Analysis of Antarctic clear-sky snow albedo

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Snow grain size dominates clear-sky albedo variations

Multi-year data from five Antarctic sites show that monthly averages of clear-sky snow albedo range from 0.77 to 0.88, varying in time and space. We use a model that describes broadband radiative transfer in both the atmosphere and the snowpack to show that the observed variations in clear-sky snow albedo are dominated by strong spatial and temporal variation in snow grain size (Figure 1).

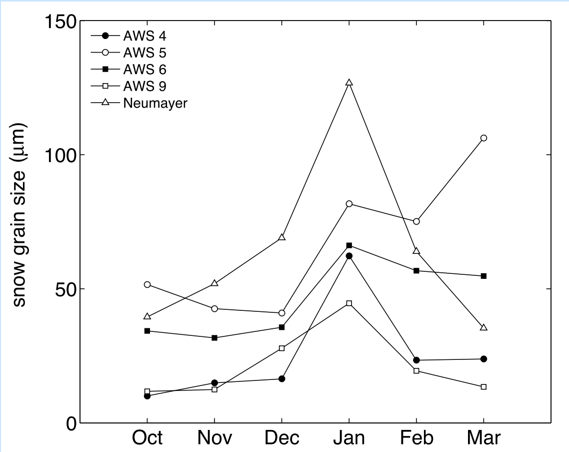

***Figure 1**: Seasonal variation in snow grain size obtained from applying radiative transfer model to Antarctic albedo measurements.*

I. Introduction

Snow albedo depends on snow grain size, snow contamination, water content, but also on atmospheric optical thickness and solar zenith angle.. The amount of radiation absorbed by a snow surface is very sensitive to small changes in the surface albedo. Identifying the factors that have a strong influence on snow albedo is therefore important.

With a radiative transfer model that describes the interaction between radiation, ice crystals and atmospheric gases, we investigate which processes drive variations in snow surface albedo that we observe at several sites in Antarctica.

II. The radiative transfer model

We use a doubling-adding radiative transfer model to describe the scattering and absorption of light by the atmosphere and by the snowpack (Figure 2). The lowermost layer(s) are filled with snow by assigning optical properties of hexagonal-plate shaped ice crystals. The albedo of snow is calculated in 32 wavelength bands spanning the shortwave radiation spectrum (250-4000 nm), at the snow-atmosphere interface.

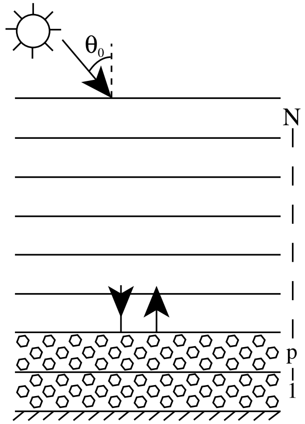

***Figure 2**: Schematic outline of the radiative transfer model. Snow albedo is calculated using the fluxes at the snow surface.*

III. Data

To study clear-sky snow albedo, we used monthly averages of radiation data from five sites in Dronning Maud Land, Antarctica (Figure 4) between 1998 and 2001. These sites range from the ice shelves to the Antarctic high plateau. Clear-sky snow albedo ranges from 0.77 to 0.88 (Figure 3). Atmospheric profiles of temperature, pressure and humidity from a regional climate model are used as input in the radiative transfer model.

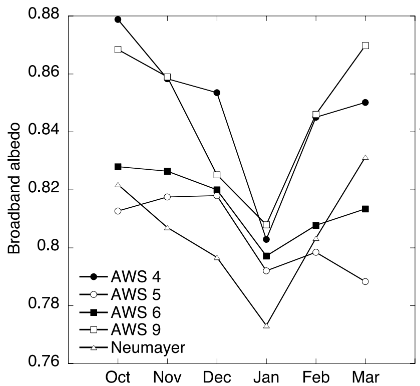

***Figure 3**: Observed monthly averages of clear-sky snow surface albedo at five Antarctic sites (1998-2001).*

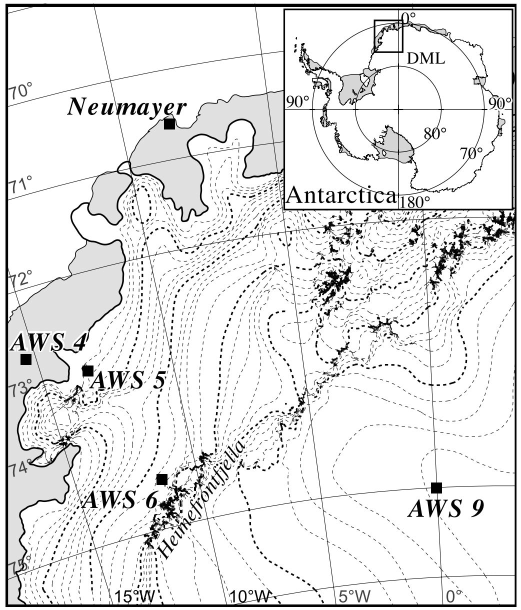

***Figure 4**: Map of Dronning Maud Land, Antarctica showing the five measurements sites*

IV. Results

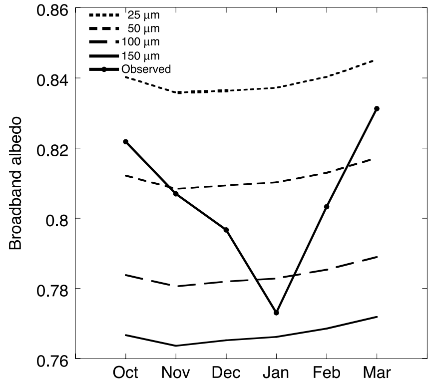

***Figure 5**: Dashed lines indicate snow albedo if snow grain size were constant. The observed albedo (solid line w. dots) at Neumayer is also plotted.*

In figure 5, the parallel lines show the albedo due to variations in atmospheric optical thickness and solar zenith angle, but with fixed snow grain sizes. The observed variations in clear-sky snow albedo must therefore be dominated by strong variations in snow grain size. In Figure 1, we show snow grain sizes derived from combining the albedo data with model calculations.

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