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Machine learning framework to classify extreme weather events based on multi-scale dynamic and thermodynamic predictors

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Extreme weather events and corresponding natural hazards have always been a major threat to people all over the globe. It is common scientific consensus that climate change comes along with increases in both frequency and intensity of extreme weather events, entailing increasing amounts of associated natural hazard events. However, describing regional extreme weather events within climate models is still challenging. Moreover, this poses a major challenge for decision-makers in the field of civil protection who require an integrated multi-hazard risk assessment and impact forecasting methodology tailored to their needs.

In order to investigate the predictability of extreme weather events and associated natural hazards (e.g. droughts, floods, storms) and to analyze trends in a climatological context, extreme events are linked to their meteorological drivers. We adopt a machine-learning framework to classify days as extreme for a given natural hazard using multiple components across different spatial scales. Synoptic-scale dynamic and thermodynamic components are included via atmospheric weather types and synoptic-scale aggregates of thermodynamic variables. Furthermore, regional components are added as additional features, capturing regional pressure gradients and regional aggregates of thermodynamic variables. Model performance is evaluated within a spatiotemporal split-sample training and testing procedure, that allows to quantify transferability and extrapolation capabilities across spatial and temporal extents and to determine the predictability of extreme events.

The model can be used as an extreme event classifier for times series analyses for a given spatial extent and natural hazard. Historic trends are analyzed using ERA5 data with a focus on Central Europe and the Alpine Region. Furthermore, the modeling framework can be applied to the output of General Circulation Model data, which allows the estimation and analysis of future trends under different climate change scenarios.