Test Report of L1-SAIF Experiment

Never Stand Still | Faculty of Engineering | School of Civil and Environmental Engineering

Mazher Choudhury

Yong Li

Chris Rizos

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Project Background

- Confirm that QZSS can provide wide area differential corrections to GPS uses via SBAS-type messages broadcast on L1 signals with a target accuracy of 1m (horizontal)

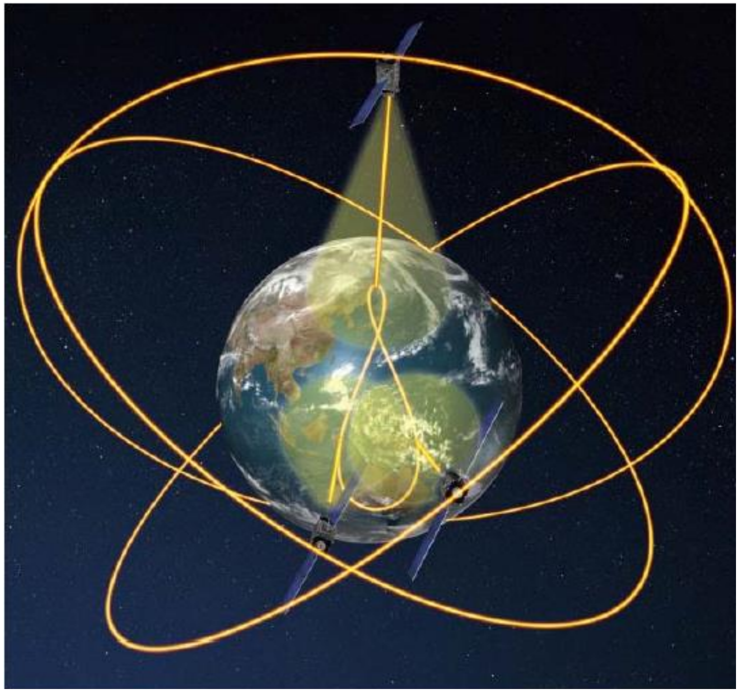
- Investigate possible use of such a service in Australia via a collaborative project between UNSW and ENRI

Introduction...

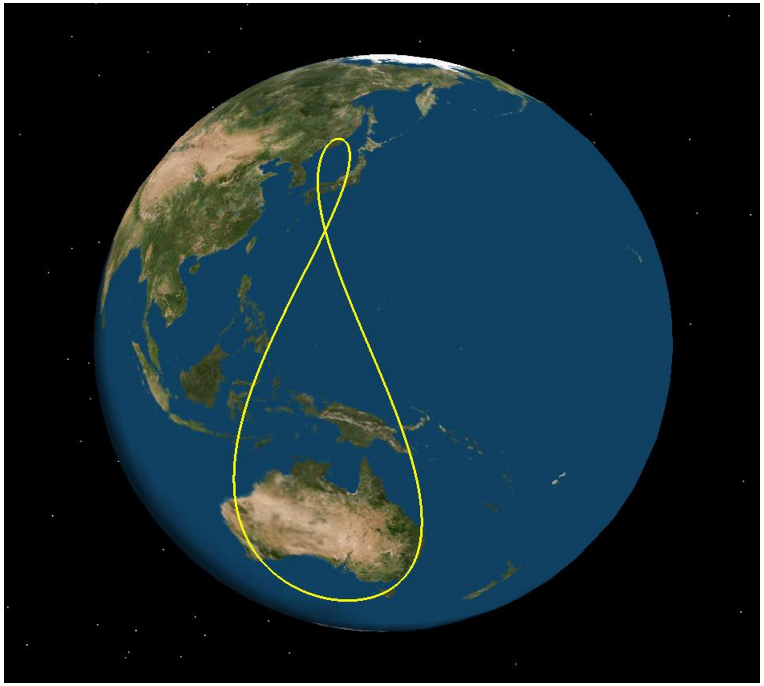
- The 1st QZSS satellite “MICHIBIKI” transmits the L1-SAIF signal
- Could QZSS L1-SAIF (SBAS-like) service benefit Australian users?
- Since 2014, UNSW has hosted an L1-SAIF receiver (provided by the Electronic Navigation Research Institute, Japan)... to collect continuous L1-SAIF data over a three month period
- Results of L1-SAIF augmented positioning are presented
- *However, positioning could not be undertaken in Australia... as the broadcast ionospheric correction messages are only valid for Japan*
- *90 days of observation and navigation data from an MGEX station located in Japan were analysed*

Quasi-Zenith Satellite System (QZSS)

The **Quasi-Zenith Satellite System (QZSS)** developed by **Japan Aerospace Exploration Agency (JAXA)** is a regional navigation augmentation satellite system, which uses a constellation of satellites placed in **highly-inclined elliptical orbits (IGSO)**. This is to ensure that one of the satellites is always **visible near zenith** over Japan, including in **urban and mountainous areas** whereby it is difficult to receive GNSS signals.



Multiple satellites on the quasi-zenith orbits ©JAXA



Asymmetry orbit in the shape of a ‘figure 8’ ©JAXA

Overview of QZSS

Functional Capability

- GNSS interoperability
  - Improve availability
  - Improve performance

Coverage

- East Asia and Oceania

Signals

- L1C/A, L1C, L2C and L5
- L1-SAIF on 1575.42 MHz
- LEX on 1278.75MHz

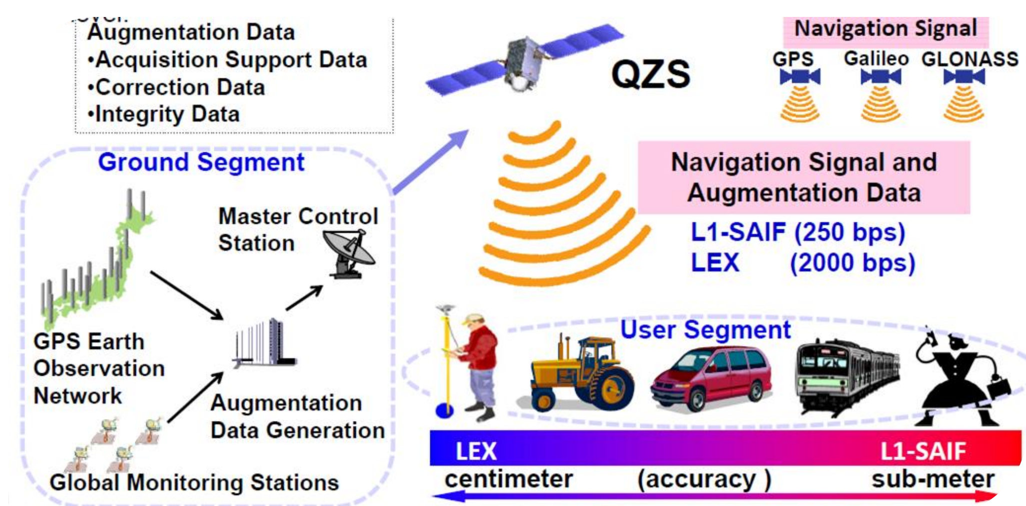
First QZSS Satellite "Michibiki"

- Launched in September 2010

Future QZSS Satellites

- Additional 2 IGSO and 1 GEO
- March 2018

The first QZSS satellite "Michibiki" ©JAXA



©JAXA

C-ITS Positioning Requirements

Type	Level	Accuracy Requirement		Research prototype	Communication Latency (second)
		95 % confidence level (m)	Root means square (order)	Root means square (order)	
V2I: absolute *(V2I = Vehicle to Infrastructure)*	Road-level	5.0	Metre	Metre	1-5
	Lane-level	1.1	Sub metre	Sub metre	1.0
	Where-in-lane-level	0.7	Decimetre	Decimetre	0.1
V2V: relative *(V2I = Vehicle to Vehicle)*	Road-level	5.0	Meter	Sub metre	0.1
	Lane-level	1.5	Sub metre	Decimetre	0.1
	Where-in-lane-level	1.0	Decimetre	Centimetre	0.01-0.1

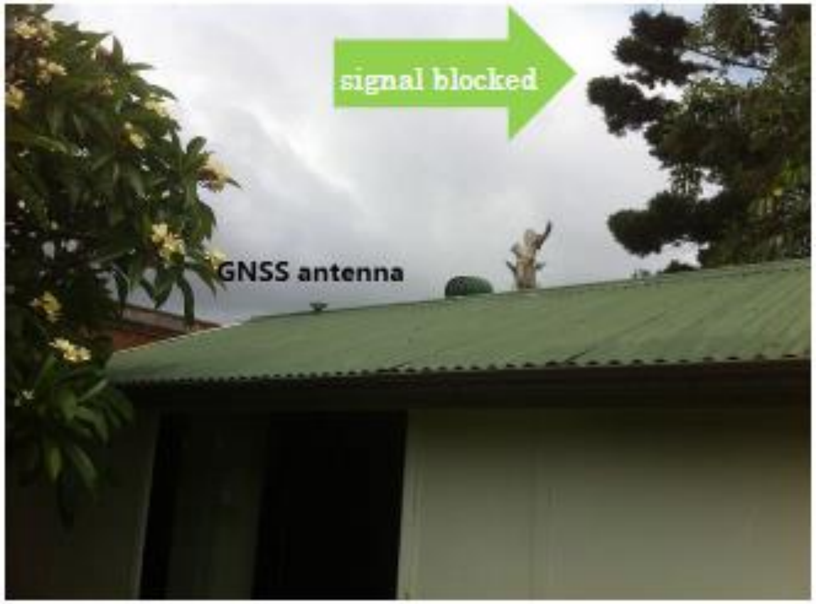
"Vehicle Positioning for C-ITS in Australia", AustRoads Research Report, April 2013

https://www.onlinepublications.austroads.com.au/items/AP-R431-13

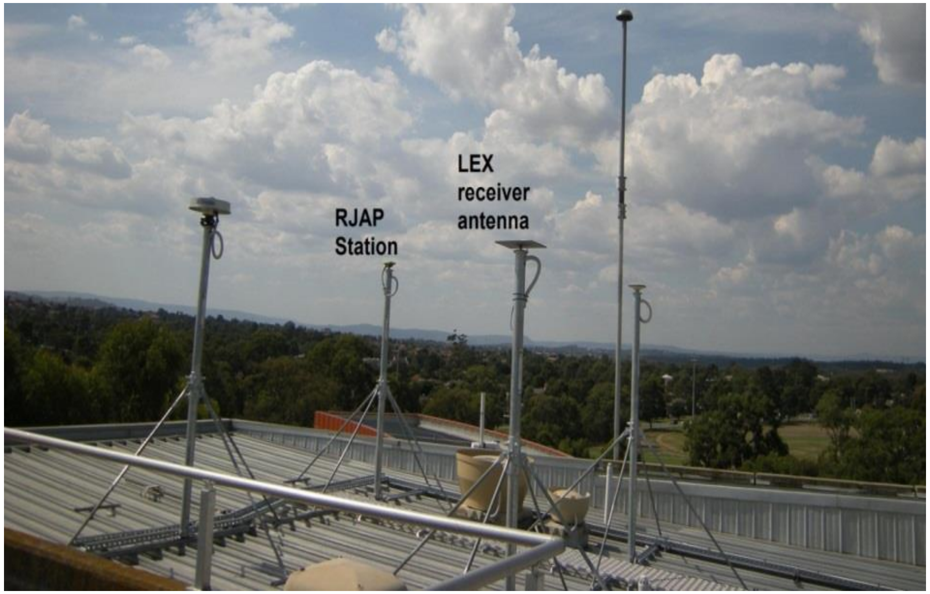
Australian Experiment Configuration

place/ devices	Sydney	Melbourne
Receiver	Javad Alpha 	Javad Delta 
antenna	Leica AS10 	Javad GrAnt-G3T 

Antenna Setup

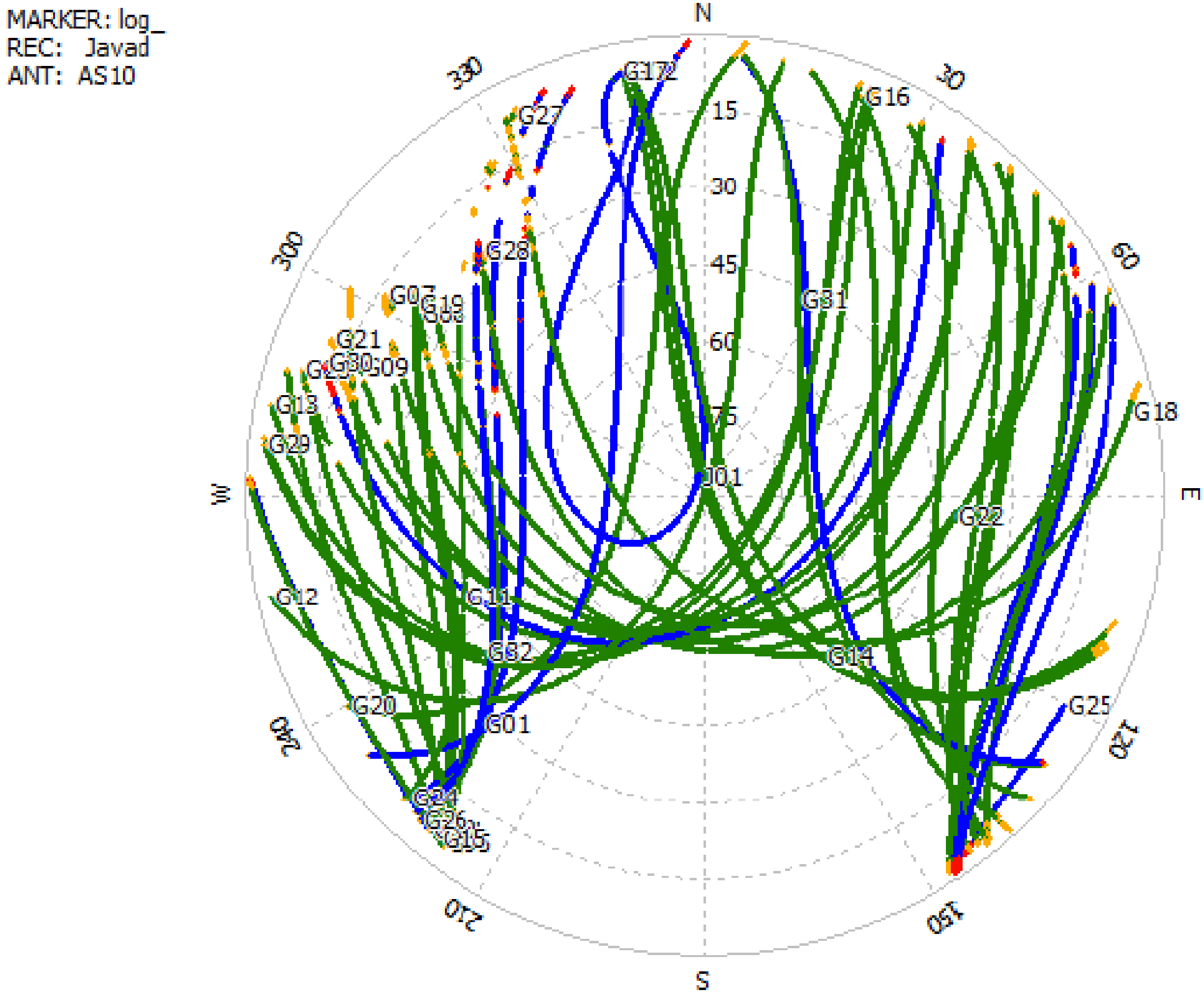


Sydney station

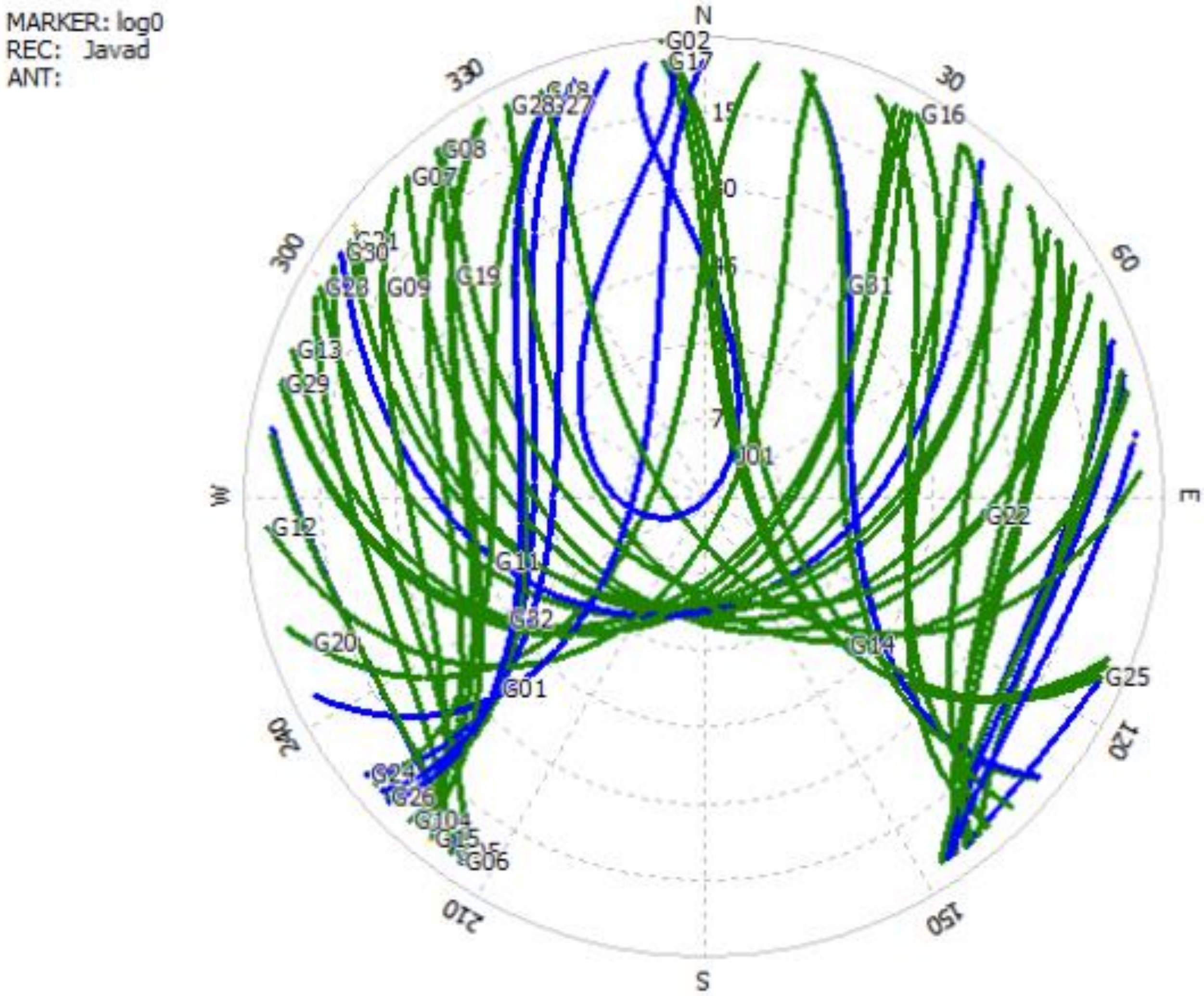


Melbourne station

Skyplot: Sydney 2014-09-01

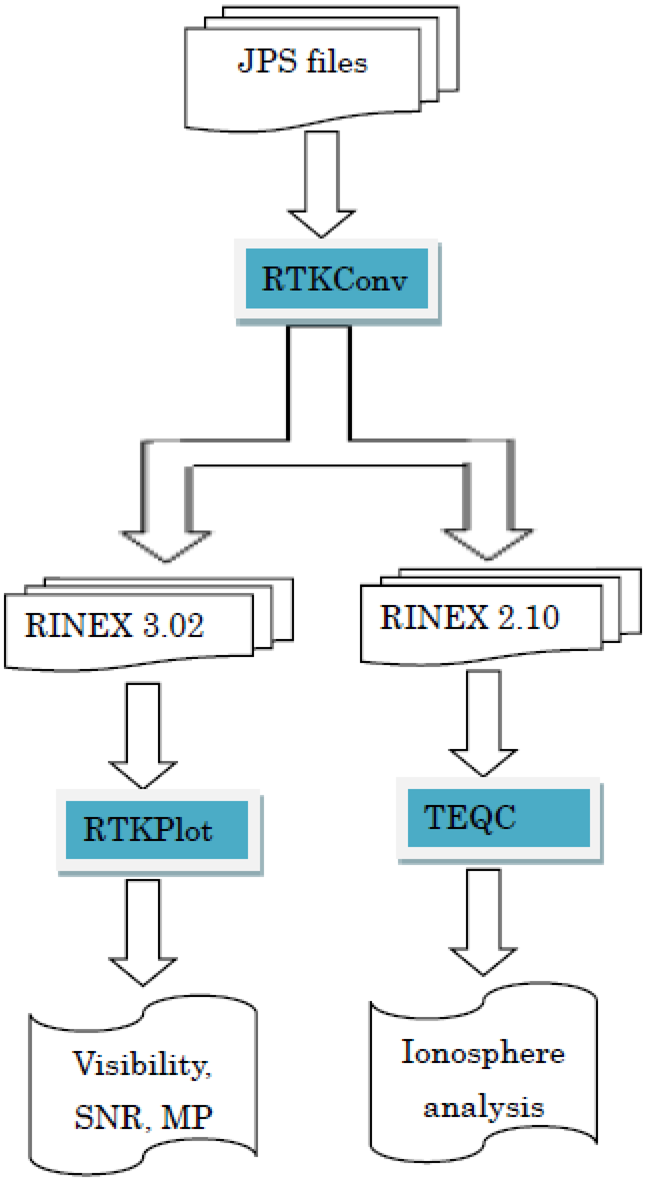


Skyplot: Melbourne 2014-09-01

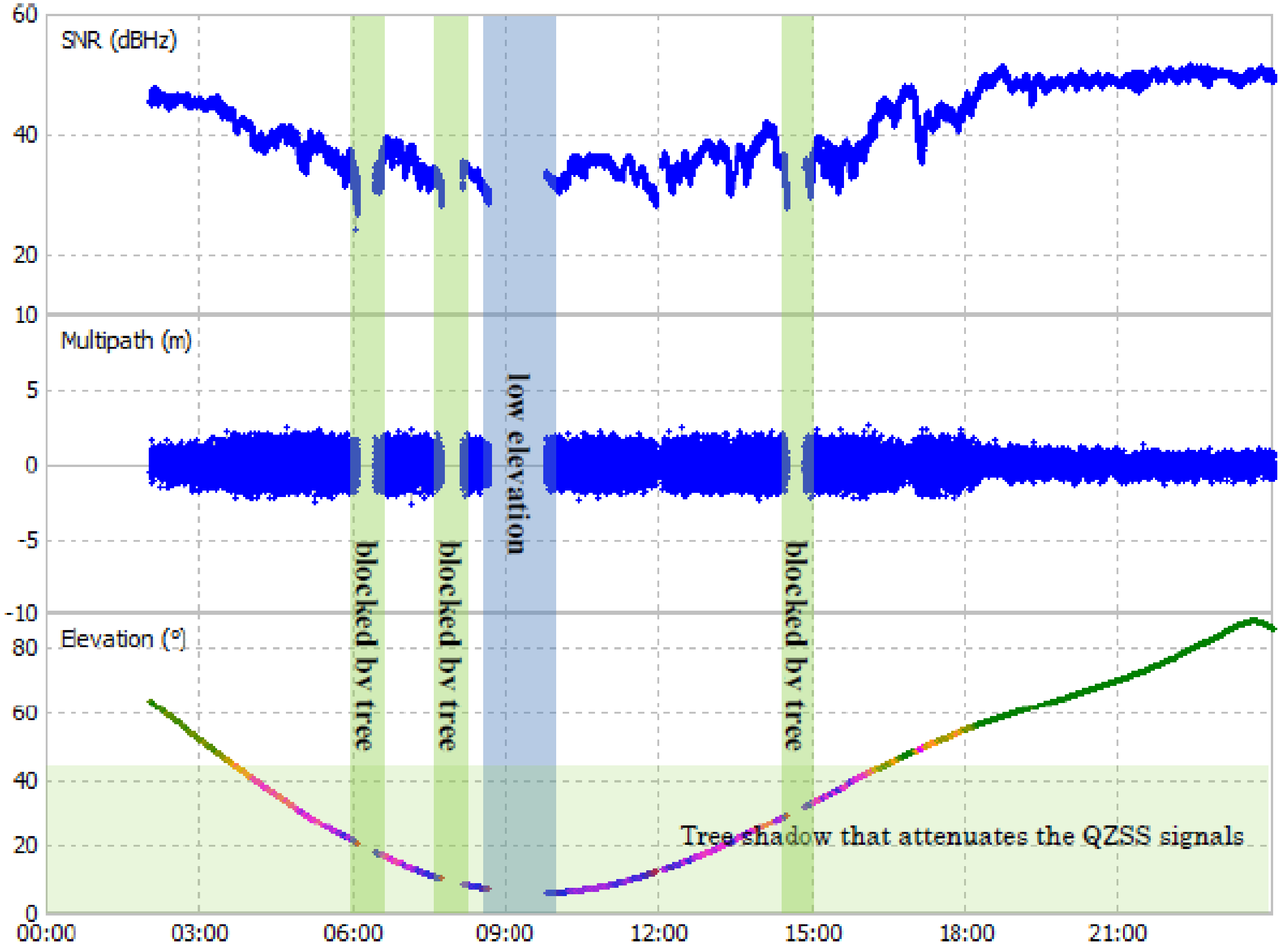


Data Analysis...

- The GNSS raw measurements were recorded in Javad JPS format
- The RTKIB version 2.4.3 was used to convert the JPS files into RINEX files (v3.02 and v2.10)
- The RINEX 3.02 files were processed using RTKLIB for visibility analysis
- TEQC software was used for analysis of ionospheric effect on L1-SAIF signals from RINEX 2.10 files

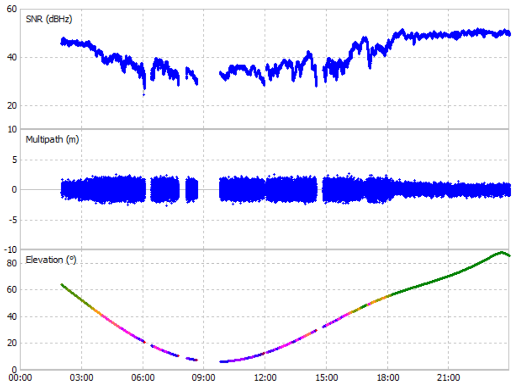


Visibility plot at Sydney on 2014-09-01

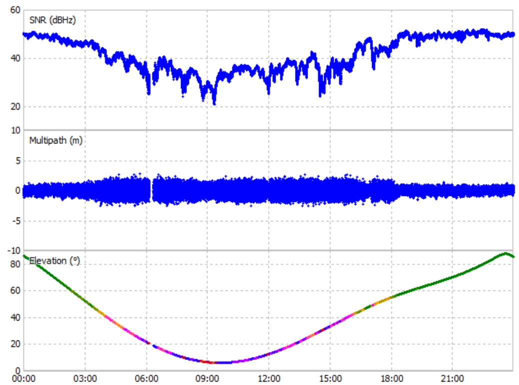


1. QZSS Visibility and L1-SAIF SNR

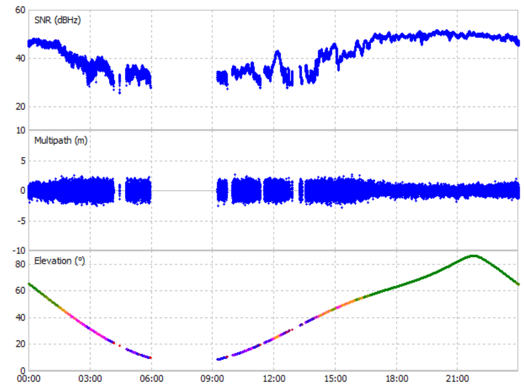
Example from three months for SAIF visibility and signal level analysis



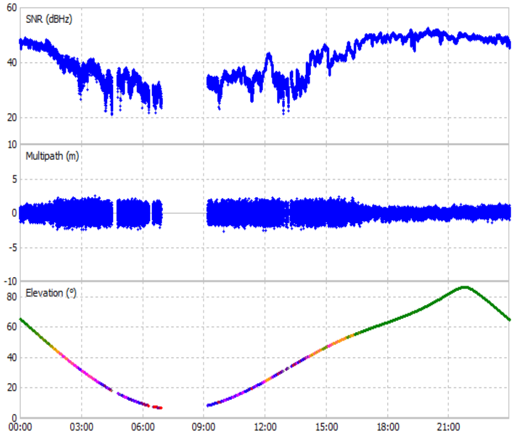
Visibility of L1-SAIF
2014-09-01 at Sydney



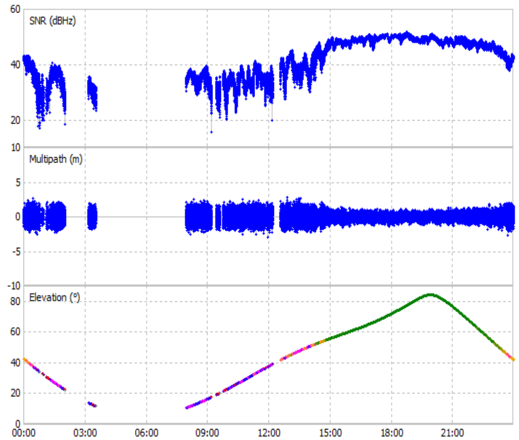
Visibility of L1C
2014-09-01 at Sydney



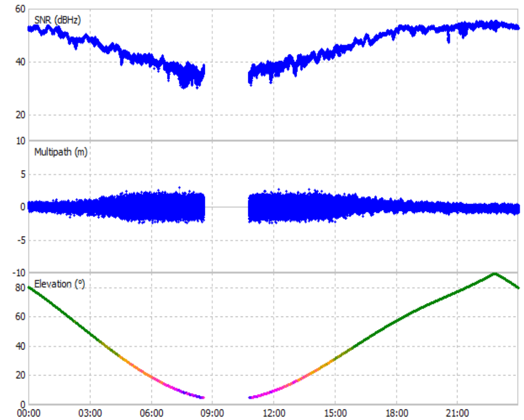
Visibility of L1-SAIF
2014-10-01 at Sydney



Visibility of L1C
2014-10-01 at Sydney



Visibility of L1C
2014-11-01 at Sydney



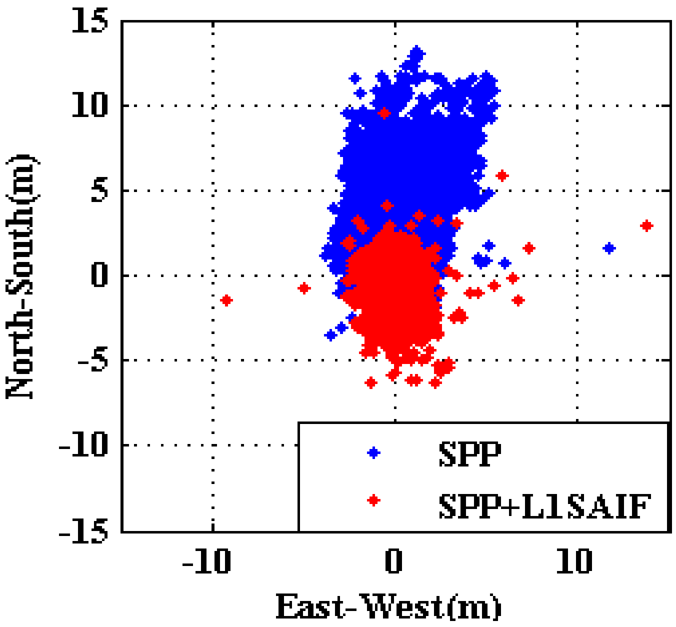
Visibility of L1-SAIF
2014-09-01 at Sydney

2. Improving SPP Accuracy Using L1-SAIF

- At present the L1-SAIF corrections are only valid for Japan
- Trial conducted with RINEX observation data from 1st September 2014 to 30th November 2014... *from the CHOF IGS MGEX station in Tokyo, Japan*
- Position solution is estimated using L1-only pseudorange-based single point positioning

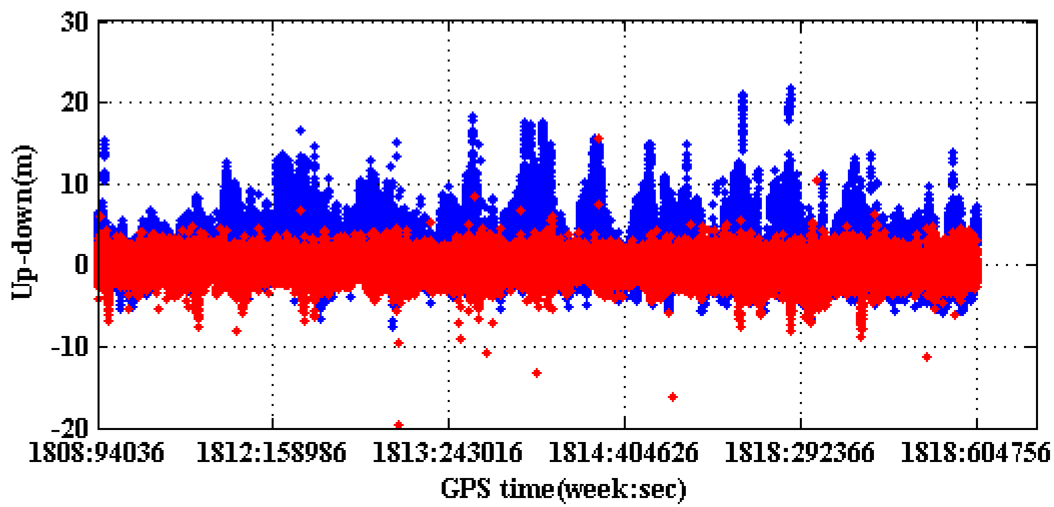
SPP Accuracy (90 days)

3D Std (SPP) (1σ) = 2.5m
3D Std (SPP+L1-SAIF) (1σ) = 0.8m



2D position errors

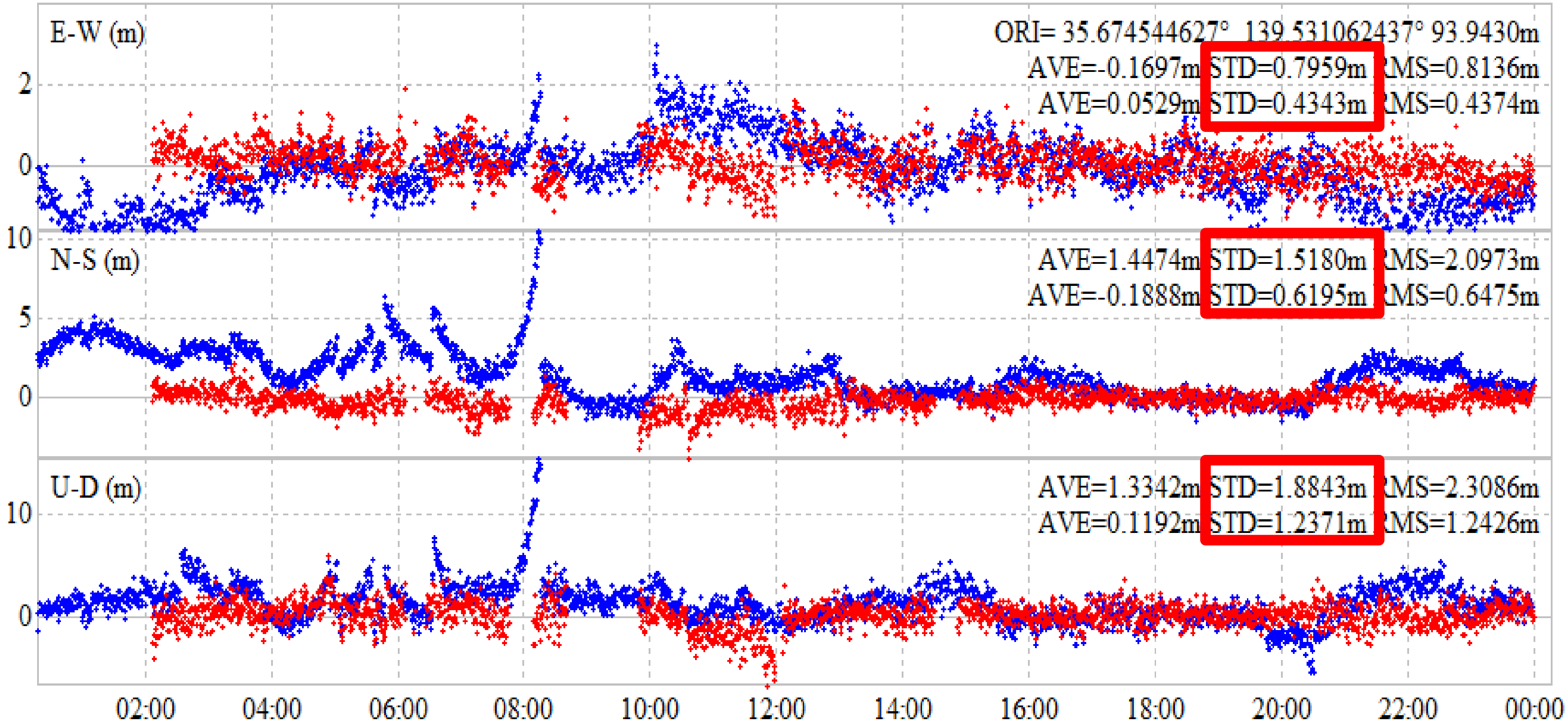
2D Std (SPP) (1σ) = 1.4m
2D Std (SPP+L1-SAIF) (1σ) = 0.5m



Height errors

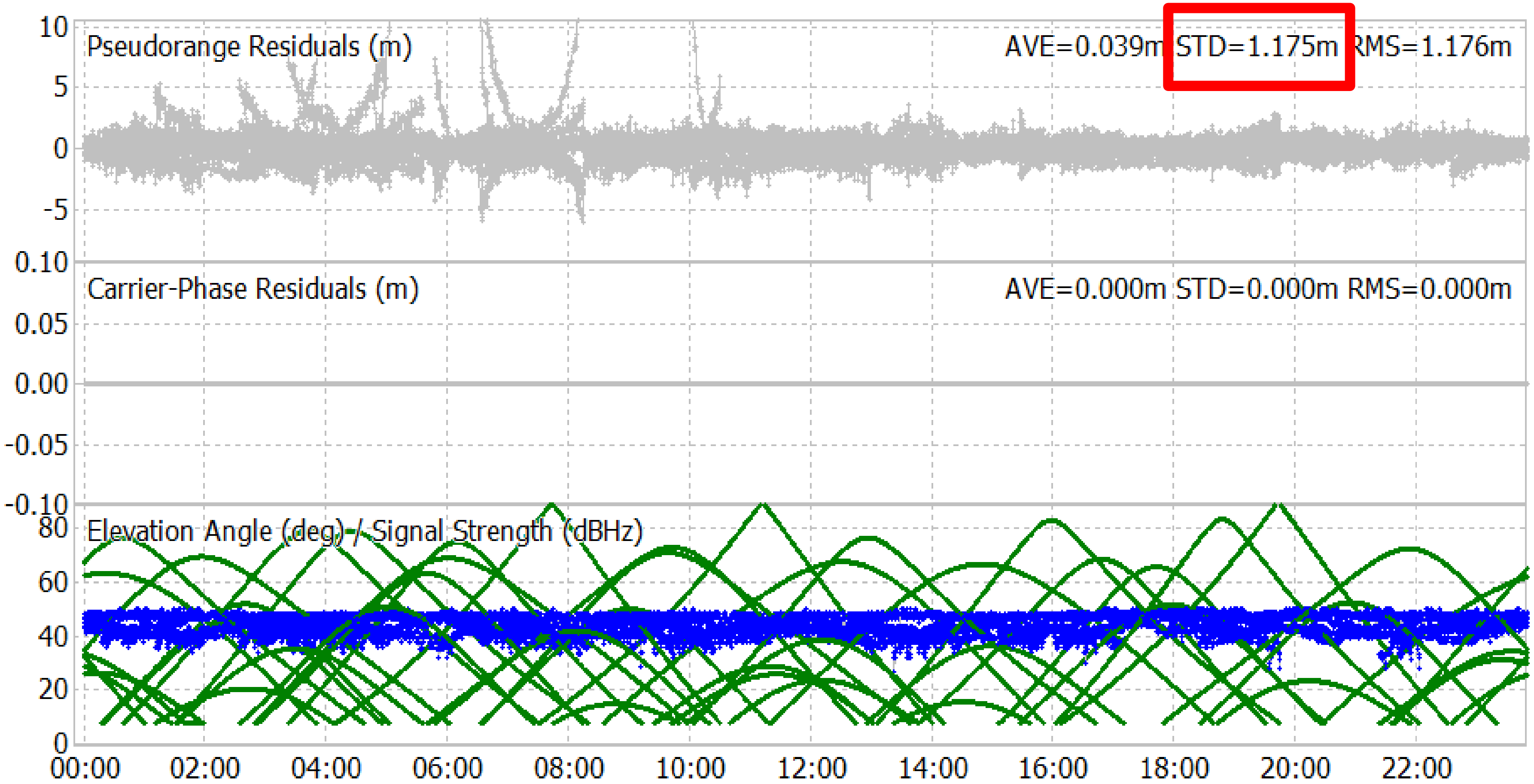
Ht Std (SPP) (1σ) = 2.95m
Ht Std (SPP+L1-SAIF) (1σ) = 1.15m

SPP Accuracy (one day)

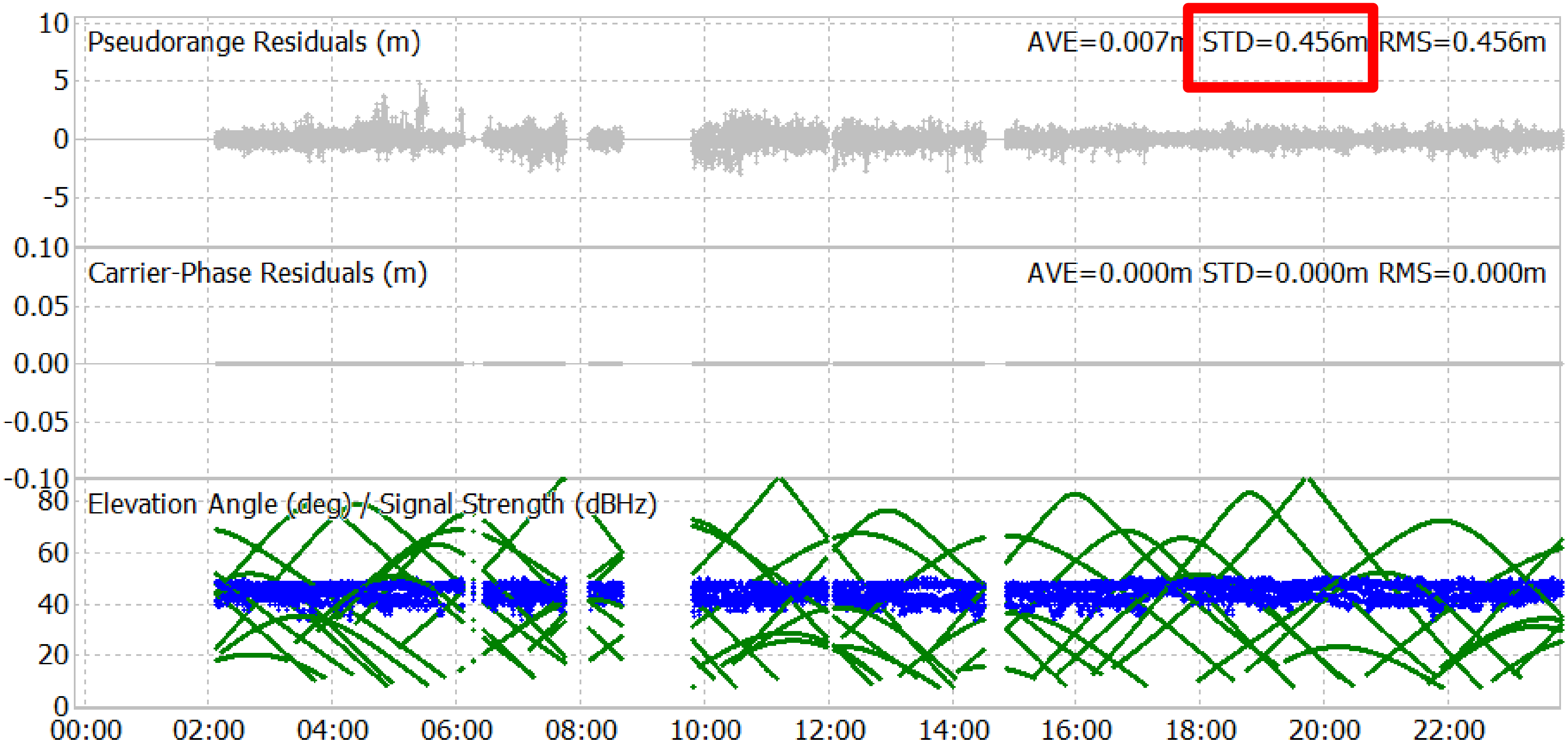


Single point position of the CHOF station. BLUE =without L1-SAIF, RED =L1-SAIF

PR Residuals w/o L1-SAIF (one day)



PR Residuals with L1-SAIF (one day)



Concluding Remarks

- QZSS satellite visibility in south-eastern Australia is *good*
- The ionosphere correction messages transmitted by *L1-SAIF are valid only for the Japan region*
- Using L1-SAIF SBAS-type correction messages can improve single-frequency PR-based solution accuracy to *sub-metre level*
- The existing GNSS CORS network in Australia can be used to derive the ionosphere correction messages for the Australian region
- Further tests need to be conducted, on different platforms, to investigate benefit for future sub-metre accuracy mass-market users such as for transport applications