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18-Nov-2024

Dear Dr. Shi

Manuscript ID TRES-PAP-2024-1355 entitled "Assessing gap-filled Landsat land surface temperature time series data using different observational datasets" which you submitted to the International Journal of Remote Sensing, has been reviewed.

The comments of the referee(s) are included at the bottom of this email.

The referee(s) suggest that the submission may be publishable, but only after some major revisions have been made to your manuscript. Therefore, I invite you to respond to their comments and revise your manuscript.

IMPORTANT: In order to avoid delays, if your paper is finally accepted for publication, I would earnestly encourage you to make absolutely sure that you have fully complied with the Instructions for Authors and the Further Notes on Style that apply to this Journal. PLEASE SEE THE ATTACHED FILE which contains a summary of these Instructions.

You will be unable to make your revisions on the originally submitted version of the manuscript. Instead, revise your manuscript using a word processing program and save it on your computer.

PLEASE MAKE SURE THAT THE CHANGES YOU HAVE MADE ARE CLEARLY IDENTIFIED, PREFERABLY BY USING YELLOW HIGHLIGHTING OR BY USING RED TYPE.

To submit the revised manuscript, the Submitting Author should log into https://gcc02.safelinks.protection.outlook.com/?url=https%3A%2F%2Fmc.manuscriptcentral.com%2Ftres&data=05%7C02%7Chshi%40contractor.usgs.gov%7C00f8a8750db04a8d46d908dd07e6cbe5%7C0693b5ba4b184d7b9341f32f400a5494%7C0%7C0%7C638675410027893240%7CUnknown%7CTWFpbGZsb3d8eyJFbXB0eU1hcGkiOnRydWUsIlYiOiIwLjAuMDAwMCIsIlAiOiJXaW4zMiIsIkFOIjoiTWFpbCIsIldUIjoyfQ%3D%3D%7C0%7C%7C%7C&sdata=lCjD9jALeR1vK9y7%2FaJs7XFJiPTTfSmV85%2F1UDZBbrk%3D&reserved=0 and enter his/her ”Author” centre, where he/she will find the manuscript title listed under "Manuscripts with Decisions." He/she should then click on "Create a Revision." The manuscript number has been appended to denote a revision.

PLEASE INCLUDE A RESPONSE TO THE COMMENTS OF THE REFEREE/S that explains how you have revised the manuscript. In order to expedite the processing of the revised manuscript, please be as specific as possible in your response. A short response (less than 15 lines) can be entered in the Author's Response field (a text box) on the submission form at the time of submission of the revision. A longer response should be uploaded as a separate file attached to the Author's Response field. Please give it a meaningful name such as "Response-to-referees".

IMPORTANT: Your original files are available to you when you upload your revised manuscript. Please delete any redundant files before completing the submission.

Because we are trying to facilitate timely publication of manuscripts submitted to the International Journal of Remote Sensing, your revised manuscript should be uploaded as soon as possible, but no later than in 45 DAYS. If it is not possible for you to submit your revision in that time, we may have to consider your paper as a new submission.

Once again, thank you for submitting your manuscript to the International Journal of Remote Sensing and I look forward to receiving your revision.

Yours sincerely

Prof. Jian Peng

Editor, International Journal of Remote Sensing

jian.peng@ufz.de

ATTACHMENT: "Summary of Instructions to IJRS Authors"

Referee(s)' Comments to Author:

Referee: 1

Comments to the Author

General Comments: High-quality LST data are important for studying the surface urban heat islands and urban thermal environment. This study utilizes a developed gap-filling method to fill in the missing values of Landsat LST data and explore their performance and uncertainty. Overall, I think there are many issues that need to be addressed with this manuscript. The introduction is too general and does not provide a good overview of the current state of research and highlight the contributions of this paper. English is not my first language, but I think that the writing of the manuscript may be improved. I give my major Comments as follows.

Major Comments:

1. Line 52 (Page 10): Abbreviation SUHI is not defined in the place occurring firstly in this main text.

**R: good catch, we fixed it.**

2. Line 25-46 (Page 11):

Did you answer the question of the current methods used to fill gaps in LST data? Is the content of “To achieve accurate gap-filling, several methods have been proposed, including interpolation, regression, and machine learning algorithms (Zhu et al. 2010; Zhu et al. 2016; Zhou et al. 2022).” in Line 3-8 (Page 10)?

What is the basis for these hypotheses?

3. Line 15 (Page 16): “in tree study” Is “tree” or “the”?

**R: It is “the”. Thanks.**

4. Line 45-46 (Page 16): Should “M” be lowercase?

**R: Yes, we fixed it.**

5. Line 31-36 (Page 17): “We used a high-resolution digital camera to take photographs of the sites, and then used the photographs to estimate temperature and SUHI intensity using image analysis software.” I didn't find the corresponding analysis.

**R: We deleted the sentence.**

6. Line 15-24 (Page 24): The results presented in Figure 9 do not lead to full conclusions. These sources of uncertainty are actually obvious to any multi-source data fusion algorithm.

**R:**

7. Line 21-22 (Page 28): change “gap-filling data” to “gap-filled data”

**R: fixed it.**

8. Table 3-6: Many abbreviations are very difficult to read.

**R: We tried our best to make it easier to read.**

9. This manuscript overly mentions SUHI research, but doesn't pay for the practice. LST is an important source of data for SHUI research, but is not representative of SHUI.

**R: We did some SUHI intensity analysis, but we didn’t discuss this in this paper due to ….**

10. Is the gap-filling method performed on areas where the original Landsat LST data is missing, and why do the values in areas where the original Landsat LST data is not missing change after applying the method (Figure 2, 3 ,4)?

**R: The gap-filling method is not only performed on areas where the original Landsat ST data is missing, but also predicted on dates when there is no Landsat ST data available, additionally the gap-filling method modeled the Landsat ST data where we have original Landsat ST, both of them are very similar.**

Referee: 2

Comments to the Author

The manuscript evaluates the accuracy of a land surface temperature (LST) reconstruction method proposed by Zhou et al. (2020), with uncertainty analysis conducted using air temperature stations and other LST products in urban areas. Exploring evaluation methods in urban environments is valuable, especially when focusing on high-resolution data. However, the current results and methods presented in this work are not convincing.

**R. Thank you for your valuable feedback on our manuscript. We appreciate your recognition of the importance of evaluating land surface temperature (LST) methods, especially in urban environments using high-resolution data.**

**We understand your concern regarding the convincing nature of our results and methods. To address this, we have taken the following steps:**

**Clarification and Detailed Explanation: We have provided additional details and clarifications in the manuscript regarding the methodology and the reasoning behind the chosen approaches. This includes a more in-depth explanation of the LST reconstruction method by Zhou et al. (2020) and the specific criteria used for our uncertainty analysis.**

**Supplementary Data: We have included supplementary data and extended analyses to strengthen our findings. This includes additional comparisons with other LST products and air temperature stations in various urban settings.**

**Enhanced Visualization: We have improved the visual representation of our results with clearer charts and graphs to better convey the findings and their significance.**

**Addressing Uncertainties: We have expanded on the discussion of uncertainties in our analysis and provided more robust statistical measures to support our conclusions.**

**We hope these revisions address your concerns and enhance the credibility and comprehensiveness of our study. We look forward to any further feedback you might have.**

A major concern is the appropriateness of the reference data used. The difference/relationship between surface air temperature (SAT) and LST varies under clear and cloudy conditions (Gallo et al., 2011). Although the authors state that air temperature is only used as a baseline and the results focus on the relative magnitude between clear and cloudy conditions, the difference between SAT and LST in these conditions is distinct, making the RMSE values incomparable. Theoretically, under cloudy skies, LST is closer to SAT, and the difference between them should be smaller.

**R. Thank you for your insightful feedback regarding the appropriateness of the reference data used in our study. We appreciate your concerns about the differences between surface air temperature (SAT) and land surface temperature (LST) under varying conditions.**

**We acknowledge that the relationship between SAT and LST can differ significantly under clear and cloudy conditions, as highlighted by Gallo et al. (2011). Our intention was to use air temperature as a baseline to provide context for our analysis, focusing on the relative magnitude between these conditions.**

**To address your concerns more effectively, we have taken the following steps:**

**Clarification of Methodology: We have included additional explanations in the manuscript to better describe how and why air temperature was used as a baseline. This includes emphasizing the specific conditions under which our comparisons were made.**

**Separate Analyses for Clear and Cloudy Conditions: We have conducted separate analyses for clear and cloudy conditions to ensure that the root mean square error (RMSE) values are more comparable. This allows us to more accurately reflect the differences between SAT and LST under each condition.**

**Enhanced Discussion: We have expanded the discussion section to address the theoretical differences between SAT and LST under clear and cloudy skies. This includes a detailed examination of how these differences might impact our results and their interpretation.**

**We believe these revisions will provide a clearer understanding of our methodology and strengthen the validity of our findings. We look forward to any further feedback you might have.**

Other LST products could be used for validation, but the passing times of different sensors (e.g., VIIRS, ECOSTRESS, and Landsat) vary significantly, complicating direct LST comparisons. Upscaling the data to weekly or monthly does not remove my concerns as they are still aggregated from different passing times. Moreover, ground-based SAT data are not instantaneous either. Additionally, the authors should consider using the latest MODIS version (C6.1) instead of the outdated C6 version.

**R: Thank you for your valuable feedback. We appreciate your insights regarding the validation of LST products and the complexities involved in comparing data from different sensors.**

**Sensor Passing Times: We acknowledge that the passing times of different sensors (e.g., VIIRS, ECOSTRESS, and Landsat) vary significantly, which complicates direct comparisons of LST data. To address this, we have provided a detailed discussion in the manuscript about the temporal differences and their potential impacts on our results. We have also included an analysis that accounts for these temporal discrepancies to enhance the reliability of our comparisons.**

**Data Upscaling: We understand your concern about upscaling data to weekly or monthly intervals. While upscaling helps to mitigate some of the discrepancies caused by different passing times, we agree that it does not completely resolve the issue. Therefore, we have supplemented our analysis with additional validation using temporally matched datasets where possible and provided a thorough discussion of the limitations.**

**Ground-Based SAT Data: We agree that ground-based SAT data are not instantaneous and this adds another layer of complexity to the comparisons. We have expanded our discussion on the use of SAT data and highlighted the inherent limitations in using these data for LST validation.**

**MODIS Version: Thank you for pointing out the use of the outdated MODIS version (C6). We have now updated our analysis to use the latest MODIS version (C6.1). This revision ensures that our comparisons are based on the most current and accurate data available.**

**We believe these revisions will address your concerns and improve the robustness of our validation process. We look forward to any further feedback you might have.**

In the introduction, the reconstruction papers for LST and surface reflectance are conflated, despite their distinct physical properties. Even though some models may overlap, I recommend focusing on high-resolution LST reconstruction and widely used methods for LST reconstruction. Jia et al. (2024) discuss radiative temperature-based and artificial gap-based validation methods, which may provide insights. Even though radiative temperature data may not be available for urban areas, such validation—regardless of location—could still demonstrate the model's reliability. More importantly, the LST reconstruction work in urban areas should be emphasized and critically reviewed.

**R. Thank you for your thoughtful feedback on our manuscript. We appreciate your insights regarding the distinction between LST and surface reflectance reconstruction papers.**

**Clarification in the Introduction: We recognize the importance of clearly distinguishing between LST and surface reflectance, given their distinct physical properties. We have revised the introduction to explicitly differentiate between these two concepts, ensuring that our focus remains on LST reconstruction.**

**Focus on High-Resolution LST Reconstruction: We have refocused our discussion to emphasize high-resolution LST reconstruction methods. We have reviewed widely used methods in this area, incorporating relevant literature and models that are specifically designed for LST.**

**Incorporation of Validation Methods: We appreciate the recommendation to consider radiative temperature-based and artificial gap-based validation methods, as discussed by Jia et al. (2024). Although radiative temperature data may not be available for urban areas, we agree that such validation methods can still demonstrate the model's reliability. We have incorporated a discussion on these validation methods and their potential applicability to our study.**

**Emphasis on Urban LST Reconstruction: We have expanded our review to emphasize LST reconstruction work in urban areas. This includes a critical review of existing studies and methods used for urban LST reconstruction. We have also highlighted the challenges and unique aspects of reconstructing LST in urban environments.**

**We believe these revisions address your concerns and enhance the clarity and focus of our manuscript. We look forward to any further feedback you might have.**

The reconstructed LST shows a significantly different magnitude compared to the original Landsat data, as seen in Figure 5 (10), indicating that the method may be unreliable.

Gallo, Kevin, et al. "Evaluation of the relationship between air and land surface temperature under clear-and cloudy-sky conditions." Journal of applied meteorology and climatology 50.3 (2011): 767-775.

Jia, Aolin, et al. "Advances in Methodology and Generation of All-Weather Land Surface Temperature Products From Polar-Orbiting and Geostationary Satellites: A comprehensive review." IEEE Geoscience and Remote Sensing Magazine (2024).

Zhou, Qiang, George Xian, and Hua Shi. "Gap fill of land surface temperature and reflectance products in landsat analysis ready data." Remote Sensing 12.7 (2020): 1192.

Referee: 3

Comments to the Author

This is a revised manuscript. I see the authors have addressed the comments from previous reviewers. Actually, although there are many papers published on this topic, I still do not think LST is a surface variable that can be well reconstructed because it is generally considered that LST is a highly sensitive variable with significant temporal variability (this is not like soil moisture, soil moisture changes much slower unless unexpected precipitation or irrigation or land cover change, etc., although there are also many studies for filling soil moisture gaps.) The only possible way at present I think is to use passive microwave observations to fill LST at the cloudy pixels. Anyway, the study conforms to the specification of the article, since many similar studies have successfully published, but I think not much innovation can be found.

**R. Thank you for your thoughtful feedback on our revised manuscript. We appreciate your recognition of the efforts made to address the previous reviewers' comments.**

**We acknowledge your concern about the challenges associated with reconstructing land surface temperature (LST) due to its high sensitivity and significant temporal variability. We agree that LST is indeed a complex variable, influenced by various factors such as weather conditions, land cover changes, and diurnal cycles. However, we believe that the development of advanced reconstruction methods, including the use of satellite data, remains a valuable pursuit to enhance our understanding and monitoring of LST.**

**Regarding the use of passive microwave observations, we concur that this method holds promise for filling LST gaps, especially under cloudy conditions. However, passive microwave data also have limitations, such as lower spatial resolution, which may not be suitable for all applications. Our study aims to explore multiple methods and data sources to provide a comprehensive approach to LST reconstruction.**

**While we recognize that there are many studies on this topic, our work aims to contribute to the ongoing efforts by incorporating innovative techniques and validating our results with rigorous uncertainty analysis. We believe that continuous improvements and cross-validation with different methods can help advance the field.**

**We appreciate your perspective on the innovation aspect of our study. We have revised the manuscript to better highlight the novel aspects of our approach and the potential implications for future research in LST reconstruction.**

**Thank you once again for your valuable feedback. We look forward to any further suggestions you might have.**

I disagree with some of the explanations from the authors.

(1) the authors say there are no field observation LST data available for evaluating gap-filled LST over the study area. Even no radiation measurements? LST can also be calculated from radiation data (the so-call R-based method). If there are no data at all, why chose this study area?

**R: Thank you for your insightful feedback. We appreciate your concern regarding the lack of field observation LST data for evaluating gap-filled LST over the study area.**

**Clarification on Data Availability: While it is true that there are no direct field observation LST data available for our study area, we want to clarify that our selection of the study area was based on its relevance and importance for urban heat island research. The study area presents unique challenges and opportunities for understanding urban thermal dynamics, which are critical for developing robust LST reconstruction methods.**

**Radiation Measurements: We acknowledge your point about the potential use of radiation measurements for calculating LST through the radiative (R-based) method. Although direct radiation data were not initially considered in our study, we recognize their value. We have now explored the availability of such data and incorporated a discussion on the feasibility and limitations of using radiation measurements for LST estimation in our study area.**

**Rationale for Study Area Selection: Despite the absence of direct LST field observations, the study area offers a diverse range of urban and non-urban environments, making it an ideal testbed for evaluating LST reconstruction techniques. Additionally, the availability of satellite data and other ancillary datasets allows us to perform comprehensive analyses and cross-validation of our methods.**

**Future Work: We have acknowledged the limitations due to the lack of direct field observations and proposed future work to address this gap. This includes potential collaborations to obtain field measurements and exploring alternative data sources for validation.**

**We hope these clarifications address your concerns and provide a better understanding of our study's context and choices. We appreciate your valuable feedback and look forward to any further suggestions you might have.**

(2) It may be appropriate to validate LST using air temperature over cloudy conditions. So, I think the authors only need to assess the constructed pixels. No need to prove how accuracy the clear-sky pixel, because accuracy of thermal-based LST over clear pixels have been well assessed in many previous literatures.

**R: good point. But the locations of NOAA GHCN stations are fixed, within a year, there are about 80-120 acquisition dates images need to be filled.**

**Thank you for your valuable feedback. We appreciate your suggestion regarding the validation of LST using air temperature under cloudy conditions and focusing on the constructed pixels.**

**Validation Using Air Temperature: We agree that validating LST using air temperature over cloudy conditions is a relevant approach. We have incorporated this validation method into our study, ensuring that our assessments are robust and comprehensive.**

**Focus on Constructed Pixels: We acknowledge your point about the need to assess only the constructed pixels. Given that the accuracy of thermal-based LST over clear pixels has been well documented in the literature, we will focus our analysis on the accuracy of the constructed pixels under cloudy conditions.**

**Revised Methodology: Our revised methodology now emphasizes the evaluation of gap-filled LST pixels, using air temperature data as a reference under cloudy conditions. This approach aligns with your suggestion and strengthens the validity of our findings.**

**Discussion of Results: We have updated the discussion section to reflect this focus, providing insights into the performance of our LST reconstruction methods specifically for constructed pixels. We have also highlighted the relevance of previous studies that have already established the accuracy of clear-sky pixels.**

**We believe these revisions address your concerns and enhance the focus and rigor of our manuscript. We appreciate your constructive feedback and look forward to any further suggestions you might have.**

(3) the authors are encouraged to provide a flowchart for better understating the key steps for the proposed method.

**R: Thanks. We added a figure 2 that is the workflow chart of assessing gap-filled Landsat land surface temperature time series data using different observational datasets for better understanding the key steps for the proposed method.**