We sincerely thank the Editor and two referees for their careful reading of our manuscript and for their thoughtful and constructive comments, which have substantially helped us to improve the manuscript. We have considered every comment carefully and revised the manuscript and supplementary information accordingly. Below, we provide our point-by-point responses to each comment.

For clarity, we use the following labelling convention throughout this document. Each referee's original comments are reproduced in full inside a shaded box and numbered sequentially within that referee's section (for example, Comment 1, 2, 3… under Referee #1). Our point-by-point response to each comment immediately follows, set in blue text and beginning with "**Response**:"

Changes made in the revised manuscript and Supplementary Information have been highlighted in blue text.

Referee #1

2. After the revision, the manuscript greatly improves and flows logically. All the comments are well addressed, though I have a few suggestions for clarity and improved quality before publication.

Response: Thanks for your positive feedback and new comments and suggestions that helped us to improve the manuscript.

2. Acronyms: Some acronyms were not properly defined at their first occurrence after the revision. Please review all instances of full forms and their corresponding acronyms in both the main text and the supplement.

Response: Thank you for pointing this out. We carefully reviewed all acronyms and abbreviations in both the main manuscript and the Supplement and revised the text so that each acronym is defined at its first occurrence (Revised Manuscript, Lines 96, 175, 186, 202-204, 229, 260, etc.).

3. Section 2.4: Is the "FAO global soil data" in the text referred to the Harmonized World Soil Database (HWSD)? If so, should the resolution be 1 km instead of 10 km?

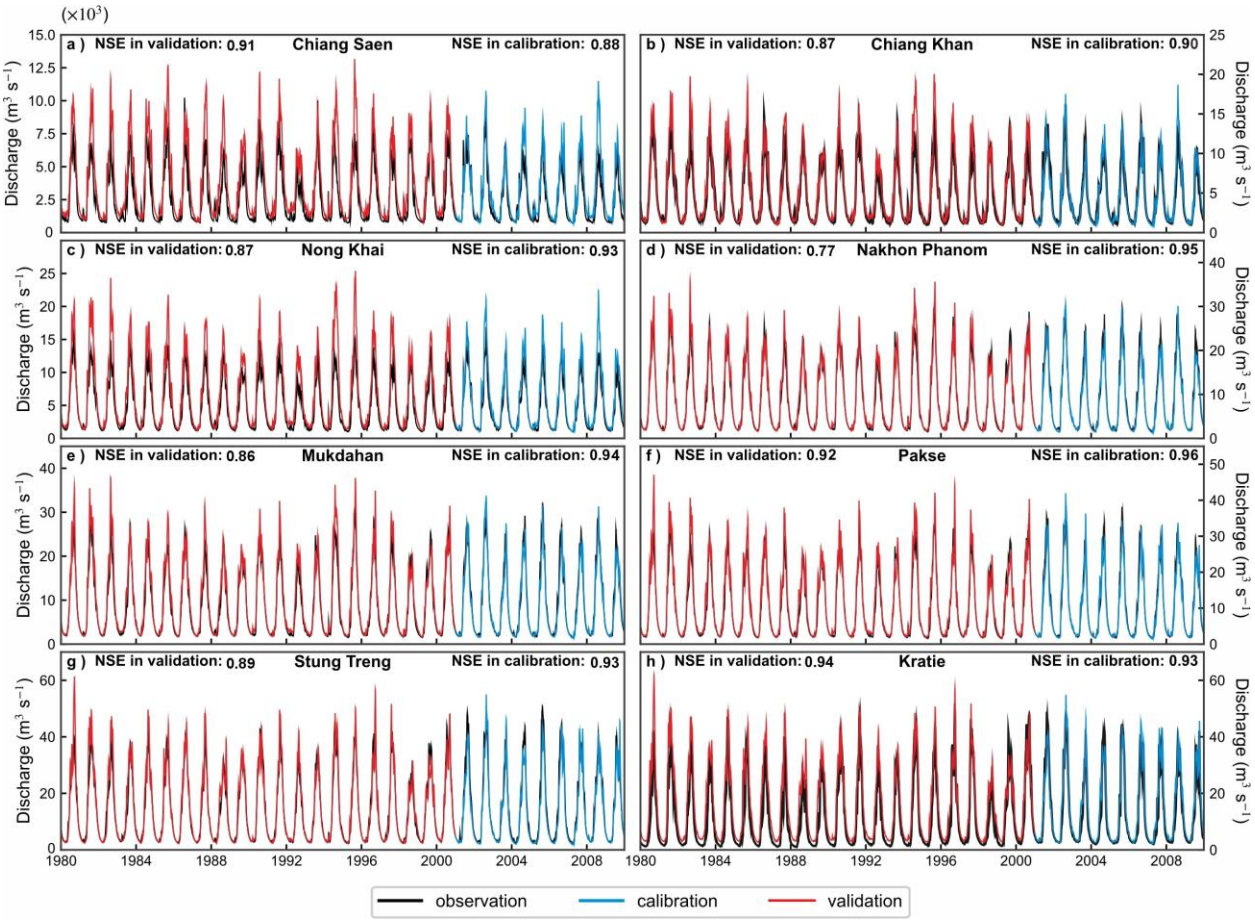
Response: Thank you for bringing this oversight to our attention. Yes, the "FAO global soil data" referred to the Harmonized World Soil Database (HWSD). We have corrected the description in Sect. 2.4 to specify that the soil properties used in the THREW model were obtained at 30-arc-second spatial resolution, corresponding to approximately 1 km, rather than ~10 km. (see Revised Manuscript, Lines 202-203).

4. Section 2.5.1, L241: "detailed performance metrics are provided in the Supplement" should include "Figure S4" in the sentence. Also, the supplement should at least contain concise information on or mention the metrics used, particularly NSE that is in Figure S4 (although the metrics are widely recognized in our community).

Response: Thank you for the suggestion. We revised the sentence in Sect. 2.5.1 to explicitly refer to Fig. S4 in the Supplement. In addition, we provided a description for all metrics used in model performance evaluation. (see Revised Manuscript, Lines 259-265).

5. Figure S4 shows results only at six stations instead of eight. Apologies for this oversight during the first round of review. Please include Chiang Saen and Kratie subplots.

Response: Thank you for pointing out this oversight. We have revised Figure S4 to include the two missing stations, Chiang Saen and Kratie, in addition to the six stations shown previously.

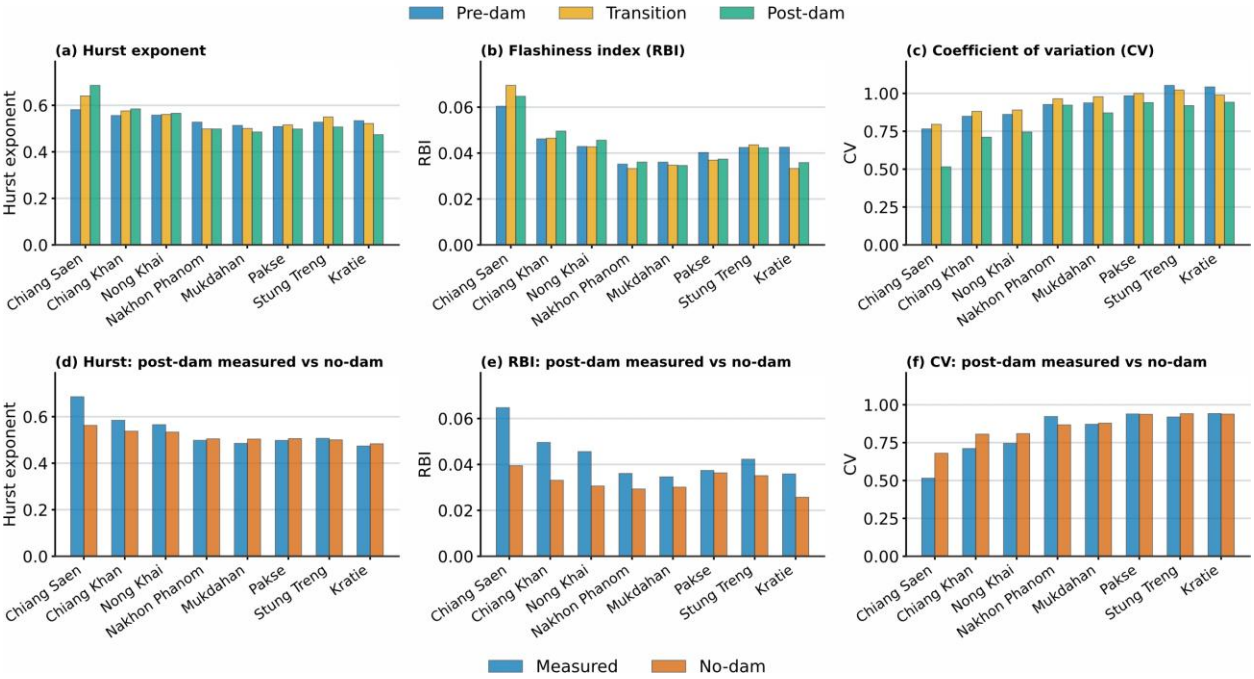


6. Section 2.5.2, L267: I noticed the revised text NSE > 0.92, but in Supplement S4, it was stated that R2 values exceeding 0.92. Are both metrics coincidentally over 0.92, or is it the same result due to the same formulation of both metrics? Moreover, in the same Supplement S4, it was mentioned that RMSE is 12%. The unit is confusing. I believe it is normalized and should be clearly described.

Response: Thank you for pointing out this inconsistency. R^2 and NSE are different performance metrics and were not intended to be treated as the same result. We have revised the text to clarify that both R^2 and NSE values for daily water-level validation exceeded 0.92 at Prek Kdam and Kompong Luong stations. In addition, we revised the sentence to explicitly refer to Fig. S6 (previously Fig. S5) for water-level validation, Fig. S7 (previously Fig. S6) for exchange-discharge validation, and Table S3 for the comparison of observed and simulated reverse-flow periods (Revised Manuscript, Lines 288-292).

7. Figure 2: I noticed the figure revision, which does improve. However, the plot is somewhat difficult to follow, as values for each circular grid line are not labeled at consistent one-decimal intervals (e.g., 0.5, 0.6), particularly for the Hurst exponent and CV. For RBI, it is even harder, as the lines are seemingly not evenly spaced.

Response: Thank you for this helpful comment. We agree that the previous circular-grid layout made it difficult to compare values across stations, particularly because the radial grid lines were not labelled at consistent intervals for the Hurst exponent, RBI and CV. In response to this comment and also following Reviewer 2's suggestion to redraw Figure 2 using a clearer format, we have replaced the circular plots with standard grouped bar plots. The revised figure presents the Hurst exponent, RBI and CV on linear y-axes with evenly spaced tick marks and clearly labelled values, making the comparisons among stations and periods easier to follow. This revision removes the ambiguity associated with the radial grid lines in the previous version.



8. Supplement: Based on the revisions in the main text, Figure S3 should appear before Figure S2, as Figure S3 was mentioned before Figure S2 in the main text, and input station map should appear before model discretization map.

Response: Thank you for this helpful suggestion. We have revised the order of the figures in the Supplement so that the meteorological input-station map appears before the THREW model discretization map. Accordingly, the former Fig. S3 has been moved before the former Fig. S2, and the figures have been renumbered. We also updated all corresponding figure references in the main manuscript and Supplement to ensure that the figure numbering follows the order in which the figures are first cited.

Referee #2

1. Thank you for considering my earlier feedback as well as the feedback provided from another reviewer and improving the manuscript accordingly.
Despite your revisions my overall assessment remains that while your manuscript provides a useful contribution in highlighting the effects of hydropower development on flow alterations in the Mekong River, largely consistent with previous studies, the implications drawn for the Tonle Sap River flow reversal are not sufficiently supported by the analysis presented.

Response: Thank you for your careful assessment and constructive feedback. We appreciate the reviewer's concern that the implications for Tonle Sap River flow reversal need to be more directly supported by the analysis. In response, we have substantially revised the manuscript to clarify the scope and interpretation of the Tonle Sap analysis. Please see our detailed point-by-point responses below.

2. As you acknowledge on line 439 of the updated manuscript, analysis of the relationship between Mekong hydrology and the TSR reversal patterns should focus on hydrological conditions at Kratie, which is the closest upstream gauge, while excluding stations that are further upstream. This is because any hydrological changes measured further upstream (e.g. in Chian Saen close to the Lao PDR – China border) are progressively attenuated as the flow propagates downstream for hundreds of kilometres and the signal, further diluted by the influence of additional tributaries, is eventually measured at Kratie. The results show that high flows at Kratie (the type of flows that control TSR reversal) have decreased by only 9.4% in the post dam period (lines 21, 441, 586). This reduction is relatively small when compared with the 130% increase on the discharge at Kratie required for the TSR flow to reverse (lines 27, 481). Previous studies have shown that the latter is not the outcome of damming and climate change but of local sand mining at the Mekong River and delta in Cambodia (and possibly further downstream in Vietnam), rather than dam regulation or climate change. While the manuscript acknowledges the influence of morphological changes it does not attempt to disentangle the influence of morphological adjustments from dam flow modulation.

Response: Thank you for this important clarification. We agree that Kratie is the appropriate hydrological control point for analysing Tonle Sap River reversal and that upstream signals are progressively attenuated before reaching the confluence. We have therefore revised the manuscript so that the reverse-flow analysis is based on lag-adjusted Kratie discharge and no longer implies that changes observed farther upstream directly control Tonle Sap River reversal.

To disentangle upstream hydrological alteration from local morphological change, we added a paired-scenario design in the revised Manuscript (Sects. 2.3, 2.5.3, 3.5, and Conclusions). The pre-dam and transition simulations use a common reference morphology, while the new post-dam fixed-bed scenario uses observed 2010-2024 Kratie discharge and tributary inflows but keeps the same reference riverbed. The post-dam + sand-mining scenario uses the same hydrological boundary conditions but updates the riverbed DEM annually to represent sand-mining-driven

incision. The difference between these two post-dam scenarios therefore isolates the additional geomorphic effect of sand mining.

The revised results support the reviewer's point that the 9.4% decrease in annual peak discharge at Kratie alone cannot explain the much larger shift in the discharge condition required for reversal. Under fixed-bed conditions, the median lag-adjusted onset threshold increases from 3.18×10^3 m^3 s^{-1} in the pre-dam period to 4.30×10^3 m^3 s^{-1} in the post-dam period, about +35%. When sand-mining-driven incision is included, the threshold rises further to 7.21×10^3 m^3 s^{-1}, about +68% relative to the post-dam fixed-bed case and ~127% (~130%) above the pre-dam baseline. Cessation thresholds show a similar distinction: hydrology alone produces little change (<2%), whereas the sand-mining scenario raises the median cessation threshold to 34.52×10^3 m^3 s^{-1} (~21% above pre-dam). The reverse-flow season shortens from a median of 132 days in the pre-dam period to 113 days under post-dam fixed-bed conditions and to 104 days when sand mining is included.

Accordingly, we revised the interpretation: dam regulation and climate variability mainly affect the timing, persistence, and frequency with which reversal-favourable hydraulic gradients are reached, whereas sand-mining-driven riverbed lowering changes the local stage-discharge relation and substantially raises the hydraulic threshold. Figure S8 validates the annually updated Delft3D configuration using Chaktomuk water levels (overall NSE approximately 0.934; annual NSE = 0.92-0.95 and R^2 = 0.928-0.952), Prek Kdam exchange discharge (R^2 approximately 0.94; MRE approximately 14%; bias = -89 m^3 s^{-1}), and observed reverse-flow periods (0-3 day discrepancies). These revisions make the attribution explicit and avoid overstating the role of upstream dam regulation relative to local sand-mining impacts.

3. Additional comments:

Lines 21-30 The max flow at Kratie has decreased by 9.4% because of damming and climate change. The discharged requirement has increased by >130% because of sandmining. Surely the 9.4% reduction is insignificant when compared with the 130% additional requirement?

Response: Thank you for raising this point. We agree that the 9.4% reduction in annual peak discharge at Kratie is modest compared with the >130% increase in the discharge condition associated with reverse-flow initiation, and this is exactly why we revised the manuscript using the paired fixed-bed and sand-mining scenarios described in our response to Comment 2. The revised results now distinguish the two effects: post-2010 hydrology under fixed-bed conditions raises the median lag-adjusted onset threshold from 3.18×10^3 to 4.30×10^3 m^3 s^{-1} (about +35%), whereas adding sand-mining-driven incision raises it further to 7.21×10^3 m^3 s^{-1}, approximately 127% (~130%) above the pre-dam baseline. Thus, we no longer interpret the threshold increase as a direct consequence of the modest peak-flow reduction at Kratie. Instead, the revised manuscript states that dam regulation and climate variability mainly alter the timing and persistence of reversal-favourable hydraulic conditions, while sand-mining-driven riverbed incision is the dominant local mechanism that raises the hydraulic threshold for Mekong-Tonle Sap flow reversal.

We have revised the Abstract, Results (Sect. 3.5), Discussion (Sect. 4.2), and Conclusions accordingly.

4. Line 56 'Most existing Mekong assessments….' Please cite some specific examples.

Response: Thanks for your comment. We have added some references to support the sentence, and it now reads as follows: (Revised Manuscript, Lines 47-48).

"Most existing Mekong assessments emphasize changes in seasonal means, extremes, and selected indicators of alteration (Cochrane et al., 2014; Hoang et al., 2016; Li et al., 2017; Shrestha et al., 2021; Lu and Chua, 2021; Ly et al., 2023; Dang and Pokhrel, 2024)."

5. Line 62-64 Please include citations to support the importance of the statistical metrics chosen.

Response: Thank you for your suggestion. We have provided several references and the revised text now reads as follows: (Revised Manuscript, Lines 48-62).

However, such descriptors do not fully capture two properties that are central to how basin-wide signals propagate through a river network and translate into downstream responses: flow memory and flow synchrony. Here, flow memory refers to the persistence (long-range dependence) of discharge variability, that is, the extent to which present conditions retain information from antecedent fluctuations (de Lavenne et al., 2022; Berghuijs et al., 2025); we quantify this using the Hurst exponent (see Methods) (Koutsoyiannis, 2005; Mudelsee, 2007). Flow synchrony refers to the coherence of hydrograph timing and shape among stations along the mainstream, evaluated here using inter-station similarity of standardized daily discharge time series (see Methods). These properties are not simply statistical: hydrological memory controls how climatic or discharge anomalies persist, accumulate, and decay through catchment storage and runoff generation, thereby influencing drought propagation, seasonal-flow predictability, and flood or low-flow risk (Alvarez-Garreton et al., 2021; de Lavenne et al., 2022; Berghuijs et al., 2025). Synchrony, in turn, reflects how coherently the flood pulse is transmitted downstream; changes in the synchrony between mainstem and tributary flows can modulate high-flow extremes, while broader discharge synchronization has been linked to spatially coherent flood risk across river networks (Rupp et al., 2021; Cooper et al., 2025; Yang et al., 2025). A decline in either property indicates hydrological fragmentation, meaning that upstream forcing becomes less persistently expressed through time and less consistently aligned across space, even when changes in mean seasonal discharge appear modest.

6. Line 195-196 Please specify sources for 'other hydrological agencies' and provide links to the data.

Response: Thank you for this comment. We have revised the text to clarify the data sources referred to as "other hydrological agencies". Where the data are publicly accessible, we now provide the relevant source information and links, including the Mekong River Commission Data

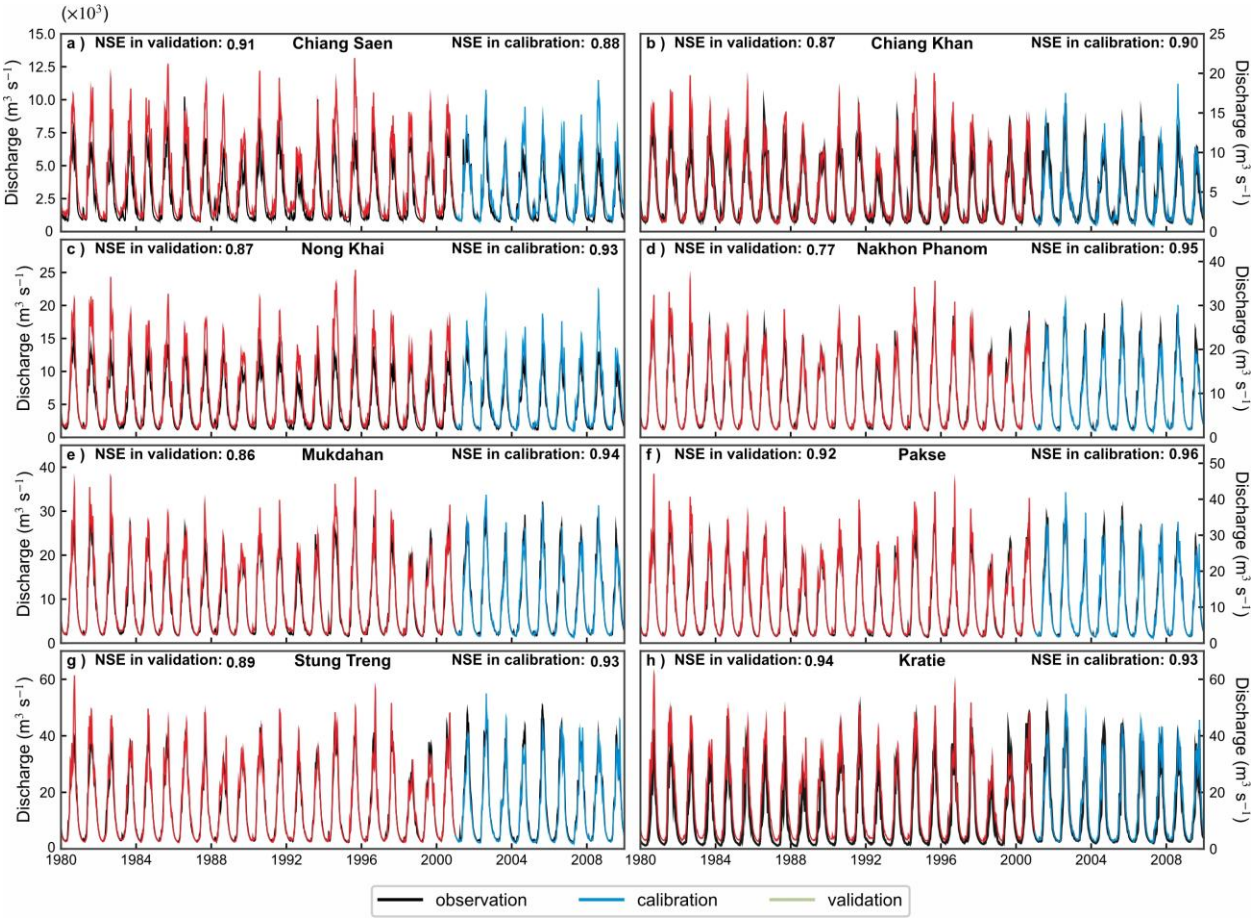
Portal, which provides hydro-meteorological time-series data for the Mekong Basin. However, some station-level hydrological records used in this study were obtained through institutional data-sharing arrangements and are not publicly downloadable or redistributable because of data-use restrictions. We have therefore clarified this limitation in the Code and data availability statement and indicated that access to these restricted datasets can be requested from the corresponding author, subject to the original data providers' permissions.

7. Line 241 Please give a summary metric of model performance here.

Response: Thank you for this helpful suggestion. We agree that the main text should include summary performance metrics rather than only directing readers to the Supplement. Accordingly, we revised Sect. 2.5.1 (Lines 259-265) to state that the THREW model achieved NSE values of 0.88-0.96 at the mainstream gauging stations during the calibration and validation periods, with detailed station-specific metrics provided in Fig. S4 of the Supplement. We also added the validation performance for the Tonle Sap tributaries used as hydrodynamic inflow boundaries: measured-simulated daily discharge comparisons at available tributary stations yielded NSE values ranging from 0.74 to 0.93, with station-specific bias and MRE values provided in Fig. S5 of the Supplement. These revisions clarify that THREW performs well for both mainstream discharge simulation and the tributary inflows used as boundary conditions in the hydrodynamic model.

8. Line 254 Supplement Figure S4 does not include Kratie and the reader is left wondering if THREW is doing a good job at simulating the flows used as an input the HD model.

Response: Thanks for your comment. We have added Kratie station to Figure S4.



9. Lines 478-490: Distinguishing only in pre-dam and post-dam periods here implies that any observed changes are the result of hydropower expansion, neglecting the role of local morphological changes stemming from sand mining as the primary reason for changes in the patterns of TSR reversal.

Response: Thank you for this important comment. We agree that a simple pre-dam/post-dam comparison could be misinterpreted as attributing all observed changes in Tonle Sap River reversal patterns to hydropower expansion, while local morphological change associated with sand mining is also a key driver. We have therefore revised this section to avoid implying a single-driver interpretation. As described in our response to Comment 2, the revised text now distinguishes between basin-scale hydrological changes associated with climate variability and dam regulation, and local geomorphic changes caused by sand-mining-driven channel incision near the Mekong–Tonle Sap confluence. We also clarified that the pre-dam/post-dam comparison is used only as a descriptive temporal contrast, not as evidence that hydropower alone caused the observed changes in TSR reversal. The revised discussion now explicitly recognises sand-mining-induced channel incision as the primary local mechanism increasing the stage difference required to initiate and sustain reverse flow.

10. Figure 2. I continue to think that rose diagrams are not an appropriate visualisation option here, even a bar plot with some transparency would work better. I will leave this decision with the editor, but if you keep the rose diagrams, please consider disconnecting KR and CS from all panels. Also on the CV panels, the positive part of the horizontal axis (connecting the origin and CS) is missing.

Response: Thank you for your suggestion. We have redrawn Figure 2 using standard grouped bar plots, following the reviewer's recommendation. This revision removes the visual issues associated with the previous rose-diagram layout. Thanks!

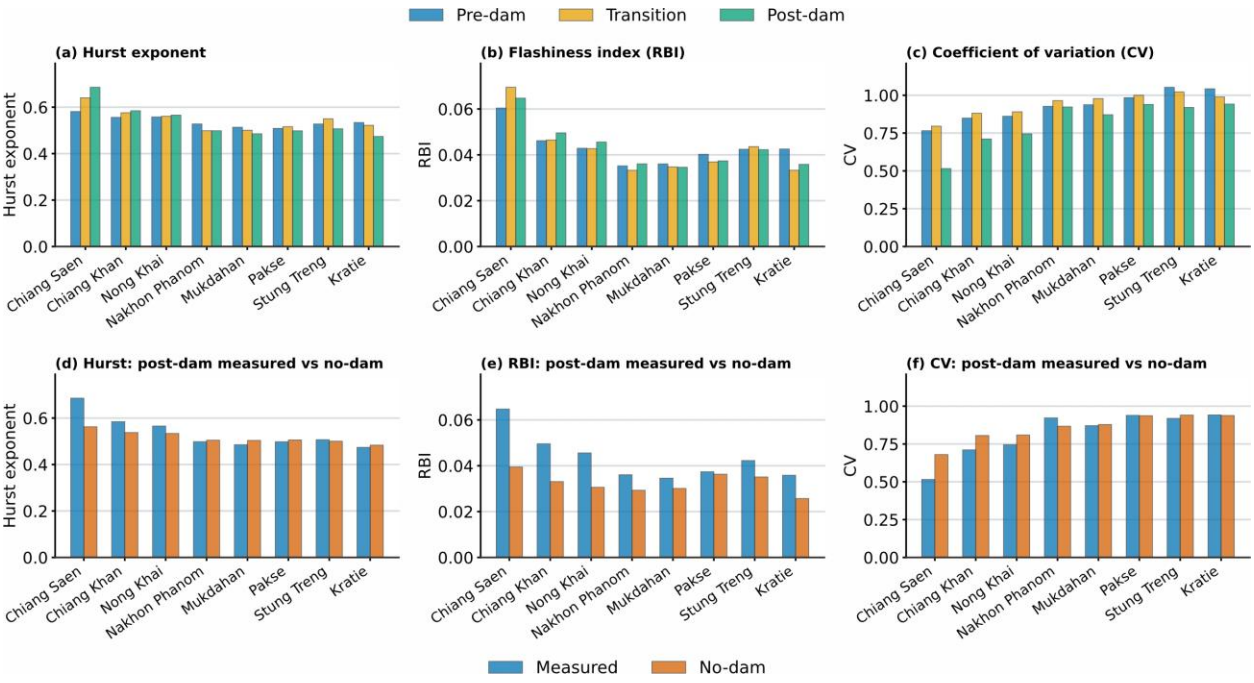


Figure 2. Spatial patterns of streamflow memory, flashiness, and variability along the Mekong mainstream under observed and no-dam conditions. Six grouped bar plots summarise hydrological dynamics at eight mainstream stations from Chiang Saen to Kratie. The top row (a–c) compares three hydrological periods: pre-dam (1976–1991), transition (1992–2009) and post-dam (2010–2024) for (a) the Hurst exponent, (b) the Richards–Baker flashiness index and (c) the coefficient of variation. The bottom row (d–f) compares post-dam measured conditions with a no-dam counterfactual simulated using the THREW hydrological model for (d) the Hurst exponent, (e) the Richards–Baker flashiness index and (f) the coefficient of variation.