Revisions of Manuscript: ESSD-2025-192

Title: Spatially adaptive estimation of multi-layer soil temperature at a daily time-step across China during 2010-2020

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Dear Reviewer,

We sincerely thank you for your thoughtful comments and constructive suggestions on our manuscript. We have carefully revised the manuscript in response to your feedback, with all changes clearly marked using track changes. In the revised manuscript and accompanying supplementary materials, modifications are highlighted in blue for ease of reference.

Below, we provide a detailed, point-by-point response to each of your comments. For clarity, your original remarks are shown in *italics*, followed by our corresponding replies. We have made every effort to address all concerns comprehensively and to improve the scientific rigor, clarity, and overall quality of the manuscript.

We sincerely appreciate the time and effort you invested in reviewing our work.

Reviewer Comment 1:

Figures S12, S13, and S14 in the Supplementary are not referenced anywhere in the main text. Please ensure all supplementary figures are explicitly cited in the relevant sections of the manuscript.

Response to Reviewer Comment 1:

We thank the reviewer for pointing out the missing references to Figures S12, S13, and S14 in the main text. To address this, we have now explicitly cited these figures in the relevant sections of the manuscript. Specifically:

(1) Figure S12 has been updated to Figure S11 and is referenced in L438-442 of the manuscript.
Revised Text (L438-L442):
Figure S11 shows the comparison between the estimated and observed annual mean T_s for the test dataset at six different depths (0~40 cm). The R² ranges from 0.94 to 0.97. The RMSE values range from 0.74 to 1.4 K, and the bias is minimal. The results suggest that the model is able to effectively capture the spatial patterns of T_s across different depths and locations.

(2) Figure S13 has been updated to Figure S9 and is referenced in L419-423 of the manuscript.
Revised Text (L419-L423):
In Figure S9, we further validated the spatial consistency between the flux tower sites and the estimated annual mean T_s at different depths. Although the validation results demonstrated high accuracy overall (R² = 0.7~0.82; RMSE = 2.93~3.58 K), a systematic positive bias of approximately +2 to +3 K was observed across all depths.

(3) The content related to Figure S14 has been referenced in L587-591 of the manuscript.
Revised Text (L587-L591):
We also quantified the variability of prediction results at the same site using grids generated from different rotation angles. The results in Fig. S14 show that the uncertainty at the 0 cm depth is higher compared to other depths, with the highest uncertainty concentrated in certain areas of the YGP and Sichuan Basin.

Reviewer Comment 2:

I welcome the addition of Figure S13, which compares the annual mean Ts against the independent flux tower observations. The R^2 values reduce to 0.70–0.87, which are acceptable, but there is a consistent and significant positive bias of +2 to +3 K across all depths. A systematic bias of ~3 K is not trivial for soil temperature applications. At least, a brief acknowledgement of this bias should be included in Section 3.1 (where flux tower validation is discussed).

Response to Reviewer Comment 2:

We appreciate the reviewer's constructive comment regarding the comparison between

Figure S13 and independent flux tower observations. We acknowledge that, although the results are still acceptable across all depths, with R² values ranging from 0.70 to 0.82, there is indeed a consistent and significant positive bias of approximately +2 to +3 K. We recognize the importance of highlighting this bias in the main text and have made the necessary revisions.

To address this comment, we have changed Figure S13 in the original supplementary materials to Figure S9, and we have added the corresponding explanation in Section 3.1 of the main text.

Revised Text (L419-L423):

In Figure S9, we further validated the spatial consistency between the flux tower sites and the estimated annual mean T_s at different depths. Although the validation results demonstrated high accuracy overall (R² = 0.7~0.82; RMSE = 2.93~3.58 K), a systematic positive bias of approximately +2 to +3 K was observed across all depths.

Reviewer Comment 3:

In the caption of Figure S14, please explicitly state that this uncertainty metric represents only the variability induced by the spatial partitioning scheme, rather than the total predictive uncertainty.

Response to Reviewer Comment 3:

We thank the reviewer for the insightful suggestion. We have revised the caption of Figure S14 to explicitly clarify that the uncertainty metric shown in the figure represents only the variability induced by the spatial partitioning scheme, rather than the total predictive uncertainty.

Here are the revisions, supplemented in the Appendix (L122-L129):
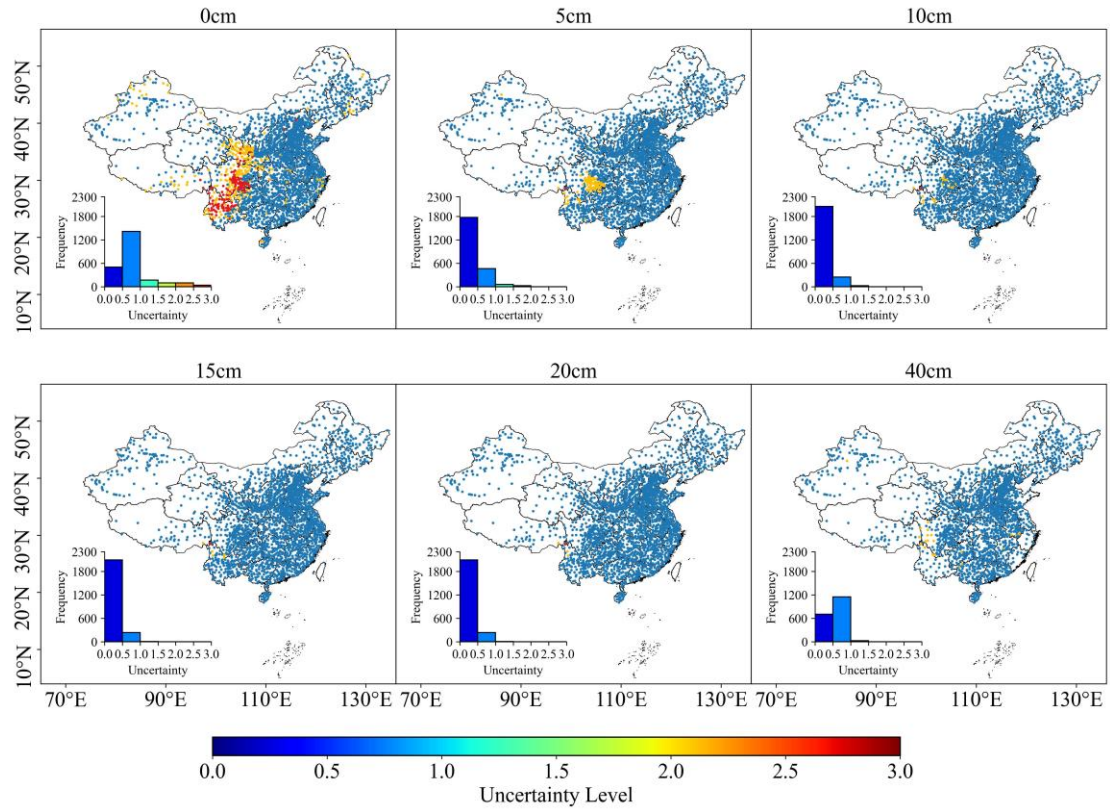
Figure S14. Spatial patterns of prediction uncertainty at six depths (0~40 cm) based on the rotated-quadtree ensemble. Note:The uncertainty metric shown here represents the variability induced by the spatial partitioning scheme rather than the total predictive uncertainty. Colored points represent site-level uncertainty values, with warmer colors indicating higher uncertainty. Insets show the frequency distribution histograms of uncertainty levels at each depth.

We believe this revision adequately addresses the comment and enhances the clarity of the figure caption.