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Remote sensing of Arctic boundary layer clouds above snow surfaces

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In the Arctic remote sensing of clouds using reflected solar radiation is mostly related to high uncertainties as the contrast between the bright sea ice and snow surface and the clouds is low. Additionally, uncertainties result from variation of the snow grain size which changes the absorption of solar radiation similarly to the size of cloud particles. This is a major issue for understanding the response of Arctic clouds to climate warming as the quantification of cloud properties in this remote region mostly relies on satellite observations.

We used spectral radiation measurements of the Spectral Modular Airborne Radiation measurement sysTem (SMART-Albedometer) to improve common used cloud remote sensing algorithms in case of snow surfaces. The measurements were collected during the airborne research campaign Vertical distribution of ice in Arctic mixed-phase clouds (VERDI, April/May 2012) above the Canadian Beaufort where both sea ice covered and ice free ocean areas were present during the observation period. Based on the spectral absorption characteristics of snow and clouds (assuming to be dominated by the liquid fraction) a combination of wavelengths was found which allows to separate the impact of clouds and snow surface on the reflected radiation measured above the clouds. While snow grain size dominates the absorption at a wavelength of 1.0 μm, information on cloud optical thickness and cloud particle effective radius can be extracted at wavelengths of 1.7 μm and 2.1 μm, respectively. Based on radiative transfer simulations lookup tables for the retrieval algorithm were calculated and used to estimate the theoretical uncertainties of the retrieval. It was found that using ratios instead of absolute radiances reduces the uncertainties significantly. The new algorithm was applied to a specific case observed during the VERDI campaign where a stratocumulus clouds was located above an ice edge. It could be shown that the method works also over water surfaces and provides similar cloud optical properties above ice covered and ice free surfaces. In addition the snow grain size could be derived also in cloud covered areas.