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Statistical bias correction of global climate projections - Consequences for large scale modeling of flood flows

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General circulation models (GCMs) project an increasing frequency and intensity of heavy rainfall events due to global climate change. This rather holds true for regions that are even expected to experience an overall decrease in average annual precipitation. Consequently, this may be attended by an increasing frequency and magnitude of flood events.
However, time series of GCMs show a bias in simulating 20th century precipitation and temperature fields and, therefore, cannot directly be used to force hydrological models in order to assess the impact of the projected climate change on certain components of the hydrological cycle. For a posteriori correction, the so-called delta change approach is widely-used which adds the 30-year monthly differences for temperature or ratios for precipitation of the GCM data to each month of a historic climate data set. As the variability of the climate variables in the scenario period is not transferred, this approach is especially questionable if discharge extremes, both in magnitude and return period, are to be analyzed. In order to preserve the variability given by the GCM, methods of statistical bias correction are applied.
Our study aims to investigate the impact of statistically bias corrected climate projections on the large scale modeling of flood discharges, using the example of 28 large scale catchments in Europe. The discharge simulation is carried out with the global integrated hydrological model WaterGAP3 (Water – Global Assessment and Prognosis) with a spatial resolution of the grid cells of 5 arc minutes. The analysis will focus on two pivotal questions:

1. How does the temporal resolution of the climate input, daily or monthly values, impact the simulation of flood flows?
2. Which impact does the correction method have on the simulation of flood flows in the scenario period?

In a first step, the WaterGAP3 model was forced with climate time series for the reference period 1971-2000 (Watch Forcing Data), with daily and monthly temporal resolution of the climate input, respectively. From the resultant hydrographs, characteristic parameters of the flood regime (median and mean annual maximum flood, 25-year flood, 50-year flood) were calculated and validated against the results from measured discharge series.
Subsequently, WaterGAP3 was forced with climate projections of the general circulation models ECHAM5, IPSL-CM4 and CNRM-CM3 for the scenario period 2041-2070. The model runs were performed with an uncorrected, a delta change and a bias corrected time series for each GCM, respectively. The resultant discharge series were evaluated using the aforementioned flood indices.
The main finding of our study is that for more frequent events (median and mean annual maximum flood) the results from the delta change and the bias corrected time series differ only slightly. In contrast, the hydrographs simulated with the bias corrected climate time series reveal significant increases or decreases of the 25-year and 50-year flood levels in the scenario period which are not reproduced by the delta change time series.