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Covariate based Time-Varying Intensity-Duration-Frequency Curve for Changing Climate

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The overwhelming increase and variations in the extreme rainfall events present a significant challenge to the research fraternity, especially, it poses a major threat to the existing stormwater management and infrastructure design since the traditional design follows the stationary assumption to develop Intensity-Duration-Frequency (IDF) curve. Hence, in recent times, water professionals have put more effort into developing a non-stationary IDF curve for a sustainable and reliable infrastructure design addressing changing climate. Previous studies model the non-stationarity by incorporating the trend in the parameters using Generalized Extreme Value (GEV) distribution with time as a covariate. However, some of the recent studies have observed that time may not be the best covariate and emphasised the need for incorporating physical processes as a covariate. The changes in precipitation are dominated by temperature changes and teleconnections. Therefore, in this study, we have used three physical processes as a covariate, namely: local temperature changes, diurnal temperature range and El Nino Modoki phenomenon, in addition to time, to develop non-stationary IDF curve for four major cities in India. Different non-stationary GEV models are constructed based on all the possible combinations of the covariates mentioned above, and the best model is chosen using the Deviance Information Criterion (DIC). Besides, this study proposes a time sliding window approach to detect the changing parameters before modelling, to reduce the complexity involved in the development of a non-stationary model. Further, Bayesian Differential Evolutionary Monte Carlo (DE-MC) algorithm is employed to estimate the uncertainty bound of the non-stationary return level. The results of this study reveal that the best covariates are localised and cannot be generalised, for constructing the IDF curve. The proposed methodology reduces the computation of non-stationary models by half and suggests that IDF curves should incorporate non-stationarity only if there is a change in the parameters, though there may be significant changes in the extreme rainfall series. Further, the results demonstrate the under/overestimation by stationary model and emphasise the importance of updating to non-stationary IDF curves for devising long-term strategies to address the changing climate.