Referee #2

The manuscript presents an updated version of the Global Lakes and Wetlands Database (GLWD), which integrates modern ground and satellite-based data to create a harmonized global map of inland surface waters and wetlands. This update provides enhanced resolution and additional classification layers compared to its predecessor (GLWD v1), offering a more detailed and consistent representation of inland surface waters. The contribution is substantial and timely, addressing critical gaps in the representation of wetlands and their dynamic properties, which are crucial for studies in hydrology, ecology, and environmental management.

RESPONSE: We are very thankful for the overall positive review of the Referee and the constructive comments and suggestions. Following all Referee comments, we prepared a major revision of our manuscript that hopefully addresses all concerns raised. As we noticed several overarching themes shared by both Referees #1 and #2, we would like to start by responding to three general issues before a more detailed point-to-point discussion is provided.

General Response (for both Referees #1 and #2)

1. While acknowledging that our new global wetland database provides a substantial and timely contribution to research, there are several comments suggesting the manuscript should contain more explanations on how this database could be used, what kind of applications might be possible, how to integrate it with other data or models, and/or how to increase its usefulness for interdisciplinary research. We appreciate this concern. In the original manuscript, we state in the Abstract that "*GLWD v2 is designed to facilitate large-scale hydrological, ecological, biogeochemical, and conservation applications*", which we kept short due to the desired brevity of the abstract. The original Introduction provides some examples of possible applications of global wetland maps, including "*to quantify [the role of wetlands] within the water, carbon, and nutrient cycles, to plan conservation and restoration actions, to assess and manage human interactions and pressures, … to set a global baseline to contextualize long-term degradation of wetland ecosystems and forecasted risks from climate change, … [and to] monitor the progress towards global targets, such as to track changes in the extent of water-related ecosystems over time as mandated by the UN's Sustainable Development Goal 6.6*" (original lines 70-80, with multiple citations). The Introduction also points out that the predecessor version of our map (i.e., GLWD v1) has been applied for "*advanced research and conservation planning addressing freshwater biodiversity, ecosystem services, greenhouse gas emissions, land surface processes, hydrology, and human health*" (original lines 44-45). Similarly, in the Conclusion section, we suggest that our product can be used to "*inform large-scale conservation strategies, Earth system modeling, and international policy making … such as the Convention on Biological Diversity (CBD), the Convention on Migratory Species (CMS), the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), the Ramsar Convention on Wetlands, and the United Nations Framework Convention on Climate Change (UNFCCC), among others*" (original lines 855-866).

   To avoid repetition with these statements, we carefully expanded the Introduction and Conclusions sections to accommodate the Referees' requests for more application examples. In the Introduction, we added that global wetland maps are needed to "*guide effective resources management, … as well as to offer interim data to countries currently lacking (or having outdated) national inventories*

(Davidson et al., 2018)." We also added that "*as a critical input to hydrologic and Earth system models, global lake and wetland distributions are of particular interest for current and future water resources assessments, carbon and nutrient budget calculations, climate change projections, and other large-scale land surface studies (e.g., Bullock & Acreman, 2003; Lauerwald et al., 2023).*" In the Conclusions, we added that "*the design of GLWD v2 as a set of 33 individual but complementary wetland layers is expected to facilitate the study of specific wetlands of interest while remaining consistent with the total global wetland extent and distribution.*"

Finally, we would like to respectfully note that the predecessor database of GLWD v1 is a similar product to GLWD v2, yet at lower resolution, with less wetland classes, and of substantially lower quality. Despite these shortcomings, the GLWD v1 database has been utilized in a broad range of often interdisciplinary studies which led to more than 2,500 publications (according to Google Scholar). As GLWD v1 is still widely used today, we believe this provides strong evidence of the general applicability of the GLWD databases.

2. Both Referees #1 and #2 raised concern over the fact that GLWD v2 only provides a static product of wetland extents (despite some temporal aspects being represented in the form of seasonal or ephemeral classes). This diminishes the value of GLWD v2 compared to datasets that show dynamic changes for applications requiring a timeseries of wetland extents. We agree with this observation in principle. However, we would also like to note that while saturation or inundation levels may fluctuate, the definition of a wetland as an ecosystem type is more holistic. I.e., a wetland still exists if it is in a drier phase, or a dry state, whether following an annual or decadal cycle. The dry state is part of the ecological condition of a wetland, and as such the extent of the wetland is not dependent on seasonal or interannual fluctuations. The goal of GLWD v2 is to represent the contemporary extent of wetlands from an ecosystem perspective, not a time-resolved inundation perspective. And for that specific goal, we believe that a static map is the appropriate approach. We added an abbreviated version of this explanation to the Discussion (section 5.3) in the manuscript to clarify the value of static wetland maps.

   In the original manuscript, we state the 'static' nature of GLWD v2 in the Abstract, and we discuss this 'shortcoming' prominently in the Discussion section (original lines 821-830). Given the concerns raised, we expanded on this discussion in the revision and reframed some parts of the text to describe GLWD v2 more clearly as complementary to (rather than rivaling) temporal datasets. Our goal is to present GLWD v2 as a unique and useful placeholder (or baseline product) until temporally dynamic products with full classifications become available. We are not aware of any existing product that can provide dynamic wetland extents and a comprehensive classification together. The closest may be the GWL_FCS30D wetland map by Zhang et al. (2024) which provides a timeseries from 2000-2022 for 8 wetland classes (compared to the 33 classes of GLWD v2). We took the opportunity of the revision to reword and emphasize (in section 5.3) the importance of static wetland classes in conjunction with maps that provide dynamic wetland extents. And in the existing section 5.4 on the "*Future of mapping wetland ecosystems globally*", we highlight existing endeavors towards creating classified and dynamic wetland maps. Nonetheless, the main intention and focus of our manuscript is to describe GLWD v2, i.e., a static product, rather than to substantially expand on the discussion of advantages or disadvantages when compared to dynamic products.

3. Both Referees #1 and #2 requested a more thorough validation and additional comparisons with other datasets, including with the predecessor database GLWD v1, remote sensing products, and/or field studies. We fully agree with the desire to provide as much validation and as many comparisons as possible. In the original manuscript, Figure 1 shows a comparison of GLWD v2 against 27 other global wetland mapping products or data sources that we are aware of, including GLWD v1 (comparing both spatial and temporal resolutions, as well as discrepancies in their classification methods). Furthermore, and most centrally, Table 4 provides comparisons against >70 individual study results, remote sensing products, and field assessments at global and regional scales, broken down by wetland types, and including some individual wetland areas, across all continents. This table provides upper and lower bounds for each of the comparisons. Table 4 is based on a major literature review and designed as a concise validation table, and we discuss this table in sections 4.3.1 and 4.3.2 in the text, including observed agreements or outliers. Inherently to the design of GLWD v2, we also face the challenge that many of the most reliable input datasets for each wetland class are already included in GLWD v2, leaving remaining independent comparisons (against potentially inferior products) to be less informative.

   That said, we addressed the Referees' comments to include more comparisons and validation by revising the manuscript in several major ways:

   - We added a new Table A1 in Appendix A which contains the basic characteristics of each of the comparison datasets shown in Figure 1.
   - We made it clearer in the manuscript that Table 4 already includes a wide variety of comparison data, from regional to global, including both remote sensing and field-based products. Furthermore, we added a new Table A2 in Appendix A in which we list all data sources shown in Table 4 individually, including a brief description of the main characteristics of each data source (e.g., field-based vs. remote sensing product).
   - We added a validation of GLWD v2 against ~25,000 verified point observations of wetland presence/absence globally (new section 4.3.3, including two new tables). As the validation dataset (compiled by Zhang et al., 2023) is not publicly available, we invited 2 co-authors of that team to join our manuscript.
   - Furthermore, we conducted a statistical comparison (including a confusion matrix) of GLWD v2 against GLWD v1 to show the substantial changes in the upgrade (new section 4.3.4) and a mostly visual comparison of GLWD v2 against GWL_FCS30 by Zhang et al. (2023; 2024), i.e., a multi-class remote-sensing product (new section 4.3.5, including a new figure).
   - Finally, we created an additional table showing the breakdown of all GLWD v2 wetland extents by class and country. Given the size of this table, it cannot be presented in the Appendix of the manuscript, so we opted to add it as Supplementary Information, and we point to it from within the text. We hope this can facilitate that users with national knowledge about wetland distributions can judge the overall quality of GLWD v2 for their own regional or local assessments.

   In total, our major revision related to validation and comparison analyses added 6 new tables (1 in manuscript, 4 in Appendix, 1 in Supplementary Information), 1 new figure, and >3 pages of new explanations and discussions, including statistical performance indicators. We hope these additions will sufficiently improve the presentation of the GLWD v2 database and allow readers to judge its validity.

Major Points:

1. I recommend emphasizing the distinct applications and improvements over other recent global wetland datasets. While the paper touches on this, a more detailed comparative analysis between GLWD v2 and existing databases (e.g., GIEMS, GLOWABO) would strengthen the argument for its uniqueness and applicability in contemporary research.

   RESPONSE: We appreciate this comment. In our major revision, we made several substantial additions to the manuscript which we describe in our **General Responses #1 (applicability) and #3 (comparisons)**. Specifically, comparisons to the GIEMS and GLOWABO datasets are already shown in Fig. 1 and in Table 4. But we would also like to point out that GIEMS and GLOWABO are rather different databases compared to GLWD v2; i.e., GIEMS, which is fully integrated in GLWD v2, only provides inundation extents rather than a wetland classification, and GLOWABO only refers to the single class of lakes (without further distinction into reservoirs or saline lakes).

2. While the authors acknowledge persistent issues in defining and classifying wetlands globally, consider proposing potential solutions or standardization efforts to improve consistency in future wetland mapping initiatives. Since the authors mention that there are very significant differences in the definitional criteria for wetlands used in different data products or studies, are the wetland classification criteria used in this dataset comparable to those used in other studies, and are the wetland products obtained comparable to other products?

   RESPONSE: These comments and suggestions are well taken as the problem of different wetland definitions is at the very core of why wetland mapping products or extent estimates are so difficult to create and compare. We feel, however, that this question is going beyond the scope of our database paper which aims to simply describe a new data product. Unifying or standardizing the definitions of wetlands is a momentous challenge that would require international and authoritative input from many organizations that are not represented by the co-authors of this manuscript. Therefore, we are hesitant to expand our manuscript towards proposing new wetland definitions. Rather, our manuscript aims to be as transparent as possible in the description of our product, and we already propose a crosswalk table to other wetland definitions (Table 5 in original manuscript; now Table 6) in order to make GLWD v2 as useful and clear as possible for future studies.

3. Clarify and potentially expand on the validation methods used to assess the accuracy of the new dataset. Although the area estimates of GLWD V2 was compared with other datasets, please consider comparing results against independent observations or field data where possible. I recommend adding a section that describes field-based or independent validation efforts for other wetland types, especially in regions with significant wetland coverage, such as Southeast Asia or the Amazon basin, to compare GLWD v2 classifications against in-situ observations or higher-resolution local datasets. This would provide empirical validation of the classification system and spatial accuracy.

   RESPONSE: We acknowledge the request for more validation, in particular field-based and in situ comparisons. We would like to refer to our **General Response #3** which outlines the additional assessment that we conducted in the major revision of our manuscript to address this concern. In particular, the comparisons shown in Table 4 already include regional and higher-resolution datasets, such as those for the Amazon Basin or various regions in Southeast Asia (Indonesia,

India), and we hope that our new Table A2 in Appendix A, which lists and briefly describes each of the comparison datasets, will increase clarity about this. In terms of validation, we add a comparison against a validation dataset of ~25,000 individual point locations of wetland presence/absence observations across the world.

4. Are there inconsistencies or conflicts between the 25 major global data products used to generate the GLWD V2 data? What measures have been taken in this work to avoid the impacts on wetland classification when there are inconsistencies between the surface types of the input data (e.g., the HydroLAKES and Global Surface Water dataset, these two estimates are highly inconsistent)? reported by Rajib et al., (2024): A call for consistency and integration in global surface water estimates)? Is it possible to be specific in the section on selection criteria for input data (coherency between datasets)?

   RESPONSE: We fully agree with the call made by Rajib et al. (2024) for more consistency and integration in global surface water estimates, and we added this new reference to our manuscript. We believe that the creation of GLWD v2 and its transparent description of input sources and integration techniques follows this call. There are indeed many inconsistencies and conflicts in the original data sources used to create GLWD v2. We aimed to describe those differences succinctly in Table 1 (now with added descriptions of major limitations of the input datasets), and then we explain in the detailed Methods sections how we treated each dataset in the amalgamation process. In particular, section 3.1 provides an overview of the methodology including the main approach that we followed to avoid that inconsistencies in the input data transgress into our results, namely by a) selecting only one input data source per wetland class rather than merging many inconsistent ones; and b) creating a hierarchy of input datasets whereby the higher ranked classes receive priority over (possibly inconsistent) lower ranked datasets. The main selection criteria and ranking decisions of datasets are described in lines 258-279 (of the original manuscript), and the hierarchy is shown in Figure 3 (now updated to add clarity). Despite all attempts to reduce issues of inconsistencies and duplication, we discuss this as a main source of uncertainty of our product in lines 788-803 (original manuscript; now slightly expanded and reworded for clarity).

5. While GLWD v2 is described as a static map representing contemporary conditions, and although they provide more detailed wetland classification information than the previous version of the data, they cannot be used to quantify seasonal fluctuations and inter-annual scales in wetland ecosystems. The importance of the data is diminished by the fact that wetlands can change significantly over relatively short periods of time. The authors may need to go into more depth to explain the critical role of this wetland classification information and potential application scenarios to highlight the importance of this dataset.

   RESPONSE: We fully acknowledge the shortcomings that stem from the fact that GLWD v2 is a static database, and we agree that it should not be used as a stand-alone database to quantify seasonal fluctuations and inter-annual trends. See also our **General Response #2** regarding this issue. In fact, we state and discuss this shortcoming in lines 821-830 of the original manuscript, and we further expanded on these explanations in the revision. Please also note our explanation as part of our **General Response #2** regarding seasonal fluctuations in the extent of inundation or saturation, which is not the same as a fluctuation in the extent of the wetland ecosystem itself

as the dry state is part of the ecological condition of a wetland. Finally, please also refer to our **General Response #1** about the applicability of GLWD v2.

6. Offer more detailed guidance on appropriate uses and limitations of the dataset for various applications. This could help users better understand how to effectively utilize the data in different contexts.

   RESPONSE: We would like to refer to our **General Response #1** regarding the applicability of our static but classified global wetland map.

7. Discuss integration with other datasets: Explore how GLWD v2 could be integrated or used in conjunction with other global environmental datasets (e.g., land cover, climate data) to enhance its value for interdisciplinary research.

   RESPONSE: Again, we would like to refer to our **General Response #1** regarding the applicability and integrability of our global wetland map.

Minor Points:

1. Overall, the manuscript is well-written and clear. However, there are instances where technical jargon may impede accessibility for a broader audience. For example, the use of terms like "mosaicking" and "ancillary data" may need more explanation. Consider simplifying or defining these terms more clearly for non-specialist readers.

   RESPONSE: We appreciate this comment, and it is certainly our goal to keep this manuscript accessible to as broad a reader community as possible. That said, the GLWD v2 database is a GIS product and thus descriptions of some specific GIS procedures are necessary. We aimed to keep the terminology simple where possible, using only GIS expressions that are rather common (such as the standard process of combining two raster datasets through 'mosaicking', an approach that is available in virtually all GIS software packages). Our goal of keeping the explanations accessible is exemplified by the fact that already the in the original manuscript we had replaced the GIS term 'mosaicking' with the simpler term 'inserting' which we defined in lines 261-264 (original manuscript). We also consider the expression 'ancillary data' to be a commonly used GIS term for 'supporting data' (though the more precise adjective 'ancillary' being preferred as even core data could be confused to be 'supportive data' within an analysis). In our revision, we carefully inspected the manuscript and made further adjustments to improve accessibility of the explanations as appropriate. For example, we replaced the only other occurrence of the term 'mosaicking' with 'merging'. That said, we also aimed to prioritize precise and correct technical terminology in cases where simplifications would introduce ambiguity.

2. The inclusion of several figures to demonstrate the different stages of data integration and the final wetland classification is excellent. However, Figure 3 could be expanded with more details on the data fusion procedures as the current methods section is complex and is not very clear. A table comparing GLWD v2 with other global wetland maps in terms of resolution, typology, and applications would be a valuable addition.

   RESPONSE: Thank you for this suggestion. In our revision, we modified/expanded Figure 3 to include more of the core processing steps, and we added class numbers to the figure to provide

a more direct link between the descriptions in the text and the location of each step in the figure. In addition, we created an even more elaborate figure that depicts many of the sub-steps of the methodology. Given the high amount of detail on this figure, we opted to place it as Figure B1 in Appendix B and refer to it from the manuscript. We hope these substantial modifications will increase clarity in the Methods section.

As for comparing GLWD v2 with other global wetland maps, we would like to point out that Figure 1 ("Common surface water datasets plotted according to their spatial and temporal resolution") intends to provide exactly this information (including also a temporal component). To make this more evident and to provide even more information, we added a new Table A1 in Appendix A which contains the basic characteristics of each of the 24 existing datasets shown in Figure 1, and we refer to this new table from within the manuscript.

3. Table 1 provides a good overview of the data sources but could be improved by adding information on the temporal coverage of each dataset.

   RESPONSE: We appreciate this suggestion. There has already been information on the temporal coverage for some datasets listed in Table 1 (in column 'Description' of the original manuscript). In the revision, we updated Table 1 by adding the temporal information for each dataset in a separate column to provide this information more clearly and more comprehensively.

4. Please consider adding a section to describe all necessary information on the data files provided in the dataset (e.g., data format, layer names and content). This would make it easy for data users to quickly know what information are provided in each data file.

   RESPONSE: We fully agree with this suggestion. In fact, all data files have already been described and documented in a dedicated Technical Documentation (in PDF format) which is distributed together with the data files and is available online (see links on the figshare repository). In addition, there is also a table (in CSV format) provided with the datasets which contains the legend information for each wetland class (i.e., a reference table showing wetland class ID and class name). We now placed the Technical Documentation more prominently on the figshare repository and we added the following sentence to section 6 (Data availability): "*The data layers are provided in different formats and are accompanied by a Technical Documentation explaining file names and specifications.*"

With kind regards,

Bernhard Lehner
on behalf of all co-authors