Sensitivity of GNSS reflected signals to changes in land surface characteristics, as recorded by TechDemoSat-1

Clara C. Chew[(1)], Cinzia Zuffada* [(1)], Anthony J. Mannucci[(1)], and Rashmi Shah[(1)]
(1) NASA Jet Propulsion Laboratory, Pasadena, CA, 91109,
http://www.jpl.nasa.gov

Ground-reflected Global Navigation Satellites Systems (GNSS) signals can be used to describe changes in the land or ocean surface. This technique, GNSS-Reflectometry (GNSS-R), has primarily been explored using receivers flown on aircraft or balloons, or in modeling studies. Many of these studies indicate that GNSS-R can be used to estimate geophysical parameters like ocean wind speed, surface soil moisture, vegetation water content, and snow structure. However, to date, the only analysis of the detection of GNSS-R signals over land using spaceborne receivers has been limited to the small amount of data recorded nearly 10 years ago by the UK-DMC satellite.

Last year's launch of the TechDemoSat-1 (TDS-1) satellite, a precursor to the Cyclone Global Navigation Satellite System (CYGNSS) constellation, represents an enormous opportunity to investigate the potential of using spaceborne GNSS receivers to sense changes in the land surface, including but not limited to soil moisture and flood-inundated area. Although the primary mission of CYGNSS is to estimate changes in ocean wind speed, it is possible that the same measurements made over land could provide information about changes in the land surface. However, much research remains to be done in terms of quantifying how sensitive the signals are to changes in ground permittivity relative to surface roughness, as well as their spatial sensing scale. With a revisit time of only a few hours, the GNSS receivers that comprise the CYGNSS constellation, or similar constellations in the future, could provide data with a temporal resolution that would be unmatched by traditional remote sensing satellites.

Here, we present data collected over land and ice by the receiver onboard TDS-1 and report its sensitivity to changes in topography, vegetation, ice, and open water (lakes and rivers), as well as standing water beneath vegetation (marshes and wetlands). In particular, we use two delay-Doppler map (DDM) parameters: the peak amplitude normalized to the noise and the normalized volume, to investigate how DDMs are affected by changes in land surface characteristics. Our analysis suggests that many reflections recorded over land and sea ice are significantly more coherent than those recorded over open ocean. Both DDM parameters are strongly affected by changes in topography. The influence of rivers, lakes, and wetlands on DDMs is also clearly seen. Examples of large signal changes coming from areas of likely-saturated ground lend credence to the idea that these data could also be sensitive to changes in surface soil moisture.