Overall Response to Reviewer Comments

We thank the reviewers for their careful and constructive evaluation of the manuscript. Their comments have helped us identify areas where the presentation and broader framing of the study can be clarified and strengthened. In response, we will incorporate additional text in the revised manuscript to more explicitly highlight the global implications of the results for wetland–climate interactions, flood propagation in wetland-dominated basins, and hydrological modelling of connected lake–river–wetland systems. We will also include a sensitivity analysis of the event-matching parameters and add a schematic graphical workflow to clarify the methodological framework. These additions aim to strengthen the clarity, robustness, and broader process relevance of the study while preserving the core analysis and conclusions. We have uploaded point-by-point responses to the reviewers separately, which include summary results from the sensitivity study and excerpts of the proposed additional text.

==========

Reviewer comments are in blue and bold font and author responses are provided below each comment

Reviewer 2 comments - author response :

We appreciate the reviewer's careful reading of the manuscript and their constructive comments. We are encouraged that the reviewer recognises the study's scientific value, operational relevance, and contribution to understanding flood-wave buffering and propagation across the Lake Victoria–Sudd system, as well as the robustness of the analysis framework and its relevance for flood hazard mitigation and water resources management. We address the specific requests and concern below.

2.1 My request is that sections 2.5.x should be supported by a graphical abstract illustrating the different steps.

We agree that a graphical representation would improve clarity. A schematic workflow diagram will be added to illustrate the methodological steps described in Sections 2.5.x, including peak identification in Lake Victoria, automated downstream event matching across the Victoria–Kyoga–Albert–Sudd cascade, sensitivity analysis of the matching parameters, and manual verification of matched peaks before estimating segment and total transit times. The graphical abstract to be added to the manuscript is shown below.

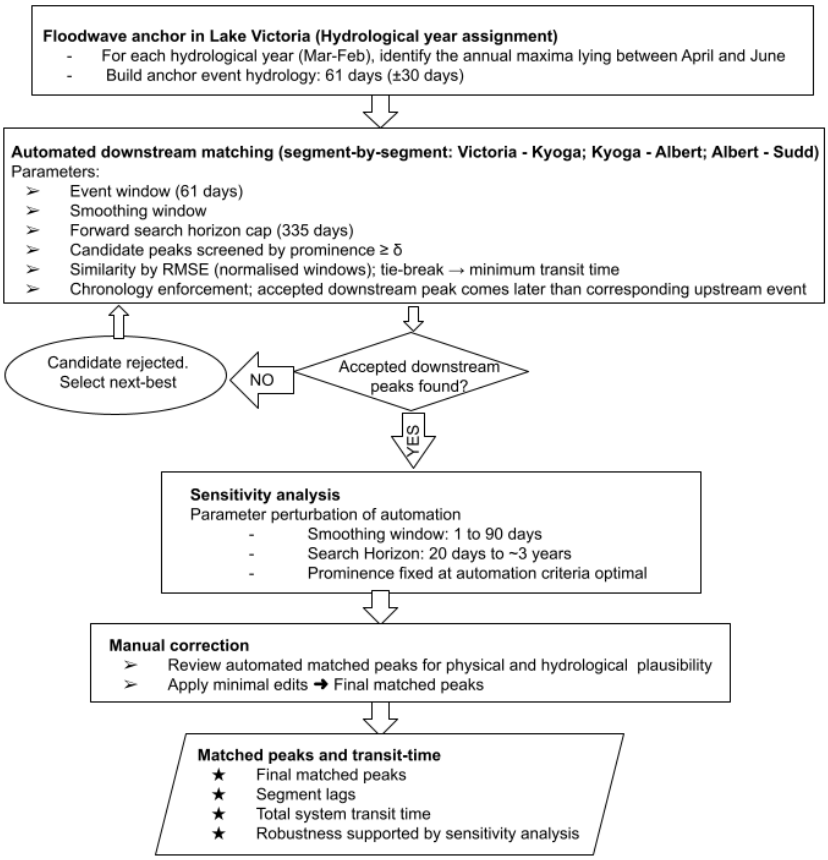

Figure R1: Schematic workflow of the automated floodwave tracking framework used to estimate system transit times. The process includes identification of Lake Victoria anchor events, automated downstream peak matching across the Victoria–Kyoga–Albert–Sudd cascade, sensitivity analysis of matching parameters, and final manual verification before estimation of segment and system-scale transit times.

2.2 My concern is that despite the excellent quality of the manuscript, this study fails both by not introducing novel methods and not illustrating a broadly applicable setup. In my assessment this study would be a perfect contribution for "Journal of Hydrology, Regional Studies". The standard scopes of HESS are in my opinion poorly met.

We thank the reviewer for their thoughtful assessment of the manuscript and for recognising its high quality. While we appreciate the suggestion that the study might be suitable for *Journal of Hydrology: Regional Studies,* we **respectfully disagree** with the assessment that the manuscript does not meet the scope of Hydrology and Earth System Sciences. Although the framework is observational rather than algorithmically novel, the study provides new empirical constraints on hydrological processes in large connected lake–river–wetland systems that are directly relevant to Earth system science. In particular, the analysis strongly contributes to global process assessments and to broader understanding of hydrological behaviour in wetland-influenced river systems. The global relevance of the study includes:

- **Wetland–climate interactions:** Variability in Sudd wetland inundation has been shown to be strongly associated with anomalously large increases in global atmospheric methane growth rates (Hardy et al., 2023). Methane is a major greenhouse gas and therefore such variability in Sudd wetland extent can influence global greenhouse gas

concentrations. Understanding the hydrological controls on wetland extent is therefore important for interpreting climate-relevant methane emissions at the global scale.

- **Improved quantification of wetland dynamics**: Accurate estimation of methane emissions requires robust characterisation of seasonal and interannual wetland extent variability (Dong et al., 2024). By identifying the hydrological controls governing downstream wetland inundation, the flood-wave propagation analysis presented here provides process understanding that is important for representing wetland dynamics in global methane budgets.
- **Process understanding in connected lake–river–wetland systems**: The study quantifies storage-mediated flood propagation through a large connected lake–river–wetland system, providing observational constraints on hydrological memory and flood transit times. Such constraints are valuable for improving the representation of inland water storage and flood routing processes in hydrological and Earth system models.
- **Broader applicability to wetland-dominated basins:** It has been estimated that wetlands cover approximately 6.4% of the global land surface. Many major river systems contain extensive floodplain and wetland complexes. The hydrological analysis presented in this manuscript for the Sudd is therefore relevant to other systems that include large wetland areas, where storage and connectivity can substantially influence flood propagation and transit times in large catchments. Understanding these processes is important for hydrological analysis and modelling in wetland-influenced river basins worldwide.

To clarify this global and broader relevance, we will add a short section in both the Introduction and Discussion sections explicitly highlighting the implications of this work for Earth system processes, wetland–climate interactions, and hydrological modelling. The following text will be added to the revised Introduction:

Recent studies have demonstrated that interannual variations in Sudd wetland inundation are associated with anomalously large increases in global atmospheric methane growth rates, identifying the Sudd as a globally influential natural methane source despite its geographically localised setting (Hardy et al., 2023). Accurate quantification of these emissions requires robust characterisation of seasonal and interannual wetland extent dynamics, which remain a major source of uncertainty in current methane estimates (Dong et al., 2024). The hydrological state of the Sudd is not locally generated but is strongly controlled by delayed flood propagation through the upstream Lake Victoria–Kyoga–Albert lake–river system, linking equatorial hydroclimatic variability to downstream wetland inundation over multi-year timescales. Quantifying system-scale transit times therefore provides the physical mechanism connecting upstream storage dynamics to wetland extent and, consequently, to climate-relevant methane emissions.

More broadly, wetlands cover approximately 6.4% of the global land surface, and many large river basins contain extensive floodplain and wetland complexes where storage and connectivity strongly influence flood propagation and hydrological memory. By providing observational constraints on storage-mediated flood propagation in a large connected lake–river–wetland system, this study contributes to improving the representation of inland water

storage, wetland dynamics, and associated carbon cycle feedbacks in hydrological and Earth system models worldwide.

Through these additions, the revised manuscript will make clearer that the study provides process understanding that extends beyond a regional case study, offering observational constraints on storage-mediated flood propagation in a large connected lake–river–wetland system with implications for wetland dynamics and Earth system processes. We therefore believe that the manuscript aligns well with the scope and objectives of Hydrology and Earth System Sciences.

References:

Dong, B., Peng, S., Liu, G., Pu, T., Gerlein-Safdi, C., Prigent, C., & Lin, X. (2024). Underestimation of Methane Emissions From the Sudd Wetland: Unraveling the Impact of Wetland Extent Dynamics. *Geophysical Research Letters*, *51*(16). https://doi.org/10.1029/2024GL110690

Hardy, A., Palmer, P. I., & Oakes, G. (2023). Satellite data reveal how Sudd wetland dynamics are linked with globally-significant methane emissions. *Environmental Research Letters*, *18*(7). https://doi.org/10.1088/1748-9326/ace272