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Discussions

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**Interactive
comment**

Interactive comment on "Effects of pan-Arctic snow cover and air temperature changes on soil heat content" *by* X. Shi et al.

Anonymous Referee #1

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The manuscript "Effects of pan-Arctic snow cover and air temperature changes on soil heat content by Shi et al." aims to evaluate influences of snow cover extent (SCE) and air temperature (SAT) on soil heat content (SHC) integrating changes in soil temperature, soil moisture, and latent heat affecting the soil thermal regime, using observation- and model-based results. Most of previous studies focused on changes of snow depth affecting soil temperature and permafrost degradation as this paper mentioned. In that meaning, it could be said that the methodological approach focusing on SCE and SHC is an interesting point of this paper. And they also examined factors that affect SHC at different snow cover zones for both North America and Eurasia, mainly based on statistical correlation analysis.

This reviewer has large questions about methodologies used in this paper. Correlation coefficients provide useful information to know and understand the relationship

between elements. However, when independent variables become multiple, the comparison of the correlation coefficients used to examine the magnitude of independent variables influencing on dependent variable could arise a fatal problem. Based on the analysis of correlation coefficients, for example, it is summarized that SHC changes in SCSZ are dominated by snow cover downtrends (L370–379). This result may be right because SCSZ is an area sensitive to changes of snow cover. However, SCE itself is also strongly influenced by SAT. Therefore, the comparison of correlation coefficients is not suitable for this case. If you want to use the correlation coefficients, the use of partial correlation coefficients removing the correlation between SCE and SAT is more appropriate. Meanwhile, authors also said that SHC changes in SCNZ is dominated by SAT. This conclusion could also be enough expected because there is no almost change in snow cover. Thus, it's no wonder that SAT becomes a major affecting factor to SHC in SCNZ. However, snow cover depth in SCNZ has insulation ability as enough as affecting SHC changes, at least in April when snow depth is still deep and SAT is relatively cold. The correlation coefficients are neglecting such effects. Therefore, the method used by this study is not enough to guarantee the quality of the results, which has to be cross-checked by other methods, for example model experiments based on various scenarios. I can't also understand why quantitative values about changes in SHC caused by changes of SCE and SAT are not provided on the manuscript.

SHC is an integrated value within the soil column to 18 m depth. There is a problem in the use of the SHC. SHC in deeper soil depths represents hydroclimatic influences in the winter season of few months ago rather than in the study months because of the effect of time lag in propagating the impact to deeper depth. In particular, influence of SAT on SHC in the period of April to June is probably limited to upper soil layers, for instance active layer thickness, because most of the heat is used for latent heat effects of thawing. Active layer thickness in the study season is not generally deeper. Therefore, the use of the integrated SHC is not suitable to the aims of this study. You have to consider shallower depth for the analysis, for example to 3.2 m.

C2

One of characteristics of this study is considered impacts of soil moisture and phase change to SHC. However, I can find no data relating to their impacts within the manuscript. Snow begins to melt during the study season, which creates the saturation of soil moisture affecting heat capacity. Active layer thickness could be an indirect proxy representing the impact of soil moisture and phase change to SHC.

It remains many uncertainties that SCE and SAT can't explain changes of SHC. For example, there was no significance between SHC and SAT in Eurasian SCNZ in April (fig 7). However, their correlation in May and June increased with significances, although it is explained by increased SAT. We can surmise thinner snow cover in May and June than in April, which is effective to heat transfer into soil. Likewise, uncertainties or limitations of SCE associating with SHC have to be included into the discussion section, based on the analysis of your results.

Data analysis has made to two regions of Eurasia and North America, and decided major factors influencing SHC changes in individual snow cover zones. The results exhibit differences in affecting factors between zones and regions. However, there were no explanations for reasons of the differences, which should be discussed in the discussion section. And the discussion in the manuscript is considerably weak and general. Thus, the discussion should be rewritten on the basis of your results, including the comparison with previous results.

It is helpful for understanding the trend of SHC if the time series are provided like figure 4.

This paper has quite complicated structure; for example, chapters 2.2 and 3.2 describes the methodology about the calculation of SHC including model description with replicated expressions, and the method of statistical analysis is divided into two chapters (3.3 and 3.4). These have to combine to one chapter individually. The section of Discussion and Conclusion should be divided into respectively. The conclusion has to be compactly written about major result obtained by this study.

L 86. "basically neglected", you want to say "hidden".

L 124–131 and L 132–134. These are redundant descriptions.

VIC has well known. It may be good the model description is focused on portions associating with this study.

L 224–229 and L231–236. These have to be combined compactly.

It may be good Table 1 is removed from the manuscript.

L259–263. It's good to be removed.

L 274. Temperature is soil or air?

L 274–280. This has to be moved to the data section.

L 291. "dynamics, which . . ." revise to "dynamics (Troy, 2010)".

L 293–294. Please remove the sentence that is repeated description.

L 304. Please add references.

L 342. "static" In nature, the insulation is not static and spatially quite heterogeneous. This is only because your methodology does not consider. The sentence could cause large misunderstanding. Please revise that.

L 358–359. Please remove.

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