Could GNSS-Reflectometry Sense Corn Growth Stages?

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Global Navigation Satellites System Reflectometry (GNSS-R) as a subset of Signal of Opportunity (SoOp) studies attracts researchers to study land applications in recent years. In fact, GNSS-R has been applied for remote sensing of ocean roughness since 1990s, but retrieval of land geo-physical parameters such as topography, surface and root zone soil moisture (SM and RZSM), and biomass features is still emerging. Understanding the vegetation and SM influences the interpretation of Earth's water and carbon cycles.

Corn plant is studied in this paper, and its five growth stages are identified and retrieved by using various input parameters and the corresponding received power via Monte-Carlo simulations. The main reasons behind the selection of corn plant are that corn fields hold a considerable portion of the world's vegetation biomass, and corn is the third most important cereal crop species in the world. We determined to make use of GNSS signals (L-band) for this study since this band has one of the most suitable wavelength ranges for remote sensing of corn. GNSS-R simulations were performed by utilizing a bistatic vegetation model in conjunction with the developed inversion model which makes use of a supervised machine learning algorithm, Support Vector Machine (SVM).

The receiver is modelled as a ground-based, realistic antenna operating at L1-frequency (1575.42 MHz) with right-hand and left-hand circular polarizations (RHCP and LHCP) at 20 m-altitude. The training and testing data are generated by simulations with predetermined and random input parameters, respectively. The input parameters of the simulations are SM, surface roughness, and antenna observation (incidence) angles. Vegetation model produces received power from various combinations of input parameters. Power consists of specular and diffuse terms, where the former represents the reflection from the specular point, and the latter refers to the scattering from vegetation particles over the field.

The preliminary retrieval results show that this methodology is highly successful to resolve the growth stages. The inversion model has an overall accuracy about 93.1 percent on recognizing the growth stages. The precision and recall values for individual stages also fit to the observations about the effects of the variations in input parameters. Finally, it is imperative to work on the subject in detail and to validate the model results with field measurements in the future.