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Updating precipitation intensity-duration-frequency (IDF) curves for Europe considering climate change impact

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Urban water infrastructure and flood control structures are typically designed based on the properties of extreme precipitation in the form of intensity-duration-frequency (IDF) curves. The IDF curves are currently based on historical precipitation statistics with a temporal stationarity assumption for these statistics. However, climate change has been altering extreme precipitation properties, leading to the violation of the stationarity assumption and an increase in the probability of structure failure designed based on the current IDF curves. Therefore, to facilitate damage limitation, current design standards based on IDF curves need to be updated considering climate change impact on extreme precipitation properties. To take into account the climate change impact and the spatial pattern of extreme precipitation, this study presents Europe-wide IDF curves for current and future climates. The current IDF curves over Europe are developed using 3-hourly precipitation data from the Multi-Source Weighted-Ensemble Precipitation (MSWEP) dataset with 12 km spatial resolution and 30-min precipitation product of Climate Prediction Center Morphing technique (CMORPH) with 8 km spatial resolution. The developed current IDF curves based on the gridded datasets are validated using sub-daily raingauge precipitation at different locations in Europe. The precipitation with different return periods (ranging between 1 and 100 yr) is calculated by fitting a Generalized Pareto Distribution (GPD) to the extreme values of different aggregation levels (ranging between 0.5 and 24 hr). The future IDF curves are derived by applying climate change signals from a large ensemble of CMIP5 GCMs and EURO-CORDEX RCMs on the current IDF curves in the framework of the quantile perturbation downscaling method. The uncertainty in projected IDF relationships arising from the choice of climate models, representative concentration pathways (RCPs) and initial conditions is quantified, corresponding to model, scenario and internal variability uncertainties, respectively. The results show that making a temporal stationarity assumption for the climate system will lead to a noticeable spatially-varying underestimation of precipitation quantiles over Europe. The uncertainty analysis reveals that the model uncertainty is the dominant source of uncertainty for all aggregation levels and return periods.