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# Weather and extremes in the last Millennium - a challenge for climate modelling

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Changes in the climate mean state are expected to influence society, but the socio-economic sensitivity to extreme events might be even more severe. Whether or not the current frequency and severity of extreme events is a unique characteristic of anthropogenic-driven climate change can be assessed by putting the observed changes in a long-term perspective. In doing so, early instrumental series and proxy archives are a rich source to investigate also extreme events, in particular during the last millennium, yet they suffer from spatial and temporal scarcity. Therefore, simulations with coupled general circulation models (GCMs) could fill such gaps and help in deepening our process understanding.

In this study, an overview of past and current efforts as well as challenges in modelling paleo weather and extreme events is presented. Using simulations of the last millennium we investigate extreme midlatitude cyclone characteristics, precipitation, and their connection to large-scale atmospheric patterns in the North Atlantic European region. In cold climate states such as the Maunder Minimum, the North Atlantic Oscillation (NAO) is found to be predominantly in its negative phase. In this sense, simulations of different models agree with proxy findings for this period. However, some proxy data available for this period suggests an increase in storminess during this period, which could be interpreted as a positive phase of the NAO - a superficial contradiction. The simulated cyclones are partly reduced over Europe, which is consistent with the aforementioned negative phase of the NAO. However, as the meridional temperature gradient is increased during this period – which constitutes a source of low-level baroclincity – they also intensify. This example illustrates how model simulations could be used to improve our proxy interpretation and to gain additional process understanding.

Nevertheless, there are also limitations associated with climate modeling efforts to simulate the last millennium. In particular, these models still struggle to properly simulate atmospheric blocking events, an important dynamical feature for dry conditions during summer times. Finally, new and promising ways in improving past climate modelling are briefly introduced. In particular, the use of dynamical downscaling is a powerful tool to bridge the gap between the coarsely resolved GCMs and characteristics of the regional climate, which is potentially recorded in proxy archives. In particular, the representation of extreme events could be improved by dynamical downscaling as processes are better resolved than GCMs.