Overall Response to Editor and Reviewer Comments

We sincerely thank the editor and reviewers for their careful, constructive, and insightful evaluation of the manuscript. Their comments and suggestions have substantially improved the clarity, robustness, conciseness, and broader framing of the study. In response to the review process, we have revised the manuscript extensively to strengthen the presentation of the methodological framework, clarify the distinction between physical flood-wave propagation and statistical lag relationships, improve figure placement and terminology definitions, and enhance consistency in citation and reference formatting throughout the manuscript.

In line with the editor's recommendations, we also strengthened the broader conceptual framing of the study by more explicitly highlighting how the inferred ~17-month system transit time challenges the commonly inferred 4–5-month timescale previously interpreted from seasonal peak alignment, and how this distinction has implications for understanding flood propagation in large connected lake–river–wetland systems more broadly. We further expanded discussion of long hydrological memory, storage-mediated flood propagation, wetland–climate interactions, hydrological connectivity, contribution to methane emissions and the representation of wetland processes in hydrological and Earth system models.

Additional revisions included incorporation of a schematic methodological workflow figure, clarification of data and methodological limitations, expanded discussion of sensitivity analysis, revisions to the Abstract and Introduction to better contextualise the 2019–2024 high-water regime across the White Nile system, and streamlining of several sections to improve readability while preserving methodological transparency and reproducibility.

We believe these revisions strengthened both the scientific clarity and broader relevance of the study while preserving the core findings and conclusions of the study. Detailed point-by-point responses to all editor and reviewer comments are provided below, together with corresponding manuscript revisions and line references.

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

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Editor comments (EC) - author response :

EC 1

As you will have noted, the reviewers are both positive on the quality and presentation of the manuscript; however they differ in opinion about the overall significance of your work. Despite the reservations of the second referee on the novelty of the work and the fit to the objectives of HESS, I have decided to retain the manuscript and request a further revision. This is not only because of the novelty of the work for a poorly characterized region of the world, but also because it challenges hydrologic intuition more broadly, and perhaps even the methodology used to derive the earlier, much shorter estimates of transit time. In addition to addressing the direct concerns and suggestions of the reviewers, I would therefore invite you to try and highlight this aspect of the study more strongly.

We thank the editor for this important observation and for recognising the broader conceptual significance of the study beyond its regional context. In response, we revised the manuscript extensively across the Abstract, Introduction, Results, Discussion, and Supplementary Material to more explicitly distinguish seasonal peak alignment from physical flood-wave propagation and to strengthen the broader hydrological and Earth-system implications of the findings.

The revised manuscript now more clearly frames the commonly inferred four-to-five-month timing between Lake Victoria and the Sudd as a seasonal synchronisation signal rather than a directly observed flood-wave transit time. We strengthened discussion of how storage-mediated routing, attenuation, delayed release, wetland buffering, and hydrological memory within large lake-river-wetland systems can fundamentally alter interpretations of downstream flood timing and basin connectivity. In addition, the revised Introduction now more explicitly highlights the White Nile as a hydrologically under-characterised large tropical lake-river-wetland system where basin-scale flood-wave propagation, storage-mediated delays, and long-memory behaviour remain weakly quantified in the published literature.

To further strengthen the fit to HESS and highlight the broader significance of the study, we expanded discussion of the White Nile as a representative storage-dominated basin with implications for hydrological connectivity, Earth-system modelling, wetland-climate interactions, methane-cycle dynamics, and large-scale inland water storage processes. Additional discussion was added linking delayed flood propagation and wetland persistence to global methane-budget uncertainty and hydrologically driven wetland extent variability.

In the revised version, these changes are reflected in:

- ***Abstract****, pages 1–2, lines 13–39, where the study now explicitly contrasts the empirically derived ~17-month transit time with the previously inferred 4–5 month seasonal timing and frames the White Nile as a long-memory system.*
- ***Introduction****, paragraph beginning "Across the historical record...", pages 2–3, lines 63–71, where the manuscript now explicitly distinguishes seasonal peak alignment from*

physical flood-wave propagation and clarifies the limitations of inferring transit time directly from seasonal synchronisation in hydrological modelling works.

- ***Introduction**, paragraph beginning "This distinction matters because...", page 3, lines 73–82, where the role of intermediate storage elements, attenuation, delayed release, and hydrological memory within the White Nile system is now discussed more explicitly highlighting how under-characterized those processes are in this system.*
- ***Introduction**, paragraph beginning "The underlying drivers of these multi-year extreme floods...", pages 4–5, lines 127–136, where we explicitly show that regardless of similar multi-year events in the past, the underlying drivers remain poorly understood in terms of system-scale hydrological controls and storage-driven propagation processes.*
- ***Introduction**, we added the paragraph beginning "Beyond regional flood dynamics...", pages 5–6, lines 153–164, where broader Earth-system implications related to methane emissions, wetland-climate interactions, and global biogeochemical relevance were added.*
- ***Introduction**, we added the paragraph beginning "More broadly, wetlands cover...", pages 6, lines 166–170, where the White Nile is now framed as a representative example of a wider class of storage-dominated basins relevant to hydrological and Earth-system modelling.*
- ***Introduction**, we added the paragraph beginning "By resolving flood wave propagation...", page 6, lines 183–192, where the manuscript now more explicitly states that the study challenges prevailing assumptions regarding the speed and mechanism of flood propagation in large storage-dominated river systems.*
- ***Introduction**, we added the paragraph beginning "By providing observational constraints...", pages 6–7, lines 194–203, where the broader implications of this study for hydrological connectivity, inland water storage dynamics, wetland inundation variability, and methane-budget uncertainty are now synthesized more explicitly.*
- ***Discussion,** Section 4, pages 33–41, lines 845–1103, where the broader implications of storage-mediated flood propagation, hydrological memory, attenuation, delayed release, and limitations of seasonal-alignment approaches are synthesised and linked to flood forecasting, hydrological interpretation, and large-scale storage-dominated river systems more broadly.*

EC 2

As this may make your manuscript, which is already very long, even longer. I would therefore also encourage you to identify opportunities to shorten the manuscript, perhaps by making use of supplementary materials as a way to balance accessibility and conciseness with the level of detail that ensures reproducibility.

We have revised the manuscript extensively to improve readability, reduce repetition, strengthen signposting, and streamline sections where methodological or contextual detail interrupted the main narrative flow. To balance accessibility and conciseness with reproducibility, several extended methodological explanations, supporting analyses, and workflow clarifications were condensed in the main manuscript and expanded within the newly added Supplementary Material sections.

In particular, Supplement S1 now contains expanded descriptions of sub-catchment delineation, geomorphological setting, paleo-lake context, lateral spillover behaviour, and hydrological connectivity across the Sudd system. Supplement S2, includes detailed SPI-6 implementation methodology, rainfall-anomaly interpretation, accumulation-window justification, and rainfall-context analysis used for event interpretation. Additional seasonal timing diagnostics and rainfall-anomaly analyses were also transferred to the Supplementary Material to streamline the Results section while preserving reproducibility and interpretability. Supplement S3 now contains expanded sensitivity analyses evaluating smoothing-window length, downstream search horizons, and workflow clarification for the automated flood-wave tracking framework.

These revisions now allowed the main manuscript to focus more clearly on the central hydrological interpretation, transit-time analysis, and system-scale findings while preserving methodological transparency and reproducibility and maintaining the supporting rainfall analyses in the supplementary.

Reviewer One (RC 1) comments - author response:

RC 1.1

Given the length of the paper, the authors may want to state central claim of the paper which is "the 16.84 months system transit time" which is mentioned in the abstract and only appears again in section 3.3. The authors may want to explicitly contrast it with the commonly held believe that the system transit time is about 5 months to sharpen novelty. This may appear at the end of the introduction.

We have revised the Abstract, Introduction, Results, and Discussion sections to more explicitly position the approximately 17-month system-scale transit time as a central finding of the study and to directly contrast it with the commonly inferred four-to-five-month timing derived from seasonal peak alignment.

The revised manuscript now clarifies that the shorter timescale largely reflects seasonal synchronization between upstream rainfall and downstream hydrological response rather than directly observed flood-wave propagation through the connected lake-river-wetland system.

To strengthen the novelty and broader hydrological implications of the study, the revised Introduction and Discussion sections now more explicitly frame the findings as a challenge to commonly applied interpretations of seasonal timing relationships in large storage-dominated river systems.

In the revised version, these changes are reflected in:

- ***About novelty,*** *refer to response to* ***EC 1***
- ***Abstract****, pages 1–2, lines 13–39, where the study now explicitly quantifies a mean system transit time of approximately 17 months (16.84 ± 1.95 months), contrasts this with the commonly inferred four-to-five-month seasonal timing, and frames the White Nile as a long-memory system governed by upstream storage and delayed flood-wave propagation over multi-season timescales.*

RC 1.2

There is inconsistency in paragraphs lengths especially in the introduction section of the manuscript. For example, compare L35–50, L51–62, L104–108, L110–126 etc. If possible, the authors should aim to harmonize paragraph lengths to improve readability, unless there is a clear rationale for maintaining the current structure.

We revised the manuscript throughout to improve paragraph balance, readability, signposting, transition flow, and overall narrative coherence while preserving the scientific structure and argument of the study. In the revised version, these changes are reflected throughout the manuscript, particularly within the Introduction, Methods, Results, Discussion, and Supplementary Material, where several paragraphs were shortened, merged, redistributed, or streamlined to improve readability and reduce repetition.

RC 1.3

For sensitivity of event matching parameter, whilst the prominence threshold (δ), smoothing window (±15 days), and the 335-day search horizon are defensible, the paper would benefit from a short supplementary sensitivity analysis. For example, show how Victoria-Kyoga-Albert-Sudd lag changes under (i) 7 days smoothing window, and (ii) ±2 months search horizon. This will strengthen confidence that the 16–17-month figure is not the result of the authors subjective decisions.

We carried out a sensitivity analysis to evaluate the robustness of inferred Lake Victoria to Sudd floodwave transit times to key event-matching parameters. A grid-based one-at-a-time (OAT) sensitivity analysis was conducted in which the smoothing window was varied from 1 to 90 days and the downstream segment search horizon from 20 days to approximately 3 years, encompassing and extending beyond the reviewer's suggested parameter ranges, while the prominence threshold was held fixed at the optimised baseline value.

The results as shown in the contour plot show that inferred transit times are largely insensitive to the smoothing window across the tested range, while the search horizon exerts the dominant control on the resultant lag estimates. For search horizons up to 1.25 years, the tested parameter combinations consistently produce system transit times clustered around ~15–17 months, supporting the mean system transit time reported in this paper. Longer horizons allow matching with Sudd wetland seasonal expansions from later years that are not causally linked to the originating Lake Victoria floodwave, which leads to artificially longer lag estimates. The violin plots, grouped by search-horizon range, illustrate the multimodal distribution of these longer lag solutions when no horizon restriction is applied. Therefore, the analysis confirms that the reported mean system transit time of ~17 months (16.84 ± 1.95 months) represents a robust hydrological signal rather than an artefact of parameter selection.

In the revised version, these changes are reflected in:

- ***Methods, Section 2.4.1**, page 16, lines 435–442, where a new paragraph summarising the sensitivity-analysis framework, its rationale and findings was added to the main manuscript.*
- *Supplement S3, where a full grid-based sensitivity analysis evaluating smoothing-window length and downstream search-horizon selection was added.*
- *Figure R1 (below; also included as Fig. S3 in Supplement S3), where the upper panel presents the contour response of inferred Lake Victoria–Sudd transit times to variations in smoothing-window length and downstream search horizon, while the lower panel presents violin distributions of inferred transit times grouped by search-horizon range.*

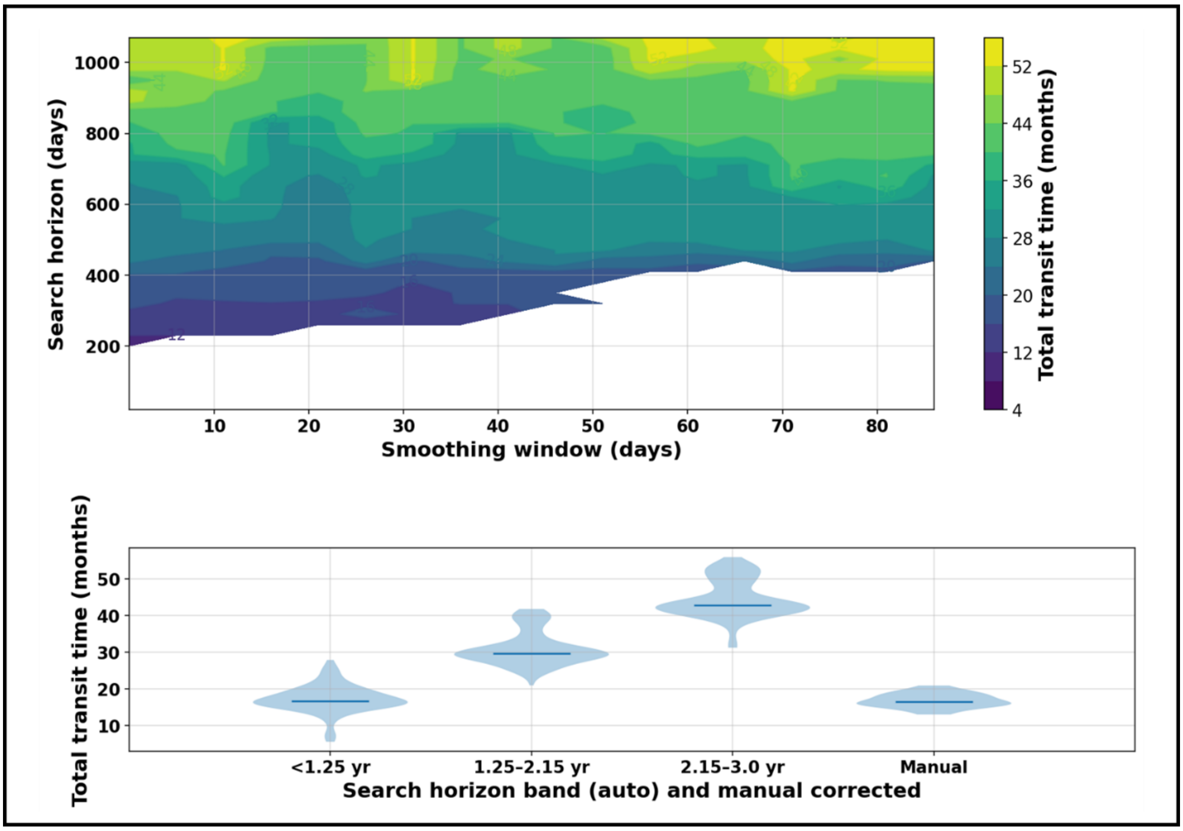

Figure R1:Sensitivity analysis of inferred Lake Victoria–Sudd system transit times to key event-matching parameters. The upper panel shows the contour response of total transit time to variations in smoothing window and downstream search horizon. The lower panel shows violin distributions of inferred transit times grouped by search-horizon range.

RC 1.4

The authors highlighted the absence of publicly available Lake Victoria outflow records; please could the authors add one paragraph in Methods or Discussion section to clarify how this limitation could (or could not) bias the transit-time inference, given that the method uses observed peak lake levels and downstream signals rather than release series.

We added a clarification paragraph in the Methods section discussing the implications of unavailable Lake Victoria outflow release records for the transit-time analysis. The revised manuscript now clarifies that the present approach infers system-scale transit times from the timing of observed Lake Victoria peak levels and downstream hydrological responses rather than directly from regulated discharge series. The revision further explains that while regulated outflows may influence short-term discharge variability near the outlet, downstream propagation through Lakes Kyoga and Albert and the Sudd wetland is strongly moderated by large natural storage, attenuation, delayed release, and wetland buffering processes. Consequently, the absence of continuous outflow release records does not prevent identification of the broader storage-mediated transit times resolved in this study.

In the revised version, these changes are reflected in:

- ***Methods,*** *Section 2.4.1, pages 14–15, lines 387–394, where a new methodological clarification discussing the implications of unavailable Lake Victoria outflow release records for transit-time inference was added. The manuscript now explicitly clarifies that* *system-scale transit times were inferred from the timing of observed peak Lake Victoria levels and downstream hydrological responses rather than directly from regulated discharge series, and that while regulated outflows may influence short-term discharge variability near the outlet, they do not prevent identification of the broader storage-mediated transit times resolved in this study.*

RC 1.5

Could the authors add a link to the MODIS-based inundation masks produced and post-processed by the World Food Programme (WFP) as many readers may not be aware that this dataset exits.

The MODIS-based inundation dataset used in this study is a proprietary product developed and maintained by the World Food Programme (WFP) and is not publicly hosted. Access to the dataset is available from WFP upon request. This clarification has now been added to Section 2.1.3 of the revised manuscript (*page 12, line 319*), which now states: "The dataset is proprietary and can be accessed upon request from the World Food Programme."

RC 1.6

Consistency in "physical" vs "statistical" timing across figures. Section 3.3 shows physical transits (splines linking matched peaks), and section 3.4 shows r²-vs-lag curves, consider providing a statement to clarify "what the line connects" vs "what the correlation peak means".

We added short clarifying sentences in Sections 3.3 and 3.4 to distinguish the physical event tracking analysis from the statistical lag analysis. Specifically, the spline-linked peaks represent the sequential tracking of physically matched flood-wave events as they propagate through the Lake Victoria–Kyoga–Albert–Sudd system. In contrast, the r^2–lag curves presented in Section 3.4 identify the lag at which the statistical association between Lake Victoria levels and downstream wetland extent is strongest. This clarification helps distinguish physically tracked flood-wave transit times from statistically derived lag relationships.

Specifically, in Section 3.3, we added: *"Flood-wave tracking provides a direct measure of propagation by following individual events through the Victoria–Kyoga–Albert–Sudd cascade. In contrast, the lagged correlations between Lake Victoria levels and downstream wetland extent, presented in Sect. 2.5, quantify the strength and timing of association between upstream and downstream states. These correlations are essential for identifying hydraulic connectivity and system memory, but they integrate the combined influence of upstream storage, routing, local rainfall, and wetland dynamics, and therefore do not represent transit time itself. The agreement between the two approaches, with strongest correlations emerging at multi-month to annual lags, supports a long-memory system while distinguishing statistical association from physical propagation."*

In the revised manuscript, *these changes are reflected in Section 3.3, page 21, lines 559–566, and Section 3.4, page 27, lines 725–726; page 28, lines 736–738, 744–746, and 751–752,* *where clarifying text was added to distinguish physically tracked flood-wave propagation from statistically derived lag relationships based on correlation analysis.*

RC 1.7

The phrase "complex system with complex hydrology" appears multiple times in close proximity (opening paragraphs); please consider pruning or varying wording to avoid diluting a strong opening statement.

We corrected the repeated use of the phrase "complex system with complex hydrology" throughout the Introduction and other relevant sections to improve readability and avoid unnecessary repetition, while preserving the intended emphasis on the interconnected and storage-driven nature of the lake–river–wetland system. In the revised manuscript, these changes were implemented in all relevant locations where repetitive phrasing occurred.

RC 1.8

Where you cite record Sudd extent (163,475 km² in 2022), place the number in the Abstract and include the six-year series for context (2019–2024).

We revised the Abstract to include the record MODIS-era Sudd Wetland extent of 163,475 km² in 2022 and added the full 2019–2024 sequence of annual maximum inundation extents for context. We also incorporated the corresponding sequence of exceptional Lake Victoria peak water levels observed during the same high-water regime. These additions strengthen the representation of the prolonged and basin-wide nature of the 2019–2024 flood anomalies and better contextualise the role of long-term storage and hydrological persistence across the White Nile system. In the revised manuscript, these changes are reflected in the Abstract (pages 1–2, lines 28–32).

RC 1.9

The terminology: "activation/backwater" is used appropriately; however, consider a one-line parenthetical definition at first use to help non-specialist readers.

We added brief parenthetical definitions for both "wetland activation" and "backwater effects" at their first use to improve clarity for non-specialist readers. Specifically, wetland activation was defined as the onset of inundation and hydraulic connectivity when inflow exceeds local wetland storage thresholds, while backwater effects were defined as hydraulic conditions in which elevated downstream water levels impede outflow or reverse tributary flow, raising upstream water levels.

The revised text now states: *"These month-to-month persistence patterns were used to highlight zones exhibiting behaviour consistent with possible wetland water pathways activation, defined as the onset of inundation and hydraulic connectivity when inflow exceeds local wetland storage thresholds (Junk et al., 1989), and with backwater effects, in which elevated downstream water levels impede outflow or reverse tributary flow, raising upstream water levels (Zhang et al., 2023)."*

In the revised manuscript, this clarification was added on page 18, lines 495–499.

RC 1.10

L42 & L45: (Mohamed et al., 2005b, 2005a) (I think it should be 2005a, 2005b). L59: (Mohamed et al., 2005a, 2005b). This approach should be adopted throughout the manuscript.

We reviewed and corrected the ordering and formatting of repeated same-author citations throughout the manuscript, including both the Mohamed et al. (2005a, 2005b) and Vanderkelen et al. (2018a, 2018b) citations identified during revision, to ensure consistency with HESS citation conventions. Beyond these corrections, we also reviewed and reformatted the reference list of the manuscript to align with the citation and reference style recommended by HESS. *These corrections were implemented throughout the manuscript where necessary, with reference list formatting updates reflected on pages 43–52, lines 1182–1467.*

RC 1.11

Figures, especially 5, 6 & 7 are placed very far from where they are first mentioned in the manuscript. Considering moving figures closer to where they are first mentioned in the manuscript.

We reviewed the placement of figures throughout the revised manuscript and moved figures closer to their first mention in the text where possible, including Figs. 5, 6, and 7 highlighted by the reviewer. While final figure positioning will ultimately be handled during typesetting, the revised manuscript was reorganised to improve the proximity between figures and their corresponding discussion sections.

Reviewer Two (RC 2) comments - author response:

RC 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 improves methodological clarity. We therefore added a schematic workflow diagram in Section 2.0 to support the methodological framework described in Section 2.4.x (previously Section 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 final manual verification of matched peaks prior to estimating segmental and system-scale transit times.

The added schematic workflow figure is reproduced below as Fig. R2.

In the revised manuscript, this figure was added as Fig. 2 in Section 2.0 on page 10, lines 268–273.

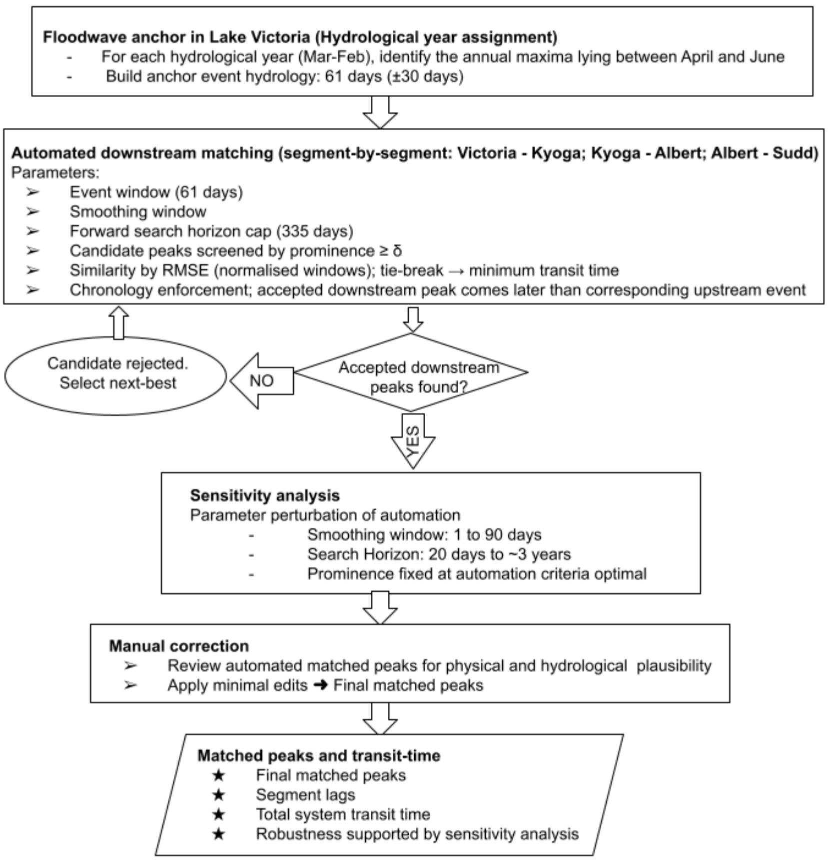

Figure R2: Schematic workflow of the automated floodwave tracking framework used to estimate system transit times. The process includes identification of Lake Victoria anchor events, automated downstream peak matching across the Victoria–Kyoga–Albert–Sudd cascade, sensitivity analysis of matching parameters, and final manual verification before estimation of segment and system-scale transit times.

RC 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 this assessment. This concern has been extensively addressed in the response to ***EC 1***, where we clarified the broader Earth system relevance of the study, including its implications for wetland–climate interactions, hydrological memory, storage-mediated flood propagation, and representation of wetland dynamics in hydrological and Earth system models. Relevant clarifications were also incorporated into the revised Introduction and Discussion sections.