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Detecting the dynamics of heavy precipitation Vb-cyclones under climate change using neural networks

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Extreme precipitation and floods, triggered by large scale atmospheric drivers, are of high societal importance. Scientific knowledge on how the dynamics of such large-scale drivers will be affected by climate change is still limited, especially due to the uncertainty of internal variability. An improved understanding of the role of internal variability can be supported by the analysis of large initial-conditions ensembles of a single climate model.
The ClimEx project (Climate Change and Extreme Events, www.climex-project.org) has developed an initial-conditions 50-member ensemble (CRCM5-LE) at 12-km resolution using the Canadian Regional Climate Model (CRCM5) driven by the CanESM2 global climate model with the Representative Concentration Pathway (RCP) 8.5 as external forcing. This dataset enables the assessment of climate change effects on meteorological and hydrological extreme events over the European domain, while considering internal climate variability as an important underlying uncertainty.
We analyze the synoptic situation of a cut-off low over Central Europe and its concomitant cyclone of type Vb – a rare cyclone type that has triggered several devastating floods in the study area of Bavaria. An artificial neural network approach is employed to address the major challenges involved in evaluating the vast amount of CRCM5-LE-data for the dynamics of Vb-cyclones. Prior to cyclone tracking, the artificial neural network filters the CRCM5-LE specifically and efficiently for the synoptic pattern of a cut-off low over central Europe, which is associated with the development of strong Vb-cyclones.
Our results demonstrate the performance of the procedure and its capacity to detect historic Vb-events in a reanalysis-driven model run. Using the large ensemble, the particular relevance of considering internal variability in climate change impact assessment is highlighted by presenting the ratio between climate change signal and internal noise. Finally, the long-term effects of climate change are illustrated in terms of higher frequencies, shifting seasonality and increasing precipitation rates related to Vb-cyclones.

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