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The Cryosphere Discussions

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Interactive Comment

Interactive comment on "Three examples where the specific surface area of snow increased over time" *by* F. Domine et al.

F. Domine et al.

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First of all, we would like to thank the reviewers for their constructive comments.

Frank Wania's major comment is that he thinks that the paper does not show the significance and implications of SSA increases well enough. That is a good point that we will address here and in the revised version. First of all, albedo changes of 1% can be measured, for example with the Kipp and Zonen CM11 and other radiometers. If needed, longer integration times can reduce errors further. Second, a 1% albedo change is important for the energy balance and radiative forcing at the surface. Taking the daily averaged solar flux at 200 W m^{-2}, the forcing is then 2 W m^{-2}, which compares to 1.66 W m^{-2} for the radiative forcing caused by the CO_2 increase between 1750 and 2007 (IPCC, 2007). This demonstrates that this effect is significant. Furthermore, this 2 W m^{-2} forcing has a stronger climatic effect than the same effect by CO_2, because it is at the surface and the forcing efficacy, as defined by Hansen et al., (2005) is 2 to 3 times as large.

Regarding the effect on contaminants, one must consider that as far as the snow is concerned, SSA and the amount of snow are the only snow intrinsic variables relevant to modeling contaminants adsorbed in snow. Other variables such as temperature and partial pressures are determined by factors other than snow properties. In any case, a 25% change in SSA will result in a 25% change in contaminants amounts. SSA changes are more rapid at the surface of the snowpack, and contaminant exchanges also. Therefore, contaminants exchanges will be greatly affected by changes in the SSA of surface snow layers. For contaminants of moderate to low volatility, most of the contaminant in the (snow + boundary layer) system will be in the snow. Simple calculations, as done by Taillandier et al. (2006) show that increases in SSA from 40 to 60 m^2 kg^{-1} for a 2 cm thick snow layer of density 0.2 g cm^{-3} can decrease its boundary layer concentration by 1 to 15%, depending on its volatility. We let readers judge on the significance of this process.

We therefore believe that in models where snow physics, and especially snow SSA, is described, it makes as much sense to describe SSA increases than the more frequent SSA decreases. It is quite possible that we do not have today sufficient data to parameterize SSA increases in models, and this work must then be taken as a humble first step in that direction.

Regarding Frank Wania's minor comments, these are helpful and will be taken into account in the revised version. They do not need to be discussed in detail here. Re. his last comment, we will show the complete data set in Figure 5. Note that the data are given in the text (page 6, line 13) and have already been shown in Fig. 1 of Cabanes et al. (2002).

Reviewer 2 requests the addition of temperature data in section 3.2, where we describe how a wind storm increased the SSA of surface snow. The air temperature was around

TCD

2, S502–S505, 2009

-35°C, as shown in Fig. 1 of Domine et al. (2002). The temperature gradient in the snow was not monitored as in the case described in section 3.1. However, temperature profiles were measured during pit studies and the temperature at the snow ground-interface was around -30°C, so that the temperature gradient remained small, in any case below 20°C m^{-1}. The temperature gradient near the surface of the snowpack may of course have been different from that mean value. However, given the winds that ventilated the surface of the snowpack and the complete absence of sunlight, our estimate is that temperature gradients were also low near the surface during that event. In any case, we do not think that temperature gradients had a significant impact on the SSA increase seen here. First, temperature gradient metamorphism of snow of SSA around 50 m^2 kg^{-1} would result in a SSA decrease, as detailed in Taillandier et al. (2007). Second, changes in SSA due to temperature gradient metamorphism have little effect on timescales of 1 day, as detailed in Taillandier et al. (2007) and our Fig. 2 does show that relevant timescales are on the order of a month. The SSA change reported here is essentially instantaneous, and we therefore think that it is caused by the sublimation and fragmentation of particles. These arguments will be developed in the revised version. Other comments brought up by the reviewer are valuable appreciations, but do not require a response.

In summary, we thank once again the reviewer for their time and comments, and we will take their suggestions into account in the revised version, as detailed here.

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