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Sensitivity of C-Band SAR Polarimetric Variables to Soil Moisture and Surface Roughness Retrievals for Field-scale Agricultural Targets

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Monitoring field-scale soil moisture and surface roughness is of importance for agricultural decision making. Sensors operating within the microwave portion of the electro-magnetic (EM) spectrum are best suited for retrieval of these parameters due to their sensitivity to soil dielectric and surface structure. Specifically, polarimetric Synthetic Aperture RADAR (SAR) sensors, which emit energy to a target and measure the returned signal, are of interest. Polarimetric SAR measures the horizontal (H) or vertical (V) alignment of the electric part of a wave, perpendicular to the direction of signal propagation. Existing research into the response of space-borne SAR sensors to agricultural targets has mostly been limited to single or dual polarizations. In contrast, fully polarimetric SAR sensors have the advantage of transmitting and receiving all four H - V signal combinations simultaneously, as well as recording the amplitude and phase difference between the four channels. The RADARSAT -2 mission, launched in 2007, is the first commercially available space-borne platform to provide fully-polarimetric SAR capabilities in the C-band wavelength (3.75 – 7 cm). Using fine-quad polarization mode RADARSAT-2 data at various incidence angles (20°, 27°, 33° and 37°), and ground data from multiple field-validation campaigns, this presentation demonstrates a sensitivity analysis of polarimetric SAR parameters to soil moisture and surface roughness over agricultural targets in Ontario, Canada. Variables examined include the linear backscattered intensity signals (HH/VV/HV/VH), as well as select polarimetric parameters. Results demonstrate soil moisture to be well correlated to several of these variables at a low incidence angle (20°). At this angle a good correlation ($r = 0.606$) is present between moisture and the linear (HH) signals, however, superior relationships can be found with several of the polarimetric parameters. Specifically, the Total Power of the backscattered signal ($r = 0.650$), the Completely Polarized Component ($r = 0.678$) and the Scattered Intensity ($r = 0.660$). In contrast, surface roughness is most correlated to linear and polarimetric variables at a high incidence angle (37°). The strongest correlation is to the linear (HH) signals ($r = 0.647$), with tested polarimetric variables demonstrating inferior relationships. Linear and multivariate regression models are derived from this analysis and applied to soil moisture and surface roughness mapping.