Fusion of Spire GNSS-R, CYGNSS, and SMAP soil moisture data products

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Abstract

Spire Global, Inc. operates a constellation of CubeSats including GNSS Reflectometry (GNSS-R) satellites that conduct GNSS-based science and earth observation. Spire currently has two GNSS-R satellites in an equatorial orbit, launched in December 2019, and two with different antenna designs in polar orbit, launched in January 2021, with plans for a full operational constellation of GNSS-R Satellites in the future.

Spire has developed a GNSS-R based change detection algorithm for measuring soil moisture dynamics from CYGNSS and Spire GNSS-R satellites flying in equatorial orbits. In this method, a relative measure of soil moisture levels ranging between %0 - 100 is calculated based on historical measurements of reflectivity. Since NASA's Cyclone Global Navigation Satellite System (CYGNSS) and Spire GNSS-R observables are similar in many ways, the parameters obtained from the time series analysis of the CYGNSS data can be tentatively used for soil moisture change detection using the Spire GNSS-R observations. The obtained Relative Surface Soil Moisture (RSSM) presents variations between dry and wet conditions that correspond to vegetation wilting point and the degree of soil saturation. For calculating absolute soil moisture values in volumetric units, the RSSM is calibrated using soil moisture measurements from NASA’s Soil Moisture Active Passive (SMAP) L-band mission.

To increase the temporal coverage, the obtained SM product from Spire GNSS-R satellites can be merged with other space-based L-band soil moisture observations. In this study, we present the results of Spire’s SM data fusion with CYGNSS and SMAP observations to generate gap-free daily soil moisture maps at a 6km grid.