

## **Observed variations in the Indian monsoon hydroclimate during recent decades**

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**Abstract** Detection of anthropogenic influences on regional hydroclimate often tends to be obscured by internal variations of the climate system. Using observed climate records and 20th-century re-analysis, we have examined the dominant modes of variability and trends in the Indian monsoon hydroclimate during recent decades. The present analysis extracts the internally-driven signals and the externally forced trends in the monsoon hydroclimate over the Indian subcontinent. It is seen that the internal variations in precipitation minus evaporation ( $P - E$ ) over the Indian monsoon region are largely related to interannually varying patterns of sea surface temperature (SST) in the tropical Indo-Pacific basins. By separating the internal component of monsoon hydroclimate variability, it is seen that the emerging pattern of  $P - E$  change reveals a significant contribution of the forced trends over the Indian subcontinent. To gain further insight into the forced changes in the  $P - E$  history during recent decades, we have conducted a detailed integrated analysis of the three-dimensional moisture budget.

**Key words** Indian monsoon hydroclimate; natural and forced trends; moisture budget; anthropogenic effect