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Moving on from Delta change towards direct use of RCM output by scaling – A method for transient impact simulations

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The real challenge when using Regional Climate Model (RCM) output in hydrological modelling, and still obtain model result that makes hydrological sense, is to get the precipitation right. One of the most common methods for handling this is the so-called delta change approach. In this approach, differences in the most relevant climate variables typically precipitation, temperature and evapotranspiration, are extracted from the control and scenario simulations of the climate model and processed in a model interface before being transferred onto an observed database. The delta-perturbed database is thereafter used to make offline simulations with a hydrological model to provide a response to the future climate. The advantage of this method is that the capability of the RCM to produce simulations that are comparable to observed climate is unnecessary. It is stable and always gives results that can be related to present conditions. On the other hand, the use of observed climate as a baseline implies that the number of rainy days does not change for a future climate and extreme precipitation is modified by the same factor as all other precipitation events.

One method that preserves the variability that is given by the RCM is the so-called scaling approach. Scaling implies an adjustment of specific variables, i.e. precipitation, temperature and evapotranspiration, to reduce systematic biases.

Precipitation is very scale dependent, relatively easy to upscale but difficult to downscale. A typical resolution in a RCM is 50×50 km^2 (2500 km^2) while the sub basins seldom are larger than 400 km^2. A critical question therefore is how to weight the RCM precipitation to the sub basins. As a first approach simple areal weighting was performed, but this method resulted in an overestimation of rainy days with too many small rainfall events and in an underestimation of the extremes. Instead all precipitation in each sub basin was assigned from the dominant RCM grid. This will only work under the assumption that the sub basins are much smaller than the RCM resolution. The RCM output however still overestimated the rainfall events and did not give large enough extremes. To adjust for this, the rainfall events below a sub basin specific threshold were set to zero, i.e. no rain. An intensity dependent scaling was thereafter applied to the RCM data to obtain the same distribution of intensity between the rainfall events as in observations for the same time period.

Potential evapotranspiration is calculated with a temperature index method for observed climate (1961-1990). The statistics from this series, i.e. annual or monthly mean values are used to find scaling factors for the RCM output of potential evapotranspiration for the same time period. Daily mean 2m temperature is treated analogously using scaling factors, but is first adjusted to sub basin mean height.

The scaling method has the advantage that it is easier to use in transient impact studies, i.e. in this study continuous simulations for 1961-2100, and also that it has potential to develop together with the RCMs, such that eventually little or no scaling may be necessary. The major drawback is that it is quite sensitive to the quality of the RCM used as input and that it assumes a static bias correction that may not adequately represent future climate changes, such as changes in circulation.

The method has so far been used in a general nationwide application and more detailed studies in four Swedish rivers, River Motala Ström, River Rönne Å, Lake Vänern and Lake Mälaren and also for the Pungwe River in Mozambique with encouraging results.