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Investigating the Effect of Surface Canopy Water on Agricultural Monitoring using Fully Polarimetric L-band backscatter

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Accurate information on crop parameters such as leaf area index (LAI), dry biomass, vegetation water content (VWC), and crop height can be used in many agricultural applications including soil moisture monitoring, crop health monitoring, irrigation management, and yield estimation. Up to now, active microwave data has been used in many studies to retrieve crop parameters. This is mostly due to the capability of acquiring radar data regardless of weather conditions. Moreover, depending on the frequencies, the radar signal can partially or fully penetrate through vegetation and provide information on the vegetation and soil.

The launch of SAR sensors on polar-orbiting satellites with high temporal resolution such as ESA's Sentinel-1 mission and Radarsat Constellation Mission (RCM) offer a unique opportunity to combine data from ascending and descending acquisitions to estimate near real-time crop biophysical parameters. However, the presence of surface canopy water (SCW), dew or interception, during single acquisitions can affect the relationship between radar observables and crop biophysical variables as a result of (multiple) scattering and also can affect the attenuation of the microwave signal through the vegetation layer. Although it has been demonstrated that the presence of water on the canopy surface affects the radar signal [1], its influence on the relationship between radar observables and crop biophysical parameters and on the attenuation of the radar signal has not been investigated.

The aim of this research is to quantitively investigate the effect of SCW on radar observables and on the relationship between these observables and biophysical crop parameters. Different radar observables such as co- and cross-polarization data (VV, HH, VH), polarimetric ratio data (VH/VV and HV/HH), and Radar Vegetation Index (RVI) were tested to better understand the influence of surface canopy water on retrieval of key parameters. In addition, the effect of SCW on vegetation optical depth (VOD) estimation and on the linear relationship between VOD and VWC is analyzed.

In order to conduct this analysis, an intensive fieldwork campaign was performed in Florida, USA, during a full growing season of corn. Fully polarimetric L-band data were collected 32 times per day using a truck-mounted scatterometer. To capture vegetation water dynamics and dry biomass, pre-dawn destructive sampling was conducted three times a week, and plant geometry was measured once a week for a full growing season. Three leaf wetness sensors, installed on different heights, were used for continuous monitoring of SCW. Soil moisture, meteorological data, and SCW were measured every 15 minutes for the entire growing season.

Results show that the presence of surface canopy water can result in an increase in backscatter of up to 3-4 dB, and also affect the relationship between radar observables and crop biophysical variables. Spearman rank correlations between backscatter and biophysical variables were higher over vegetation without SCW compared to vegetation with SCW. Using cross-ratio and RVI can reduce the effect of SCW on the radar observable. However, it generally does not mitigate the influence of SCW on crop parameter retrieval. The estimated VOD from Vegetation with SCW were generally higher than those estimated from vegetation without SCW, resulting in a different regression parameter when assuming a linear relationship between VOD and VWC for wet and dry vegetation. These results demonstrate the importance of considering the influence of SCW in the retrieval of biophysical crop parameters. In particular, it is important to consider the connection between overpass time and the increased likelihood of there being dew on the vegetation.

References

[1] P. C. Vermunt, S. Khabbazan, S. C. Steele-Dunne, J. Judge, A. Monsivais-Huertero,958L. Guerriero, and P. W. Liu. Response of sub daily L-band backscatter to internal and surface canopy water dynamics. IEEE Transactions on Geoscience and Remote Sensing, pages 1–16, 2020