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Development and evaluation of a bootstrap sampling based method for downscaling extreme precipitation events

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Climate change is expected to affect the subsystems of the hydrological cycle, which is a major concern for achieving the goals of sustainable water resources management. According to IPCC AR5, it is anticipated to occur more intense and more frequent extreme precipitation events, and the elevated intensity of storm events is a major threat to urban areas. Such future events may cause urban flooding mainly due to the lack of drainage capacity, calling for to consider the effect of climate change in the design of urban drainage infrastructure. To study the effect of climate change, General Circulation Models (GCMs) simulations are the major source of data for the possible future emission scenarios. However, these projections cannot be directly used for the hydrological impact assessment at regional scale as a result of the mismatch of spatial resolution between GCM simulations and the extent of study area. Although numerous downscaling techniques are available to resolve this spatial mismatch, these techniques are more generic and are applied to the entire time series. Since the trends in mean and extremes of the time series are often different, a bootstrap sampling based downscaling technique with specific application to extreme precipitation events is proposed. The uncertainty due to the downscaling method is quantified using imprecise probability theory. The new downscaling method has been evaluated on the GCM projections for Chennai, a coastal city of the peninsular India, and extreme precipitation events of the area are often associated with the cyclonic disturbances in the Bay of Bengal. Mean annual rainfall of Chennai is 1300 mm, while the mean annual maxima is more than 170 mm/day. The downscaled precipitation suggests that the present methodology outperforms the conventionally used quantile mapping and linear scaling. The projections from MOHC-HadGem2-ES model are downscaled to Chennai city scale using the developed methodology for rcp2.6, rcp4.5, rcp6.0 and rcp8.5 scenarios. The frequency analysis of the downscaled precipitation data indicated an increase in the frequency of future occurrences of extreme precipitation, and also a higher intensity as compared to historical precipitation. The results suggested that the rainfall in Chennai during December 2015 (348.1 mm/day), which caused a heavy flood, had a return period of 166 years. However, this 166 year event is expected to become 30, 31, 26 and 37 year event respectively under rcp2.6, rcp4.5, rcp6.0 and rcp8.5 scenarios. It is also noted that the design intensity of rainfall that is used to design drainage structures (currently 39 mm/h, 2 year event of 1 hour duration) has changed to 50 mm/h in the recent years (1969-2015), and may even increase to 54 mm/h in the near future under rcp4.5 scenario. Therefore, appropriate changes in the design values and procedures need to be taken up so as to make the city sustainable under the changing climate scenario.