Response Letter

Dear editor,

We thank the Editor and reviewers for providing valuable comments to help improve our paper. Therefore, we submit the revision and a point-by-point response to address these comments.

Here is the summary of major changes in our revised paper.

1. Following the comment of Reviewer 1, we have revised the title and Figure captions to better convey the ideas. We also polished the manuscript to avoid grammer mistakes.
2. Following the comment of Reviewer 2. We newly added a paragraph in the Introduction part to highlight the important role of the South China Sea in the Studying of internal waves.
3. A new Figure and paragraph was added in Section 3 to validate the dataset with field observations.
4. Two new paragraphs are added to dicuss the potention error and limitations of the dataset and some outlooks of the dataset was added.

Regards,

Xudong Zhang
On behalf of all co-authors.

RC1:

To further improve the manuscript presentation, this reviewer gives the following suggestions.

Response: We thank the reviewer for carefully reading and providing detailed comments to improve the manuscript. We have revised the paper accordingly and the following are one-to-one responses for the valuable comments.

1. Change the title to "Statistical features of spatiotemporal distributions of internal waves in the northern South China Sea derived from MODIS imagery by deep learning approach".

Response: We have changed the title as advised.

2. Change the title of Section 3 to "Signature extraction and validation".

Response: We have changed the title of Section 3 as advised.

3. Change the title of Section 4 to "Statistical analysis".

Response: We have changed the title of Section 3 as advised.

4. Change the title of Sub-section 4.3 to "IW silence regions". It is not "new IW findings". See Figure 13a in Zhang et al., 2023, IEEE TGRS.

Response: We agree the silence regions are not new findings. We have revised the title.

5. Change the caption of Figure 5 to "Statistical histograms of IW pixel number vs the water depth for (a) the whole northern SCS (orange) and (b-e) four regions as shown in Figure 4 (blue)".

Response: We have changed the figure caption as suggested.

6. Change the caption of Figure 6 to "Statistical histograms of monthly distributions of IW days for (a) the whole northern SCS (orange) and (b-e) four regions (blue)".

Response: We have changed the figure caption as suggested.

7. Change the caption of Figure 7 to "Statistical histograms of IW pixel number vs the lunar day for (a) the whole northern SCS (orange) and (b-e) four regions (blue)".

Response: We have changed the figure caption as suggested.

8. Change the caption of Figure 8 to "IW silence regions (black arrows) in (a) Region 2 and Region 1 derived from superimposed IW location".

Response: We have changed the figure caption as suggested.

9. Wording and writing need further improvement. Take a sentence from L189 to L191 as an example.

> As shown in Figure 4, We classified we divided the detected IW locations into four regions 1 - 4, according to the spatial locations. Region 1 includes which covers the area between from 112.5°E to -114.2°E and from 18.5°N to-20.9°N,; Region 2 includes the area between from 114.2°E to-118.1°E and from19.5°N to-22.2°N,; Region 3 includes the area between from 118.1°E to-120.0°E and from 22.0°N to-223.80°N,; Region 4 includes the area between and from 118.1°E to-120.5°E and from 19.5°N to -22.0°N, respectively.

Response: We have fixed the sentence and improved the overall writing in the revised paper using Grammarly and other language polishing software.

RC2:

This study offers a valuable dataset of internal waves (IWs) in the northern South China Sea, employing advanced deep learning techniques to extract high-resolution data. The analysis of spatial and temporal IWs distributions, along with the identification of key patterns and regional characteristics, significantly enhances our understanding of IWs dynamics. However, some minor revisions are required before acceptance by ESSD.

Response: We thank the reviewer for the constructive comments. We have revised the paper accordingly and the following are point-to-point responses for the valuable comments.

1. Confirm whether the abstract needs to mention the described data and include the DOI number.

Response: we have added the DOI number for the dataset in the abstract.

2. The introduction lacks sufficient detail about the South China Sea and does not adequately explain the reasons for studying this region. It would be beneficial to include information on the complex topography, circulation patterns, eddies, Kuroshio intrusion, and other dynamic processes. Additionally, consider discussing the current challenges in IWs research and the necessity of releasing this dataset to address these issues. Relevant references include Liu et al. (2016), and Xu et al. (2020).

Liu, T., Xu, J., He, Y., Lü, H., Yao, Y., & Cai, S. (2016). Numerical simulation of the Kuroshio intrusion into the South China Sea by a passive tracer. Acta Oceanologica Sinica, 35, 1-12.

Xu, J., He, Y., Chen, Z., Zhan, H., Wu, Y., Xie, J., ... & Cai, S. (2020). Observations of different effects of an anti-cyclonic eddy on internal solitary waves in the South China Sea. Progress in Oceanography, 188, 102422.

Response: we have revised the manuscript to highlight the SCS as a hotspot for IW studies while also having active multi-scale dynamic processes. Six new references are added:

1. Dong, D., Yang, X. F., Li, X. F., and Li, Z. W.: SAR Observation of Eddy-Induced Mode-2 Internal Solitary Waves in the South China Sea, IEEE Trans. Geosci. Remote Sensing, 54, 6674-6686, 10.1109/Tgrs.2016.2587752, 2016.
2. Liu, B., Yang, H., Zhao, Z., and Li, X.: Internal solitary wave propagation observed by tandem satellites, Geophys. Res. Lett., 41, 2077-2085, 10.1002/2014GL059281, 2014.
3. Liu, T. Y. and Abernathey, R.: A global Lagrangian eddy dataset based on satellite altimetry, Earth System Science Data, 15, 1765-1778, 10.5194/essd-15-1765-2023, 2023.
4. Liu, T. Y., He, Y. H., Zhai, X. M., and Liu, X. H.: Diagnostics of Coherent Eddy Transport in the South China Sea Based on Satellite Observations, Remote Sens., 14, 10.3390/rs14071690, 2022.
5. Liu, T. Y., Xu, J. X., He, Y. H., Lü, H. B., Yao, Y., and Cai, S. Q.: Numerical simulation of the Kuroshio intrusion into the South China Sea by a passive tracer, Acta Oceanologica Sinica, 35, 1-12, 10.1007/s13131-016-0930-x, 2016.
6. Xu, J., He, Y., Chen, Z., Zhan, H., Wu, Y., Xie, J., Shang, X., Ning, D., Fang, W., and Cai, S.: Observations of different effects of an anti-cyclonic eddy on internal solitary waves in the South China Sea, Prog. Oceanogr., 188, 102422, 10.1016/j.pocean.2020.102422, 2020.

3. For Figure 4, please clarify the criteria used for dividing the study area into Regions 1, 2, 3, and 4.

Response: We have added the criteria in the revised manuscript as: "The division was based on the geometry of IW crests, which suggest distinct sources for Regions 1 and 3, and different life stages of IWs before and after they propagate from the deep ocean to the continental shelf areas in Regions 2 and 4.".

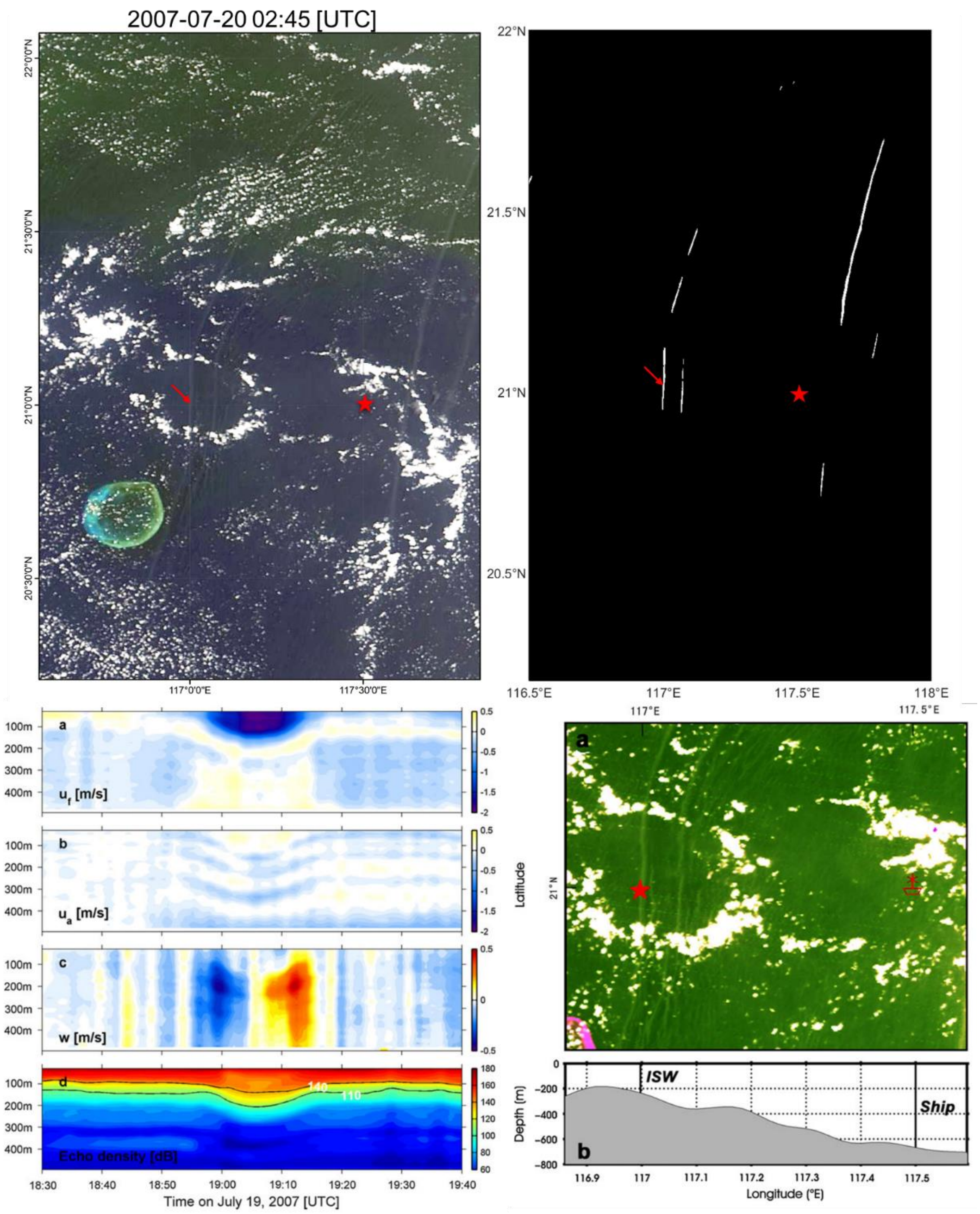
4. The dataset primarily focuses on IWs in the South China Sea. It would be helpful if the authors could provide a rough estimate of the proportion of internal solitary waves versus internal tides in the dataset.

Response: Internal solitary wave (ISW) can be well detected by MODIS image because the ISW-induced surface capillary waves can modulate the energy received by the MODIS sensor. Hence, the ISW manifest as alternating bright and dark bands on MODIS images. However, internal tide can not be observed directly by satellite images. Because internal tide has larger scale than ISW and less amplitude or weaker wave-induced currents. Only the altimetry data can detect the internal tide by measuring the tide associate surface elevations. In this paper, we detect the ISW signatures based on the alternating bright and dark band features of IWs. So the dataset contains only the ISW signals, without the internal tide signals.

5. Given the extensive accumulation of Argo profiles (or other observations), it would be interesting if the authors could provide a few examples matching identified IWs and show the vertical T/S profiles. This would demonstrate the actual presence of IWs and offer stronger validation of the dataset.

Response: Thank you for the advice! The internal solitary wave (ISW) has very short characteristics and wavelength along its propagation direction, usually in the order of 1 km. Considering the fast propagation speed, the ISW can propagate across a specific point in less than 30 minutes. Every 10 days the Argo floats descend to 2,000 meters and then collect a vertical profile of temperature and salinity during ascent to the surface. So the Argo profile can hardly capture the ISW signal. Usually mooring observation working in high frequency (sampling frequency less than 10 minutes usually in 1 or 3 minutes) was used for ISW vertical structure study. The mooring observation data is difficult to obtain as we showed in a previous study in the Andaman Sea (Zhang et al., 2022).

Nevertheless, we compared our results with previously published work by Zhao et al. (2012) in the SCS, and the results are shown below. The field observation was conducted using 75kHz ADCP and CTD. The red arrow in supplement Figure 1 indicates the ISW detected by the satellite images as well as field observation. An ISW was well detected with an obvious amplitude of several tens of meters and wave-induced vertical currents exceeding 0.5 m/s. Since we do not have the copyright for using the mooring data, in the revised manuscript, the field observation data is cited but not used.



Supplement Figure 1. The top panels show the Terra MODS image and IW locations in the dataset. The bottom panels show the mooring and MODIS observations taken from Zhao et al. (2012).

Reference

Zhao, W., Huang, X., Tian, J., 2012. A new method to estimate phase speed and vertical velocity of internal solitary waves in the South China Sea. Journal of Oceanography 68, 761-769.

Zhang, X., Wang, H., Wang, S., Liu, Y., Yu, W., Wang, J., Xu, Q., Li, X., 2022. Oceanic internal wave amplitude retrieval from satellite images based on a data-driven transfer learning model. Remote Sensing of Environment 272, 112940.

6. Besides its use in validating numerical models, the dataset's potential applications could be further expanded. For example, it could be employed in studying IWs interactions with other processes, enhancing IWs monitoring and prediction systems, and supporting broader climate and oceanographic research. Expanding this discussion would underscore the dataset's broader impact and versatility, encouraging its use across various fields.

Response: We have expanded the dataset discussion in Section 5, highlighting its importance in studying multi-scale dynamic process interactions and artificial intelligence-based studies. Two paragraphs are expanded as follows:

"The generated IW dataset potentially advances our understanding of IW characteristics in the northern SCS. By analyzing the spatial and temporal distributions of IWs based on the collected MODIS images, researchers can gain insights into the region's prevalent locations and seasonal variations of IW activity. This dataset also provides valuable information for studying the interactions between IWs and mesoscale ocean phenomena, such as eddies, facilitating further investigations into ocean dynamics (Li et al., 2016; Xie et al., 2016). The cyclone and anticyclone mesoscale eddies can cause vertical fluctuations in ocean temperature isopleths and accompany currents, affecting characteristics such as the amplitude and propagation direction of IWs. By analyzing the IW spatial and temporal information provided in this dataset, changes in IW characteristics after passing through different types of eddies can be statistically examined over longer timescales. Additionally, other dynamic phenomena, such as the intrusion of the Kuroshio current, also affect the generation and propagation of IWs in the SCS. Analyzing the statistical characteristics of IWs across different seasons and years can enhance understanding of how dynamic phenomena like the Kuroshio affect the IW generation and propagation process, ultimately improving the study and knowledge of multi-scale dynamic interactions in the SCS.

Moreover, the availability of this extensive IW dataset is crucial for advancing artificial intelligence oceanography studies. It serves as valuable ground truth data for validating IW generation or forecast models, allowing researchers to assess the performance of AI models by comparing their predictions with the dataset-provided IW locations. The dataset serves as a validation tool for numerical simulations (Gong et al., 2023), enabling researchers to refine and improve numerical models based on the observed IW distributions. This dataset can also serve as a benchmark for collaborative observations of IWs in the SCS with other satellite sensors or field measurements, thereby facilitating the construction of matched datasets to support IW research with artificial intelligence technologies."

7. As this dataset is derived from observational data, it is important for the authors to discuss its limitations and potential sources of error. Additionally, since the current dataset includes only surface information, consider exploring the potential for future versions to incorporate 3D data. This would provide deeper insights into the vertical structure of internal waves and enhance the dataset's overall utility.

Response: Thank you for the advice. We have added a new paragraph to discuss the limitations and potential sources of error of the built dataset in Section 5. In addition, we also expand future outlooks for the potential vertical structure of IWs.