Response Document

Referee 2 Comments and Responses

General Remarks

The manuscript investigates the flood-generating mechanisms in the Godavari basin using hydroclimatic variables and catchment characteristics. The topic is relevant for monsoon-dominated regions and large basin flood dynamics. The integration of temporal analysis and EOF-based spatial attribution is a strength, and the findings are potentially useful. Overall, the manuscript is scientifically promising; however, it currently needs revision to explicitly highlight the novelty, provide scientific justification on use of only 5 stations, neglect of the role of human interventions, reliance on VIC outputs and ignoring the use of groundwater on flood generation in the study region.

We would like to thank the reviewer for their overall assessment and for their constructive feedback on our research. We have carefully addressed each of the concerns through the detailed responses below, including novel contributions, station justification, human interventions, VIC model limitations, and groundwater. Overall, we have improved the writing part in the revised manuscript and addressed the reviewer's comments.

Major Comments

- The manuscript largely confirms known concepts: Long-duration vs short-duration flood regimes, role of antecedent soil moisture and spatial heterogeneity in runoff contribution. Suggesting authors to clearly articulate what is fundamentally new for large basin of India and why this is beyond previous works.

  Thank you for this important comment. We acknowledge that some individual concepts, such as long-duration vs. short-duration flood regimes, the role of antecedent soil moisture, have been explored in previous studies (Garg and Mishra, 2019; Keller et al., 2018; Nanditha et al., 2022; Nanditha and Mishra, 2022; Nied et al., 2014; Tarasova et al., 2019). However, the novelty of this manuscript lies in three specific contributions that have not been previously addressed, particularly for large river basins in a monsoonal climate:

  (i) <u>Multi-criteria flood event characterization based on temporal properties of precipitation and runoff</u>:

  Here, we identified three flood-generation storylines, following the studies by Keller et al., (2017) and Berghuijs et al., (2016): (a) flood caused by a single high-intensity precipitation day; (b) flood caused by multiple high-intensity precipitation days; and (c) floods caused by low-to-medium intensity precipitation days and performed the most comprehensive flood mechanism analysis for the Godavari basin to date, systematically distinguishing flood-generating mechanism between different climate zones (semi-arid to semi-humid climates) within a single

large basin. We highlighted that the *majority of floods in the semi-humid regions predominantly occur due to multiple high-intensity rainfall days (10-11 days) and floods in the semi-arid Mancherial sub-basin are triggered by a single high-intensity precipitation event.*

<u>(ii) Flood-dominant catchment area delineation using EOF analysis:</u>

While previous studies established multiday precipitation as a flood driver and examined role of initial conditions in flooding, neither study explicitly identified which specific regions dominate flood generation through spatial EOF analysis. Our study is the first to quantitatively identify the flood-dominant spatial areas in the Godavari basin using EOF analysis. We highlighted that the *central and downstream areas of the Godavari River basin dominate in the flood occurrence.*

<u>(iii) Sub-basin-specific flood characterization using runoff analysis:</u> Our pixel-based runoff analysis provides new insights into the role of the Tekra sub-basin as a disproportionate runoff contributor. This is a novel finding for the Godavari basin and offers directly actionable information for flood management.

We have highlighted these points in the abstract and discussion sections of the manuscript to clearly articulate these three specific novel contributions and explicitly position them relative to prior work.

- The study depends on VIC-simulated runoff and soil moisture without robust validation of extremes. Add a discussion of limitations of VIC in monsoon-dominated basins.

Thank you for your comment and suggestion. We acknowledge that our study relies on VIC-simulated surface runoff and soil moisture, and typically model performance at extreme flow conditions may differ from performance at daily mean conditions. Regarding the validation of extremes, we have also evaluated the VIC model performance during extreme conditions (specifically at high-flow percentiles). The bias at the 95th percentile streamflow (Bias_Q95, reported in Table S2) shows that the VIC model reproduces high-flow magnitudes with acceptable accuracy at most stations. Moreover, the bias at the 95th percentile is less than the bias in mean discharge at the majority of stations (Table S2).

Additionally, we have included a dedicated paragraph in the "Discussion and Conclusions" section of the revised manuscript, acknowledging the limitations of our study (including VIC model limitations). Please refer following lines in the revised manuscript (Line 579-587):

"In this study, we used the calibrated-VIC model for streamflow and runoff simulations, which also exhibits several structural and parametric limitations when applied to predict extreme streamflow events (Abdulla and Lettenmaier, 1997; Liang et al., 2003; Tsai et al., 2021). The VIC model simulates runoff using a saturated-excess mechanism (Liang et al., 1994), which underestimates excess runoff and infiltration estimations during intense monsoon events (Beven, 2012). Considering multi hydrological models (with human influence) for streamflow prediction, we can reduce the model limitations and develop the robust understanding on flood-generating mechanisms over India in the future."

- The study analyzes flood mechanisms using only 5 gauging stations across a very large heterogeneous basin (312, 800 km^2). Can these 5 stations (selected on major river reaches) capture the spatial heterogeneity of the Godavari basin? Further, the stations are nested, and the results are not independent samples. Clearly state the limitations in extrapolating the findings to the entire basin.

Thank you for raising this critical concern and your suggestion. In this study, we considered the observed streamflow data from five stations (Mancherial, Tekra, Pathagudam, Perur, and Polavaram), which are located at major river reaches and collectively drain sub-basins ranging from 35,625 km² (Pathagudam) to 257,500 km² (Polavaram), spanning the basin from semi-arid upper reaches to the semi-humid lower reaches. Since long-term daily discharge data from Central Water Commission (CWC) (with acceptable data quality) are limited and unavailable for other minor independent streams, we considered the limited number of stations for our study. According to your suggestion, we have added the limitation of our results (based on limited observed datasets) in the "Discussion and Conclusions" section of revised manuscript. Please see following write-up in the revised manuscript (Lines 573-579):

"Additionally, our study currently considered limited (five) observed streamflow stations on five major tributaries of Godavari River Basin, which provides limited understanding on flood mechanisms at fine resolution (sub-catchment level) for more robust flood mitigation measures. Based on the availability of long-term streamflow data on other streams of Godavari River, we can further improve the understanding of flood mechanisms and dominate catchment area contribution in flood-generation in the future using the framework discussed in our study."

- The manuscript does not consider baseflow contributions in the analysis, despite using the VIC model which simulated surface runoff and baseflow. For long-duration floods in large monsoonal basins, particularly under wet antecedent conditions, baseflow can significantly contribute to peak discharge. The authors are encouraged to consider separating baseflow and quickflow components or explicitly discuss this limitation.

Thank you for your comment. The VIC model simulates runoff and baseflow (simulated using nonlinear baseflow parameterization from the bottom soil layer) separately for each grid. In this study, we used the baseflow during the streamflow routing. Therefore, our analysis considers the baseflow contribution in the extreme streamflow events. However, we have not

performed the separate baseflow analysis and its role on river floods. In this study, we primarily focus on the two major hydrometeorological variables (precipitation and surface runoff). Previously, Sharma and Mujumdar (2024) demonstrated the role of baseflow on floods in Peninsular India. We have discussed their work in the revised manuscript. Please refer Discussion and Conclusion Section in the revised manuscript (Lines 451-459):

"In our analysis, we considered two hydrometeorological variables, precipitation and surface runoff, across the basin to evaluate the flood generation mechanism where high-intensity precipitation is the primary driver in the flood occurrence. However, previous studies (Garg and Mishra, 2019; Sharma et al., 2018; Sharma and Mujumdar, 2024) showed that high-intensity precipitation and floods are not always linked due to initial hydrological conditions over the catchment. There is only 50 to 70% of high-intensity precipitation, which causes flooding in a basin (Garg and Mishra, 2019; Wasko and Sharma, 2017). Moreover, Sharma and Mujumdar (2024) showed that baseflow has substantially high-influence on flood magnitudes than soil-moisture."

- EOF used to identify "flood-dominated areas"; however, EOF identifies variance patterns not causality. Please clarify the physical representation of modes.

Thank you for your comment. In this study, we did not perform any analysis for the causal attribution. EOF analysis conducted in this study identifies dominant modes of spatial variance and does not directly imply causality. We have carefully reviewed the related sections (Section 3.3.2 and Section 4.3) and updated in the revised manuscript to clarify the physical interpretation. Please refer following sections/lines in the revised manuscript:

Section 3.3.2 (Lines 293-316):

"Next, we evaluated the dominated catchment area in flood generation by examining the precipitation and runoff spatial variability (Figure 2). For that, we used the empirical orthogonal function (EOF) analysis and obtained the leading modes of spatial variability in precipitation and surface runoff (Mishra et al., 2012). EOF analysis identifies the dominant modes of spatio-temporal variability in a dataset by solving an eigenvalue problem derived from spatio-temporal covariance matrix (Lorenz, 1956; Preisendorfer, 1988; Wilks, 2006; Navarra and Simoncini, 2010; Joliffe, 1986; Hannachi, 2022). Here, we first estimated the dominant spatiotemporal modes of variability in the gridded precipitation (surface runoff) to assess its coupling with peak discharge. To do so we formed the spatial covariance matrix of N x N (where N is number of grid points) using following equation:

$$C = \frac{1}{t-1} P' P'^{T}$$

where P' is precipitation (runoff) anomaly; t is number of peak events; and T represents the transpose matrix.

Further, spatial covariance matrix (C) was decomposed as:

$$Ce_k = \lambda_k e_k$$

where e_k and λ_k are the k^{th} spatial EOF and its associated eigenvalue, respectively (Lorenz, 1956). The fraction of total variance explained by each mode is $\lambda_k / \Sigma\lambda_j$. We also obtained the Principal component (PC) time series by projecting the anomaly field onto each EOF:

$$a_k(t) = \sum_{i=1}^{N} P'_{i,t} . e_{k,i}$$

Finally, coupling between each PC time series and the peak discharge anomaly was quantified using the Pearson correlation coefficient. In the EOF analysis, we used the accumulated precipitation and mean surface runoff at each pixel for the time windows found most correlated with peak discharge, according to the findings in step 1 above."

Section 4.3 (Lines 398-422)

"Based on EOF analysis, we captured the dominant pattern of accumulated precipitation during the flood events. We found that floods in the Mancherial and Tekra sub-basins are associated with precipitation occurred over downstream areas of these sub-basin, which are located in the central part of the Godavari basin (Figure 4a-c). However, the leading spatial pattern (Mode-1) of accumulated precipitation covers the entire region of Pathagudam (Figure 4a-c). Perur sub-basin also showed a similar spatial pattern of EOF analysis for the 10 and 11 days accumulated precipitation and indicated the high weightage over the central and downstream parts of the sub-basins during flood generation (Figure 4e-h). For the Polavaram sub-basin, we found a high dominance of the central and downstream part of the Godavari basin in the flooding mechanism (Figure 4i-k). Moreover, the correlation between peak streamflow and the leading mode (mode-1) of 10 or 11 days of accumulated precipitation is higher at Tekra, Pathagudam, Perur, and Polavaram sub-basins than the leading mode of 2 days of accumulated precipitation in same basins (Figure 4d) due to long-rain type floods (Table 1). Furthermore, EOF analysis for mean surface runoff (Figure 5) showed a similar leading spatial pattern, although its area is slightly smaller compared to the precipitation (Figure 4). Other than EOF analysis, we also computed the pixel-based correlation between accumulated precipitation and peak streamflow (Figure S4) and between mean runoff and peak streamflow (Figure S5), for each sub-basin over the relevant duration. Our results showed spatial patterns of correlation analysis that were similar to those

obtained from the EOF analysis. In addition, our analysis (Figure S4 and Figure S5) confirms the previous finding (Figure 4 and Figure 5) where higher correlations of peak streamflow in the Tekra, Pathagudam, Perur, and Polavaram sub-basins are with long-duration precipitation and runoff, compared to short-duration, while for the Mancherial station, the opposite behavior was found."

- Godavari basin is heavily regulated and these structures attenuate flood peaks, alter timing of peak discharge and modify flow accumulation downstream. The assumption that human impacts are negligible is not sufficiently justified especially for downstream stations.

Thank you for comment and feedback. We agree that the Godavari basin and other Indian River basins are significantly regulated and affected by human activities. In the present study, we did not consider the interventions of human activities in the water cycle due to the limited availability of human intervention datasets, which is the limitation of our study. Therefore, we have added the study limitations (related to human influence) in the "Discussion and Conclusions" section of revised manuscript. Please refer following lines in the revised manuscript (Lines 570-579):

"The flood generating mechanisms cannot be fully understood by natural drivers of floods (such as climate) and static catchment attributes. The current study does not consider the extensive role of human activities on water resources and the simulation of hydrological components, which can affect the flood-generating mechanisms (flood propagation and attenuation) in the catchment (Boulange et al., 2021; Haddeland et al., 2014). For instance, previous studies (Boulange et al., 2021; Han et al., 2019; Ruan et al., 2024) showed the role of human activities and dynamic catchment attributes on flood severity and exposure. Therefore, a similar study can be conducted separately in the future to analyze the role of human activities (intensive agriculture practices, reservoir operation, groundwater depletion, urbanization, etc.) in the occurrence of flood events."

- Discussion section can be strengthened by adding comparison with global studies, process understanding and implications for forecasting systems.

Thank you for you suggestions. We have substantially updated the discussion section the revised manuscript and included suggested three dimensions (global studies, process understanding, and implication for forecasting system). Please refer the following "Discussion and Conclusions" section:

"*Floods pose severe challenges to the infrastructure, ecology, and socio-economic development of the largely populated Indian Subcontinent. Moreover, the risk of floods has increased significantly under global warming (Ali et al., 2019; Arnell and Gosling, 2016; Dottori et al., 2018; Hirabayashi et al., 2013; Milly et al., 2002). Thus, an effort is required to better understand flood generation mechanisms in the large river basins of the Indian Subcontinent*

during the monsoonal climate for effective flood management. In this study, we examined the temporal and spatial variability of hydrometeorological variables to identify the dominant flood-generating mechanisms and flood-contributing areas using the observed and VIC-simulated hydrological variables-

In our analysis, we considered two hydrometeorological variables, precipitation and surface runoff, across the basin to evaluate the flood generation mechanism where high-intensity precipitation is the primary driver in the flood occurrence. However, previous studies (Garg and Mishra, 2019; Sharma et al., 2018; Sharma and Mujumdar, 2024) showed that high-intensity precipitation and floods are not always linked due to initial hydrological conditions over the catchment. There is only 50 to 70% of high-intensity precipitation, which causes flooding in a basin (Garg and Mishra, 2019; Wasko and Sharma, 2017). Moreover, Sharma and Mujumdar (2024) showed that baseflow has substantially high-influence on flood magnitudes than soil-moisture. Our results show that the attribution of high-intensity precipitation to flood generation varies with time. For instance, the majority of high-intensity precipitation events in the late monsoon season (August-September) cause flooding in the Godavari basin (Figure S3) due to wetter soil moisture conditions. Therefore, we used a bottom-up approach in our study to examine the temporal and spatial variability of hydrometeorological variables, i.e., we first identified the flood events, and then precipitation and surface runoff variables before the flood events were evaluated to understand their role in the flooding mechanism.

We evaluated the temporal properties of hydrometeorological variables (precipitation and surface runoff) to identify the flood types and processes (Keller et al., 2018; Merz and Blöschl, 2003) that predominantly occur over the Godavari basin in the monsoonal climate. We found that the majority of floods in the Godavari basin (except Mancherial Basin) are long-rain type floods (Keller et al., 2018; Merz and Blöschl, 2003), which are associated with the 10 to 11 (7 to 8) days long precipitation (mean surface runoff) with multiple high-intensity precipitation events. However, the majority of floods in the semi-arid Mancherial sub-basin are short-rain type. The majority area of the Godavari basin, associated with long-duration precipitation (surface runoff), falls in the semi-humid climate. The rivers in the humid climate can carry a large volume of water (or have a large storage capacity); therefore, a significant amount of rainfall is required for the flood occurrence (Merz and Blöschl, 2003). Previous studies (Hirschboeck et al., 2000; Merz and Blöschl, 2003; Nanditha and Mishra, 2022) have found that persistent rainfall in the region is the primary factor in generating long-rain type floods. Consistent with our results, Nandith and Mishra, (2024) showed that the Multiday precipitation is predominant driver of floods over Indian Subcontinent. Similar to long-rain type flood (associated with humid climate), we observed that short-rain type flood in the semi-arid Mancherial region is associated with the small storage capacity of the river in the region, which *can be easily achieved with shorter rainfall. Therefore, to minimize the risk of flooding in the region, we require a forecast system, which can predict the rainfall for 10 to 11 days duration in the semi-humid climate region. Moreover, we need to understand the occurrence of multiple concurrent extreme precipitation events in the future changing climate.*

While the temporal properties of hydrometeorological variables have been widely evaluated to identify flood processes (Keller et al., 2018; Merz and Blöschl, 2003; Nanditha and Mishra, 2022), the spatial patterns of hydrometeorology and catchment conditions before peak streamflow are commonly ignored. This study also evaluated the spatial variability of precipitation and surface runoff before peak streamflow to delineate the dominating flood-generating areas using the EOF and correlation analyses. We showed that the (long or short duration accumulated) precipitation and mean surface runoff before peak streamflow dominantly occur over the central and downstream areas of the Godavari basin, which contribute to the flood generation.

Apart from spatial patterns of precipitation and surface runoff prior to the flood, catchment properties also play an essential role in flood generation. We found that the majority area of the Tekra sub-basin generates more runoff compared to the other sub-basins. The high runoff ratio in the Tekra sub-basin can be associated with various catchment characteristics ~~(such as high slope, forest-crop land cover, clay soil, etc.)~~ (such as high slope, conversion of forest to cropland (agricultural land cover), clay-dominant soils, etc.) in this semi-humid region, which results in a large fraction of precipitation contributing to the surface runoff and causing flooding in the downstream areas. Previous studies (Boardman et al., 2003; Holman et al., 2003; Lane, 2017; Marc and Robinson, 2007) showed that the high irrigation area, deforestation, and high slope accelerate the runoff generation mechanism, which causes high runoff in the basin.

With a limited understanding of flood processes in the Indian Subcontinent during the monsoonal climate, this study initiates a new discussion to better comprehend the flood generation mechanisms in India, aiming to improve flood management. Using the same approach, we can identify the temporal and spatial variability of hydrometeorological variables for the other Indian River basins, which can be used for numerous flood control applications. Overall, our findings provide a better insight into the flood generation mechanism over a large river basin of the Indian Subcontinent during the monsoonal climate. Based on our study, we conclude the following:

1. *The majority of floods in the Godavari river basin occurred during the monsoon season. However, during the late monsoon, there is a higher ratio of high flood events to high precipitation events due to wet soil-moisture conditions.*

2. Four out of five sub-basins (except the Mancherial sub-basin) showed the dominance of long-duration type floods in the period 1967-2019. Long-duration (10-11 days) rainfall causes floods in the semi-humid region of Tekra, Pathagudam, Perur, and Polavaram sub-basins. However, Floods in the semi-arid Mancherial sub-basin are associated with short-duration (2 days) precipitation and surface runoff.
3. Floods in the Tekra, Pathagudam, Perur, and Polavaram sub-basins predominantly occur due to multiple high-intensity rainfall days. Therefore, long-duration type floods occurred in these sub-basins. Moreover, our analysis revealed that short-duration floods in the semi-arid Mancherial sub-basin are primarily associated with single-day high-intensity precipitation.
4. Based on the EOF and correlation analyses of precipitation and surface runoff, central and downstream areas of the basin dominate in the flood generation mechanism in the Godavari River, which highlights the importance of these areas in flood management in a future warming climate. Moreover, medium-term (10 to 11 days lead) precipitation forecasts in these regions will be useful for flood and reservoir management forecasting.
5. Our analysis also indicated the importance of the Tekra sub-basin in the high runoff generation in the Godavari basin. Due to favorable catchment characteristics, a large fraction of precipitation contributes to the surface runoff in the Tekra sub-basin. Therefore, more efforts (i.e., afforestation and sustainable infrastructure development) are needed in the Tekra sub-basin for flood management in the downstream region.

In the changing climate and land use land cover (urbanization and deforestation), the risk of floods is projected to increase over the Indian Subcontinent (Ali et al., 2019; Gosain et al., 2006; Gupta and Nair, 2011; Rogger et al., 2017; Shah et al., 2019). Moreover, the moisture-holding capacity of the atmosphere increases (Karl and Trenberth, 2003; Kharin et al., 2007) due to a warming climate, which leads to frequent, intense, and more extended extreme precipitation events (Ali et al., 2019, 2014; Roxy et al., 2017; Vittal et al., 2013). Therefore, reliable information on precipitation and runoff forecasts in the basin is crucial for effective flood mitigation. Since flood in semi-human regions of Godavari basin occur due to multiple high-intensity rainfall days, there is need of high skill medium-range precipitation forecasting (special over central and downstream regions of basin) to mitigate flood risk in the warming climate. Moreover, real-time soil-moisture monitoring system is required in Tekra basin (which generates high runoff during monsoon season) for flood mitigation. In addition to real-time monitoring and forecasting system, significant steps are needed to reduce the rapid runoff generation in the Tekra sub-basin using natural flood management methods for flood control in the downstream area of the basin (Lane, 2017). For instance, attenuation of surface runoff can be achieved through afforestation (Marc and Robinson, 2007), changes in arable land-use practices

(Boardman et al., 2003), reductions in livestock density (Orr and Carling, 2006), and changes in tillage practices (Holman et al., 2003).

The flood generating mechanisms cannot be fully understood by natural drivers of floods (such as climate) and static catchment attributes. The current study does not consider the extensive role of human activities on water resources and the simulation of hydrological components, which can affect the flood-generating mechanisms (flood propagation and attenuation) in the catchment (Boulange et al., 2021; Haddeland et al., 2014). For instance, previous studies (Boulange et al., 2021; Han et al., 2019; Ruan et al., 2024) showed the role of human activities and dynamic catchment attributes on flood severity and exposure. Therefore, a similar study can be conducted separately in the future to analyze the role of human activities (intensive agriculture practices, reservoir operation, groundwater depletion, urbanization, etc.) in the occurrence of flood events. Additionally, our study currently considered limited (five) observed streamflow stations on five major tributaries of Godavari River Basin, which provides limited understanding on flood mechanisms at fine resolution (sub-catchment level) for more robust flood mitigation measures. Based on the availability of long-term streamflow data on other streams of Godavari River, we can further improve the understanding of flood mechanisms and dominate catchment area contribution in flood-generation in the future using the framework discussed in our study. In this study, we used the calibrated-VIC model for streamflow and runoff simulations, which also exhibits several structural and parametric limitations when applied to predict extreme streamflow events (Abdulla and Lettenmaier, 1997; Liang et al., 2003; Tsai et al., 2021). The VIC model simulates runoff using a saturated-excess mechanism (Liang et al., 1994), which underestimates excess runoff and infiltration estimations during intense monsoon events (Beven, 2012). Considering multi hydrological models (with human influence) for streamflow prediction, we can reduce the model limitations and develop the robust understanding on flood-generating mechanisms over India in the future."

Minor Comments

- Cleary describe the novelty in the abstract.

Thank you for your comment. Our study has three specific novel contributions:

1. **Multi-criteria flood event characterization in different climatic zones based on temporal properties of precipitation and runoff**
2. **Flood-dominant catchment area delineation using EOF analysis**
3. **Sub-basin-specific flood characterization using runoff analysis**

Novelty is underlined in the below abstract:

"Indian River basins experience frequent flooding during the Indian summer monsoon rainfall and pose several challenges to the large population of the region. To effectively manage flood risk in the region, a better understanding of flood-generating mechanisms is essential, yet hydrometeorological and catchment drivers controlling flood processes are poorly explored across India. In this study, we examine the role of hydrometeorological variables (such as precipitation and surface runoff) and catchment area in the flood occurrence in one of the largest river basins (Godavari River basin) of the Indian Subcontinent using observed and VIC-simulated datasets. Based on the temporal analysis of precipitation, runoff, and streamflow, we show <u>that floods caused by multiple high-intensity precipitation days predominantly occur in the semi-humid sub-basins (Tekra, Pathagudam, Perur, and Polavaram) of the Godavari River.</u> The majority of floods in the semi-humid sub-basins are associated with 10 to 11 days of accumulated precipitation, having multiple high-intensity precipitation events prior to flood. <u>In contrast, the majority of floods in the semi-arid region of Godavari (Mancherial sub-basin) are triggered by a single high-intensity precipitation day and associated with short-duration</u> (2 days) accumulated precipitation. In addition to temporal analysis, we also performed <u>Empirical Orthogonal Functions (EOF) analysis</u> using precipitation, runoff, and streamflow data to identify the flood-dominant catchment area. Our results demonstrate that <u>central and downstream areas of the basin contribute disproportionately to flood occurrence, with the Tekra sub-basin generating substantially higher runoff due to favorable catchment characteristics.</u> Overall, this study advances understanding of flood-generating mechanisms over the Godavari River basin, which can be helpful for flood control and management during the monsoonal climate of the Indian Subcontinent."

- Literature review in the introduction section is generic and global, with limited focus on Indian basins. Recent works can be added to sharply define the motivation to this study.

  Thank you for comment and suggestion. We have revised the Introduction and included additionally regional studies on flood mechanism over Indian basins (such as, Sharma and Mujumdar (2024), Nanditha and Mishra (2022), Nanditha et al. (2022), etc.)