Time Series Soil Moisture Retrievals Using the CYGNSS Constellation

Mohammad Al-Khaldi and Joel T. Johnson
The Ohio State University, Columbus, OH, USA

Spaceborne remote sensing of surface soil moisture is of interest due to the fundamental role played by soil moisture in the modulation of key climatic cycles and phenomena. Due to its relative cost efficiency and extensive spatial and temporal coverage, Global Navigation Satellite System Reflectometry (GNSS-R) represents an emerging technology for improved monitoring of near-surface soil moisture levels. The launch of NASA's Cyclone Global Navigation Satellite System (CYGNSS) in December 2016 has resulted in the availability of an extensive dataset of GNSS-R measurements for investigating remote sensing applications. CYGNSS's GNSS-R measurements form a bistatic radar geometry where the CYGNSS receivers observe the specular reflections of signals transmitted from GPS satellites. The fundamental GNSS-R measurement obtained is the delay-Doppler map (DDM), which represents the specular scattered power from Earth's surface as a function of offsets in delay and Doppler from the specular point.

This presentation will report results from a time-series retrieval of soil moisture for the 6 month period December 2017 to May 2018 using land observations of the The retrieval approach developed attempts to address the confounding influences of surface roughness, land cover, and incidence angle variations.

In particular, NRCS ratios derived from CYGNSS measurements are used to form a system of equations for surface reflectivities. While an individual CYGNSS NRCS measurement will exhibit dependence on a wide range of properties such as soil moisture and composition, vegetation cover and surface roughness, ratios at consecutive acquisitions, with sufficiently low latency, should cancel many of these effects and then be direct proportionality to reflectivity ratios. The resulting ratios are then a function of soil permittivity and therefore soil moisture. The application of a dielectric mixing model then provides a location (i.e. soil texture) dependent inversion of reflectivity to soil moisture.

The use of NRCS ratios implies that the system of equations formed is not full rank, so that additional information must be incorporated for its solution. This additional information at present is provided in the form of monthly spatial maps of maximum and minimum soil moisture values. The final retrieved moisture values are compared against observed values reported by the Soil Moisture Active Passive (SMAP) mission. The findings of this study suggest that there exists potential for using GNSS-R systems for global soil moisture retrievals with an RMS error on the order of $0.04\ cm^3/cm^3$ over varied terrain.