Observation of L1-SAIF Signal in Australia

Never Stand Still

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Agenda

- Introduction
- Experiment configuration
- Experiment results
- Concluding remarks

Project background

L1-SAIF aims to provide wide area differential corrections to GPS uses with a target accuracy of 1m (horizontal).

To investigate potential use of L1-SAIF services in Australia, a collaboration project between UNSW and ENRI has been established.

Schedule of the project

Data collection: September to November 2014

Data analysis: December 2014 to January 2015

Draft report: February 2015

Final report: March 2015

Project purpose

Through analysis on the three month continuous data, the project aims to study:

- Phase I: observation and characterisation of MSAS/QZSS augmentation signal.

- Phase II: observation and modelling of the ionosphere using a GNSS ground observation network.

This investigation would give the information to support expansion of GNSS wide area augmentation service to the Asia region.

Outline of the project

The L1-SAIF messages from QZSS and MSAS were collected at two stations, in Sydney and Melbourne, during September to November in 2014.

As the first step, the visibility of the QZSS and MSAS satellites in Australia is evaluated from the collected data.

This study can provide a pattern of the real L1-SAIF signals in the Australian region - its visibility and signal strength.

Experiment configuration

The Javad Alpha GNSS receiver and Leica AS10 antenna were utilised in Sydney.

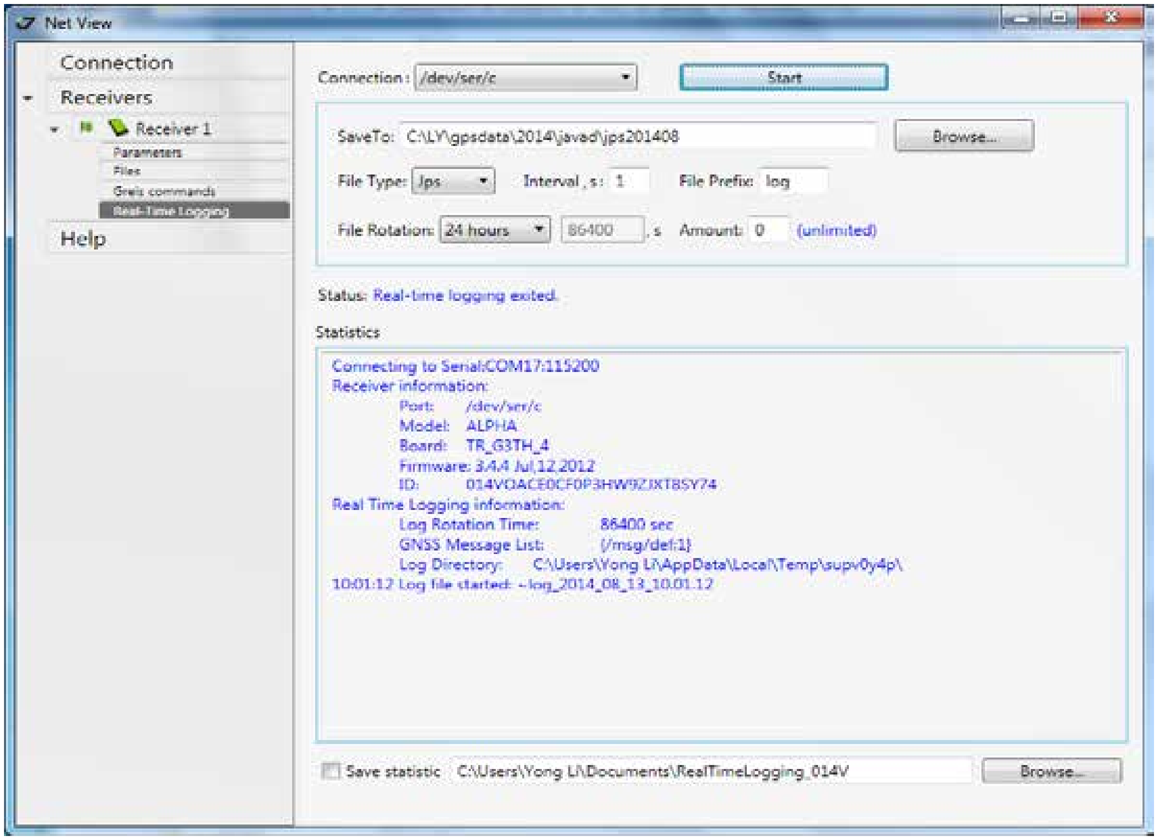
Javad Delta receiver and GrAnt-G3T antenna were used in Melbourne.

GNSS receivers and antennas

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

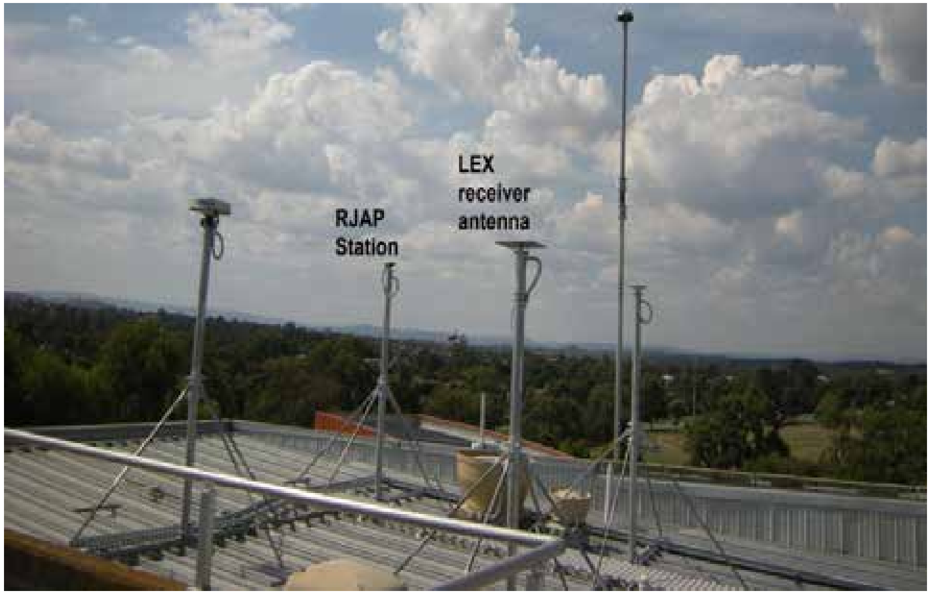
Data collection tools

The Javad NetView program was used to configure the receivers and store the data onto the hard disk of the host computer via serial port.



Antenna setup

Sydney station



Melbourne station

Recorded observations

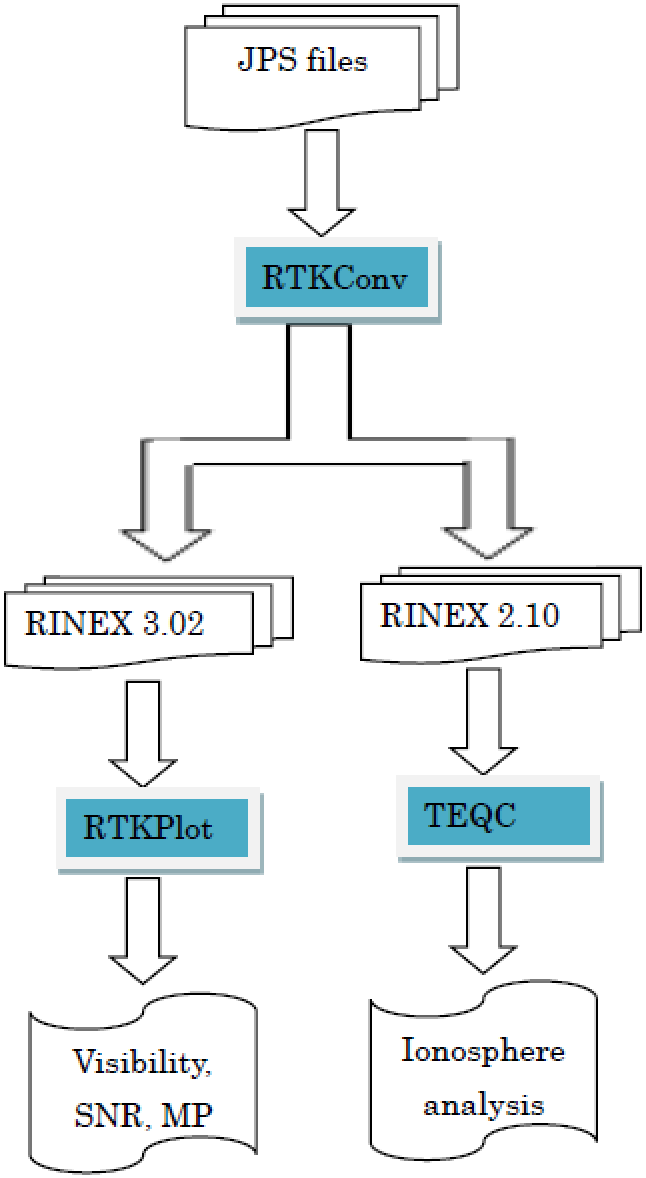
The GNSS raw measurements were recorded, signal levels, carrier phase measurements, pseudoranges; and Doppler.

Observations of QZSS in Sydney at GPST = 2014- 9-1 00:00:00

Observation	C	L	D	S
C/A	33194328.141	174437371.784	-1559.059	49.500
L1C	33194328.324	174437373.561	-1559.064	51.250
L1-SAIF	33194326.747	174437371.777	-1559.045	49.750
L2X (M+L)	33194329.007	135925228.308	-1214.85	48.000
L5X (I+Q)	33194333.183	130261662.807	-1164.224	52.000

Data analysis procedure

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



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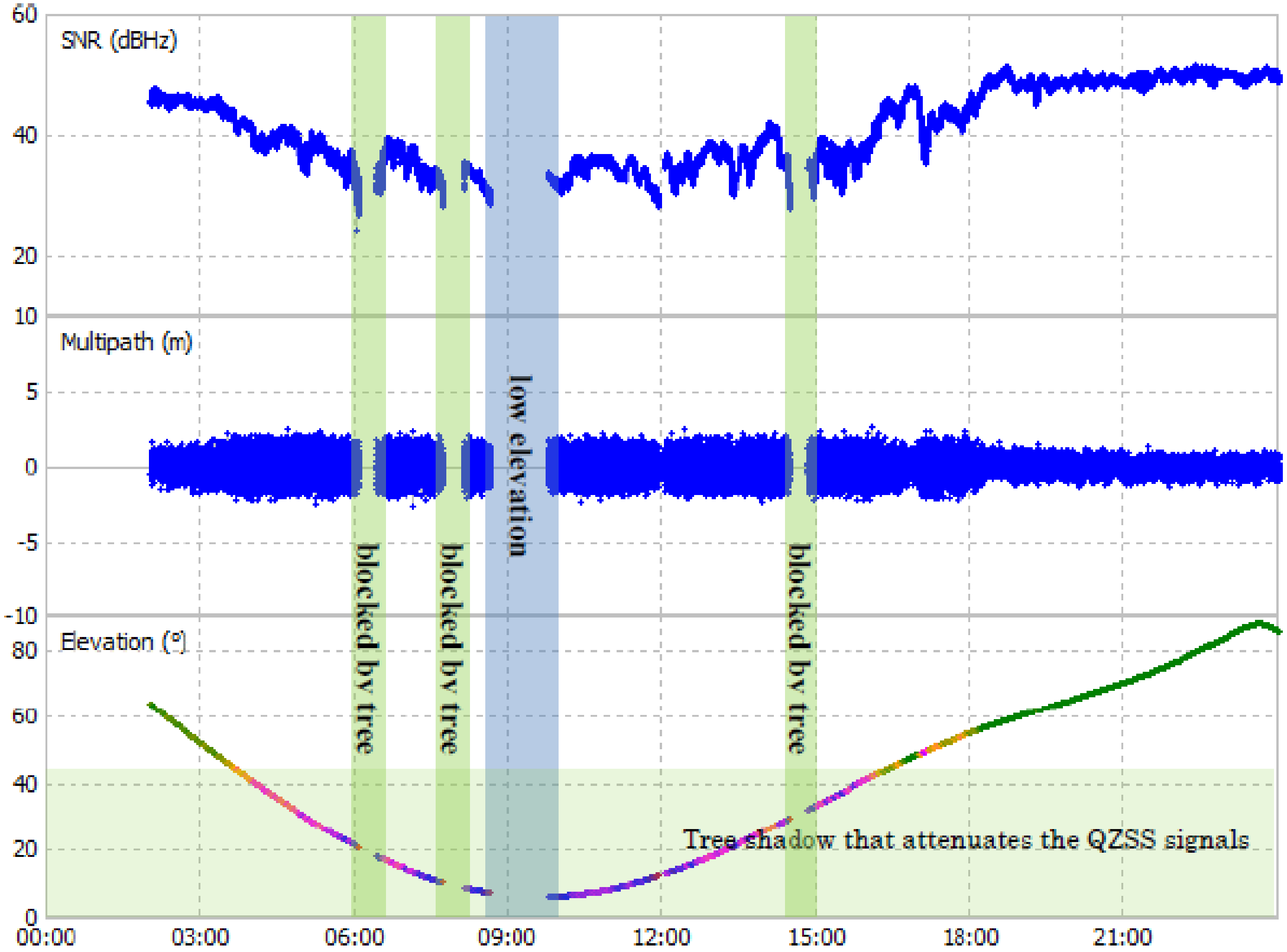
L1-SAIF visibility and signal level analysis

The results below are visualised: elevation of QZSS, signal level of L1_SAIF, and code-phase multipath of L1-SAIF.

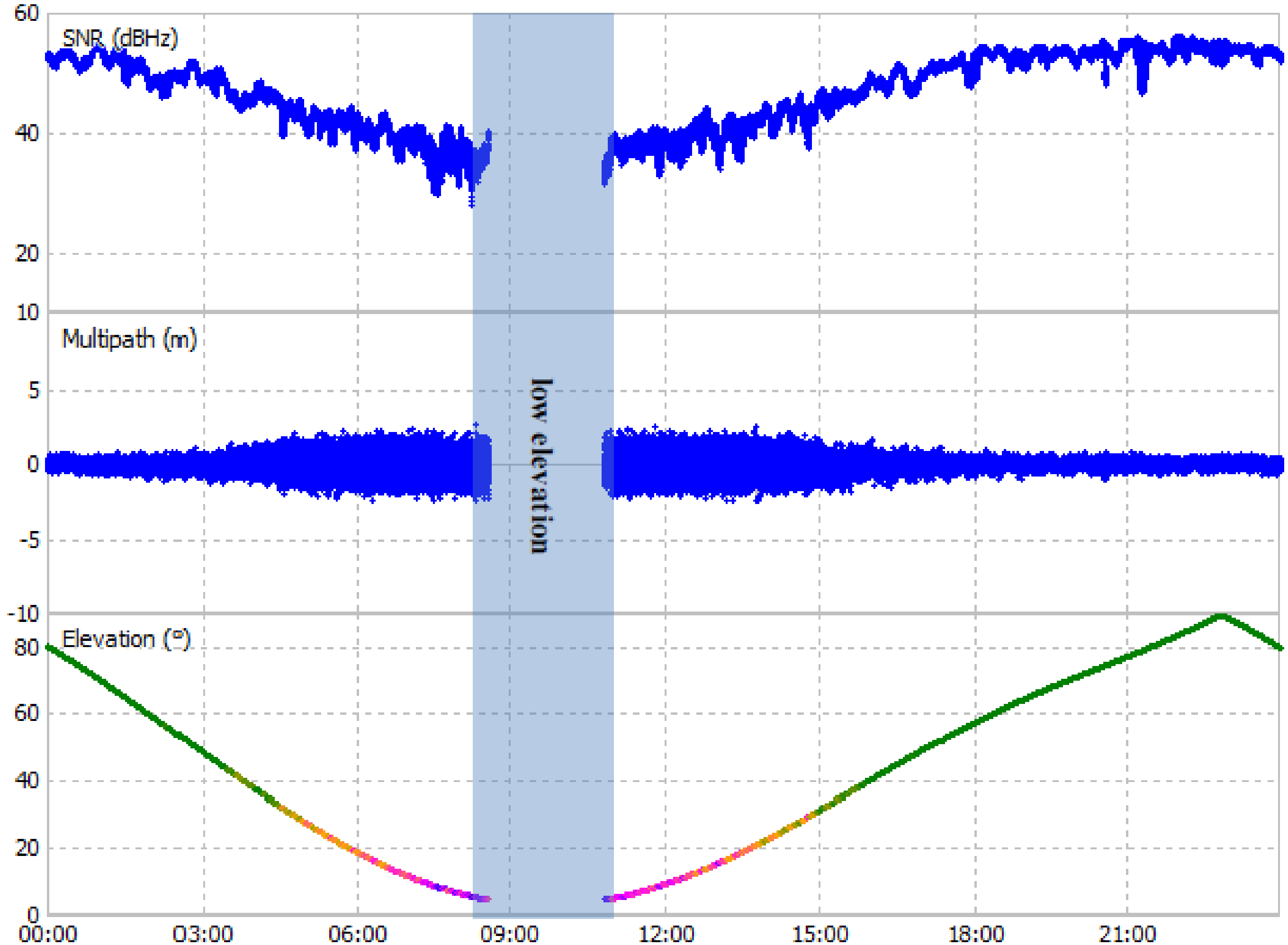
From Figures it can be seen that the SNR >40dB during the time J01 at high elevation at the Sydney station (because of the tree near the antenna).

However, from Figures the L1-SAIF signal is strong of SNR > 40dB most of the time at the Melbourne station because the antenna has an unobstructed sky view.

Visibility plot at Sydney on 2014-09-01

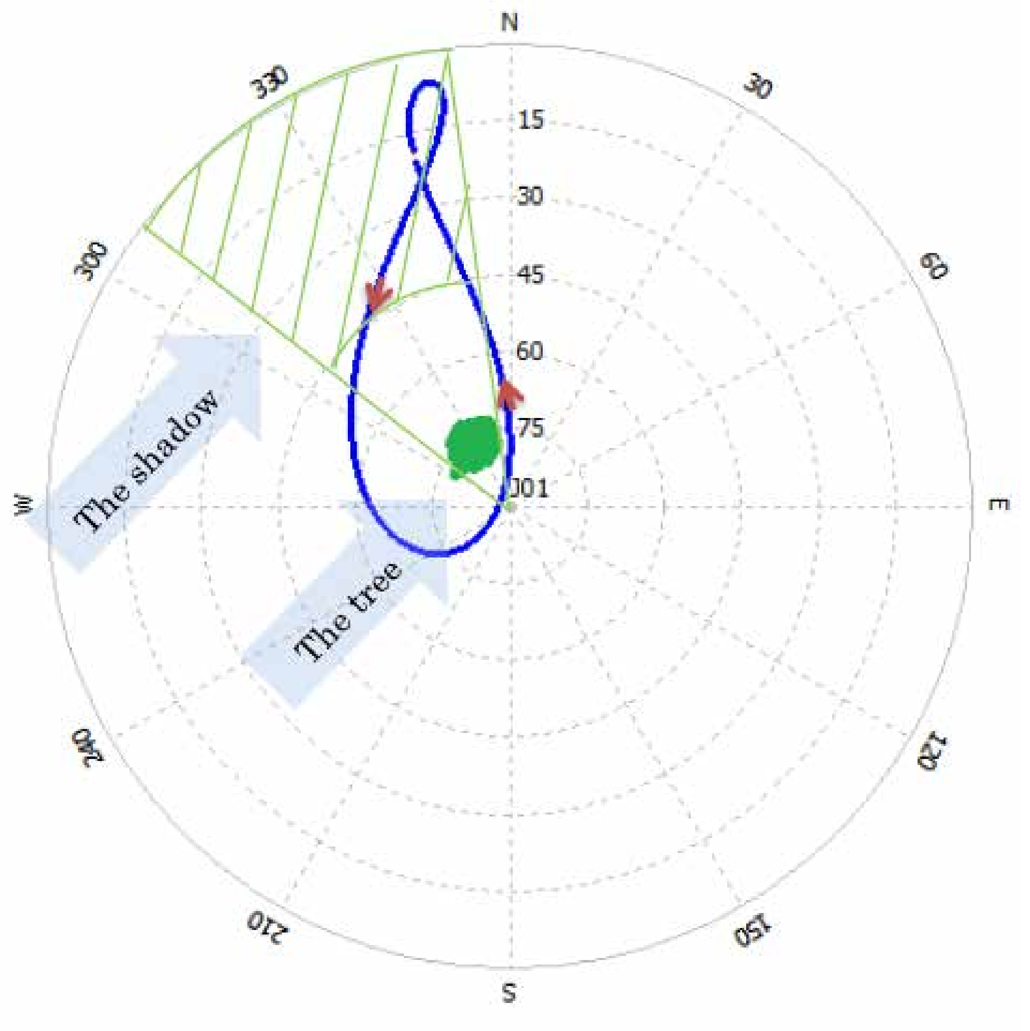


Visibility plot at Melbourne on 2014-09-01



The signals attenuation under the tree shadow

The tree is about 3m away and has a tall of about 3~4m above the antenna, which makes a shadow of about 45deg low, which attenuates the QZSS J01 signals under elevation of 45deg.



L1-SAIF ionosphere analysis

The ionospheric delay can be derived from the combination of L1 and L2 carrier phase measurements (Estey and Meertens 1999),

$$I_1 + \frac{1}{\alpha - 1}[n_1\lambda_1 - n_2\lambda_2 + m_1 - m_2] = \frac{1}{\alpha - 1}(L_1 - L_2)$$

$$I_2 + \frac{\alpha}{\alpha - 1}[n_1\lambda_1 - n_2\lambda_2 + m_1 - m_2] = \frac{\alpha}{\alpha - 1}(L_1 - L_2)$$

The time-rate of change of ionospheric delay is defined as

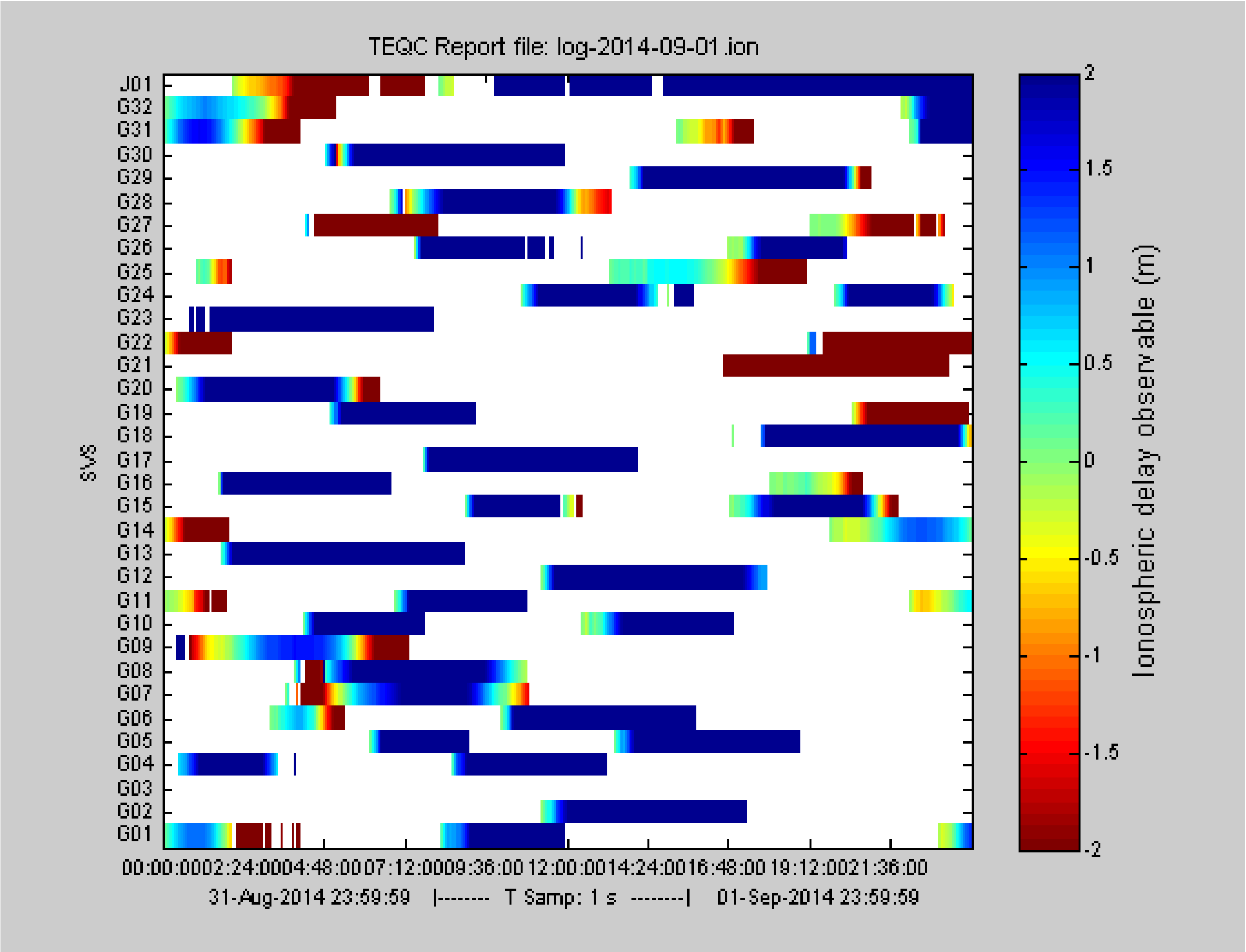
$$IOD_2 = \frac{\alpha}{\alpha - 1}\left[(L_1 - L_2)_j - (L_1 - L_2)_{j-1}\right]/(t_j - t_{j-1})$$

The ionospheric delay observable calculated by TEQC is obtained by

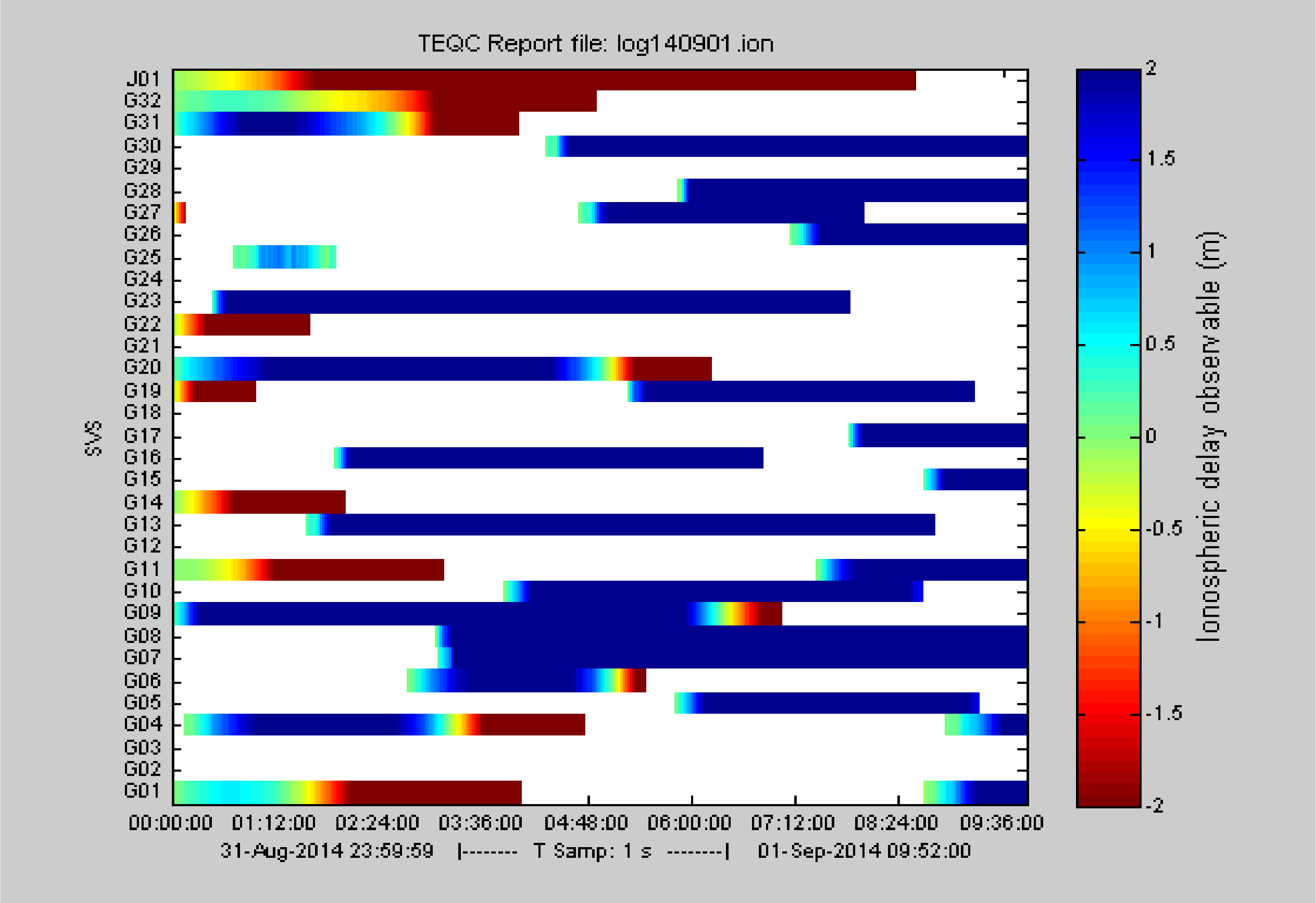
$$IONO_j = IONO_{j-1} + IOD_2\ (t_j - t_{j-1})$$

Estey L.H. and Meertens C.M (1999), TEQC: The Multi-Purpose Toolkit for GPS/GLONASS Data, GPS Solutions, 3(1):42-49.

Ionospheric delay at Sydney on 2014-09-01



Ionospheric delay at Melbourne on 2014-09-01



Ionospheric error analysis

As shown in Figures, the ionospheric delay of J01 varies rapidly around 2:00 (GPST, = AET12:00), which means the ionosphere is relatively active during this period of time. However the ionospheric delay does not change so much around 19:00 (GPST = AET5:00), indicating that the ionosphere is calm during this period of time.

Concluding remarks

The L1-SAIF signals can be received for most of the day. Data gaps mainly are due to: (a) the QZSS J01 setting below the horizon; (b) the tree near the antenna at the Sydney station blocked low elevation signals from the northwestern direction.

The L1-SAIF signal is strong, with SNR > 40dB for most of the time at the Melbourne station because the antenna has an unobstructed sky view. SNR >40dB during the time J01 was at high elevation was also observed at the Sydney station.

The SNR and multipath of L1-SAIF and L1C are similar. They have the same trend - the lower the elevation the smaller the SNR, and the lower the SNR the larger the MP.

The ionospheric delay of J01 can reflect ionospheric activity, for example the ionospheric delay does not change around 19:00 (GPST) indicating that the ionosphere is calm during this period of time.

Further work

(1) The ionosphere correction parameter transmitted by L1-SAIF is valid only for the Japan region. Positioning with L1-SAIF can obviously improve solution accuracy in Tokyo. However it is necessary to extend the correction coverage area to the south Asia and Pacific regions.

(2) Use of the existing GNSS observation network in Australia can derive the ionospheric delay parameters, and be used to derive the correction messages for the Australian region.

(3) With the L1-SAIF correction generated for positioning in Australia, tests can then be conducted on different platforms - such a land vehicles, vessels, and airplanes - to verify the position accuracy improvement.

(4) The signal attenuations by the tree are different on L1-SAIF and L1C - more attenuation on L1-SAIF than L1C. More investigations are needed for the exact reasons of this difference.

Thank you !