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A framework for the super attribution of multiple extreme events

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Detection and attribution of anthropogenic influence on extreme events has always been one of the focuses of climate research. A number of studies have been undertaken that employed different approaches (such as the risk-based, Boulder, and circulation-based ones) for attributing individual extreme events of various types over the globe. While many of these extreme events are attributable to anthropogenic or natural factors, some still remain inconclusive. To this end, a super attribution framework is proposed, in which multiple extreme events occurring in one region within a predefined timeframe are considered as a whole instead of individually. The rationale is that climate change may influence large-scale circulation over a region, which subsequently alters the frequency of extreme events in multiple locations in this area. Specifically, the supervariable is proposed to characterize how severely a region is affected by extreme precipitation in terms of area. It is defined as the fraction of area in a region that experiences extreme precipitation of over 99.9^{th} percentile in each day. The trends in the supervariable in the 20 Italian regions are examined. For regions with positive but not significant trends, there could be an anthropogenic signal present, but it could be too weak to be detected. Therefore, regions with positive trends are selected, and a super attribution is undertaken on them simultaneously. It is accomplished by calculating the combined supervariable, which is obtained by pooling the stations/grids of the selected regions together. Simultaneous events that occur in the autumn of each year are then considered. The results show that a statistically significant increasing trend can be identified in the combined supervariable for the selected regions, which suggests an increase in the area affected by extreme precipitation. In parallel to the statistical analysis, dynamical attribution is also carried out using the analog method, and the type of pattern that is both significantly influenced by climate change and associated with significant increases in precipitation is identified.