General comments:

Considering that accurate estimation of Tsa is a fundamental prerequisite for accurately estimating H, the authors first employed a RF to estimate Tsa, followed by the estimation of H based on LSTM, ultimately producing a high-resolution dataset. This work is of significant value for studies on climate change and land–atmosphere interactions. However, the Methods section is overly detailed and somewhat cumbersome, and the Results section lacks clear organization. Therefore, the manuscript still requires further improvement before it can be considered for publication. I would like to offer the following suggestions, which I hope will useful for the authors.

Re: Thanks for your comments and suggestions. All the comments have been replied one by one as following.

Introduction

Point1:

It is recommended to consider changing the notation from "T_{sa}" to "$T_{s–a}$".

Response1: Thank you for the suggestion. We have replaced “Tsa” with “Ts–a” throughout the manuscript as recommended, as it provides greater clarity and precision in terminology.

Point2:

The authors emphasize the importance of Ts–Ta in estimating sensible heat flux (H), which is understandable. However, since the H product has already been produced, it remains unclear why there is still a need to derive or produce Ts–Ta separately. The manuscript does not sufficiently justify the necessity of generating Ts–Ta as an independent product, especially given that H has already been estimated. A clearer explanation of the added value or specific applications of the Ts–Ta product is needed to support its relevance.

Response2: Thank you for your valuable comment. We would like to clarify that in our study, the H product was estimated based on the generated Ts–a product. This has been clarified in lines 133–136: “Initially, we employed the RF method, utilizing pertinent parameters mentioned above to precisely estimate Ts-a, followed by an in-depth uncertainty analysis. Subsequently, a global H product for the period of 2000 to 2020 was generated using LSTM models, incorporating data from the Global LAnd Surface Satellite (GLASS) product suite and the estimated Ts-a.”

Given that Ts–a is the primary driver of H, and that directly computing it as LST minus Ta from existing products can lead to considerable uncertainties, we first developed a dedicated Ts-a dataset with improved spatial and temporal consistency. This rationale is also explained in lines 97–99: “Since Ts-a significantly influences H, its variability directly reflects in H fluctuations. Therefore, improving the accuracy of Ts–a estimation and minimizing related errors is crucial for developing a reliable, globally applicable method for H estimation,” and in

lines 114–116: “Additionally, estimating Ts-a by subtracting Ta from LST, using the same or different products, can introduce significant uncertainties (Wang et al., 2020).”

Only after ensuring the reliability of the Ts-a product did we proceed with estimating H. Thus, generating Ts-a is not redundant but a necessary and foundational step. Moreover, the Ts-a product has independent value and broad application. The corresponding points are further elaborated in the Section 5.2.

Point3:

The manuscript does not provide a clear explain for selecting Random Forest (RF) and Long Short-Term Memory (LSTM) as the baseline methods for predicting H and Ts–Ta. The choice of these specific models requires further justification.

Response3: Thank you for this insightful comment. The selection of RF and LSTM was based on the characteristics of the target variables and the nature of the available data. To clarify this rationale, we have revised the corresponding text in lines 126–130 as follows:

“Considering the different characteristics of the target variables, we adopted two ML models tailored. Specifically, RF was used for Ts-a estimation due to the availability of dense in-situ measurements and its robust performance in such scenarios, whereas LSTM was applied for H estimation to better handle the limited data samples and capture temporal dependencies.”.

Methods

Point4:

The methodology section is overly detailed. It is recommended to streamline the description to enhance clarity and readability.

Response4: Thank you for your suggestion. We have streamlined the methodology section by removing overly detailed descriptions, particularly for well-established machine learning methods and statistical metrics. The revised section now focuses on key model settings and implementation details relevant to this study, thereby improving clarity and readability.

Point5:

It is recommended to introduce the data used for model development and those for comparison respectively. Presenting these two types of data separately will help improve the clarity of the manuscript.

Response5: Thank you for the constructive suggestion. We fully agree that clearly distinguishing between the datasets used for model development and those used for comparison is important for improving clarity. In fact, this distinction was already presented at the beginning of Section 2 in the original manuscript, where we stated:

"This study utilized three distinct types of data: in-situ measurements, remotely sensed products, and reanalysis datasets. In-situ measurements were employed for both model development and independent validation. Remotely sensed products, including GMTED2010 DEM and GLASS product suite, supported the modeling and generation of new Ts–a and H products, while FLUXCOM was used for comparison with H estimates. Reanalysis datasets were used for comparative analysis with H and Ts–a estimates. Detailed descriptions of each dataset are provided in the subsequent sections."

We have carefully considered your suggestion regarding restructuring, and while we understand the potential benefits of presenting the two types of data separately, we found that doing so would fragment the description of certain datasets—particularly the GLASS product suite, which plays multiple roles in this study. As such, we believe that retaining the current structure, while clearly summarizing the data roles in both the main text and Table 3, offers a balanced solution that preserves both clarity and coherence.

Result

Point6:

The superiority of the Tsa dataset is primarily illustrated through comparisons with other available products. While this approach is valuable, it is recommended to include a more thorough and explicit discussion of the advantages of the generated Tsa data.

Response6: Thank you for your insightful suggestion. We agree that a clear discussion of the advantages of the generated Ts–a product is important. In the current manuscript, we have already provided a detailed evaluation of our Ts–a dataset through comprehensive comparisons with GLASS and ERA5-Land products. These comparisons, presented in Figures 6–7 and discussed in lines 476–517, include performance under various conditions such as elevation, slope, NDVI, and land cover types. Our results consistently demonstrate that the estimated Ts–a using the RF model outperforms the existing products across nearly all scenarios, particularly in complex terrain and heterogeneous land surfaces.

Point7:

Estimating Tsa as an intermediate step before deriving H may provide more reasonable than directly estimating H. A comparative analysis of these two approaches would be valuable in highlighting their respective strengths and limitations.

Response7: Thank you for your valuable suggestion. In the preliminary phase of our study, we tested two alternative approaches: one involved directly subtracting Ta from LST (derived from the GLASS product) to obtain Ts-a as the model input, while the other used LST alone for direct H estimation. The results showed that neither of these methods provided better predictions compared to our current approach. Therefore, we believe using Ts-a as an intermediate step for estimation better captures the close physical relationship between Ts-a and H and reduces the errors that can arise when directly estimating H. Furthermore, Ts-a itself

has practical value illustrated in section 5.2. The preliminary testing of these alternative approaches was not included in a detailed comparison within the main text, as our primary focus was on introducing the new H dataset and highlighting its generation methodology. However, we fully recognize the value of this comparative analysis, and we plan to explore it further in future research to better assess the strengths and limitations of different direct estimation approaches.

Point8:
The title of section 4.1 is "Uncertainty quantification of Tsa model", however, this section mainly compared product Tsa with GLASS and ERA5-land.

Response8: Thank you for pointing this out. To better reflect the actual focus of the section, we have revised the title to "Evaluation of estimated Ts–a" accordingly.

Point9:
P245： Please remove the validation method to Method section.

Response9: Thanks for your suggestion. Considering the characteristics of the target variables and the nature of the available data, we initially selected LSTM for predicting the temporally varying H variable. To demonstrate the superiority of this approach, we compared it in Section 4.2 with three other representative models: the generative model DBN, the tree-based model RF, and the classic time-series model Transformer. Therefore, we have retained the current structure, which we believe best represents the strengths of our model.

Point10:
It is noted that Figure 7 is missing tick marks for the R^2 axis. Including these would enhance the figure's readability and allow for better quantitative comparison.

Response10: Thank you for your helpful comment. We have added tick marks to the R^2 axis in Figure 7 as suggested to improve readability and facilitate quantitative comparison.

Point11:
Although comparing with other daily H datasets is valuable, the discussion spans eight paragraphs, which may overwhelm the reader. Condensing this section while retaining the key findings would improve readability and better highlight the strengths of the proposed dataset.

Response11: Thank you for your suggestion. While we understand your concern about the length of the discussion, we believe that a detailed comparison is essential for a thorough evaluation of our product. Our results first present the global spatial distribution of the products, highlighting significant spatial details. We then provide a site-level analysis, distinguishing

between remote sensing and reanalysis products. Each product is further analyzed across various conditions, which we consider necessary for a comprehensive assessment. Moreover, given the current absence of comparative studies on sensible heat flux products in this context, a detailed comparison is crucial for understanding both the global distribution and the performance and limitations. Therefore, we have decided to retain the current level of detail in this part to ensure a complete and robust evaluation.

Discussion

Point12:
To enhance readability and guide the reader through the key arguments, the Discussion section would benefit from the inclusion of subheadings that reflect its main themes.

Response12: Thank you for your suggestion. We have added subheadings in the Discussion section to improve readability and guide the reader through the key themes.

Point13:
While the analysis of variable importance in estimating Tsa is useful, the primary objective of the study is the accurate estimation of H. Therefore, investigating the contribution of each variable to the estimation of H would be more directly aligned with the study's goals and would provide greater practical insight.

Response13: Thank you for your thoughtful suggestion. We agree that examining the contribution of each variable to H estimation would offer valuable insights. In this study, we did not perform such an analysis because our input variables were selected based on established literature (e.g., (Wulfmeyer et al. 2022)) where their importance has already been thoroughly examined. Additionally, we also conducted correlation analyses during feature selection (Section 3.2.1), which provide indirect evidence of each variable's influence. Moreover, since H was estimated using an LSTM model, it is not straightforward to interpret individual variable contributions as in models like Random Forest. In contrast, Ts–a is influenced by a complex interplay of atmospheric and surface factors, and the contribution of individual variables to its estimation has been less explored in previous studies. Therefore, we placed greater emphasis on discussing the drivers of Ts–a in the manuscript, as it serves as the key variable for deriving H.

Wulfmeyer, V., Pineda, J.M.V., Otte, S., Karlbauer, M., Butz, M.V., Lee, T.R., & Rajtschan, V. (2022). Estimation of the Surface Fluxes for Heat and Momentum in Unstable Conditions with Machine Learning and Similarity Approaches for the LAFE Data Set. Boundary-Layer Meteorology, 186, 337-371

Point14:

The current manuscript outlines the application scenarios of Tsa; however, since H is the final product of interest, its application scenarios should also be discussed. This will better demonstrate its scientific and practical significance.

Response14: Thank you for your valuable suggestion. We have already outlined the potential applications of H in the first paragraph of the Introduction, where we highlight its critical role in global energy flows, land-atmosphere interactions, and its significant impact on climate and weather systems. This provides a comprehensive understanding of its applications and demonstrates the significance of our dataset from the outset. We believe this approach ensures a clear and focused presentation of the study's contributions, which is why we have not included this information in the Discussion section.

Regarding Ts–a, as it serves as an intermediate product, its application scenarios and significance require further discussion. Therefore, we have placed the application scenarios of Ts–a in the Discussion section.

Conclusions

Point15:
Please consider refining and condensing the description of both the methods and the main conclusions. This will help to emphasize the mainly point of the manuscript.

Response15: Thank you for your suggestion. We have revised the manuscript to condense and refine the description of both the methods and the main conclusions.