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Studying the impact of climate change on flooding in large river basins

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Assessing the potential impact of global climate change on hydrological extremes becomes crucial for regions such as Bangladesh, where a high population density results in a large exposure to risks associated with extreme flooding. In addition, low-lying countries such as Bangladesh are especially vulnerable to sea-level rise and its influence on present-day flood characteristics. By combining the impact of climate change on upper catchment precipitation as well as on sea-level rise at the river mouths, we attempt to analyze the development of flood characteristics such as frequency and magnitude in large river basins. Since flood duration is also of great importance to people exposed to flooding, the development of the number of days with extreme flooding is evaluated for possible trends in the future.

Data used includes historical observations from the Global Runoff Data Centre, while recently released model output for upper catchment precipitation and annual mean thermosteric sea-level rise is taken from the four CCSM4 1° 20th Century ensemble members, as well as from six CCSM4 1° ensemble members for the reference concentration pathway scenarios RCP8.5, 6.0, 4.5 and 2.6.

A peak-over-threshold approach is used to quantify the expected future changes in flood return levels, where discharge exceedances over a certain threshold are fit to a Generalized Pareto Distribution. Return levels are compared from both 20th century and future model simulations for time slices at 2030, 2050, 2070 and 2090. It can be seen that return periods of flood events decrease as the 21st century progresses in all RCP scenarios, with this shift most pronounced in RCP 8.5. The evaluation of flood duration, or the number of days with discharges above a certain threshold, yields an increase. While the number of days with flooding increases in all RCP scenarios, with the largest increase seen at the end of the 21st century, this increase is only statistically significant for RCP 8.5.

Finally, we study how sea-level rise governs the flooding behavior further upstream by calculating the effective additional discharge due to the backwater effect of sea-level rise. Sea-level rise anomalies for the 21st century are taken from CCSM4 model output at each of the river mouths. Judging from our work, the increase in effective discharge due to sea-level rise cannot be neglected when discussing flooding in the respective river basins. Impact of sea-level rise on changes in return levels will be investigated further by using extreme-value theory to calculate how the tails of the current river discharge distribution will be shifted by changing climate.