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Multi-century disaster gaps followed by strong clusters of extreme precipitation – understanding the irregular occurrence of local heavy rainfall

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Historical archives and climate model simulations show that there can be multi-century periods with no local extreme precipitation, referred to as disaster gaps, followed by intense temporal clusters of extreme precipitation. The irregular occurrence of extreme precipitation represents a major challenge for detection and attribution of climate signals, adaptation planning and for insurance pricing. Here we use the first large ensemble of a convection permitting model (including twelve 100-yr simulations) and multi-century GCM simulations to study the irregular occurrence of local precipitation extremes.

We show that local extreme precipitation events occur highly irregularly, with potential clustering (11% probability of five or more 100-year events in 250 years) or long disaster gaps with no events (8% probability for no 100-year events in 250 years). Even for decadal precipitation records, there is almost a 50% chance of a complete absence of any tail events in a 70-year period, the typical length of observational or reanalysis data. This generally causes return levels – a key metric for infrastructure codes or insurance pricing – to be underestimated.

We then explore whether the occurrence of extreme events is purely random (“white noise”) or induced by low-frequency modes of internal variability, such as the multi-decadal variability in the North Atlantic. Surprisingly, we find based on millennial climate simulations that long-term variability in extreme precipitation is largely random, with no clear indication of low-frequency decadal to multidecadal variability.

We also evaluate the potential of employing information across neighbouring locations, which substantially improves the estimation of return levels by increasing the robustness against potential adverse effects of long-term internal variability. The irregular occurrence of events makes it challenging to estimate return periods for planning and for extreme event attribution.