Interactive comment on “The growth of sublimation crystals and surface hoar on the Antarctic plateau” by J.-C. Gallet et al.

Anonymous Referee #2

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I would summarize the argument of this paper as follows: At latitude 75 S on the East Antarctic Plateau in summer, there is a large diurnal cycle in surface temperature and a somewhat smaller diurnal cycle in near-surface air temperature. The result is sublimation during the day and frost deposition (surface hoar) at night. But the daytime sublimation also results in growth of frost ("sublimation crystals") because of a centimeter-scale boundary layer just above the surface where the air can be supersaturated in the hours around noon. If the crystals growing in daytime have larger specific surface area (SSA) than the nighttime crystals (as is claimed in the paper), then they enhance the albedo during the hours when sunlight is most intense.

The paper is interesting but not convincing. Sublimation crystals and surface hoar crystals both form by deposition of frost, so it is not obvious that their SSAs should be different. The authors made measurements over only a 38-hour period, and the SSA did seem to be larger around noon. But the different SSAs were not explained on the basis of different crystal shapes, and no reason was given to expect the shapes to differ. Indeed, in the "discussion" section the authors say that crystals formed by the two mechanisms are difficult to distinguish in their appearance. I therefore question whether the variations of SSA observed during those 38 hours are due to a systematic difference in shape between sublimation crystals and surface hoar. However, I do think the paper is worth publishing.

We wish to thank referee#2 for his/her comments.

However, we wish to kindly point out some misunderstanding in our paper. Sublimation and surface hoar crystals do not both form by deposition of frost. In fact, we refrain from using the word “frost” which describes a result (crystals formation, irrespective of the process that formed them) and instead use the words “surface hoar” which refers to atmospheric water vapor deposition onto the surface, and “sublimation crystals” which refers to the formation of crystals on the surface because of an upward flux of water vapor from the warmer snowpack into the cooler air above. Both formation processes are therefore very different, and, as suggested by referee #1, we will specify that in the introduction by adding a couple of sentences.
Regarding the study of grain shape as a function of formation process, this would require a very detailed study that is clearly beyond our scope and in fact probably not possible with the data at hand. We can nevertheless make reasonable suggestions in the revised version. In general, surface hoar crystals grow at a moderate rate and are hollow striated faceted crystals. Hollowness is caused by a Hopper (Minkoff and Lux, 1974) growth instability. When the growth rate increases, a Mullins-Sekerka growth instability (Mullins and Sekerka, 1963) can take place, with dendritic crystal formation. These dendritic crystals have a very complex shape and a higher SSA can reasonably be expected. We did observe the formation of faceted and dendritic crystals, but these formed mixed clusters and separating them was impossible. Documenting their formation would require the use of time-lapse photomicrography, and it is almost certain that the presence of a camera would perturb the temperature field and crystal formation. We will therefore detail the theoretical aspect of crystal shape as a function of growth rate, and discuss these in relation to our observations. This will present a self-consistent picture of the crystal formation process in relation to SSA variations, but unfortunately we cannot present an undisputable demonstration of the relationship between crystal shape and SSA in the intricate clusters that formed.
Finally, we will mention in the revised version the work of (Champollion et al., 2013).They followed the texture of the snow surface using infra-red camera over more than a year. They observed also dendritic like crystals, needles, crystals with irregular structure and surface hoar crystals in summer

time but only surface hoar crystals in winter. This comforts our hypothesis that the steep temperature gradient due to absorption of incoming solar energy is responsible of a second process different from the traditional hoar deposition.

Minor comments:

p 5973 line 23. Van As 2005 and Van den Broeke 2006 are not in the reference list.

Thank you for that remark, we will add the references.

p 5974 lines 9-10. " . . . rapid growth of snow crystals . . . These crystals grow slowly". These statements are contradictory; "slowly" is the opposite of "rapid".

Thank you very much for this crucial detail. The reason for such confusion is related to the discussion above. Our observations showed that the size of the clusters, once formed, is not changing very quickly while dendritic outgrowths form within an hour time scale. We will modify this in the revised version.

References cited:

Champollion, N., Picard, G., Arnaud, L., Lefebvre, E., and Fily, M.: Hoar crystal development and disappearance at Dome C, Antarctica: observation by near-infrared photography and passive microwave satellite, Cryosphere, 7, 1247-1262, 10.5194/tc-7-1247-2013, 2013.
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