The Cryosphere Discuss., 8, C135–C139, 2014
www.the-cryosphere-discuss.net/8/C135/2014/

Interactive comment on "Drifting snow measurements on the Greenland Ice Sheet and their application for model evaluation" *by* J. T. M. Lenaerts et al.

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Received and published: 6 March 2014

This paper deals with a field campain of blowing snow measurements over the Greenland Ice Sheet, in order to validate the parameterization of that process in the RCM RACMO. The paper provides to the community some highlights about the behaviour of blowing snow over huge ice sheets, as well illustrates the difficulty for RCMs to accurately simulate that process. Some points of the paper should be considered more deeply and apparent contradictions must be explained before the paper is published.

We thank the reviewer for the valuable suggestions. We respond to these point-by-point below.

The authors suggest that the representation of blowing snow particles distributions they use is calibrated for antarctic snow and is not adapted to Greenland, because observed snow particles are larger for the last (p.31, line 2). Using that argument they claim that the model overestimates the simulated TRds by several orders of magnitude. (p.31, line 8). Why in this case does the model overestimate much more the snow transport during dry events, when actual snow particles size is better described by the gama distribution parameters they use, than during snowfall, when the snow particles are larger and their description by the gama distribution worserÂa?? This behaviour of the model seems to apparently contradict the explanation the authors give. Could the author clarify that pointÂa??

This is a valid point, but we believe that this is clearly indicated in the manuscript (page 33, line 11): *As a result, drifting snow transport in RACMO2/PIEKTUK-B is significantly overestimated in the katabatic case, but less so during the synoptic event. This can have various reasons; (1) the better agreement between observed and simulated friction velocity in the synoptic case; (2) the synoptic case is associated with fresh snowfall contributing to the observed transport; the effect of larger (fresh) snow particles may compensate for the model flux overestimation; or (3) a more general model deficiency in properly simulating the characteristics of small drifting snow events such as on 24 September, when saltation is the dominant transport process and snow suspension is limited (Bintanja, 2000).* The effect of a better description of the gamma distribution in the precipitation case is marginal; comparing Figure 10a and Figure 14a, we do not see a better agreement between model and observations on 26 September compared to 24 September. This is due to the small contribution of the number of precipitating particles to the observed particle distribution.

Other points.

p.27, line 13. What is the RACMO2 domain and what is the model sensitivity to the domain sizeÂa??

The RACMO2 simulations analysed here are part of a much longer time integration of the entire Greenland ice sheet and surroundings. The domain spans from the Canadian Arctic in the west and Svalbard/Iceland in the east, and from 55°N to 84 °N. We will refer to Lenaerts et al., 2013 and van Angelen et al., 2013 in the text of model setup. The physical schemes of RACMO2 are updated with respect to these papers, but the domain size, and drifting snow routine has been unchanged. The time step of the simulation is 2 minutes. Each time step, the meteorological variables of RACMO2 are passed on PIEKTUK, and the drifting snow output is passed back to RACMO2, see Lenaerts et al. (2012a) for details. We will add this information in the revised version.

p.28 line 13. Why did the authors not measure the snow density, or at least the water equivalent of fallen snow during the field campainÂa?? Have they at least an estimation of snow density variationsÂa??

The density nor the volume of falling snow were measured. First of all, it is is challenging to discriminate between falling and drifting snow (so e.g. precipitation gauges are not well suitable for this purpose). Snow density is not measured, since the measurement setup has been working autonomously during the entire campaign. To our knowledge, there is no device on the market that is able to measure snow density independently. Instead we have used a typical value from available literature, which is used only to estimate the SMB during the measurement period.

p. 31 lines 3 – 4. What is the sensitivity of the model (i.e., its local snow horizontal transport accumulated over the day) to the improved parameters of the gamma distributionÂa??

This is a justified issue raised by the reviewer, also raised by the other reviewers. To discuss the sensitivity of the drifting snow module to its input parameters, we have performed a sensitivity analysis, varying (a) drifting snow density

(500,700,900 kg/m3), (b) mean saltation particle radius (100,200,400 micrometer), (c) shape parameter α (2,5,8), and (d) friction velocity (-10% and +10%). This sensitivity analysis clearly demonstrates that the drifting snow model is highly sensitive to the input parameters, in particular to (b) and (c) as the resulted flux can vary several orders of magnitude within the applied range of input. For this sensitivity analysis, it appears that the contribution of saltation to the simulated flux at 1 m height is overestimated in the model; if we suppress saltation by applying a larger particle radius, the resulting transport is largely decreased. If we increase the mean saltation particle diameter to 200 micrometer (default 100 micrometer) and alpha to 5, both of which are assumed to be more representative of the observed conditions, we get much more reliable (within one order of magnitude) simulated transport fluxes in both cases (24 and 26 September 2012); it appears that saltation in PIEKTUK is overestimated in the default case, leading to much too high fluxes. This is an important result, which will be presented in detail in a separate table and a detailed discussion. The minimum detectable snow particle diameter of the SPC is 50 micrometer. The omission of very small particles could lead to an underestimation of the observed transport, although we do not believe that this will greatly influence the results. We will add this comment in the revised manuscript.

p.31 lines 5. What is the relative importance of the particle snow weight in influencing the behaviour of the horizontal snow transport simulated by the modelÂa?? If the model is not sensitive to the parameters of the gamma distribution, the representation of the particle snow weight is not a critical parameterization of the model (see also comment about p.33, line 27 until p.34, line 1).

See below, we tested the sensitivity of the drifting snow model to several of its input parameters.

p. 33, line 9. Walden et al., (2003) did observations at South Pole, which is not fully representative of East Antarctica. Moreover they found that snow grains (and not diamond dust) are the main contributor to the volume of ice crystals precipitation they observe (see their table 3). Are the authors aware of other studies that confirm the importance of diamond dust over AntarcticaÂa??

Thanks for pointing this out. We will add Hou et al., 2007 and Noone et al., 1999 to the references.

p.33, line 27 until p.34, line 1. The authors find that the simulated horizontal transport of snow TRds is not significantly altered by an improvment of the gamma distribution parameter, suggesting that this process seems not to be critical in driving the horizontal transport of snow simulated by the model, in apparent contradiction with their explanation of p.31.

See below, we tested the sensitivity of the drifting snow model to several of its input parameters.

References

Hou S., Li Y., Xiao C. et al (2007): Recent accumulation rate at Dome A, Antarctica, Chinese Science Bulletin, 52(3): 428-431, doi: 10.1007/s11434-007-0041-3

Noone, D., J. Turner, and R. Mulvaney (1999), Atmospheric signals and characteristics of accumulation in Dronning Maud Land, Antarctica, J. Geophys. Res., 104(D16), 19191–19211, doi:10.1029/1999JD900376.

Interactive comment on The Cryosphere Discuss., 8, 21, 2014.