Assessment of Ocean-Reflected GNSS Signals Received from SMAP

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Recent radar receiver measurements made by the Soil Moisture Active Passive (SMAP) satellite provide a unique opportunity to investigate space-based GNSS-R (Global Navigation Satellite System Reflectometry) signals. GNSS-R remote sensing uses reflected GNSS signals from the Earth's surface for applications such as measurement of ocean surface winds, ocean altimetry, soil moisture, and others. In July 2015, the SMAP radar transmitter failed; however, the receiver continues to collect data. Since August of 2015, the SMAP radar has been tuned near the center frequency of the GPS L2C signal and has been continuously collecting raw I & Q sample data over a 1 MHz bandwidth. The presence of GNSS-R signals in this data has been previously reported [1]. SMAP has a 6 meter reflector antenna that provides high-gain (36 dBi), dual-polarized measurements over a roughly 40 km footprint. The antenna is oriented at a 40 deg. incidence angle with the Earth's surface and rotates to provide coverage over a 1000 km swath. This is in contrast to existing and future space-based GNSS-R instruments, such as UK-DMC, TDS-1 and CYGNSS, that provide single-polarization GPS L1 C/A-code measurements with peak gains of 11-14 dBi and very large antenna footprints. Therefore, the high-gain, dual-polarized measurements from SMAP can offer unique insight into the observability of important geophysical phenomena in space-based GNSS-R signals.

This presentation will provide results of an investigation into SMAP GNSS-R signals with a focus on ocean surface observations. Using the SMAP L1A data products, DDMs of reflected GPS L2C signals will be presented and compared to simulations. For this analysis, the CYGNSS End-to-End Simulator (E2ES) has been modified to account for properties of the SMAP instrument in order to provide a high-fidelity forward model of the DDMs which depend on a number of relevant ocean surface parameters. The focus of this analysis are on confirming the presence of DDM features in both models and measurements that take advantage of SMAP's unique abilities. SMAP's high gain should provide improved abilities to observe ocean scattering properties at high wind speeds (i.e. hurricanes), which would otherwise result in low SNR. The high gain should also allow observation of ocean wind properties away from the specular point; such observations may contain wind direction information. SMAP's dual-polarized antenna also allows for observation of both circular reflected polarizations as well as their correlation properties. Finally, the rotating footprint of SMAP will produce a discernable observation of each patch of ocean from two different angles; this multi-look observability is expected to reveal directional information in the amplitude of the scattered signals. Results will be presented to investigate these features of the measurements.

[1] A. Freedman *et al*., "GPS Reflectometry With SMAP: First Impressions," JPL, Pasadena, CA, presentation at CYGNSS Science Team Meeting, Ann Arbor, MI, Oct. 2015