

Interactive comment on “Soil frost-induced soil moisture precipitation feedback over high northern latitudes” by Stefan Hagemann et al.

R. Orth (Referee)

rene.orth@env.ethz.ch

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Review of Hagemann et al. 'Soil frost-induced soil moisture precipitation feedback over high northern latitudes'

This paper investigates how the introduction of cold region soil processes (mainly melting and freezing) in an Earth System Model affects the respective land hydrology and climate. In the example of the MPI-ESM, accounting for these processes improves discharge and precipitation simulated by the model, but degrades existing biases in radiation and temperature.

General comments:

C1

The paper addresses an interesting topic which should be relevant to the readers of ESD. Freezing and melting of soils in high latitudes are basic processes with obvious implications for land hydrology and surface climate. Almost surprisingly current climate models do not adequately account for these processes. Furthermore in these regions a warming much stronger than in the global mean is projected by the models. This underlines that this study is an important contribution to understand basic land-related processes in these key regions of global warming.

The paper is nicely written and straightforward to understand.

One main comment concerns the proposed soil moisture-precipitation feedback. While this feedback seems to be a plausible explanation of the reported results, more analysis is needed to confirm its operation. There may be many ways to do this, I could think of the following: Compute correlations between soil moisture and precipitation using seasonal values from all available years at any particular location. The resulting correlation maps for each simulation could be insightful.

Furthermore I am missing discussion and reasoning on the fact that the hydroclimatic changes following the introduction of the new PF scheme also occur in warmer regions (eg. aggravating the temperature bias in central North America and southern Russia). Why is that? Why is it not possible to adapt the model modifications to prevent such effects? And in essence, is it more than a trade of model performance in one region against another region?

Another general comment refers to the terminology used in the paper. The authors should state more clearly that they refer to liquid moisture if they use 'soil moisture'. Furthermore Figures 6 and 10 present results already contained in Figures 2-4. I understand the motivation of the authors to first present a global picture and to then focus on particular regions. However, maybe the text describing these figures can be shortened to be less repetitive.

I do not wish to remain anonymous - Rene Orth.

C2

Specific comments:

line 24: insert 'the' before MPI-ESM line 45: please explain 'Pg of C' line 57: CH4 does not simply 'become' CO2 line 82: replace ', which' with '. The parameterizations' line 107: What is the 'potential rate'? line 126: abbreviation ESM was introduced earlier lines 143/144: How can properties 'decrease'? line 145: delete 'now' line 146: confusing sentence, please rephrase line 154: replace 'for' with 'during' lines 154/155: delete 'so that' line 156: if it is switched off anyway why do you mention it? lines 178-180: Please clarify if you are using the WATCH or the WFDEI forcinf data. line 194-195: How do your results differ if you consider all ET datasets instead of only the diagnostic datasets? line 217: why the fifth layer? and how deep is that? line 222: insert 'to' before 'avoid' line 228 and elsewhere: please use consistent simulation names (ECH-PF / ECH6-PF) lines 234/235: 'evaluated ... to the evaluation'? line 301/302: Problem with brackets line 339: Please clarify that the spring soil moisture deficit from increased discharge extends into the summer thanks to the soil moisture memory (e.g. Koster and Suarez 2001, Orth and Seneviratne 2012) line 361/362: This is wrong, these studies compute diagnostics at seasonal time scales! lines 388/389: replace 'not an issue' with 'beyond the scope of the present study'

Figure 1: It almost seems to me as if the new parameterization leads to too little permafrost extent.

Figures 1-4: please label the color bars Figure 7: include dashed blue line in legend
Figure 8: repetitive titles, no x-axis label

Figure 12: Your line of arguments is that first the soil freezes and then more runoff occurs such that consequently soil moisture is decreased. This is not clear from this scheme.

References:

C3

Koster, R. D., and M. J. Suarez, 2001 Soil moisture memory in climate models. *J. Hydrometeorol.*, 2, 558-570.

Orth, R., and S.I. Seneviratne, 2012 Analysis of soil moisture memory from observations in Europe. *J. Geophys. Res. - Atmospheres*, 117, D15115.

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C4