

Response to Reviewer 1's Comments

Dear reviewer,

We sincerely thank the reviewer for the continued careful evaluation of our manuscript and for the constructive suggestions provided in this round of review. We are grateful that the reviewer found that most previous concerns had been adequately addressed based on our response letter. We also note the reviewer's comment that the revised manuscript was not available in the review system. According to the ESSD interactive review procedure, our current response is provided as a structured author response rather than as a separately uploaded revised manuscript. Therefore, in the present response letter, we describe the corresponding manuscript changes as clearly and specifically as possible.

The reviewer's remaining comments are highly valuable for further improving the focus and interpretation of the manuscript. In the subsequent revision stage permitted by the journal workflow, we will further clarify the conceptual scope and limitations of VSRE, streamline the comparison with existing structural-complexity metrics where appropriate, and strengthen the discussion of national-scale mapping results, especially for mangrove canopy structural complexity. These revisions will help make the manuscript more focused and better aligned with its core contribution.

(Black Italic: reviewer comments; Blue: our responses; Purple: revised text).

Comment 1: *I highly appreciate the authors' efforts in addressing my previous concerns. I am not sure whether I used the review system correctly, but I was unable to locate the revised manuscript in the system. Therefore, my evaluation is based solely on the authors' response letter. Fortunately, the authors provided a detailed and well-structured response letter with clear explanations of how the manuscript was revised. Based on these responses, I believe that most of my previous concerns have been adequately addressed. However, I still have a few comments that the authors may wish to consider during further revision.*

Response: Thank you very much for your positive evaluation of our response letter and for acknowledging that most of your previous concerns have been addressed. We also appreciate your continued constructive suggestions for further improving the manuscript.

We will carefully consider all remaining comments and incorporate the corresponding revisions in the subsequent revision stage according to the ESSD workflow. In particular, we will further clarify the scope and limitations of VSRE, reduce or reorganize non-essential metric comparisons where appropriate, and expand the interpretation of national-scale mangrove canopy structural complexity.

Comment 2: *First, I continue to hold the view that the proposed index, relative entropy, primarily characterizes structural dissimilarity among vertical canopy layers. I do not dispute that this can serve as an indicator of one aspect of the vegetation structural complexity. However, I am concerned that its applicability may be limited in forest types with more homogeneous vertical structural distributions. I suggest that the authors explicitly acknowledge this potential limitation in the manuscript.*

Response: Thank you for this important suggestion. We agree that VSRE should be presented more explicitly as an index that captures a specific aspect of vegetation structural complexity, namely the dissimilarity among local voxelized three-dimensional structural configurations. Although VSRE is not restricted only to vertical layers, we agree that it is particularly sensitive to differences in vertical and local spatial point-cloud distributions. Therefore, its interpretation should be made carefully in ecosystems where vegetation structure is highly saturated, vertically homogeneous, or composed of repeated similar structural units.

In the revised manuscript, we will explicitly acknowledge this limitation. We will clarify that VSRE is most informative when vegetation structural complexity is expressed as local configurational heterogeneity, but that it may be less sensitive in forest types or canopy systems where local vertical distributions are highly homogeneous or nearly saturated. This limitation will be added to the Discussion so that readers can better understand the ecological scope and appropriate application conditions of the index.

Revised text:

1.4.4 Limitations and Uncertainties

Although VSRE offers significant advantages in theoretical interpretability and computational efficiency, several limitations should be acknowledged. First, VSRE requires a high degree of information fidelity in the input point cloud. Specifically, the spatial distribution of points should accurately represent the actual three-dimensional vegetation structure, with limited distortion from sampling methods or external factors. A major challenge in applying VSRE to airborne or satellite-borne LiDAR data is the potential information distortion caused by dense canopy cover,

which can reduce laser penetration and bias the observed point distribution (Wulder et al., 2012). In this study, the application of VSRE to coastal wetlands, where vegetation canopies are generally more open than closed forests, reduces but does not eliminate this concern.

Second, VSRE should be interpreted as an index that primarily captures spatial configurational heterogeneity rather than the total area of occupied vegetation. In a broad ecological sense, vegetation structural complexity may include both spatial occupancy and spatial heterogeneity (Coverdale and Davies, 2023). VSRE is more closely aligned with the latter because it compares differences among local voxel-based structural distributions. Therefore, in structurally more complex ecosystems or in mature ecosystems where vegetation space is nearly saturated, VSRE alone may not fully capture all dimensions of structural complexity. In such cases, combining VSRE with complementary metrics such as canopy cover, vegetation height, or a spatial occupancy index (Zhao et al., 2026) would provide a more complete characterization of VSC.

Third, RE-based algorithms have theoretical limitations, although these conditions are rarely encountered in natural ecosystems. When vegetation structures become extremely saturated and local point-cloud distributions within windows become highly similar, RE values may decrease toward zero because little distributional divergence remains across windows. In addition, when structures consist of simple rearrangements of identical elements, such as repeated clusters of uniform vegetation point clouds distributed across space, RE may be unable to distinguish them if their normalized voxel distributions are effectively equivalent. These limitations indicate that VSRE is most informative when structural complexity is expressed as local configurational heterogeneity rather than as uniform saturation or repeated relocation of identical structural units.

Finally, though VSRE remains relatively insensitive to point-cloud density, we therefore recommend using LiDAR datasets with comparable point-cloud densities, preferably greater than 250 points m⁻², to ensure reliable comparisons among samples or ecosystems.

Comment 3: *Second, because relative entropy appears to capture a different aspect of canopy structural complexity than existing metrics, I do not believe that extensive comparisons with other complexity metrics are particularly necessary. Instead, I suggest that the authors clearly state that the proposed metric is designed to quantify structural dissimilarity among vertical layers and explain why this characteristic makes it especially suitable for assessing canopy structural complexity in mangrove forests (possibly due to their relatively short but dense canopy structure). Accordingly, I recommend reducing the lengthy comparisons with other metrics and placing greater emphasis on the national-scale mapping of mangrove canopy structural complexity across China.*

Response: Thank you for this thoughtful suggestion. We agree that VSRE captures a structural dimension that differs from many existing metrics, and we will further clarify this point in the revised manuscript. Specifically, we will explain more clearly that VSRE is designed to quantify dissimilarity among local voxelized three-dimensional point-cloud configurations, with particular sensitivity to vertical and local spatial differences in vegetation structure.

At the same time, we would like to clarify that the scope of this manuscript is not limited to mangrove forests, but covers coastal wetland vegetation across China, including both saltmarshes and mangroves. Therefore, we have tried to maintain a balanced description of different coastal vegetation types throughout the manuscript. Mangroves

are an important component of our national-scale mapping results, but the main objective of this study is to develop and validate a structural-complexity metric applicable across multiple coastal wetland vegetation communities.

We also agree that the comparison with existing metrics should not distract from the main contribution of the manuscript. However, because VSRE is proposed as a new index, a certain level of comparison with representative existing metrics remains necessary to demonstrate its added value and clarify how it differs from commonly used LiDAR-derived VSC metrics. In the subsequent revision, we will consider shortening or reorganizing this comparison, retaining only the most necessary benchmark metrics and moving non-essential details to the Appendix where appropriate. This will allow the manuscript to remain focused while still providing sufficient methodological validation.

Comment 4: *Third, the above comments naturally lead to my final suggestion. I encourage the authors to expand their discussion and interpretation of the national-scale mangrove canopy structural complexity map. After all, this topic is highlighted in the title of the paper and represents one of its most important contributions.*

Response: Thank you for this valuable suggestion. We agree that the national-scale mapping results deserve clearer interpretation, including the structural-complexity patterns observed in mangrove communities. In the revised manuscript, we will strengthen the discussion of the mapping results, especially where VSRE reveals structural variation that cannot be captured by vegetation classification or optical vegetation indices alone.

At the same time, we would like to clarify that the dataset and analysis presented in this manuscript cover coastal wetland vegetation as a whole, including both saltmarshes and mangroves. Therefore, while we will add more discussion of mangrove structural-complexity patterns where appropriate, we will keep the interpretation balanced across the major coastal vegetation types included in the study.

We also note that ESSD primarily emphasizes the description, quality, uncertainty, and potential use of data products, rather than extensive ecological hypothesis testing or over-interpretation of spatial patterns. Therefore, we will expand the discussion cautiously and proportionately, focusing on what can be directly supported by the dataset. In particular, we will add interpretation of regional differences in mangrove VSRE, the value of VSRE as a complementary structural layer, and its potential relevance for coastal wetland conservation and restoration, while avoiding unsupported mechanistic over-interpretation.