

Point by point response

Major Points:

Thank you for your very constructive and detail comments concerning our manuscript. Those comments are all valuable and very helpful for revising and improving our paper, as well as the important guiding significance to our researches. We have studied comments carefully and have made correction which we hope meet with approval.

1. Introduction, Line55: It is necessary to clarify the scientific issues existing in previous studies on pCO₂.

Response: The clarification content has been marked in red font in the article ‘Through summarizing previous research, it has been found that existing achievements mostly focus on independent analysis of local sea areas or zones, lacking a global perspective, and modeling methods do not fully consider the interactions between sea areas, which affects the accuracy of overall assessment.’

2. Line 94: pCO₂ 600 μ atm is considered an outlier in the article, but sufficient literature support or physical mechanism explanation is not provided.

Response: Corrected, please see lines 98, Corresponding references have been added.

3. Results and discussion: During the discussion, it is suggested to supplement some references and compare and discuss the results of this paper with those of previous studies.

Response: Corrected, please see lines 300, we have undertaken a thorough comparison of our model outputs with the datasets from Zhong et al. (2022) and the Copernicus Marine Service product.

4. Line 150: The transition between Section 3.1 (Correlation Detection) and Section 3.2 (Model construction and evaluation) feels somewhat abrupt. To enhance the logical flow, it would be helpful to briefly state at the beginning of Section 3.2 how the findings from the correlation analysis informed the subsequent modeling step.

Response: Done, please see lines 195.

5. Line 275: Describe missing and blank values in multi-source data

Response: Done, please see lines 283-286.

6. Line 290: To better showcase the novelty of your work, please add a direct comparison with the cited studies (Zhong et al., 2022; Chau et al., 2021)..

Response: Corrected, please see figure 9.

7. Line 320: Regarding the description of Figure 12, do the influencing factors of

PCO₂ in nearshore areas take into account river inputs or anthropogenic CO₂ emissions?

Response: We fully agree that river input and anthropogenic CO₂ emissions are key processes affecting the carbon cycle in nearshore waters. In the global scale modeling framework of this study, due to the significant regional heterogeneity of the above process and the lack of continuous and consistent observational data support on a global scale, it was not included as an independent driving factor in the random forest model. It should be noted that the biogeochemical parameters (such as pH, chlorophyll concentration, etc.) used in this model as comprehensive environmental indicators have indirectly responded to environmental disturbances caused by river inputs and human activities. Therefore, the reconstruction results of the model in nearshore areas have to a considerable extent reflected the comprehensive effects of these local processes.

8. Line 376: The text beginning at line 376 should be moved to a new "Conclusion" section. As this content serves as the concluding discussion for the entire study.

Response: Done, please see lines 389.

Some minor suggestions:

1. Line 14: It is recommended to correct the indefinite article for grammatical accuracy. "a ocean surface..." should be changed to "an ocean surface..."

Response: Done, please see lines 14.

2. Figure1: It is suggested to supplement the longitude and latitude

Response: Thank you for your suggestion. However, during the revision process, we have attempted to overlay latitude and longitude grids with scale markings. However, the research area has a large span and dense sub regions, and the newly added values significantly obscure the details of the original data and route information. As a result, the map tends to be cluttered and the readability significantly decreases.

3. Figure3: The variable represented by the horizontal coordinate needs to be marked

Response: Thank you for the reviewer's suggestion. We have examined Figure 3, where the x-axis represents the Spearman correlation coefficient (ρ). This statistic is a dimensionless indicator defined within the $[-1,1]$ interval, used to measure the strength and direction of monotonic relationships between variables. Therefore, according to the prevailing display standards in this field, physical units are usually not labeled.

4. Line 120: "d represents the level difference of the variable", d should be corrected to D.

Response: Done, please see lines 126.

5. Figure 3: o2 in the coordinate axis needs to be corrected

Response: Done, please see figure 3.