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Extreme cold events: global climatology and relation to cyclones

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Extreme cold weather events cause major damage to industry, agriculture and human health. While regional extremes are often associated with different large-scale atmospheric circulation anomalies, it is yet unclear which mechanisms and weather systems are relevant on a global scale, i.e., across regions. This study aims to identify the large-scale processes leading to extreme cold events from a global climatological perspective, and specifically quantify the non-local contribution of midlatitude weather systems using a Lagrangian approach.

Here, we objectively identify anomalously cold extremes by applying local percentile-based thresholds of 2-m temperature in ERA5 reanalysis. We further track air parcel trajectories of dry, cold intrusions occurring in the wake of extratropical troughs and cyclones, previously shown to induce cold anomalies following cold frontal passages. We find a strong association between cold extremes and dry intrusions, reaching 45% of cold extremes in the midlatitudes, despite the intrusions' natural occurrence frequency of only 12% in those areas. Using clustering methods, additional atmospheric precursors to cyclones producing cold extremes are highlighted. The identification of mechanisms governing the predictability of cold extremes, on a global scale, is key for societal preparedness.