EGU24-5628, updated on 18 Apr 2025
https://doi.org/10.5194/egusphere-egu24-5628
EGU General Assembly 2024

Worldwide Small-Scale Land Surface Roughness Retrieval at L-band Using Space-born GNSS-R Observations

Mina Rahmani[1,2], Jamal Asgari[2], and Jens Wickert[1,3]
[1]German Research Centre for Geosciences GFZ, Potsdam, Germany (mina@gfz-potsdam.de & mi.rahmani@trn.ui.ac.ir)
[2]University of Isfahan, Isfahan, Iran (jamal.asgari@gmail.com)
[3]Technische Universität Berlin, Germany (TUB) (wickert@gfz-potsdam.de)

Soil moisture (SM) is a crucial factor influencing the exchange of energy between the soil and the atmosphere, playing a key role in hydrological processes. GNSS Reflectometry (GNSS-R) has recently become an innovative method for remotely monitoring various geophysical and hydrological parameters, including soil moisture. GNSS-R operates by utilizing signals from Global Navigation Satellite Systems (GNSS) that are reflected off the Earth's surface. In addition to the quantity of soil moisture content, the features of vegetation, such as vegetation water content, and the soil surface roughness influence GNSS-R observations. Consequently, accurately parameterizing these effects is essential for achieving precise and high-quality estimates of soil moisture. Nevertheless, separating the influences of surface roughness and vegetation on reflected signals is often challenging.

In this context, we employed a methodology aimed at assessing and mapping the sensitivity of GNSS-R observations to soil roughness effects. This analysis is based on observations collected by NASA's GNSS-R mission, CYGNSS, on a global scale in 2021. Initially, we endeavored to explore the responsiveness of CYGNSS observations to soil effects across a regular 0.2-degree global grid. The results revealed that CYGNSS observations exhibit sensitivity to soil effects over around 90% of the Earth's land surface covered by CYGNSS, spanning latitudes from 37° in the Northern Hemisphere to 37° in the Southern Hemisphere for all longitude values. Nevertheless, they show low sensitivity in the remaining 10% of land areas, primarily attributed to the impact of dense vegetation covers, particularly in the Amazon and Congo forests. In the second step, over regions where CYGNSS observations are sensitive to soil effects, we attempted to compute a map of the roughness parameter (Hr). To achieve this goal, we suggested integrating the effects of both vegetation and roughness into a single parameter, referred to as VR in this study. Initially, VR values were retrieved on a global scale from CYGNSS by inverting the L-MEB model. The L-MEB (Land Microwave Emission Model with Briggs approach) is a radiative transfer model used to simulate microwave emissions from land surfaces for remote sensing applications. Then, the effects of vegetation and soil roughness included in the VR parameter were decoupled by assuming a linear relationship between VR and Leaf Area Index (LAI) (~0.5 in this research) for the purpose of mapping the roughness parameter, Hr.

In this study, the obtained Hr values range from 3.2 to 4.6. The spatial distribution of Hr values is observed to be influenced by predominant vegetation types, where forests demonstrate higher roughness values (Hr = 4-4.6), whereas deserts, shrubs, crops, and bare soils exhibit lower values (Hr = 3.2-3.4). We also inferred vegetation optical depth (VOD) using CYGNSS observations in conjunction with estimated Hr values as an ancillary dataset. The evaluation of the obtained VOD in comparison with Vegetation Water Content (VWC) and LAI produced correlation coefficients of 0.57 and 0.71, confirming the effectiveness of the recently introduced Hr dataset in our research and highlighting its promising potential for future applications in GNSS-R.