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Evidence of ice crystals at cloud top of Arctic boundary-layer mixed-phase clouds derived from airborne remote sensing

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Abstract. The vertical distribution of ice crystals in Arctic boundary-layer mixed-phase (ABM) clouds was investigated by airborne remote-sensing and in situ measurements during the Arctic Study of Tropospheric Aerosol, Clouds and Radiation (ASTAR) campaign in March and April 2007. Information on the spectral absorption of solar radiation by ice and liquid water cloud particles is derived from airborne measurements of solar spectral radiation reflected by these clouds. It is shown by calculation of the vertical weighting function of the measurements that the observed absorption of solar radiation is dominated by the upper cloud layers (50% within 200 m from cloud top). This vertical weighting function is shifted even closer to cloud top for wavelengths where absorption by ice dominates. On this basis an indicator of the vertical distribution of ice crystals in ABM clouds is designed.

Applying in situ measured microphysical properties, the cloud-top reflectivity was calculated by radiative transfer simulations and compared to the measurements. It is found that ice crystals near cloud top (mixed-phase cloud top layer) are necessary to reproduce the measurements at wavelengths where absorption by ice dominates. The observation of backscatter glories on the cloud top generally indicating liquid water droplets does not contradict the postulated presence of ice crystals. Radiative transfer simulations reproduce the observed glories even if the cloud top layer is of mixed-phase character.

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