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Understanding the compound risk of extreme pluvial and fluvial floods

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Extreme precipitation events often lead to pluvial floods, in particular in urban environments dominated by impervious surfaces. Likewise, excessive rainfall over an extended period or heavy snow melt may lead to extreme river floods, which historically have caused loss of many lives, extensive damages to human and natural systems, and displacement of millions of people. In Europe, fluvial floods are generally focused along the larger rivers in Central Europe like the Danube and the Elbe, and in Eastern England.

Risk assessment generally consider the potential hazards from pluvial and fluvial floods as separate events. This can lead to a significant underestimation of the risks. Thus, the physical processes (e.g. precipitation) that drive these extreme events may interact and/or exhibit a spatial or temporal dependency, which could lead to an intensification of the hazard or modify the associated vulnerability and/or exposure. This is, e.g.,the case of Budapest, where the urban drainage system relies on gravity flows. At about 3-m above the normal water level of the Danube, excess rainwater is no longer able to drain into the river without pumping, which may in turn result in increased inundation if this is coincident with an extreme precipitation event.

Here, we investigate the compound risk of pluvial and fluvial floods in Budapest. We particularly strive to understand the dynamics of the correlation, e.g. timing and location that drives a compound flood event and its associated probability under current and future climates. We consider 4 members of the Euro-CORDEX regional climate model ensemble and their historical and future simulations (RCP4.5 and RCP8.5). 30-year time slices (e.g. 2071-2100) are extracted from each simulation, which is then bias-corrected and finally statistically inflated (Sparks et al. 2018) to yield 10k years daily time series with the same overall statistical properties as the underlying Euro-CORDEX model but with an enhanced representation of rare (precipitation) extremes. This time series is then feed into a detailed hydrological model for the entire Danube catchment (Hattermann et al. 2018) from where we extract water levels and other relevant parameters for Budapest. Likewise, we extract the precipitation time series (10k years) for Budapest. Based hereon we analyse the coincidence of compound pluvial + fluvial flood events for both a current and future climate, including the potential physical links between extreme precipitations events in Budapest, and larger scale rainfall in the Danube catchment. We show how a better understanding of compound events may improve projections of potential extreme events.

Hattermann, F.F., et al. (2018): Simulation of flood hazard and risk in the Danube basin with the Future Danube Model, Climate Services, 12, 14-26.
Sparks, N.J. et al. (2018). IMAGE: a multivariate multi-site stochastic weather generator for European weather and climate. Stoch. Environ. Res. Risk Assess., 32, 771–784.