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Accounting for long-term climatic trends in Probable Maximum Precipitation estimation

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The compounding evidence on the aberrant behavior of extreme precipitation has drawn attention of hydrometeorologists towards re-evaluating the existing hydraulic design criteria for protection of large structures (e.g., spillways of dams, nuclear power plants) in changing climate. Traditionally, design flood estimates for those structures were based on Probable Maximum Precipitation (PMP) to minimize or avert the risk of failure and consequent catastrophic damage to mankind and the environment. PMP, as defined by the World Meteorological Organization (WMO), does not account for long-term climatic trends. However, in recent decades, there has been an increase in frequency and magnitude of extreme precipitation events in different parts of the globe. This necessitates devising potential strategies to arrive at effective PMP estimates to re-assess the existing design criteria. Against this backdrop, researchers have been actively developing new methods or modifying the existing ones to adapt to changing climate. The majority of these methods are physics-based whose application demands voluminous data on various hydrometeorological variables and computationally intensive systems to run simulations on weather models. In comparison, statistical approaches are simple and not data intensive. Among available statistical approaches, Hershfield method is widely used due to its ease of application. There is a dearth of attempts to extend it for use in climate change scenarios.

In the present study, a new variant of Hershfield method is proposed which yields reliable PMP estimates by accounting for long-term trends in precipitation data for better estimation of at-site frequency factor in the climate change scenario. The applicability of the proposed method is illustrated over India considering 119 years (1901-2019) long 0.25-degree gridded precipitation records from IMD (India Meteorological Department). The country has more than 5000 dams, and currently PMP estimates are being considered for risk analyses of several ageing dams through the aid of the World Bank, under DRIP (Dam Rehabilitation and Improvement Project). The proposed methodology is applied to arrive at PMP estimates for sites/grids in homogeneous precipitation regions delineated in the country using cluster analysis. The overall impact of increasing/decreasing trend of precipitation on the regional estimate of frequency factor and one-day PMP estimates is clearly demonstrated using the proposed and conventional Hershfield methods.