The Cryosphere Discuss.,
doi:10.5194/tc-2016-258-RC1, 2016

The Cryosphere
Discussions
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Interactive comment on "Process-level model evaluation: A Snow and Heat Transfer Metric" *by* Andrew G. Slater et al.

Anonymous Referee #1

Received and published: 13 December 2016

This is an interesting and concise paper that proposes a compact method to evaluate the capacity of land surface models to represent the effect of snow inflation on the underlying soil. I have no doubt that the proposed metric, with some little changes proposed in the following, will be widely used. The paper is yet another illustration why the first author's recent passing away is a huge loss for the scientific community.

The figures are all relevant and easily readable. Relevant scientific literature is appropriately referenced. No unnecessary detail clutters the simple and clear message of the paper.

This work should therefore be published after a few minor changes suggested below.

Specific remarks.

- Page 2, line 12: The primary motivation is certainly a good representation of soil temperatures. One could add, however, that wrong temperatures at the snow/soil interface, caused by wrong snow conductivity, can feed back on the snow pack itself via a modified snow metamorphism (in cases models do simulate snow metamorphism dependent on temperature or vertical temperature gradients).

- Page 2, line 26: There is a little incoherence that could be acknowledged: The theory presented here initially supposes a periodic (sine) air temperature signal; however, the theory is then limited to the "cooling season".

- Page 3, line 3 : "2m air temperature serves as a sufficient proxy as the two quantities tend to equilibrate towards each other, particularly in colder months of high latitude regions with low solar input": Yes and no: In some cases (strong inversion), temperature difference between the snow-air interface and the air at 2 m height can be substantial.

- Equation 3: Why not use immediately A_0 and A_z instead of introducing new variables A_air and A_soil which are not really used?

- Equation 6: The general form of this equation, in particular the numerator of the right hand side, makes sense, but the specific form of the denominator does not. The denominator (which is a constant) should be chosen such that if snow depth is constant (i.e. all snow falls in October), the efficient snow depth is equal to this constant value. Therefore the denominator should read: \sum\limits_{n=1}^{M} n (or (M+1)*M/2, which is equivalent). For the case of the blue curve in figure 1, which is apparently S(i) = i*0.1 (with i=1 for October and i=6 for March), this would yield S_eff=0.266 m, which is less than the average depth of 0.35 m. This would make sense; in Figure 1, for the same case, S_eff is higher than the simple time average, which is incoherent. By the way, I have the impression that equation 6 is not what is plotted in Figure 1. In any case, the difference is only a constant factor, so this has no important effect on the results presented in the rest of the paper. But I think that the definition of S_eff should make immediate sense for simple cases. Right now, it does not.

- Equation 6: What would the results look like if the time period considered would be limited to the period before substantial snow melt occurs? In southerly areas, uno can already melt in March. Does this introduce noise?

- Page 5, line 12: Would it make sense, and would it change the results, to offset the snow depths by adding a positive constant corresponding to a slab of snow with equivalent thermal insulation as 20 cm of soil?

- Page 6, line 9: Some models have a vertical 'soil' axis that comprises the snow. That is, 'soil' depth is not counted from the soil-snow interface downwards, but it starts at the snow-atmosphere interface. That could explain some very far off outliers.

- Page 6, line 20: Yes, but the initial argumentation says that the metric presented here is valid in the case when there are no phase changes. (But the argument is correct nevertheless)

- Equation 7 is not particularly elegant. It must be artificially limited to exclude values below 0. A more elegant definition could be: SHTM= SUM(MIN(A_{norm,obs,i},A_{norm,mod,i}))/SUM(MAX(A_{norm,obs,i},A_{norm,mod,i})) This would automatically yield values between 0 and 1 because A_norm is always >=0. Other rather natural and coherent forms for the RHS of equation 7 can be easily defined.

Interactive comment on The Cryosphere Discuss., doi:10.5194/tc-2016-258, 2016.