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A Time-Series Study of Bistatic Delay-Doppler Maps Over Vegetated Terrain: Comparison of Simulations and CYGNSS Observations

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Abstract

The use of signals-of-opportunity (SoOP) has opened up a new host of possibilities for global environmental observations. A prominent recent example is the NASA Cyclones Global Navigation Satellite System (CYGNSS), which consists of a constellation of 8 small satellites in low-Earth orbit, collecting GNSS reflectometry (GNSS-R) signals from the surface of the Earth [1]. The CYGNSS mission was designed for observations of cyclones over the oceans, but more recently, several land-focused applications have also emerged. In particular, soil moisture observations are currently of great interest for the mission [2, 3]. To develop soil moisture retrieval algorithms using GNSS-R signals, we have previously developed a bistatic electromagnetic forward scattering model that includes provisions for a range of vegetation landcover types, including grass, shrubs, savannas, and single and multi-species forests, in addition to bare surfaces [4, 5]. The model can also be simulated for heterogeneous landscapes. In this paper, we will focus on areas of flat topography but with different landcover types. We will present the results of our simulation studies and sensitivity analyses for at least two soil moisture calibration/validation (cal/val) sites for which we have access to in-situ soil moisture data and vegetation characteristics. The results of bistatic scattering cross section (BCRS) simulations are converted to delay-Doppler maps (DDMs), which are how the GNSS-R observations made and reported. The comparison of model simulations and CYGNSS observations will be shown for a seasonal (3-6 months) time-series for the two cal/val sites, which will demonstrate the effect of variations in incidence angle, vegetation, and soil moisture. The outcomes of this study will be key in determining the sensitivities of CYGNSS observations to these parameters and variables, resulting in optimizing the soil moisture retrieval algorithm that will ensue.

References

[1] C. Ruf *et al.*, "The NASA EV-2 Cyclone Global Navigation Satellite System (CYGNSS) mission," *2013 IEEE Aerospace Conference*, Big Sky, MT, 2013, pp. 1-7.

[2] M. P. Clarizia, N. Pierdicca, F. Costantini and N. Floury, "Analysis of CYGNSS Data for Soil Moisture Retrieval," in *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing*, vol. 12, no. 7, pp. 2227-2235, July 2019.

[3] Chew, C.C. and Small, E.E., 2018. Soil moisture sensing using spaceborne GNSS reflections: Comparison of CYGNSS reflectivity to SMAP soil moisture. *Geophysical Research Letters*, *45*(9), pp.4049-4057.

[4] A. Azemati and M. Moghaddam, "Circular-linear polarization signatures in bistatic scattering models applied to signals of opportunity," *2017 International Conference on Electromagnetics in Advanced Applications (ICEAA)*, Verona, 2017, pp. 1825-1827.

[5] A. Azemati, M. Moghaddam and A. Bhat, "Bistatic Scattering Forward Model Validation Using GNSS-R Observations," *IGARSS 2019 - 2019 IEEE International Geoscience and Remote Sensing Symposium*, Yokohama, Japan, 2019, pp. 5964-5967.