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Extreme extratropical cyclone characteristics during the last millennium and the future

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Extratropical cyclones are fundamental phenomena of the day-to-day variability, responsible for wind and precipitation extreme events. Despite the advances in a better understanding of the underlying processes of cyclones, their development and intensification, there is still considerable uncertainty of how extratropical cyclones react to changes in external forcing. This is because competing and partly canceling processes are difficult to grasp. Some of these uncertainties arise from the fact that the observed time period is rather short.
The purpose of this study is to present variability of different cyclone characteristics for the future under RCP 8.5 and to put these changes for the first time in a perspective of low-frequency variations during the last millennium. Therefore, we use a seamless simulation with Community Earth System Model (CESM1) spanning the period AD 850 to 2099. The analysis is based on December to February for the North Atlantic European region. Cyclones are detected and tracked by a state-of-the-art Lagrangian method providing a range of cyclone characteristics, such as cyclone intensity measured by cyclone depth, cyclone-related precipitation, area affected by cyclones, or number of cyclones.
Results show that solar and volcanic forcing has no clear imprint on cyclone characteristics during the period 850 to 1850. Thus, cyclone characteristics are dominated by internal variability showing pronounced low-frequency variations. Extremes in cyclone depth are associated with an increase in the number of cyclones over Scandinavian and a decrease over Central Europe. Further, cyclone depth extremes are linked to a NAO-like pattern which is displaced to the northeast, and a strong cooling over the Greenland-Iceland-Norwegian Sea and a warming over Siberia. Extremes in cyclone-related precipitation show no clear link to the large-scale atmospheric circulation, but are associated with a warming along the Atlantic coastline of Europe. Changes of extratropical cyclone characteristics in the future exceed the range of the last millennium showing a decrease in the number of cyclones by roughly 10% but no clear trend in cyclone intensity, whereas cyclone-related precipitation and the area affected by cyclones increases by 12% in the 21st century.