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The effect of surface roughness and polarization on snow bi-directional reflectance: Model simulations and validation using NASA Cloud Absorption Radiometer measurements

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Snow radiative transfer modeling plays an important role in remote sensing and climate studies. Measurements of the polarization properties of snow have become more and more available. Model-derived snow bi-directional reflectance factors (BRFs) that ignore the impact of surface roughness and polarization do not agree with measured snow BRFs. To investigate the reasons for this discrepancy, we evaluated the impact of surface roughness and polarization on the snow BRF by constructing a coupled-atmosphere-snow radiative transfer model based on the discrete-ordinate method. This method accurately accounts for surface roughness and polarization effects. The simulated reflectance of a roughened snow surface becomes less isotropic for large solar zenith angles compared to that of a flat surface. The snow BRF simulated by a vector radiative transfer model is significantly different from that resulting from a scalar radiative transfer model, especially in the shortwave infrared range where snow is moderately absorptive. Comparisons with full 360 degrees BRF measurements obtained with the NASA Cloud Absorption Radiometer show that consideration of snow roughness as well as polarization effects can significantly reduce the difference between radiative transfer model simulations and measurements.