A Theoretical Study of the Relationship Between Bistatic scattering Cross Sections and GPS Reflectometry Delay-Doppler Maps Over Vegetated Land In Support of Soil Moisture Retrieval

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Soil moisture is a critical variable in studying the global ecosystems, exerting first-order control on land-atmosphere interactions. Soil moisture measurements on global and local scales contribute to many areas of human interest such as weather and climate forecasting, flood prediction, drought analysis, crop productivity evaluation, and human health. Thus, developing novel and reliable soil moisture observation and retrieval techniques is a subject of great interest. Development of bistatic retrieval techniques and receiver systems give us the possibility to use the existing signals of opportunity (SoOP), such as those transmitted by GPS/GNSS, TechDemoSat-1 (TDS-1), and Military Communication Satellites (MilComSats). The basic bistatic measurement from these sources is the Delay-Doppler Map (DDM). To be able to use these observations for quantitative soil moisture retrieval, we need to convert the DDMs to the more familiar scattering cross sections.

In previous research works, we presented a coherent bistatic forward scattering model at L-band and P-band for various terrain types including forests. This model is built on its mono-species backscattering model counterpart, and comprises three main scattering mechanisms that include the direct bistatic scattering from ground, bistatic scattering from the vegetation layer, and double bounce bi-scattering from trunks and branches. Consequently, the total bistatic scattering cross section of vegetated terrains is computed by superimposing the three stated scattering contributions. This model produces co-pol and cross-pol radar cross sections for linearly polarized incident waves.

This paper will first discuss the extension of the model to circularly polarized (mimicking GNSS signal) incident wave cases, and will present numerical simulation results for various vegetation land covers. It will then present an analysis relating the backscattering cross sections of vegetated land cover to the customary DDMs resulting, e.g., from GNSS reflectometry (GNSS-R) observations. This step is key in being able to use GNSS-R data in soil moisture retrieval algorithms. While some analyses exist for this purpose for scattering from sea surface, to our knowledge such analysis has not been carried out specifically for land surface. In Future, the validity of model will be examined by using the data available from bistatic platforms, which include Cyclone Global Navigation Satellite System (CYGNSS) and (TDS-1).