L2C Signal Assessment Using IGS L2C Network

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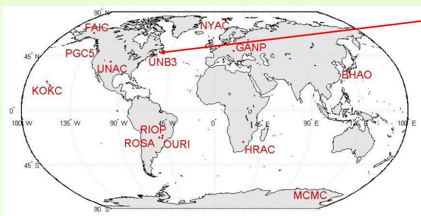
INTRODUCTION

- The United States has started an extensive **modernization program** to provide better service to GPS users.
- A new open civil signal is available on L2 frequency (L2C), currently broadcast by Block IIR-M satellites:

PRN 17 operational since: *2005 Dec 16* (launched *2005 Sep 26*)
PRN 31 operational since: *2006 Oct 12* (launched *2006 Sep 25*)
PRN 12 operational since: *2006 Dec 12* (launched *2006 Nov 17*)

- The International GNSS Service (IGS) has organized a network of L2C signal tracking stations (**L2C Test Network**) which has been established in different places in the world.



- Data is available in compact RINEX format from **CDDIS ftp**, with L2C data starting intermittently on day 2005:294 (*21 Oct 2005*) to date
- Receivers capable of tracking the modernized L2C signal have been developed and provided by a number of manufacturers, such as Trimble, NovAtel, Septentrio, Leica and Topcon.

Receiver types used in the L2C Test Network for stations:

TRIMBLE NetRS FAIC HARC KOKC MCMC NYAC PGC5 UNAC BHAO OURI RIOP ROSA

TRIMBLE NetR5 UNB3 GANP

OBJECTIVES

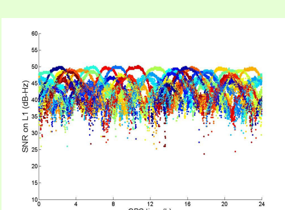
- The main objective of the investigation is to analyze the L2C signal – **SNR** values, **multipath and noise** level of the observations.
- Other objectives are to maintain an L2C-capable station, UNB3, using Trimble R7 and Trimble NetR5, and to test the receivers' firmware versions in terms of L2C signal tracking capabilities.

DATA COLLECTION AT UNB

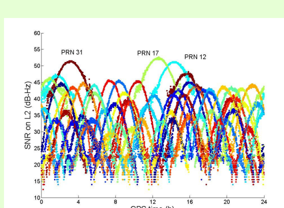
- **Trimble R7:** installed *11 Jan 2006* - removed *10 Oct 2006;*
- **Trimble NetR5:** installed *02 Nov 2006* - currently operational;
- data uploaded to
  ftp://cddis.gsfc.nasa.gov/gps/data/l2ctest/hourly/2007
  ftp://cddis.gsfc.nasa.gov/gps/data/l2ctest/daily/2007

RESULTS:

SNR ON L1



SNR ON L2



Max SNR on L1: PRN17-50.00, PRN31–49.00 and PRN12–51.25 (dB-Hz)
Max SNR on L2: RRN17–52.75, PRN3–51.50 and PRN12–49.25 (dB-Hz)

METHODOLOGY

A pseudo-observable which contains only **receiver noise and multipath** effects is created by differencing the raw pseudorange measurement, and the raw carrier-phase measurement, both of them with their ionospheric delay removed.

C/A Code Noise and Multipath level

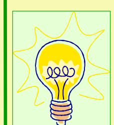
$$\left[c_1-\left(\frac{f_2^2}{f_1^2-f_2^2}\right)(\Phi_1-\Phi_2)\right]-\left[\Phi_1+\left(\frac{f_2^2}{f_1^2-f_2^2}\right)(\Phi_1-\Phi_2)\right]$$

$$= mp_{c_1}+noise_{c_1}-\left(\frac{f_1^2+f_2^2}{f_1^2-f_2^2}\right)(\lambda_1N_1+mp_{\Phi_1}+noise_{\Phi_1})+\left(\frac{2f_2^2}{f_1^2-f_2^2}\right)(\lambda_2N_2+mp_{\Phi_2}+noise_{\Phi_2})$$

The ionospheric delay on the two frequencies can be related as:

$$d_{ion_2}=d_{ion_1}\frac{f_1^2}{f_2^2}$$

L2C Code Noise and Multipath level can be similarly derived



CODE NOISE AND MULTIPATH ANALYSIS BASED ON THE L2C TEST NETWORK

- The L2C code has an effective chipping rate of 1.023MHz. For noise and multipath performances, the L2C code behaves similarly to a BPSK modulation at 1.023MHz. This means, that **the same level of noise and multipath is expected on C/A and L2C** (Simsky et al., 2006)

Data used for analysis

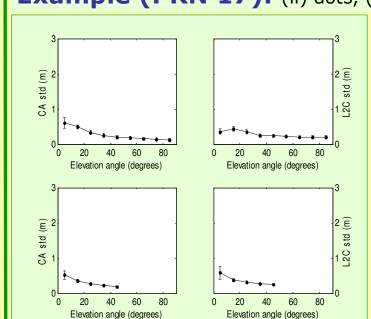
- four stations:
  - UNB3, GANP (R7)
  - FAIC, UNAC (NetR5)
- 24 day data from 1st Dec 2006 to 24th Dec 2006

Computed values

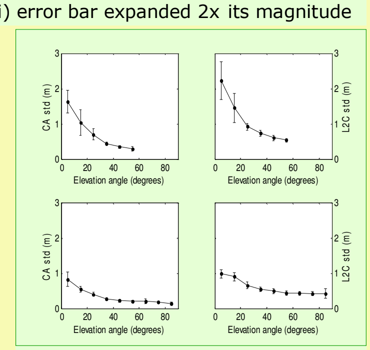
- C/A and L2C code multipath and noise values for each epoch.
- The standard deviations of multipath and noise values for each of:
  - 10-degree elevation angle bins, from 0 to 90 degrees (9 bins);
  - the four stations from the L2C Test Network;
  - the modernized satellites; and
  - C/A and L2C codes

  in two ways:
  - for each day separately (i);
  - for the entire 24-days period as a whole (ii)

Example (PRN 17): (ii) dots, (i) error bar expanded 2x its magnitude



C/A and L2C code multipath and noise standard deviation, stations UNB3 (top) and GANP (bottom)



C/A and L2C code multipath and noise standard deviation, stations FAIC (top) and UNAC (bottom)

RESULTS AND THEIR ANALYSIS

- elevation angle dependence of the noise and multipath standard deviations (std)
- higher error bars in the first elevation angle bin can be explained by a smaller number of observations
- Stations *UNB3 and GANP (Trimble NetR5)* results meet the expectation of similar noise and multipath of C/A and L2C code
- Stations *FAIC and UNAC (Trimble NetRS)* results **DO NOT** meet this expectation, L2C code noise and multipath std are apprx. 1.5x larger than the C/A code noise and multipath stds.
- the reason of higher noise and multipath level of the L2C code can be explained by the firmware version used in Trimble NetRS

CONCLUSIONS

- SNR of the L2C code is higher than the SNR of the P2 code, reaching similar values as those of the C/A code
- EVEREST, Trimble Multipath Mitigation Algorithm was enabled on both frequencies for Trimble NetR5, but was NOT enabled on L2 for Trimble NetRS receivers: (receivers' firmware version issue)