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A climatological look on the intersection of synoptic conditions and extreme weather-induced potential impact events in the cross-border region of Austria and Italy

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Extreme weather events and associated natural hazards pose a significant global threat to all levels of society. It is scientific consensus that climate change contributes to an increasing frequency and intensity of these events. One of the key challenges for decision-makers in the field of civil protection is to deal with the changing landscape of weather-induced impact events, that are driven by climate change. Hence, assessing the current and changing conditions across spatiotemporal scales for extreme weather events under a changing climate is essential.

This study explores the potential of utilizing weather circulation type classification through its correlation with observed weather-induced extreme events and their potential impacts on the local-scale. Thereby, high-impact weather types can be determined as a relevant background field, serving as a measure about the potential of severe weather hazards. We employ ERA5 reanalysis data as baseline meteorological input data to derive long-term and robust time series of weather types from mean sea level pressure that are relevant for the cross-border region of Austria and Italy. The classification scheme 'Gross-Wetter-Typen' (GWT) with 18 classes was used to assign each day a prevailing weather type class. The overlap between derived classes is further investigated by means of unsupervised clustering techniques, to evaluate clusters of groups across all GWT classes. Additional meteorological fields (e.g. equivalent potential temperature, geopotential height, precipitable water, ...) are validated on top of the GWT classes for further characterisation of extreme weather events. Days exhibiting extreme weather-induced potential impact events are derived via percentile methods applied to precipitation data from observational gridded datasets (Enigl et al., 2024, EGU24-10058). Finally, we extend our analysis with an evaluation of potential changes by applying found relationships to state-of-the-art climate model data from the Coupled Model Intercomparison Project 6 (CMIP6) to investigate the changing landscape of potential weather extremes.

Our findings indicate that a specific subset of large-scale weather circulation patterns acts as a crucial precursor to high-impact weather extremes. Furthermore, considering the climate change scenario SSP3-7.0, the frequency and associated precipitation totals linked to these weather patterns exhibit an increase. This suggests a potential rise in both the frequency and intensity of extreme weather events and their corresponding impacts if emissions continue to increase.