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Supplementary Information

Theoretical Modeling and Analysis of L- and P-band Radar Backscatter Sensitivity to Soil Active Layer Dielectric Variations

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Simulations of Snow and Vegetation Effects on L- and P-band Radar Observations

To quantify the impacts of possible presence of snow and vegetation on AIRSAR observations over the three ISAs of North Park on March 28, 2003, additional simulations were made using snow and vegetation scattering models with *in-situ* measurements from the snow pits as inputs. Detailed information of the snow model is found in [1] and [2], while the Michigan Microwave Canopy Scattering Model (MIMICS) based vegetation model is described in [3]. Only the direct backscatter and the attenuation of a layer of snow/vegetation were calculated.

According to the in-situ measurements from 48 snow pits within NP, NI and NM ISAs, snow tended to be shallow and loose, with average depth of 5.5 cm and average density of 163.5 kg/m^3. The snow grains were relatively small, with an average size of 0.60 mm. Also, except for 3 locations without data, snow wetness conditions were either described as moist (29 locations) or dry (16 locations). Moist snow is normally defined as snow with volumetric content of liquid water in the range from 0% to 3% while dry snow has 0% water content [4]. Therefore we assumed an overall snow wetness of 1.0% for the study sites. Dielectric properties of wet snow were calculated according to [5]. For the vegetation, the only information we have is vegetation type and height described in the snow pit measurement dataset. Except for 4 locations without vegetation information, vegetation was found to be sparse, with most locations described as bare soil (32 out of the total 48 snow pits) and short grass or sage with an average height 16 cm found in 12 locations. For completing the simulations on vegetation, other parameters (leaf thickness 0.2 mm, leaf number density 900/m^2 and leaf size 40 cm $\times$ 2 cm) required by MIMICS were adopted from the literature [6]. Another input parameter, vegetation water content, was assumed as 60%, which was the upper bound considered for evaluating the effects of vegetation since the vegetation was likely in a frozen or partially frozen state with an average air temperature −1.7 °C. Based on the above input parameters, simulations were made at incidence angle 40°, HH-polarization for both L- and P-band. The simulation results indicated negligible contribution and very small attenuation from the snow layer with one-way transmissivity of 0.982 and 0.998 for respective L- and P-band results; respective backscatter from the snow layer was −73.7 dB and −92.2 dB. Similarly, the attenuation from the short grass layer was also negligible with one-way transmissivity higher than 0.99 for both frequencies and with respective backscatter of −38.3 dB for L-band and −55.3 dB for P-band.

The quantified simulation results indicate that for the North Park alpine tundra MSA depicted in this study, sparse frozen grass/sage vegetation and shallow dry/moist snow conditions are not expected to significantly influence the potential P-/L-band backscatter sensitivity of underlying soil layers.

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