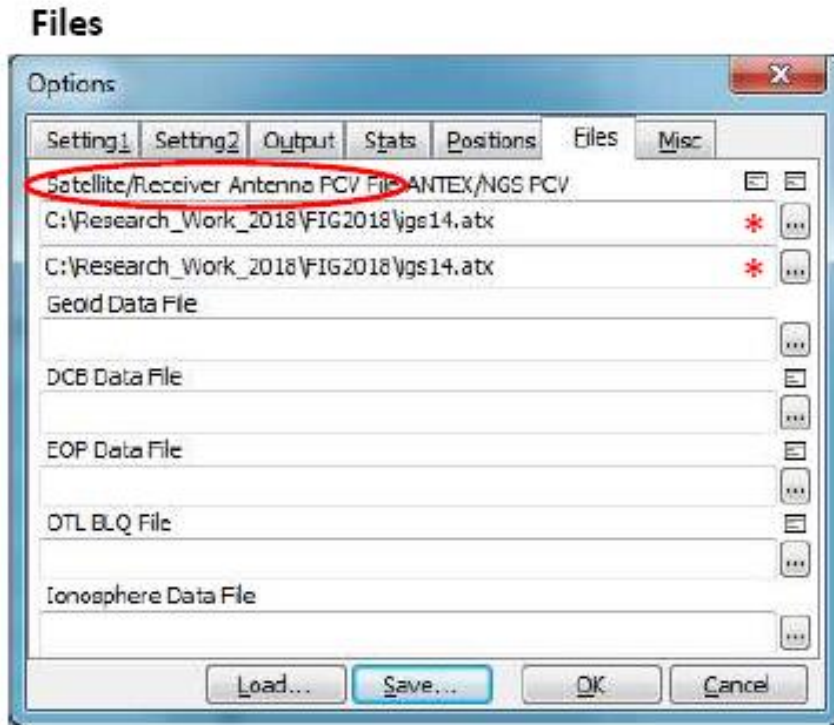
Receiver Accel Horiz/Vertical (m/s ²)	1.00E+01	1.00E+01
Carrier-Phase Bias (cycle)	1.00E-04	
Vertical Ionospheric Delay (m/10km)	1.00E-03	
Zenith Tropospheric Delay (m)	1.00E-04	
Satellite Clock Stability (s/s)	5.00E-12	

Positions

Options dialog, Positions tab. 'Rover' coordinates: Lat/Long/Height (deg/m) 90.000000000, 0.000000000, -6335367.6285. 'Antenna Type (%: Auto)' is checked. 'Base Station' coordinates: X/Y/Z-ECEF (m) -4611310.9584, 2583118.1924, -3558095.3761. 'Antenna Type (%: Auto)' is checked. 'Station Position File' is empty.



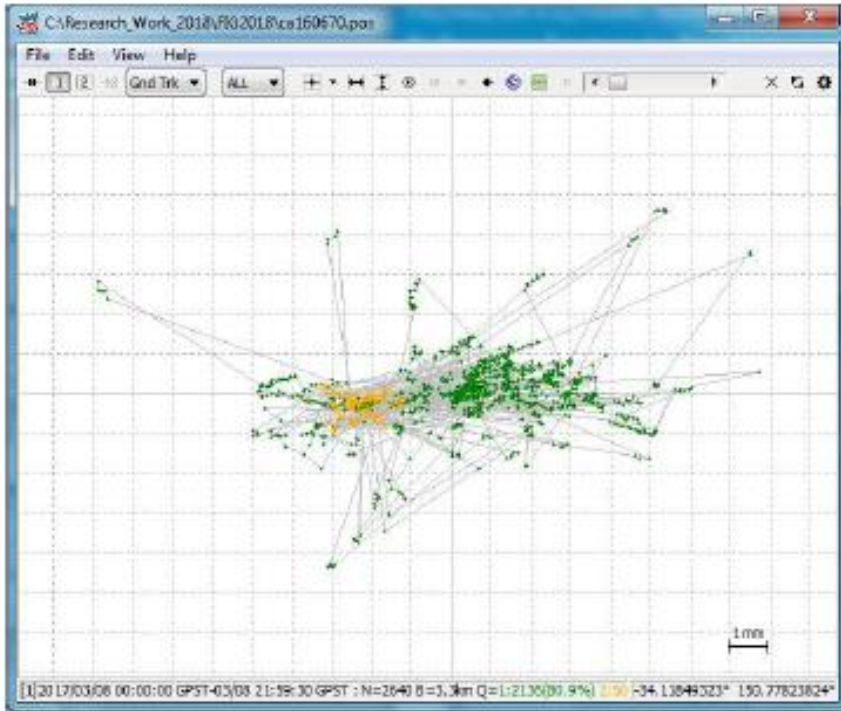
Static Post-Processing – Options (RTKPOST)



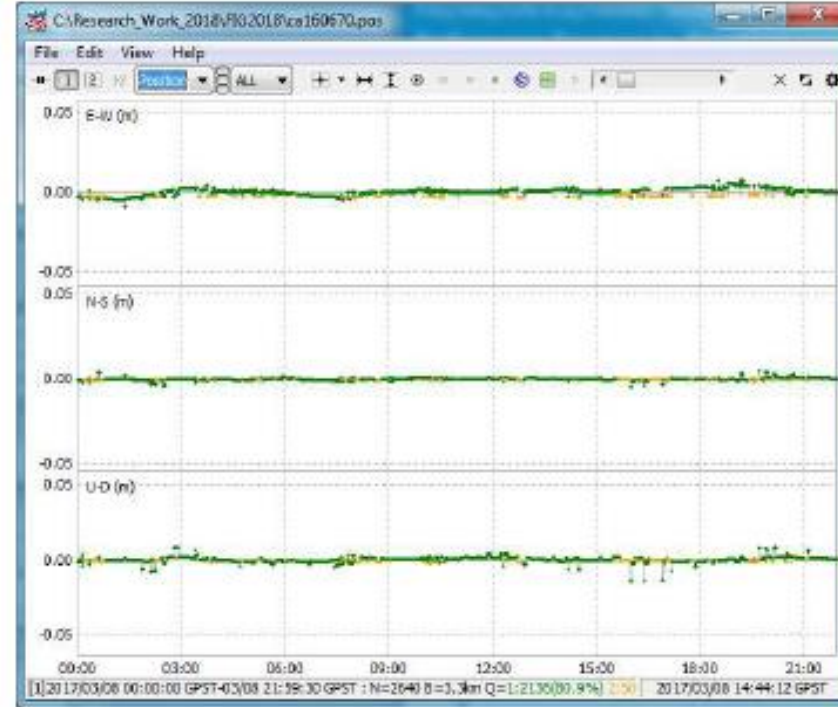


Plot (RTKPLOT)

Ground Track



Position





Comparison of Solutions (RTK PLOT)

DOY 067 2017

Point (GDA 2020)	X (m)	Y (m)	Z (m)
CA16 (RTKLIB)	-4613300.916 ± 4 mm	2580586.721 ± 4 mm	-3557416.539 ± 3 mm
CA16 (AUSPOS)	-4613300.917 ± 11 mm	2580586.721 ± 11 mm	-3557416.542 ± 14 mm
	ΔX 1 mm	ΔY 0 mm	ΔZ 3 mm

DOY 066 2018

Point (GDA 2020)	X (m)	Y (m)	Z (m)
CA16 (RTKLIB)	-4613300.918 ± 10 mm	2580586.720 ± 8 mm	-3557416.535 ± 8 mm
CA16 (AUSPOS)	-4613300.918 ± 11 mm	2580586.723 ± 11 mm	-3557416.544 ± 13 mm
	ΔX 0 mm	ΔY 3 mm	ΔZ 9 mm



Overview

- Introduction and installation of RTKLIB.

Tutorial

- Files required for post-processing
- Looking at observation data quality
- Baseline post-processing



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Questions?