To: Editor-in-Chief

Earth System Science Data (ESSD)

Copernicus Publications

Dear Editor,

We are pleased to submit our revised manuscript entitled: "Two Centuries of Oceanographic Data in the Indonesian Seas and Surroundings: Historical Patterns of Data Availability, Gaps, and Future Challenges" for consideration for publication in *Earth System Science Data (ESSD).*

This manuscript presents a comprehensive, quality-controlled compilation of oceanographic observations spanning over two centuries in the Indonesian Seas, one of the world's most dynamic and climatically significant marine regions. By consolidating data from multiple international and national sources—including Argo, GOOS, WOD, INAGOOS, and BRIN—this dataset provides a robust foundation for regional and global oceanographic research, climate modeling, and Earth system studies.

We thank the reviewers for their positive evaluation of our work and constructive feedback. Please check below the cover letter for our response. In general, we agree with the reviewer comments and revised the content:

1. Improved manuscript structure and readability: Section 4 has been dissolved and its unique insights integrated into the Methods and Results sections, streamlining the narrative and reducing redundancy. We have also enhanced Section 3 to better contextualize the physical setting, data sources, station distribution, and historical progression of observations.
2. Clarified historical trends: To avoid ambiguity, we revised the manuscript and figures to make clear that the trends discussed pertain to historical patterns of data availability, not changes in ocean variables. Figure 8 now defines cast density categories (Q0–Q6), explains red lines as high-traffic shipping lanes, and indicates empty grid cells with open circles.
3. Enhanced clarity and grammar: The manuscript underwent a thorough language and spell-check, correcting grammatical errors and incomplete sentences to improve readability throughout.
4. Updated figures and data presentation: We revised Figure 6 with an improved color scheme for better contrast and readability, aggregated country contributions by continent or region in Figure 5, and added clarifications to Figures 7 and 8.
5. Clarified modeling statements: Text describing the impact of observational gaps on ITF climate models has been revised to emphasize that limited data constrain model evaluation and confidence, rather than being the direct cause of simulation errors.

The manuscript continues to highlight the vital role of the Indonesian Seas in global climate and ocean circulation, identifies remaining gaps in historical data, and provides openly accessible datasets to support ongoing and future research.

Thank you for considering our manuscript for publication. We look forward to your response.

Sincerely,

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RC2 Matrix

General Evaluation

This manuscript delivers a valuable and comprehensive collation of two centuries of oceanographic observations in the Indonesian Seas, tracing how spatial coverage of key variables has evolved over time. The detailed source descriptions and clear maps provide a solid foundation for researchers seeking to understand both the strengths and the remaining gaps in this dataset. Overall, the work represents an important reference for the community and will spur targeted efforts to fill critical historical voids.

We thank the reviewer for their positive evaluation and recognition of our efforts in compiling two centuries of observations. We are pleased that this work is considered a strong foundation, and we emphasize that the Indonesian Seas play a vital role in the era of climate change. By identifying strengths and gaps in historical data, we aim to support future efforts that enhance monitoring and improve understanding of this critical region.

However, a few aspects should be addressed before this paper is suitable for publication in Earth System Dynamics.

Main points:

1. There is some structural redundancy that hinders readability. In particular, Section 4 feels very repetitive, as it revisits content already discussed in the Results and Methods, merely adding further depth. I recommend dissolving Section 4 and blending its unique insights into the appropriate Methods or Results sections. This consolidation will streamline the manuscript, enhance readability, and prevent readers from navigating through repetitive content.

   Thank you for your input. We agree with your suggestions and have revised and restructured the content accordingly. Additionally, we have made corrections throughout the manuscript and added further information in Section 3 to enhance clarity and completeness.

   Now, the section begins with the physical setting, showing how tides, the Indonesian Throughflow (ITF), monsoon currents, ENSO, IOD, and bathymetry affect ocean–atmosphere interactions and ecosystem productivity in the Indonesian Seas. Since the 1990s, regional studies have focused on specific phenomena in specific locations, such as upwelling and eddies off southern Java, the ITF in the Banda and Makassar Straits, and eddies and the warm pool in northern Papua. Next, data sources are highlighted, including Argo, GOOS, WOD, INAGOOS, and BRIN. Station distribution highlights the roles of Indonesian government agencies and international partners in expanding observational coverage. After screening for redundancy, bias, and poor-quality records, big datasets like XBT, Argo, and EWOCE were reduced. The section then returns to history, noting that early observations in the 19th and early 20th centuries were scarce due to inadequate technology, colonial missions, and delays in archiving. The account then covers the global increase in observations between the 1940s and 1970s, driven by naval priorities and international projects

such as WOCE, before returning to Indonesia and describing the 1967 founding of LIPI (later merged into BRIN), which initiated systematic national oceanographic programs. The emergence of Argo floats, satellites, and moored buoys in the 2000s revolutionized data collection but also led to a drop in casting due to cost and logistical constraints. The US, Japan, Australia, and China are heavily involved, but Indonesia, Malaysia, and the Philippines are underrepresented despite their vital locations. Data from international shipping corridors leaves archipelagic and deep-sea regions underrepresented, causing sample biases. Temperature and salinity dominate records due to their ease of measurement, while dissolved oxygen, nutrients, and pH are scarce despite their importance for climate and ecosystem studies.

2. The title promises to assess historical trends is undermined by ambiguity. It is unclear whether the authors refer to trends in data coverage or to actual temporal changes in the ocean variables. Indeed, Figure 8 (the only one showing trends) is hard to interpret: the dot colors lack reference to a specific temporal window, the colorbar uses absolute units without temporal context, and the red contour line is unexplained. The manuscript should define the temporal windows used for each trend calculation, state trend units and magnitudes (e.g., °C decade^{-1}), and detail the statistical methods (linear regression, significance testing) used to compute and characterise these trends.

    a. [Title]. Thank you for this constructive comment. We have revised the manuscript to clarify that the trends discussed in this study pertain to historical patterns of oceanographic data availability, rather than temporal changes in ocean variables. Accordingly, the manuscript title has been updated to: *"Two Centuries of Oceanographic Data in the Indonesian Seas and Surroundings: Historical Patterns of Data Availability, Gaps, and Future Challenges."*
    b. Thank you for the suggestion. We have clarified that Figure 8 depicts historical patterns of data availability rather than trends in ocean variables. We have also enhanced the figure and now clearly define the cast density categories (Q0–Q6) and their corresponding ranges, as shown in the legend. The red lines indicate high-traffic shipping lanes, where sampling has historically been concentrated. Open circles denote grid cells without data. This revision ensures that readers can interpret the spatial distribution of historical oceanographic observations with clarity and precision.

3. The paper is generally well written but contains a few grammatical errors and incomplete sentences that sometimes hinder the understanding. I recommend a thorough spell-check and language edit to ensure clarity throughout.

    We thank the reviewer for bringing this point to our attention. We have carefully revised the manuscript to correct grammatical errors and incomplete sentences, and we conducted a thorough language and spell-check to improve clarity throughout the text. Please check the track changes mode.

Addressing these points will sharpen the paper's focus and ensure that its key contributions, both in data synthesis and trend analysis, are presented with maximum clarity and impact.

Other additional points:

Lines 49-50: Rewrite to "These modes of variability influence weather and regional climate via air-sea interactions…"

Thank you for your suggestion. We have changed the mentioned sentences.

Lines 56-57: Can you elaborate on how the lack of observations affects projections? These are simulations run with coupled global climate models that are not initialized from observations.

Thank you for your suggestion. We have added the necessary information.

Line 65: What do you mean by “has been emphasized”?

Thank you for your comment. The intention was to inform that the combination of in-situ and satellite technology have been emphasized as necessary. We have revised the sentence structure.

The global system for observing the ocean combines **in-situ technologies** (such as sensors and instruments placed directly in the ocean) and **satellite technologies** (which observe the ocean from space). This combination (integration) has been **highlighted and emphasized as important** in studies by **Garzoli et al. (2010)** and **Weller et al. (2019)**.

Line 66: Please rewrite. You mention twice the word challenge but in both instances it is unclear what specific challenges you refer to.

Thank you for your comment. We have added additional information to enhance clarity.

Lines 74-75: The phrasing is unclear. What do you mean by “as fast as possible in (near) real-time”?

Thank you for your comment. The intention was to inform that the early warning system should be delivered to the community as quickly as possible. We have revised the mentioned phrase.

Lines 132-133: What potential collaborations do you refer to? Also, it is hard to reconcile the first part of the sentence with the second. You mention that there is no governmental data available and at the same time say that you use open-source data. If this later is not from governmental sources you should specify it.

Thank you for your suggestion. ‘Potential collaborations’ refers to cooperation to improve oceanographic data recording capabilities in Indonesia. We have added the necessary information.

Lines 147-148: This sentence has no verb.

Thank you for your comments. We have modified the mentioned sentences. Also we have revised in the whole file related to grammatical errors and thypos.

Lines 170-171: Did you also check if the actual values were the same as a final proof that the data was actually duplicated?

Thank you for your comments. We checked the actual values as well. The sentences have been modified.

Lines 215-227: You should use verb tenses consistently throughout the paragraph

Thank you for your comment. We have checked the verb tenses and made necessary changes.

Lines 244-246: Note that some word are capitalized but they shouldn’t (i.e. A, Calculation)

Thank you for your comment. We have checked the capitalization and made necessary changes.

Lines 262-268: You define a category for empty cells and Q1-Q5 quantile bins, which does not seem appropriate for separating in 6 quantiles. I suggest separating "No Data" (or call it Q0) and then defining six true quantile bins Q1-Q6 (0.1-16.7%, 16.7-33.3%, …, 83.3-100%). This will make it semantically clear and align each bin with its exact percentile range.z

Thank you for your comment. The calculation was executed exactly as you suggested. However, we have realized that some writing errors caused a misunderstanding. Nonetheless, we have solved the mentioned issue

Lines 330-334: Could you elaborate, or at least hypothesize, on why measurements have dropped so drastically in the most recent period? I find this surprising, given the dense observational network active from the 1950s through the 1990s and the fact that global measurement counts have actually risen over the last decade.

Thank you for your comment. We hypothesized that the monetary crisis in the late 1990s and COVID-19 negatively affected to the in-situ data retrieval in Indonesia.

Lines 348-351: It would be more useful if you discuss global numbers in parallel with those specific to the ISS region. Indeed, these global numbers do not illustrate the evolution in the ISS region, which indeed experienced a decrease in stations over the last 2 decades.

Thank you for your suggestions. We have added the total global stations as a comparison.

Lines 368-369: Some of this information is repeated from the last sentence in the previous paragraph. Please avoid repetition.

Thank you for your comments. We have made changes in the mentioned paragraph.

Lines 368-377: Instead of repeating the numbers from the plot for individual countries, it would be more interesting to aggregate some together, for example, for the different continents or geographical areas (Europe, North America, Australia, Southeastern Asia...).

We thank the reviewer for this suggestion. In the revised manuscript, we have aggregated the contributions by continent and major geographical regions (e.g., Europe, North America, Australia, Southeast Asia) rather than reporting individual country percentages. This provides a clearer overview of regional contributions while still highlighting key patterns, such as the significant portion of "Unknown" data (17.37%) and the minimal contributions from certain countries. Please check the paragraph after Figure 5

Figure 6: The choice of colors hinders the readability of the plots, as several regions have very similar color shades, and is therefore very difficult to distinguish them.

We thank the reviewer for this observation. Actually, we follow the guidance from ESSD to make readable to blind colours persons. All the figures used crameri colours types. However, in this figure, we have revised Figure 6 by updating the colour scheme to improve contrast and readability, making it easier to distinguish the different regions. Please check Figure 6

Figure 7: Could you be a bit more specific on what the plot is actually showing? I can't even tell if the first two sentences refer to the plot

Thank you for your comments. We have changed the figure location and added additional information to ensure the clarity.

Figure 8: Can you clarify if you are showing total counts of casts per grid point over the whole observational period?

Thank you for your comment. It is true that the figure is showing total counts of casts per grid point over the whole observational period. We have added additional information for better clarity

Lines 609-611: The sentence as it is written implies that scarce observations actually cause model errors. In reality, model biases in ITF variability stem from incomplete or imperfect representation of physical processes. The primary impact of limited high-resolution data in Makassar and Lombok Straits is that it prevents rigorous evaluation and validation of those model simulations, rather than introducing the errors themselves. You might rephrase to clarify that observational gaps constrain our confidence in model performance, rather than being the root cause of simulation inaccuracies.

We thank the reviewer for the clarification. We have revised the text to emphasize that observational gaps constrain our confidence in model evaluation, rather than being the direct cause of simulation errors.

Revised sentence:

"Second, while the data cover extensive depths, availability varies across the region, with some areas providing measurements up to 6000 m while others are limited to only 800 m. These gaps limit the ability to rigorously evaluate ITF climate models, affecting confidence in predictions of ocean heat transport, monsoon variability, and ENSO dynamics. For example, as the main pathways of the ITF, the limited high-resolution subsurface data in Makassar Strait and Lombok Strait constrain the assessment of coupled climate models' performance in simulating ITF variability, which in turn impacts estimates of Pacific–Indian Ocean exchange. Similarly, the scarcity of deep-sea data in the ISS complicates assessments of long-term heat storage and ocean circulation changes, critical for understanding regional climate feedback (Figure 8)."