GNSS Antenna Comparison for Bistatic Applications

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GNSS signals are gaining more and more traction as a passive bistatic radar source for remote sensor measurements. Measurements of soil moisture and ocean surface roughness can be flagged as two examples.

Two of the main collection approaches for these measurements are: (a) to use a base station on the ground; or (b) airborne equipment onboard an aircraft. Where the aircraft approach leverages a dual receiver with two antennas, one upward looking (direct signal) and one downward looking (reflected signal), and the GNSS satellite is the transmitter.

This paper focuses on the first approach, data collected using the base station method and, in particular, the role that the antenna and its design has on the measurements at the base station. It will discuss how different antennas, with different beam patterns, impacting the reflected signal which is used for the bistatic applications. The particular application of interest in this case is as a dual snow depth sensor and soil moisture sensor. The analysis is done by examining the signal to noise ratio of the received GPS satellite signal over the period of a complete pass of the satellite. Multiple measurements are taken, varying parameters such as antenna height and surface moisture to assess the performance of the antennas for such bistatic applications.

A GPS/GNSS antenna design made for a high precision ground station is designed to suppress reflected signals, especially those signals that are reflected from the ground and incident upon the antenna from below. This is controlled by the pattern of the lobes and by minimizing the left hand circular polarized signal, since the GNSS signals is broadcast with a right hand circular polarization and a change of polarization occurs when the signal is reflected. How successful the reflected signals is suppress depends on the surface it reflects upon as well as the polarization design of the antenna. Such features are not desirable when the GPS receiver is being utilized as a snow depth/soil moisture sensor. Instead the combination of the direct and reflected signals contains the desired information.

As a result, a basic, low cost, compact antenna designing for receiving both the direct and the reflected signal was designed for this application. Three monopole antennas were developed, one for each band (L1, L2 and L5) with the L2 and later on the L5 holding the most interest, for some testing to see how the measurements change relative to a survey grade antenna. The goal for these antennas was to be an (inexpensive and effective) alternative for a snow depth measuring system and also a low cost substitute to other bistatic applications, such as soil moisture measurements systems.
The measurement were recorded both in raw RF data to process later on with a software defined radio (SDR) in MATLAB and with Trimble’s NetR8 receiver. The commercial receiver from Trimble also provided a converter to give its measured data as a RINEX file, which could be parsed out in MATLAB.

The two interested component of the data that was to be calculate was signal to noise ratio (SNR) and the elevation angle of the satellite. This was done to be able to compare the different set of measurement, both a look between different antennas and then of the different heights of the monopole antenna, to conclude of the impact the multipath has on the different scenarios.

The main objective is to observe the fluctuation of the SNR for the different elevation angles. That is to say, to observe the constructive and destructive interference the multipath has on the height of the antenna. The multipath profile is heavily dependent on the height of the antenna above the surface as well as the antenna site including the “wetness” or reflectivity of the ground.

The test site of the data collection was on a high roof at the University of Colorado (urban area) that had a top layer of small stones and a drainage system to avoid water buildup.

The result indicated that the higher the antenna is place the weaker is the influence of the multipath, while a wet surface will increase the influence compare to a dry. As expected the monopole antenna that has wide beams and ignores the polarization of the signal is much more open to multipath. The advantage of that is the constructive and destructive interference comes out much distinctly but that in itself put some new demands on the receiver, especially in the phase of a destructive interference on low elevation angle that may drop the SNR value below the receiver threshold. But the best result was observed when the satellite is at a high elevation angle, where the other antenna is best on suppressing the multipath, the monopole picks up a nice pattern of the constructive and destructive interference that only becomes clearer when the surface is wet.