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## Spaceborne GNSS Reflectometry for soil moisture using data from CYGNSS mission: results in the Contiguous United States

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Soil moisture is an essential climate variable, influencing geophysical and hydrological processes such as vegetation and agriculture, land-atmosphere circulation, and drought development. It is possible to remotely sense soil moisture based on the dielectric constant of soil at microwave frequencies. Low earth orbit (LEO) satellites are capable of receiving Global Navigation Satellite Systems (GNSS) signals reflected off the surface of the Earth to infer properties of the reflecting surface itself, in a technique known as GNSS-Reflectometry (GNSS-R). However, converting surface reflectivity derived from GNSS-R into soil moisture is not straightforward. Reflectivity is influenced by other factors such as the vegetation optical depth and the soil roughness around the specular reflection. The Cyclone Global Navigation Satellite System (CYGNSS) is a mission from the National Aeronautics and Space Administration (NASA) consisting of eight small GNSS-R satellites with the primary objective of measuring wind speed in hurricanes and tropical cyclones. The satellites were launched in December 2016 in a 35° inclination orbit, and the measurements are made of reflected Global Positioning System (GPS) L1 (1.575 GHz) navigation signals. Reflections over land can be used to estimate soil moisture in the upper 5 cm of soil surface if they are correctly treated and modelled. In this work, we use three years of observations from CYGNSS mission (March 2017 - March 2020) to compute surface reflectivity over land assuming coherent reflections. Using linear regression models and ancillary information from Soil Moisture Active Passive (SMAP) mission (soil moisture, vegetation optical depth, and roughness coefficient), these reflectivity observations are then used to estimate soil moisture. Retrievals are compared with observations from 44 in-situ soil moisture stations from the International Soil Moisture Network (ISMN) in the Contiguous United States (CONUS), presenting in most of the cases a good agreement. Results are also correlated with vegetation optical depth, surface roughness, and topographic relief around the in-situ stations. In addition, some challenges regarding soil moisture estimation using spaceborne GNSS-R data are presented and discussed.