Forward Modeling of CYGNSS GNSS-R Land Reflection Measurements

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CYGNSS is a constellation of eight satellites launched in December of 2016 that receives GPS L1 C/A-coded signals reflected off the surface of the Earth. CYGNSS is primarily intended to measure the scattered power of signals reflected off the ocean surface, and data products are focused on ocean wind speed retrieval. The CYGNSS and GPS satellites form a bistatic radar geometry, and the scattered signal power from ocean surfaces originates from a zone centered around the specular reflection point. The instrument forms a delay-Doppler map (DDM) by cross-correlating the received signals with GPS C/A-code reference signals at different delay and Doppler shifts. The CYGNSS End-to-End Simulator (E2ES) serves as a forward model for the CYGNSS DDM measurements over ocean surfaces. It accounts for all important aspects of the CYGNSS instrument, bistatic scattering calculations based on a wind driven ocean, and formation of the DDMs. Previously, match-ups between CYGNSS measurements over the ocean and the CYGNSS E2ES have shown very good agreement. CYGNSS measurements over land surfaces are also of increasing interest. In order to better interpret these results, it is necessary to extend the forward model to these new surface types.

This presentation will show results of an investigation into match-ups between measured CYGNSS Level-1 data products over land with simulated measurements generated by the CYGNSS E2ES. To support this study, it was necessary to modify the E2ES in several ways. Internally, the E2ES generates a grid around the predicted specular reflection point. Over land, the E2ES inputs digital elevation model (DEM) data to generate a grid that properly accounts for delay and Doppler information across topography. Furthermore, high resolution land/water masks are included in the E2ES to quantify the percentage of land and water that contributes to each pixel in CYGNSS's measured DDM. Additionally, the forward model has been modified to include both coherent and incoherent scattering models for land surfaces. Results from both models are useful for classification of CYGNSS measurements. The work presented in this paper is relevant to future improvement of retrieval algorithms for land surfaces to obtain products such as soil moisture, flood extent, or vegetation properties.