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Producing physically consistent and bias free extreme precipitation events over the Switzerland: Bridging gaps between meteorology and impact models

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Extreme precipitation episodes, although rare, are natural phenomena that can threat human activities, especially in areas densely populated such as Switzerland. Their relevance demands the design of public policies that protect public assets and private property. Therefore, increasing the current understanding of such exceptional situations is required, i.e. the climatic characterisation of their triggering circumstances, severity, frequency, and spatial distribution. Such increased knowledge shall eventually lead us to produce more reliable projections about the behaviour of these events under ongoing climate change. Unfortunately, the study of extreme situations is hampered by the short instrumental record, which precludes a proper characterization of events with return period exceeding few decades. This study proposes a new approach that allows studying storms based on a synthetic, but physically consistent database of weather situations obtained from a long climate simulation.

Our starting point is a 500-yr control simulation carried out with the Community Earth System Model (CESM). In a second step, this dataset is dynamically downscaled with the Weather Research and Forecasting model (WRF) to a final resolution of 2 km over the Alpine area. However, downscaling the full CESM simulation at such high resolution is infeasible nowadays. Hence, a number of case studies are previously selected. This selection is carried out examining the precipitation averaged in an area encompassing Switzerland in the ESM. Using a hydrological criterion, precipitation is accumulated in several temporal windows: 1 day, 2 days, 3 days, 5 days and 10 days. The 4 most extreme events in each category and season are selected, leading to a total of 336 days to be simulated.

The simulated events are affected by systematic biases that have to be accounted before this data set can be used as input in hydrological models. Thus, quantile mapping is used to remove such biases. For this task, a 20-yr high-resolution control simulation is carried out. The extreme events belong to this distribution, and can be mapped onto the distribution of precipitation obtained from a gridded product of precipitation provided by MeteoSwiss. This procedure yields bias-free extreme precipitation events which serve as input by hydrological models that eventually produce a simulated, yet physically consistent flooding event. Thereby, the proposed methodology guarantees consistency with the underlying physics of extreme events, and reproduces plausible impacts of up to one-in-five-centuries situations.