The impact of specific surface area and clouds on surface albedo: Investigations made at Kohnen Station, Antarctica, during summer 2013/2014

M. Belke Brea1,2, M. Birnbaum, J. Freitag, S. Kipfstuhl, A. Humbert,2 M. Schäfer, G. König-Langlo, B. Loose

1 Alfred Wegener Institute (AWI), Helmholtz Centre for Polar and Marine Research, Bremerhaven, P.O. Box 123161, D-27701 Bremerhaven, Germany
2 Faculty of Geosciences, University of Bremen, Kleefurter Str., D-28359 Bremen, Germany
3 Institute of Meteorology, University of Leipzig, Stephanstr.3, D-04103, Leipzig, Germany

Introduction

Antarctic snow physical properties and atmospheric conditions are considered to change with increasing temperatures, hence also modifying surface albedo. Albedo is one of the most important factors determining near-surface energy fluxes and is therefore a key parameter in regional and global climate models. Albedo is, however, highly variable, and it is of great interest to incorporate albedo variability into models for accurate prognoses.

In Dec 2013 and Jan 2014 a field campaign was conducted at Kohnen Station (79°00’ S, 0°54’ E). Broadband albedo and specific surface area (SSA) of snow, as a measure of grain size, were investigated simultaneously for the first time in Antarctica. Furthermore, synoptic observations were documented for the whole measuring period. This offers the unique opportunity to analyze and correlate synchronized data sets of atmospheric and snow physical properties and surface albedo of the Antarctic plateau. Questions to answer are:

What are the characteristic variations of SSA?
What is the impact of changes in SSA and abundance of low-level clouds on snow albedo?

Results

Figure 1: > grid with SSA values, each square = one sample. > y-axes: 100 samples along a 100m profile measured at the same day. > x-axes: each step = one day. > squares: color coded with red colors for high and blue for low SSA values.
Observations: In time, several days with high SSA events can be seen. However, appearance of high SSA is not homogeneous along the whole profile and this spatial variation is considered to result from small scale topography, where SSA values at ridges remain low. In time, several days with high SSA events can be seen. However, appearance of high SSA is not homogeneous along the whole profile and this spatial variation is considered to result from small scale topography, where SSA values at ridges remain low. However, many peaks can be seen in the albedo plot, which do not correlate with the SSA values.

Figure 2: > daily mean SSA values (of 100 samples, which were taken every day).
Observations: The high SSA events, here visible as peaks (marked by red lines), correlate with heavy precipitation events (max. total accumulation of 1mm). High SSA values are followed by a gradual decrease resulting in a cascading pattern throughout the season.

Discussion and Conclusion

Sketch below:
> cloud abundance in the lowest cloud layer increases albedo by 3%
> albedo increase of 3% is also provoked by SSA increase of 18 m²/kg
> average precipitation induced increase in SSA is 20 m²/kg

→ Both clouds and SSA have a similar power to modify albedo. However, cloud abundance results in an abrupt, short-term increase whereas changes in SSA provoke a sudden increase, too, but with a long-term cascading decrease, which is a result from metamorphic processes within the snow increasing the grain size. SSA is therefore considered to alter the basic seasonal albedo pattern whereas clouds overprint the seasonal trend only for the period of their abundance.

Due to those opposing trends no final conclusion can be drawn about the future development of SSA, and hence albedo, with increasing temperatures.