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Evaluation of satellite remote sensing albedo retrievals over the ablation area of the southwestern Greenland ice sheet

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Greenland ice sheet (GrIS) surface albedo has declined considerably in recent decades, with the greatest reduction in the lower southwestern ablation area. Monitoring changes in surface albedo is crucial given its importance in modulating the surface energy balance, and thus, melt and mass balance of the ice sheet. Moderate Resolution Imaging Spectroradiometer (MODIS) albedo products are typically used to characterize changes in ice sheet albedo. Remotely sensed albedo retrievals have been validated with ground albedo measurements from distributed automatic weather stations. However, these studies assume that both satellite and in situ observations are captured within the same spatial domain. Unless the surface is homogeneous or an adequate number of dispersed ground point measurements are collected within a pixel during satellite overpasses, then a direct 'point-to-pixel' comparison is insufficient.

Here, we adapt Roman et al.'s [1] method to perform a robust spatial inter-comparison of in situ spectral albedo measurements with satellite retrievals of narrow and broadband surface albedo from the GrIS. Our study uses transect point data collected with an Analytical Spectral Devices Inc. (ASD) spectroradiometer over southwest Greenland's ablation area during the 2013 melt season to carefully evaluate two MODIS pixels, Pixels A and B, using data from the recently developed MODIS (Version 006) MCD43A daily albedo retrievals. The high density of the ground measurements allows for the first-ever spatial characterization of the lower GrIS ablation area's heterogeneous surface within each MODIS pixel. Furthermore, we investigate within-MODIS pixel spatial variability by using a high-resolution WorldView-2 (WV-2) image. Initially, a direct point-to-pixel comparison between ground ASD and MODIS albedo retrievals was conducted. Secondly, WV-2 data was used as an intermediate between the ground and MODIS satellite retrievals to conduct a spatial representativeness analysis, aggregated into three spatial domains (200 m, 320 m, and 480 m).

Our direct point-to-pixel comparison reveal that MODIS Pixels A and B are 7% larger and 3% lower, respectively, than in situ ASD albedo observations. Large MODIS sub-pixel spatial heterogeneity in albedo is observed across all MODIS wavebands. MODIS Pixel A, closest to the ice sheet margin, has the greatest spatial variability, and poorest fit between in situ and satellite retrievals, at all spatial scales. In contrast, MODIS Pixel B is relatively homogeneous at all spatial scales. The results of this study demonstrate the need for future studies to utilize a combination of surface measurements as well as fine-scale satellite and airborne remote sensing data. To overcome the issues of spatial scale and highly inhomogeneous landscapes, future concurrent field, airborne, and spaceborne campaigns need to be conducted. Finer spatial and spectral resolution imagery, as well as spatially-distributed field surveys, is needed to adequately characterize the ablation area, and improve our understanding of the contribution of ablation area albedos to future changes in Greenland's energy budget and ice mass.

References:

[1] Roman et al. (2009) Remote Sens Environ 113(11): 2476–2498