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The Cryosphere Discussions

Interactive comment on "Vertical profiles of the specific surface area of the snow at Dome C, Antarctica" *by* J.-C. Gallet et al.

Anonymous Referee #1

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Gallet et al measured a transsect of SSA profiles from the coast to Dome C, and in higher detail around the station. The data give a first detailed picture about the typical distribution of SSA-profiles in the East Antarctic. The motivation for the measurements is not becoming completely clear: are they for snow chemical studies, for understanding the relation between snow-albedo, or just for a first exploratory study?

The title of the paper suggests the last case, namely an exploratory study. As such, this paper has value, although the sampling design is very ad-hoc, and any geostatistical concept, especially around Dome C, is missing.

However, the paper as presented here strives to answer another question, namely the reason for the high albedo observed by the extremely careful measurements of Grenfell and Hudson, and if these SSA measurements can be used as indirect ground

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truth for satellite measurements. Surprisingly, this aspect is completely absent in the title, although almost half of the figures are wavelength-reflectance charts, and a major part of text is devoted to this question!

I will in the following review this paper with this aspect as the key point.

To start with, the expression of SSA in units as a mass per unit volume (of ice) makes little sense for optical purposes. A division by 3 to get r_eff is straightforward, but maybe the authors like to multiply the result by 0.917. As the focus is clearly on the optical properties of snow, the standards set by the optical community should be followed, see the papers by Maetzler, Grenfell, Mitchell, etc., which all use a length or an inverse length.

The authors seem also not to be aware of international standards concerning the classification of snow. Either the old standard by Colbeck et al (1990), or even better the new reference (Fierz et al. The international classification for seasonal snow on the ground. IACS Contribution (2009) vol. 1 pp. 1-88 http://unesdoc.unesco.org/images/0018/001864/186462e.pdf) should be used. This is a framework which makes traditional observations comparable, and the nomenclature as defined there should be used throughout the paper in text and figures.

A discussion how SSA can be measured in snow is missing, but a few sentences mentioning the advantages and disadvantages of each would be highly useful to the non-specialized reader. I especially missed near-infrared photography, and SSA measured using stereological or tomographical methods.

The limitations in resolving snow profiles is excellently documented in a paper by

Langlois et al. On the relationship between snow grain morphology and in-situ near infrared calibrated reflectance photographs. Cold Reg Sci Technol (2010) vol. 61 (1) pp. 34-42 http://dx.doi.org/10.1016/j.coldregions.2010.01.004 and (also for alpine snow) in Pielmeier and Schneebeli. Stratigraphy and changes in hardness of snow measured

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by hand, ramsonde and snow micro penetrometer: a comparison with planar sections. Cold Reg Sci Technol (2003) vol. 37 pp. 393-405 http://dx.doi.org/10.1016/S0165-232X(03)00079-X .

As it is very well known that the spatial resolution of traditional profiles is limited to at most 1 cm, and that thinner layers can be very important for the albedo at the surface (see also in this context Dadic, R., M. Schneebeli, M. Lehning, M. A. Hutterli, and A. Ohmura (2008), Impact of the microstructure of snow on its temperature: A model validation with measurements from Summit, Greenland, J. Geophys. Res., 113, D14303, doi:10.1029/2007JD009562), the usefulness of the method applied in this paper for this purpose may be very questionable.

The abrupt introduction of the SAI is unrelated to the main topic and purpose of this paper - or do the authors stipulate that SAI is useful to know to calculate reflectance? The effect of wind can affect an Antarctic snowpack very deeply: see eg. Courville, Z. R., M. R. Albert, M. A. Fahnestock, L. M. Cathles IV, and C. A. Shuman (2007), Impacts of an accumulation hiatus on the physical properties of firn at a low-accumulation polar site, J. Geophys. Res., 112, F02030, doi:10.1029/2005JF000429

Under such condition, the definition of SAI is highly questionable. The limit taken of 45 and 70 cm, respectively, are highly arbitrary. The comparison with an Arctic snowpack is highly misleading, because it will never exist under similar radiative conditions as in Antarctica. In my view, this is a moot comparison. In any case, the term "snow area index" is in low accumulation areas with a multi-year snowpack per se not clear, because an often used definition is that firn is multi-year snow. A strict definition of SAI in an antarctic snow pack would therefore consider only the top 10 cm or so, which would mean that the SAI in an antarctic snowpack is an order of magnitude smaller than in the Arctic.

Finally, the hypothesis of Grenfell et al is practically refuted as improbable in this paper (also not stated, simply statistics let me conclude this). However, the methods used

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are not appropriate to answer this question: only vertical thick sections (Courville et al, op.cit.) or micro-tomography (Kerbrat et al. Measuring the specific surface area of snow with X-ray tomography and gas adsorption: comparison and implications for surface smoothness. Atmos Chem Phys (2008) vol. 8 pp. 1261-1275 http://www.atmos-chem-phys.net/8/1261/2008/) would be appropriate to resolve the principal question of this paper.

Recommandation: the paper has interesting data, but the applied method has several shortcomings, which make it impossible to validate or refute the hypothesis. The paper may be considered for publication in the context of snow chemistry, but the methods are not appropriate to answer the question of the high albedo in Antarctica. The paper does not deserve publication as a final paper in TC in this form with the hypothesis presented here.

Minor comments:

1648/1 Part -> part

1651/5 Particularily -> particularily

1652/8 ff what are the diameters of the cutters?

1652/22 10% of what measure?

1668/8 A quantitative calculation of the rate of coarsening of small snow particles is in Kerbrat et al. op. cit, and in detail also in Enzmann, F., Miedaner, M. M., Kersten, M., von Blohn, N., Mitra, S. K., Borrmann, S., Stampanoni, M., Ammann, M., and Huthwelker, T.: Pore structure 3-D imaging by synchrotron micro-tomography of graupel grains, Atmos. Meas. Tech. Discuss., 3, 4761-4789, doi:10.5194/amtd-3-4761-2010, 2010

Interactive comment on The Cryosphere Discuss., 4, 1647, 2010.