

Summary

The authors would like to thank the two anonymous referees for their helpful comments. We have incorporated their feedback in the revisions. In particular, we have shortened Section 3.4 (Regridding of Reanalysis Products and Calculation of Ensemble Mean Soil Temperature), and have substantially reorganized Sections 4.1 (Annual Mean) and Section 4.2 (Seasonal Cycle). As part of this, we have added the annual mean bias and RMSE to Figure 2, and changed the order of Figure 4 and 5 to align with the revised text in Section 4.2. We also made some minor changes to other subsections in Section 4 and Section 5 to improve clarity.

Referee 1 Comments

P1, L3-4: The topic of permafrost carbon is of course important, but does it make sense to include it in the abstract since the manuscript does not mention it?

We have removed the mention of permafrost carbon - the sentence now reads:

“Soil temperatures are an important control of many land-atmosphere exchanges and hydrological processes, and permafrost soils are thawing as the climate warms.”

P2, L55: Please consider merging this paragraph with the one above since it only contains one sentence

We have merged this paragraph with the above one.

P11, L253: Could you please be more specific about "small to moderate negative"?

By “small to moderate negative cold biases, we are referring to the result that most products biases on the order of roughly 1°C to 4°C in both seasons.

This section has been restructured and we now note the following about biases:

“Most products are biased cold over the annual mean, and display soil temperature biases of between +0.3°C and -3.1°C...”

P12, L280: is the “2)” a typo

This should say “(Figure 2)”. We’ve corrected this.

P13, L324: Consider changing the section title to “soil temperature trend”

We have renamed this section to “Soil Temperature Trends”, and have similarly renamed Section 5.2 to “Ensemble Mean Soil Temperature Trends”.

P14, L355: Merge this paragraph with the one above since it only contains one sentence

This sentence was removed as the section underwent some reorganizing at the advice of the other referee.

P29, L435: Please double-check, the overall warming trend should be 0.29 ± 0.12 . The warming trend of 0.39 ± 0.15 is specifically for continuous permafrost.

We thank the reviewer for pointing this out – we have corrected this.

P30, L474-475: References are not formatted appropriately

Corrected.

P32, L539: figure ?

This figure was removed from the manuscript. The sentence now reads “A robust ensemble mean can be computed with four products (**not shown**)...”

Referee 2 Comments

My main concern with this manuscript is the presentation quality, especially the length, structure and level of detail in the text. The text would benefit from a stricter focus on the main message, but is instead riddled with distracting details of the results.

We interpreted the reviewer’s comment regarding a stricter message to refer to some reorganization and reformatting of the results section. We found that some of the material in Section 4.1 (Annual Mean) fits better in Section 4.2 (Seasonal Cycle), so we incorporated it into Section 4.2. In addition we added the annual mean bias and RMSE to Figure 2, which is now mentioned explicitly in Section 4.1. As a result, the order of Figures 4 and 5 have changed.

We also made some minor reorganizations to Section 4.3 (Spatial Variability), Section 4.4 (Soil Temperature Trends), Section 4.5 (Variability in Seasonal Extremes), Section 5.1 (Ensemble Mean Validation), Section 5.2 (Ensemble Mean Soil Temperature Trends), and Section 5.3 (Ensemble Mean Variability in Seasonal Extremes) to improve clarity.

There are also many typos and some redundancies of information in the text (I have pointed out some of them below).

We have corrected the typos/redundancies that the reviewer points out below, along with those pointed out by the other reviewer.

Information presented in figures is also on several occasions discussed far after the figure appears, making a confused impression on the reader.

We have attempted to move the relevant figures closer to the sections where they are discussed, where possible.

In all, this demands a lot of any reader and I would urge the authors to improve the structure, length, and language of the manuscript so that this research, when published, will be more easily accessible to the community.

We have worked to shorten and clarify Section 3.4, and many of the subsections in Sections 4 and 5, and have rearranged the figures where possible in LaTeX. For example, we have reduced Section 4.1 (Annual Mean) from nearly 500 words, to 275 words, and Section 3.4 from 360 words to 230 words. Section 4.5 has been reduced from approximately 300 to 200 words, while Section 4.5 (Ensemble Mean Variability in Seasonal Extremes) has been reduced from 550 words to 430 words. The authors believe that the manuscript should be easier to follow as a result.

Section 3.4: Much (or most) of this text feels redundant and could possibly be dramatically shortened or merged with previous sections.

We agree that this section contained many redundancies. It has been shortened substantially to improve clarity. In the revised manuscript, we removed the redundant explanations describing how the soil temperatures were calculated, and now refer readers to Table 2 for more information about the soil layers in each product in order to shorten the second paragraph. The third paragraph has been incorporated into a much shorter second paragraph.

Line 2-4: Permafrost soils do not contain twice as much carbon as the atmosphere. This has been corrected later in the text after last reviewer comments. And permafrost does not melt, it thaws

We have removed the mention of permafrost carbon on the suggestion of the other reviewer - the sentence now reads:

“Soil temperatures are an important control of many land-atmosphere exchanges and hydrological processes, and permafrost soils are thawing as the climate warms.”

L27-31: Not necessarily relevant/central focus for this work.

We believe that Line 27-29 on the permafrost carbon feedback provide critical motivation as to why it is important to study permafrost soils. That being said, we do realize that Line 30-31 likely fits better with the previous paragraph, so we've moved that sentence up.

L94: “the the”

Corrected.

L104 “ term term”

Corrected.

L160 wasn't = was not

Corrected.

L176 Reanalysis/LDAS (but earlier it was stated the only the term reanalysis would be used)

We have changed this to “Reanalysis” here.

L192: σ_{norm} , R, and SS is already defined above.

The redundant explanations have been removed.

L247: is that a good skill score? (A very brief explanation on how to interpret the skill score would be helpful!)

We have added a brief explanation as follows to the text: “The Taylor Skill Score ranges between a minimum of zero and a theoretical maximum of one. A product with a skill score of 1.0 would display a perfect correlation of 1.0 relative to in-situ soil temperatures, and a soil temperature variance identical to that of the in-situ data.”

L250: Unclear sentence: Unclear if soil temperatures at depth are too slow in the JRA55 or if they should be slower due to lag of heat transfer to deeper layers.

This section underwent some reorganization, and this particular sentence was changed. However we include the following statement regarding the JRA55 near surface skill score:

“JRA55, however displays an annual mean skill score of 0.54 near the surface, and skill score of 0.79 at depth (Figure 2). This arises because JRA55 uses a simplified land model that uses just a single vertical layer; the soil temperatures used are computed as averages over the soil column that are, therefore, more similar to deeper soil layers than to the surface. Consequently, JRA55 underestimates the seasonal cycle of observed soil temperatures in the near-surface, and the timing of its annual maximum and minimum soil temperatures are offset by roughly a month relative to other products (not shown).”

L366: most or all?

This sentence has been changed to “The ensemble mean soil temperature product shows closer agreement with in-situ soil temperatures than any of the individual product, when all depths, seasons and regions are considered as a whole.”

L375: Sentence lacking a period (.)

Corrected.

L376: “The near surface skill of the ensemble mean in the cold season is nearly 10% than the next best product (Figure 2).” 10% what?

Corrected. This should read “The near surface skill of the ensemble mean in the cold season is nearly 10% **higher**..”