Earth Remote Sensing with the Global Navigation Satellite System Reflectometry

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ABSTRACT

The Global Navigation Satellite System (GNSS) reflectometry uses GNSS signals reflected from the Earth's surface to infer its properties such as sea surface height (SSH), ocean winds, sea-ice coverage, vegetation, wetlands and soil moisture, to name a few. This concept takes advantage of the existing GNSS transmitting satellites, and uses the signals that have been scattered off the Earth surface and are collected by one or more specially designed GNSS receiver(s) forming a bistatic radar. By exploiting signals of opportunity as transmitter and requiring only development of the receiver, this type of radar can provide many randomly distributed measurements with broad-area global coverage and rapid revisit time in all weather conditions, at lower cost than traditional radar systems. The technique has been demonstrated in a number of field experiments with GPS receivers on towers, airplanes, balloons, and most recently satellites.

Most GNSS-R measurements are either altimetric or scatterometric. GNSS-R altimetry uses the difference in arrival time at the receiver between the direct and reflected signals to measure the surface height (at and around the specular reflection point) relative to the receiver. This, combined with the receiver location deduced from GNSS, gives measurements of the surface topography. Mapping meso-scale ocean eddies and sea-ice free board are examples of possible science measurements using GNSS-R altimetry. The talk discusses the role of a GNSS-R science instrument design parameters and signal processing scheme in the altimetric performance.

GNSS-R scatterometry uses features of the returned signal pulse shape such as peak power or fall-time and Doppler spread to deduce surface/media properties. Example measurements include sea-surface roughness, ocean winds, soil moisture, wetland extent and sea ice age. The measurement is more established, as attested by the CyGNSS NASA mission (currently in development) that will measure hurricane winds with a constellation of eight small satellites. Data provided by a recent CyGNSS-precursor tech demo satellite, TDS-1 by Surrey, is increasing confidence in the power of GNSS-R scatterometry. A summary of results from analysis of TDS-1 data is presented.

Finally, this communication discusses the scientific value of GNSS-R to furthering our understanding of ocean mesoscale circulation toward scales finer than those that existing nadir altimeters can resolve. In particular, the role of filtering played in the assimilation of these data to reduce the altimetric error (when averaging many measurements) is presented.