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A classification algorithm for selective dynamical downscaling of precipitation extremes

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High-resolution climate data [O(1 km)] at the catchment scale can be of great value to both hydrological modellers and end users, in particular for the study of extreme precipitation. Despite the well-known advantages of dynamical downscaling for producing quality high-resolution data, the added value of dynamically downscaling to O(1 km) resolutions can often not be realised due to the prohibitive computational expense. Here we present a novel and flexible classification algorithm for discriminating between days with an elevated potential for extreme precipitation over a catchment and days without, so that dynamical downscaling to convection-permitting resolution can be selectively performed on high-risk days only, drastically reducing total computational expense compared to continuous simulations; the classification method can be applied to climate model data or reanalyses.

Within the framework of the H2020 project BINGO (Bringing INnovation in onGOing water management; <www.projectbingo.eu>), we use observed precipitation and the corresponding synoptic-scale circulation patterns from reanalysis to identify characteristic extremal circulation patterns for a catchment, via a clustering algorithm. These extremal patterns serve as references against which days can be classified as potentially extreme, subject to additional tests of relevant meteorological variables in the vicinity of the catchment.

Applying the classification algorithm to reanalysis, the set of potential extreme days (PEDs) contains well below 10% of all days, though includes essentially all extreme days; applying the algorithm to reanalysis-driven regional climate simulations over Europe (12 km resolution) shows similar performance and the subsequently dynamically downscaled simulations (2 km resolution) well reproduce the observed precipitation statistics of the PEDs from the training period. Additional tests on continuous 12- and 2 km resolution historical and future (RCP8.5) climate simulations show the algorithm again reducing the number of days to simulate by over 90% and performing consistently across climate regimes.

The downscaling framework we propose represents a computationally inexpensive means of producing high-resolution climate data, focused on extreme precipitation, at the catchment scale, while still retaining the advantages of the physically-based dynamical downscaling approach.