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Perturbing high-resolution precipitation time series to represent future climates

Hjalte Jomo Danielsen Sørup (1,2,*) and Karsten Arnbjerg-Nielsen (1,2)

(1) Technical University of Denmark, Department of Environmental Engineering, Urban Water Systems Section, Lyngby, Denmark, (2) Technical University of Denmark, Global Decision Support Initiative, Lyngby, Denmark, (*) (hjds@env.dtu.dk)

Climate change impact water management worldwide as the water cycle is embedded in the climate system. For urban infrastructure the time resolution of precipitation data needed for design and planning (minutes) is much finer than what is normally provided by climate models (hourly to daily). Thus, a lot of effort is put into giving reliable estimates of what the expected change in precipitation will be at these fine scales. The relevant urban design criteria span from the minute scale up to yearly water balance scale and time series that show realistic changes across these scales and all those in-between are needed.

Generally, fine resolution precipitation time series for future climates do not exist and a multitude of statistical approaches exist to try to overcome this problem. RCM outputs must be downscaled to higher spatial and temporal resolution to meet these needs. This is often done by applying weather generators or scaling of model output statistics. Both of these methods have known shortcomings in generating representative time series at the sub-hourly to hourly time scales.

In the present study we utilize 1) that we have high resolution precipitation for present climate in the form of observational data, and 2) that we have robust estimates on how precipitation will change due to climate change for all temporal scales. This latter is quantified through change factors which are available for yearly and seasonal precipitation as well as for short term extreme events for a range of return periods. We demonstrate a novel methodology where the regional knowledge about expected changes in precipitation through the use of Intensity-Frequency-Duration (IDF) relationships is used to non-linearly perturb existing precipitation time series at 1-minute resolution to reflect complex expectations to a future changed climate. The methodology process the precipitation time series at event level where individual change factors are calculated based on the actual IDF relationship for each event across relevant time scales relative to the corresponding regional IDF estimate.

The results show that it is possible to generate time series that reflect expected changes due to climate change where changes are realistic across scales ranging from yearly and seasonal precipitation to the extreme values at sub-hourly event level for a range of return periods.