Response to Reviewers' comments to manuscript ESSD-2025-264

"Spatial Patterns of Sandy Beaches in China and Risk Analysis of Human Infrastructure Squeeze Based on Multi-Source Data and Ensemble Learning"

Dear Reviewers:

Thank you very much for your thoughtful and detailed review. Your suggestions have provided us with important and constructive insights, which have significantly improved the manuscript. We have carefully considered all of your comments and have made substantial revisions to the manuscript based on your feedback. We have done our best to enhance the manuscript and hope that the revised version will meet your approval. A point-by-point response to the outstanding comments is attached to this manuscript. The major revisions are summarized as follows:

Response to Comments by Reviewer 1:

1. *L161: The window size used for gray-level co-occurrence matrix (GLCM) texture feature extraction (e.g., 3×3, 5×5) is not reported. Please specify and explain the choice, as window size has a substantial impact on metrics such as Entropy and ASM.*

Response:

We Thank you for the valuable comments. Regarding the window size for extracting texture features using the Gray Level Co-occurrence Matrix (GLCM), we have chosen a 3×3 window size, which has been updated in Table 2 (see **L179**). The choice of a 3×3 window is based on its widespread use in the literature as well as the practical needs of our study. Specifically, a 3×3 window provides a good balance in texture feature extraction, as it captures local detail without introducing excessive noise. Additionally, using a 3×3 window effectively extracts texture features for most land cover types, including beaches, especially when image resolution and spatial scale are moderate.

We have referred to relevant literature, where many studies also used a 3×3 window size for texture analysis with successful results. In these studies, the 3×3 window was shown to effectively reflect the spatial structure and texture variation of land cover types, especially when dealing with different land cover types such as beaches, urban areas, and forests. In contrast, larger windows (e.g., 5×5 or larger) may capture more spatial information but tend to over-smooth the image, resulting in the loss of local details. Smaller windows, on the other hand, may not capture sufficient texture features. Therefore, a 3×3 window provides an ideal compromise, preserving enough local information while avoiding computational overhead and the loss of detail.

Specifically, the 3×3 window has significant effects on metrics such as Entropy and Angular

Second Moment (ASM), which help us better identify and distinguish different land cover types. In practice, using a smaller window helps reduce noise and interference in the image, enhancing the reliability and usability of the texture features. Moreover, adopting the 3×3 window size ensures the consistency and reproducibility of the algorithm, which is crucial for subsequent experimental validation and result comparison.

In conclusion, the choice of a 3×3 window size is based on its extensive application and excellent performance in texture feature extraction. We believe this choice is reasonable for our study and will ensure the accuracy and effectiveness of the extracted results.

2. ***L304****: The overall English fluency is good; however, some minor errors in singular/plural forms and article usage remain. For example, in Section 5.2, the sentence "Stacking not only ensures competitive accuracy but also offers strong applicability…"—the term applicability could be replaced with generalizability. A final proofreading or use of a grammar-checking tool is recommended.*

Response:

Thank you for your valuable feedback. We have reviewed the manuscript and corrected the small errors related to singular/plural forms and article usage. Specifically, in **Section 5.2**, the term "**applicability**" has been replaced with "**generalization**" as suggested. We appreciate your recommendation and have made the necessary adjustments to ensure the accuracy and fluency of the language.

3. *In Figures 1, 2, 5, 6, 10, and 13, the blue regions represent the ocean. However, adjacent countries bordering China are not labeled, which may cause confusion. It is recommended to label neighboring countries to avoid potential misinterpretation.*

Response:

Thank you for your valuable suggestion. We appreciate your careful attention to detail. Based on your feedback, we have updated **Figures 1, 2, 5, 6, 10, and 13** by labeling the neighboring countries bordering China. This revision aims to clarify the geographical context and avoid any potential confusion that might arise from the blue areas representing the ocean. We believe this addition will significantly improve the clarity of the maps and ensure that the readers can easily distinguish between China and its neighboring countries. Thank you again for your thoughtful recommendation, and we trust that this update will enhance the overall quality of the manuscript.

4. *In Figure 7, consider including Sentinel-2 true-color imagery for comparison with the classification results, thereby enhancing the intuitiveness and persuasiveness of the figure.*

Response:

Thank you for your valuable suggestion. Based on your feedback, I have added the true-color Sentinel-2 image to Figure 7. This addition allows for a comparison with the classification results, enhancing the visual clarity and persuasiveness of the figure, making it easier for readers to understand the classification outcomes. Thank you again for your thoughtful recommendation; the necessary adjustments have been made.

5. *Several figure captions contain redundancies or unclear phrasing. Please review and refine them to ensure clarity and conciseness.*

Response:

Thank you for pointing that out. I have reviewed and revised the titles of the figures and tables to ensure they are clear and concise, removing any redundancy and improving clarity. The necessary modifications have been made to enhance the overall readability and precision of the manuscript. Thank you again for your helpful suggestion. For example, we have changed "**Figure 2: Spatial distribution of Sentinel-1 and Sentinel-2 images used in this study: (a) Image Count of Sentinel-1, (b) Image Count of Sentinel-2**" to "**Figure 2: Spatial distribution of Sentinel-1 and Sentinel-2 images used in this study from 2016 to 2024: (a) Image Count of Sentinel-1, (b) Image Count of Sentinel-2.**"

6. *The minimum detectable sandy beach size is not explicitly addressed. Please clarify this aspect in the discussion.*

Response:

Thank you for your valuable feedback. Indeed, the impact of tides on beach extraction is a complex issue, especially when dealing with beach data on a national scale. The differences in tidal times across various regions can cause dynamic changes in beach areas, which in turn affect the accuracy of the extraction. To address this, we have synthesized the results of beach extractions over multiple years to minimize the influence of tidal fluctuations and construct a more representative dataset reflecting the actual beach distribution. Firstly, regarding the minimum beach size, we have set the threshold at **1,000 square meters**. This threshold helps avoid retaining small areas below this size during post-processing, as these small areas are often misidentified as beaches due to noise or fluctuations. This setting ensures the reliability of the beach extraction and improves the overall quality of the dataset.

7. *The conclusion primarily emphasizes the value of the study, but provides limited discussion of methodological limitations and future perspectives. Please expand this section accordingly.*

Response:

Thank you for the valuable comments on our research. Indeed, the conclusion section currently focuses mainly on summarizing the value and contributions of the study, with limited discussion on the methodological limitations and future perspectives. We acknowledge this and plan to give more attention to these aspects in future versions. Due to space constraints, we were unable to elaborate on the limitations of the methodology and future outlook in the current paper, but we aim to address these in subsequent versions.

First, regarding the methodological limitations, although our approach has shown good performance in beach extraction tasks, there are still some limitations. For instance, the exposure of beach areas changes due to tidal fluctuations, which may lead to beach regions being misclassified as water bodies at certain times, affecting the accuracy of extraction results. While we have reduced tidal influences by merging multi-year data, tidal differences still contribute to some errors. Future research could consider incorporating more detailed tidal correction models or combining higher-resolution remote sensing imagery to improve the accuracy of beach extraction. Secondly, the generalizability of the methodology is another important consideration. Currently, our method has been validated mainly in specific regions in China, particularly along coastal beach areas. However, different regions, with varying topographies, climates, and tidal conditions, may result in different beach extraction outcomes. Therefore, future work should aim to extend our approach to other regions and types of land cover, especially those with significant tidal variations, such as tropical and subtropical areas. Additionally, given the complexity of beach extraction, we could further optimize the model to better adapt to other land cover types, such as dunes and coastlines. As for future prospects, we believe that with ongoing advancements in remote sensing technology, particularly the increasing resolution of satellite imagery, there is great potential to further improve the accuracy and reliability of beach extraction. Future research could incorporate multi-source data, such as combining LiDAR data with remote sensing imagery to gain richer land cover information. Additionally, we could explore the application of deep learning methods in beach extraction to automate feature extraction and classification, further improving model precision and efficiency. Finally, we hope to apply our method to broader real-world scenarios in the future, such as beach environmental monitoring, management, and conservation, to enable effective monitoring and management of global beach ecosystems. These will be key directions and goals for our future research. Once again, we appreciate the reviewer’s valuable suggestions, and we will refine our research based on your feedback. We aim to continuously improve the application value and practical effectiveness of the methodology in future work.

8. *Inconsistent use of Chinese and English punctuation marks is observed. Please standardize*

formatting throughout the manuscript.

Response:

Thank you for your valuable comment. We have reviewed the manuscript and made the necessary revisions to ensure consistent use of punctuation between Chinese and English throughout the document.

9. *The conclusion would benefit from elaborating on the transferability of the method, such as its applicability to other countries or to datasets with different spatial resolutions.*

Response:

Thank you for your valuable feedback. The point you raised regarding the transferability of the method is indeed an important aspect. In this study, we primarily focused on beach extraction and analysis in China, utilizing existing remote sensing data and algorithms for effective application. However, the transferability of the method to other countries or datasets with different spatial resolutions is an area that requires further discussion. First, our methodology relies primarily on Sentinel-1 and Sentinel-2 remote sensing imagery, which provide accurate spatial information across different land cover types. The high temporal frequency and spatial resolution of Sentinel data give it strong potential for global applications. By utilizing an ensemble learning model, we effectively combined different feature information to address beach area identification tasks. If similar high-resolution remote sensing data, like that from Sentinel-1 and Sentinel-2, are available in other countries or regions, we believe the method could still be feasible and applicable. However, the environmental and geographic differences between countries or regions may influence the performance of the method. For example, beaches in tropical regions might differ from those in temperate zones in terms of texture and morphology, which could affect the applicability of the model in different areas. Moreover, lower-resolution datasets might impact the model's ability to capture fine details, thereby affecting the accuracy of extraction results. Therefore, optimizing the model to handle data of varying resolutions and adjusting the algorithm’s parameters to accommodate different land cover characteristics will be an important direction for future research. Additionally, while we mainly used remote sensing imagery in our study, other countries might employ different types of data, such as UAV imagery or aerial photography. Ensuring the adaptability and consistency of the algorithm across these different data sources is another challenge to consider. For instance, lower-resolution satellite images may not provide the same level of detail as high-resolution imagery, requiring adjustments to the algorithm to handle such data, including applying appropriate data processing and analysis techniques for lower-resolution images. In summary, while our method has shown good results in China, its applicability and transferability to other countries or regions still need further exploration and validation. In future research, we plan to explore how this method can be extended to beach extraction tasks in other countries, and how to optimize it for different resolutions and types of data.

10. *Some English references do not follow the journal's formatting guidelines regarding author abbreviations (e.g., use of "and" vs. "&"). Please check and revise.*

Response:

Thank you for your valuable feedback. We have carefully reviewed the references and ensured that all English references adhere to the journal's guidelines regarding author abbreviations and formatting, particularly the use of "and" and "&." Any discrepancies have been corrected accordingly.

11. *For Table 3, please clarify whether the model parameters were optimized through hyperparameter tuning or adopted as default values.*

Response:

Thank you for your suggestion. We have used the default values for the model parameters in Table 3, and no hyperparameter tuning was performed. Additionally, we have updated the base learners in the ensemble model to tree-based models that are better suited for handling large datasets and wide geographical areas. These models include Random Forest (RF), Gradient Boosting Decision Tree (GBDT), eXtreme Gradient Boosting (XGB), and Light Gradient Boosting Machine (LGBM).

12. ***L35–40****: The statement that "traditional field surveys are inefficient" could be strengthened by citing 1–2 recent field-based studies (within the past three years), to demonstrate coverage of the latest research progress.*

Response:

Thank you for your suggestion. We have added references to 1-2 recent field studies (published within the past three years) to strengthen the statement on the "inefficiency of traditional field surveys" and to demonstrate coverage of the latest research advancements.