The Cryosphere Discussions

The Cryosphere Discuss., referee comment RC1
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Comment on tc-2022-5

Anonymous Referee #1

Referee comment on "Validation of Pan-Arctic Soil Temperatures in Modern Reanalysis and Data Assimilation Systems" by Tyler C. Herrington et al., The Cryosphere Discuss., https://doi.org/10.5194/tc-2022-5-RC1, 2022

General comments

The authors present a comprehensive evaluation of soil temperature from eight reanalyses and LDAS products based on in-situ observations. Authors reported that the soil temperature bias is generally larger in the cold season, indicating the presence of soil freeze/thaw transition and snow layer introduced additional difficulties for soil temperature simulations. Authors also found that the ensemble generally outperforms any individual product. These findings improved the understanding of the current body of knowledge on soil temperature simulations in land surface models. However, a large part of the manuscript remained unfocused and an in-depth discussion is missing. I hence strongly suggest authors reformulate and shorten the manuscript (maybe as a brief communication) with a very specific focus on soil temperature validation.

- **Manuscript structure and discussion**
  In Sec. 4 & 5, the authors present the evaluation results together with a large part of the discussion, and additional discussions are given in Sec. 6. This makes the manuscript very unclear and difficult to follow.
  The discussion in Sec 6 is very general and superficial. Most of the part has been extensively discussed in other studies, and they are not tightly connected with the previous parts. For instance, the gab of site-scale observation and model grid (about 10–100 km), or so-called scale effects, is widely reported. P23, L392–398, this part is very confusing. Does the misclassification of permafrost affect the results? Please make sure only to present the most relevant parts here to avoid diluting your real contributions.
- **Soil temperature standard deviation**
  The authors presented and discussed the reanalysis soil temperature deviation. I am wondering why this is important here and how this could be used for validation purposes? The strong variation of soil temperature in the cold season could be expected due to the presence of a snow layer, see Figure 6 from Burke et al., (2020).

- **Climatology**
  Again, the climatology based on the ensemble results is somehow unfocused. The purpose of this study is "*validation of pan-Arctic (and Boreal) soil temperatures from eight reanalyses and land data assimilation system (LDAS) products.*" (see P2, L53–54), rather than analyzing the climatology. To be more focused, authors could compare and evaluate the trend of ensemble results with site-scale observations. Otherwise, I do not see the necessity of this part.

Specific comments:

- P2, L24: Permafrost carbon and climate warming loop are complex, and thus ...could act as a "possibly/potentially" positive...
- P2, L31: Qinghai-Tibetan **P**lateau.
- P2, L45–49: Ensemble simulation has also been used for permafrost simulation, for instance, Cao et al., (2019), although these studies do not directly use the soil temperature.
- P4, L122: The variation of soil temperature is complex and typically depends on surface condition (i.e., snow layer, vegetation), soil properties (i.e., soil organic content), and soil depth. It could vary very large at the hourly and daily scales.
- P6, L135: How much the difference could be? Could you please write it down?
- P6, L141: ...2 to 12...
- P6, L142: The so-called "scale effects" has been widely reported, see Gubler el al., (2011) for the Alps and Cao et al., (2019) for high latitudes. Please cite relevant references.
- P8, L172: you have two "also" here
- P8, L180: Then why not directly use the IPA map? You could also find the global permafrost zonation index map from Gruber et al., (2012).
- P9, L192: "*more*" □ greater/larger
- P14, L250: Qinghai-Tibetan **P**lateau
- P16, L256: Zero curtain period is heavily dependent on the soil moisture rather than the active layer thickness.
- P22, L357: Remove the redundant '*)*'.

Tables & Figures

- **Table 1:** Could you please also add the soil discretization information here, such as depth for each layer and the total soil column depth? Please double-check the spatial resolution of all the reanalyses, ERA5 should be 0.25°, ERA-Interim is 0.75°, and MERRA-2 is 0.5°×0.625°. Depending on the datasets you used, JRA-55 is 1.25° for the reanalysis level and 0.56° for the model level.
- **Figure 4:** Do you really need so many sub-plots? The inter-comparisons among different reanalyses are shown here but not discussed in the main text. Did I miss something important? Please also add the 1:1 line, so that readers could clearly see the cold/warm bias.
- **Figure S3:** Could you please improve the resolution of Figure S3?

References

- Burke, E. J., Zhang, Y., and Krinner, G.: Evaluating permafrost physics in the Coupled Model Intercomparison Project 6 (CMIP6) models and their sensitivity to climate change, The Cryosphere, 14, 3155–3174, https://doi.org/10.5194/tc-14-3155-2020, 2020.
- Cao, B., Quan, X., Brown, N., Stewart-Jones, E., and Gruber, S.: GlobSim (v1.0): deriving meteorological time series for point locations from multiple global reanalyses, Geosci. Model Dev., 12, 4661–4679, https://doi.org/10.5194/gmd-12-4661-2019, 2019.
- Gruber, S.: Derivation and analysis of a high-resolution estimate of global permafrost zonation, The Cryosphere, 6, 221–233, https://doi.org/10.5194/tc-6-221-2012, 2012.
- Gubler, S., Fiddes, J., Keller, M., and Gruber, S.: Scale-dependent measurement and analysis of ground surface temperature variability in alpine terrain, The Cryosphere, 5, 431–443, https://doi.org/10.5194/tc-5-431-2011, 2011.