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Externally forced and internal variability of tropospheric variability modes in the past millennium

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The North Atlantic Oscillation, together with the Arctic and Antarctic Oscillations, dominate the variability of the atmospheric circulation in wintertime in each hemisphere, and hence the understanding of the variability of these modes at multidecadal timescales is important to estimate the range of possible fluctuations and evaluate their predictability under climate change scenarios.

This study analyses whether external forcings exert a detectable fingerprint in the long-term evolution of these atmospheric circulation patterns during the last millennium. This detection has to be seen in the backdrop of internal variability due to the internal dynamic of the climate system, and for this purpose a large ensemble of long palaeoclimate simulations over the past millennium has been analysed. The results show that the external forcings do not significantly add variability in any frequency band to the internal variability of the atmospheric modes in control runs, where no variations of the forcings are included. Additionally, a method designed to detect coherence in the time evolution of these circulation patterns among millennium simulations is suggested, and applied to demonstrate that the null hypothesis of an evolution dominated by internal variability can not be rejected regardless the time filtering applied to the series.

Given that these atmospheric modes do respond to external forcing in future climate change projections, we suggest that either the amplitude of past variations of the external forcings has not been large enough, or the sensitivity of the simulated modes is underestimated, or the anthropogenic greenhouse gas forcing is more effective driver of atmospheric circulation modes.