First Analysis of SSTL GPS-R experiment

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OBJECTIVE

The objective of this TB is to analyse data (complex waveforms) provided by SSTL from their GPS-R space experiment and evaluate Starlab model performace.
In this note, only the reflected GPS signal is studied.
Questions to be answered:

- *Are DDMs as predicted by the models?*
- *Is the SNR budget as expected? This is of course a rather important question for the design of future missions.*
- *..*

DDM ANALYSIS

This technical note reports on the activities conducted by Starlab in the analysis of the UK-DMC GNSS-R space data. Concerning DDM analysis, the fist iteration consisted in running Starlab's StarGym software to produce a model of the reflected Delay Doppler Map, in power, and compare it to the measurements. To this end, the model was fed with the ancillary data provided by SSTL.

Geometry definition

The information concerning the geometry of the reflection was extracted from the International GPS Service data file for satellite transmitting PRN 17, provided by SSTL.

These ancillary data describe the kinematics of the receiver and transmitter platforms during 20 s at a rate of 1 Hz. These data have been averaged over 20 seconds and fed (see Figure 1) into the Starlab StarGym software. The output is:

- Transmitter altitude: H_t=20546 km
- Transmitter local elevation: ε=67.8 deg
- Receiver altitude: H_r=690 km
- Receiver speed: v_r =7.6 km/s
- Angle between receiver velocity and transmitter-receiver line: Φ_r=35.5 deg
- Angle between transmitter velocity and transmitter-receiver line: Φ_t =188 deg
- Resolution of the area mapping: 1 km
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In Figure 2, we also provide an illustrative map of the sea-surface reflections, off the coast of California.

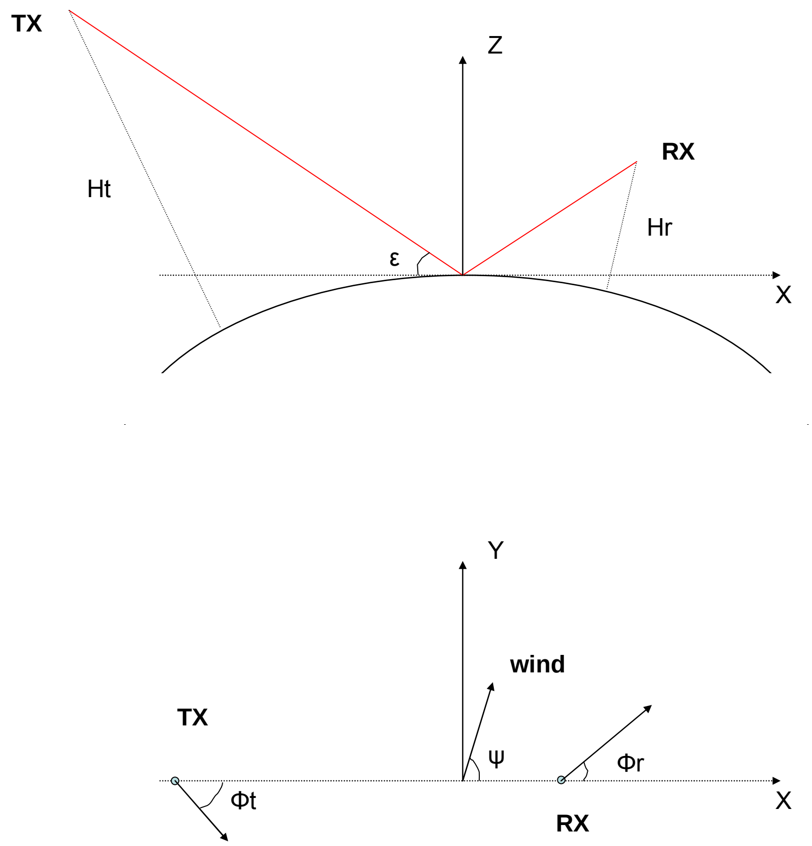

Figure 1: Geometric parameters needed by the StarGym software

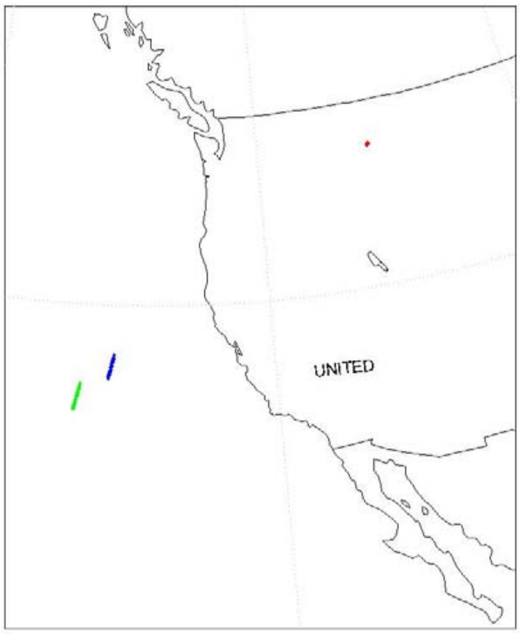

Figure 2: Map showing the receiver track (green) specular points (blue) and the transmitter track (red) during the 20 s measurements.

Instrument definition

Concerning the instrument characteristics needed to model the DDM, the following data have been input to StarGym software. These data are standard GPS signal characteristics or have been provided by SSTL.

- Wavelength: 19 cm (L1 signal)
- Code Bandwidth: 1.024 MHz (C/A code)
- Coherent integration time: 1 ms
- Sampling Frequency: 5.714 MHz
- Delay mapping: from -5 C/A code chips to +20 C/A code chips, at the sampling period
- Doppler mapping: from -5.5 kHZ to +5.5 kHz with a step of 100 Hz
- Antenna gain pattern:
  - Assumed Gaussian
  - Along-track 3 dB aperture = +/- 14 deg
  - Across-track 3 dB aperture = +/- 33.5 deg
  - Pointing: 10 deg along track, backwards

In Figure 3, the simulated antenna gain pattern that has been used is shown.

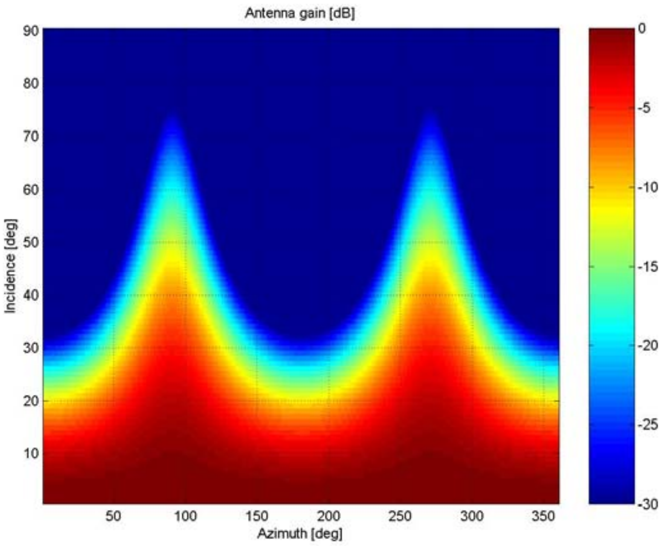

Figure 3: Simulated antenna gain pattern.

Geophysical parameters' definition

The information was extracted from the noaa46059met_sept3_cut.dat file, provided by SSTL. From this file, the wind vector has been calculated for the moment of the signal reflection, roughly 2004 Sept. 03, 07:25. The wind vector is about 10 m/s speed and 4 deg direction.

Using the Elfouhaily spectrum, this was translated into the following DMSS parameters:

- MSS-upwind: 0.023
- MSS-crosswind: 0.015
- Slope PDF direction with respect to the transmitter-receiver line: ψ=225 deg

Here, we have implicitly assumed that the wind field was homogeneous over the sensed area. This is obviously a non-valid assumption given that the area spans some hundredth of km.

Model outputs

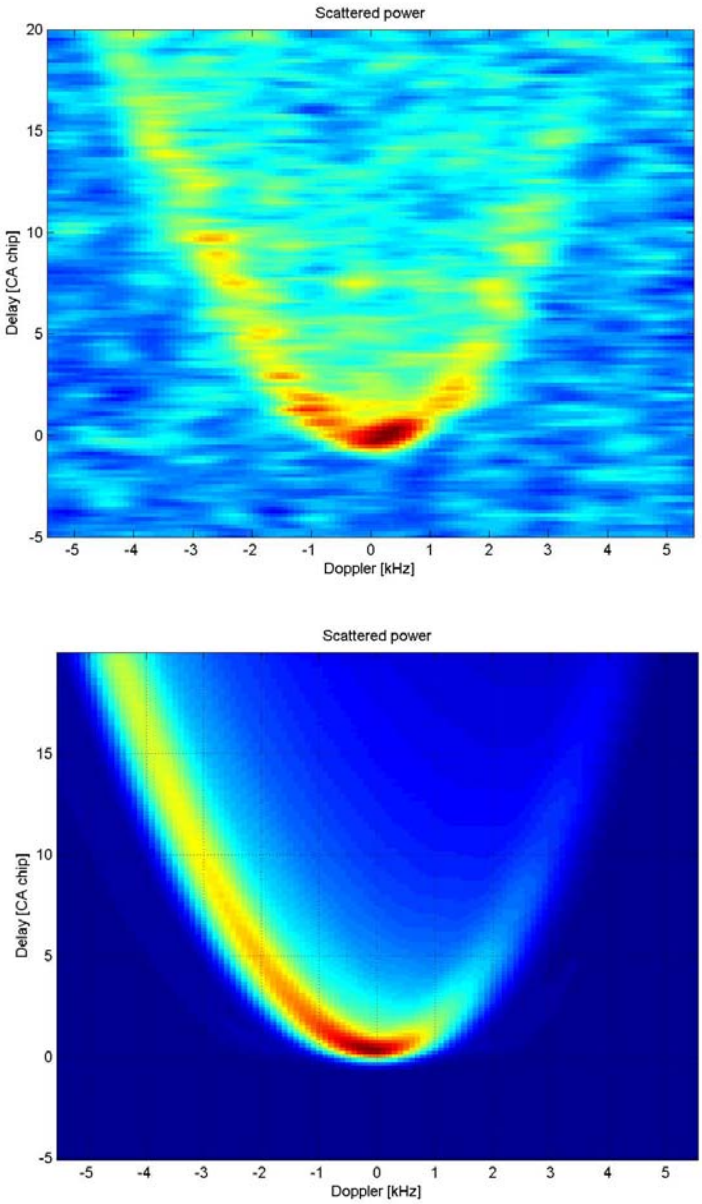

Figure 4: Data vs. Model Delay Doppler Maps. (Top: data. Bottom: StarGym software output).

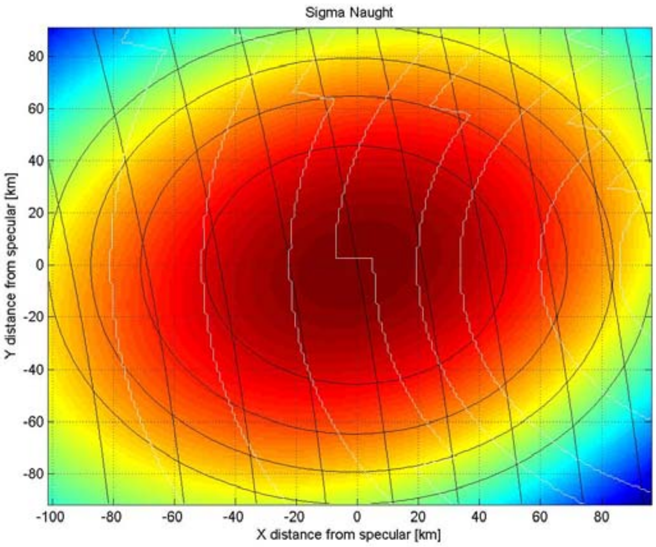

Fig 1 Mapping of the glistening zone in the specular point frame (X axis is the transmitter-receiver line). Colour: sigma naught. Black ellipses: delay lines (5, 10, 15 and 20 chips). Black straight lines: Doppler lines (-5,-4, …, 3, 4 kHz). White ellipses: antenna gain levels (0.1, 0.2, …, 0.8):

CONCLUSIONS

Next steps

- To run the model using a realistic 2D map of the wind field.
- To feed the model with the actual antenna pattern.
- To compare Starlab model with SSTL and UofC models.
- To run the model for more datasets.