**Abstract**

Runoff efficiency represents the potential of a basin to generate runoff in response to precipitation and it varies based on climatology and physiography. But with urbanization, rapid changes in land use, and climate change, basin responses have changed over time. In larger river basins of South Asia, runoff efficiency has implications for floods and droughts, but has not been studied systematically. This study uses an integrated hydrologic-hydrodynamic modeling system to investigate the spatiotemporal variability of runoff efficiency and their climatological and physiographic controls. `High runoff efficiency is observed over the Central Indian basins such as Narmada, Brahmani, Tapi, Godavari, and Mahanadi during monsoon season due to monsoonal rainfall. Overall, mean RE is higher wherever mean annual rainfall is higher. However, large basins such as Brahmaputra and Subarnarekha exhibit low runoff efficiency despite high monsoon rainfall due to a major contribution towards baseflow. The temporal variability of RE is primarily attributed to the event precipitation magnitude and antecedent soil moisture with relatively higher degree of influence by the latter. ENSO is also observed to influence the temporal variability of RE. La Niña event coinciding with monsoon season, increases the RE over the Central eastern, Central, and Peninsular India. The ENSO effect on RE is due to the amplified ENSO response on runoff than the precipitation. The ENSO effect is reversed in the winter season in North India and has significant impact on precipitation while it has not translated to runoff efficiency. Further, long-term trend analysis shows an increasing trend in runoff efficiency over different basins without any trend in rainfall showing the accelerated response of water cycle owing to climate change. A positive trend in RE is observed in West Flowing Kachh Sabarmati basins in Monsoon, Pre-monsoon, and Winter.