Session CR5.1

Cascading decrease of the surface snow SSA at Kohnen Station, DML, Antarctica

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Introduction

The grain size of the surface snow is the key parameter of albedo in interior Antarctica, as impurity content is very small.
The snow surface at the end of austral winter is characterized by very small grains. The small snow grains consist of broken precipitation particles and partially sublimated or mechanically fractured older ice particles. The albedo is consequently very high.
The size of snow grains can be determined quite accurately by measuring its specific surface area (SSA). The specific surface area (SSA) is defined as the free surface area of the ice matrix S per unit ice mass m^2 kg^{-1} (Legagneux et al. 2002, Domine et al. 2006, Gallet at al. 2011):

$$SSA = \frac{S}{V \cdot \rho_{ice}} = \frac{3}{\rho_{ice} \cdot r_{eff}} \quad (1)$$

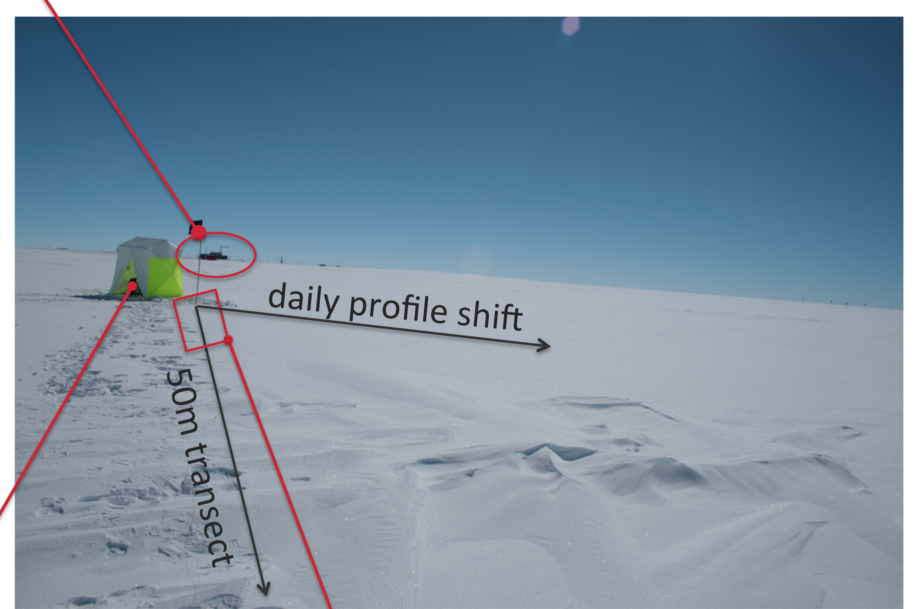
(with the density of ice $\rho_{ice} = 917 \text{ kg m}^{-3}$ at 0°C and the radius of the effective or equivalent sphere r_{eff}).

The SSA as a material property used for albedo estimates typically shows an annual cycle. During the summer it decreases due to grain coarsening caused by snow metamorphism.
A recently published study of Picard et al. 2012 showed that the grain size increase in DML during the summer is noticeably high.
But until now there are no field studies available investigating the sensitivity of grain size increase respectively albedo decrease due to snow surface processes.

SSA measurements

The SSA measurements were taken on a daily basis during a field campaign in austral summer 2012/2013 at Kohnen Station (75°00'S, 00°04'O at 2892m a.s.l.) in Dronning Maud Land (DML).

The whole setup was build up in a tent to be protected against weather and radiation influences and disturbances.
The sampling site was about 500 m SE of the main station.
The location could be reached during all weather conditions.
The transect had a length of 50 m across the main wind direction.
Every 2 m a sample was taken (daily profile shift).



IceCube device in the tent

Left: The SSA of the snow samples was determined by the hemispherical reflectance at 1310 nm (IceCube, A2-photonic Sensors, Grenoble, France)

Sample distance: 2m

Results

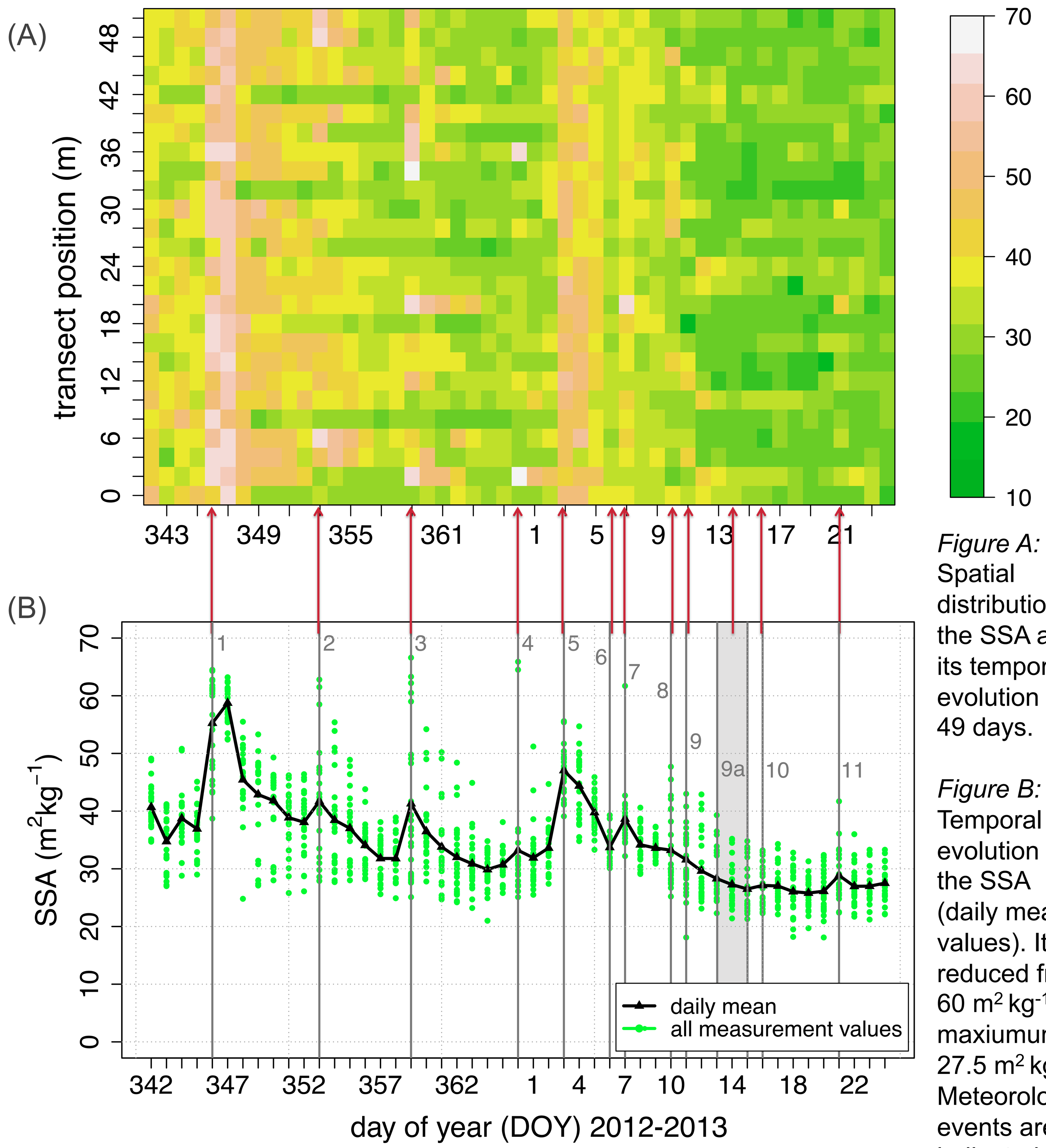


Figure A: Spatial distribution of the SSA and its temporal evolution over 49 days.

Figure B: Temporal evolution of the SSA (daily mean values). It reduced from 60 m^2 kg^{-1} at maxiumum to 27.5 m^2 kg^{-1}. Meteorological events are indicated with numbers.

Event No.	Day of year (DOY) 2012-2013	Description
1	346	heavy snowfall, white-out
2	353	sunny
3	359	diamond dust
4	366	cloudy, windy
5	3	hoar frost
6	6	sunniest, warmest day of the season
7	7	cloudy, windy
8	10	strong drift, cloudy
9	11	white-out, strong wind (>20kn)
9a	13-15	appearance of glazed surfaces
10	16	no wind, very large temp. gradients, change to very hard surfaces
11	21	formation of surface hoar

Meteorological data

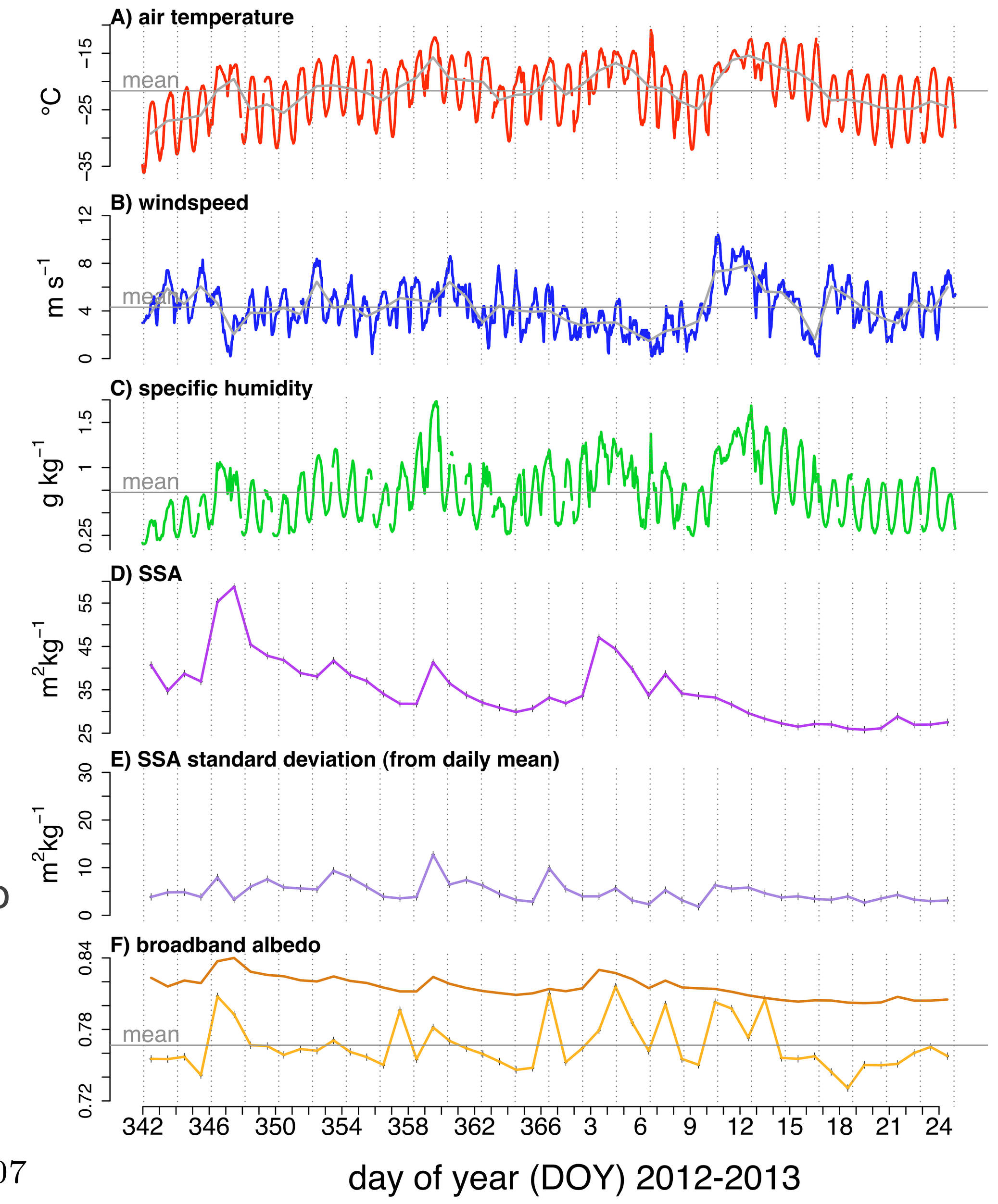
The meteorological data are from the Automatic Weather Station AWS 9 close to Kohnen Station (maintained from the IMAU in Utrecht, NL).

The albedo is calculated from the measurements of solar incoming and outgoing radiation around noon (11-13 UTC):

$$\alpha = \frac{S_{out}}{S_{in}}$$

Comparison with an albedo parametrization from Gardner et al. 2010 using the daily mean SSA are shown in F:

$$\alpha_{SSA} = 1.48 - SSA^{-0.07}$$



Discussion & Conclusion

- The surface snow SSA decreased about 46% over the measurement period during the austral summer 2012/2013 at Kohnen Station. This corresponds to a decrease in broadband albedo of about 5% in less than 7 weeks.
- The snow surface layer in DML is affected by a variety of processes including wind driven redistribution, precipitation or surface hoar formation.
- We found that the SSA was not reducing smoothly but showed a cascading decrease:
  Alternating temperature gradient metamorphism (ATGM) plays an important role for SSA decrease over the summer. Its effect is interrupted by precipitation events (occurring as 'cascades' in the mean SSA).
- Even small amounts of precipitation during the summer period can affect the decrease of SSA, respectively the albedo, in the DML region on the East Antarctic Plateau.
- The peaks in the daily mean SSA correspond to precipitation events and surface hoar formation inhibit the general expected decrease over the summer period (supporting the findings from Picard et al. 2012)
- But: Redistribution caused by wind drives the re-decrease of the mean SSA so that the precipitation effect in DML vanishes after 3-5 days.

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