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The Cryosphere Discussions

Interactive comment on "Brief communication "Modeled rain on snow in CLM3 warms soil under thick snow cover and cools it under thin"" *by* J. Putkonen et al.

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General Remarks

The problem addressed in this brief communication is undoubtedly of importance. The main outcome is a snow depth threshold for cooling/warming of the ground in higher latitudes of the Northern Hemisphere (NH) due to Rain On Snow (ROS) events.

Furthermore, the methodology used seems quite inappropriate. Indeed, applying the same large precipitation event (and air temperature increase of 30 K in one day?) over each pixel alike will not reveal more than carefully performed test runs with differing initial conditions in one point. From the present study, influence of other factors such

as meteorological conditions, state and structure of the snowpack, and snow cover duration can hardly be disentangled from the alleged snow depth "signal". This makes me strongly feel that the threshold mentioned above is hardly supported by the data shown in Figure 3.

Finally, for a brief contribution, there is quite a number of imprecision in the text and the quality of the figures is not yet at its best (sloppy labeling, for example).

I therefore recommend rejecting the paper but would encourage the authors to perform a much more detailed analysis of ROS events first and apply then the knowledge gained on a simulation over the NH. This would imply, however, that a realistic modeling of ROS in those regions can be performed.

A few points in detail (page, line)

2560, 12-17: I would argue that you should do a careful analysis without "modeling" the full NH first, disentangling the contributions from various factors. The main challenge in applying a ROS to the NH will be to model the latter. After all, none of your "cooling" pixel may ever be hit by a ROS event of this magnitude, or vice versa, or any combination of both.

2562,13: I agree that it cannot be the purpose of a brief communication to describe a model in detail and you give the appropriate reference (by the way, why did you not use CLM4?). However, I would expect that what is said about the model be done carefully and correctly (see below for a few examples).

2562, 22: "By artificially introducing a rain on snow event on the order of 50mm in a one day period" This may be the main crux of this contribution.

2563, 5-10: Note that there is hardly no compaction during and after the ROS event; it is comparable to the "control case". Thus in this case the main increase in density is due to the refreezing of around 95 % of the rain water. This would not be the case if the snowpack would be quite warmer initially and initial snow depth plays a role too.

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2563, 12: “The ROS event is shown by air temperature (TBOT), which was raised to freezing for four days surrounding the rain fall” Thus rain with a temperature of 0 °C falls on a subfreezing snowpack at about -40 °C? It is well known that such an event very efficiently warms a subfreezing snowpack indeed. However, is this scenario realistic (40 °C air temperature raise in one day)? What would happen if the snow temperature was near the freezing point before the event?.

2563, 15-16: “even though the average snow temperature (not shown) is below freezing.” When is this the case? The snowpack needs to be isothermal at 0 °C to allow percolating water reaching the ground surface. The state of the snowpack before the ROS is thus crucial to the advancement of the warming and wetting front. Not taking the influence of such factors in more details weakens your analysis even more.

2564, 24-28: I have hard times to follow that argumentation to justify the methodology used in this contribution.

2565, 20: “enhanced heat flux” What causes this enhanced heat flux? A wetted snowpack is isothermal and shows no temperature gradient.

2565, 27: “to timing and duration of the snow cover” I would argue that this factor is of importance for any pixel.

Minor points

2558, 18: Replace “Brown et al.” by “Brown and Romanovsky”.

2559, 5: Is 1998 recent?

2559, 20: “slow”? I would argue that this depends on the cold content of the snowpack just prior to the event (cold and dry vs almost isothermal near the melting point) as well as on the weather conditions following the event.

2560, 26: “such as” why not name all four PFTs as three are already! 2561, 7: “with thinnest layers at the soil/snow boundary.” Are you sure? According to the TD of CLM3

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it is the other way round, which is what I would expect anyway!

2561, 8: Darcy's law is valid for saturated snow, which is hardly the case for subfreezing snow before the first wetting. It is an oversimplification! Anyway, it seems CLM3 does not use that scheme in snow (see p 103 ff of Tech Notes)!

2561, 19: "incoming solar radiation" What about long wave radiation?

2562, 6: I suggest to replace "between the" by "to each"

2562, 10: "Thermal conductivity is calculated" Did you replace the conductivity used in CLM3 by Sturm's equation too?

2563, 10: Use "control case" throughout the text. For example, see caption to Fig. 2 ("base case")

2563,18: "due to a limited snow fall" I do not understand the argument here. What is due to this limited snowfall? Which snowfall?

2564, 6: "defined" arbitrarily!

2564, 9: Replace "> -1 °C" by "< -1 °C" (correct in Fig. 3). Why not using kelvins?

2564, 10: To speak of "natural" in this modeling context sounds odd!

2564, 15: Replace "depth" with "depth range"

2564, 21-23: Rather arbitrary in my view!

Figures

The quality is far from overwhelming and the labeling often very bad. This definitely needs improvement. Also, do not use model variable names such as TBOT for air temperature or SNOWDP for snow depth HS.

Interactive comment on The Cryosphere Discuss., 5, 2557, 2011.