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Low-frequency variability of wintertime Euro-Atlantic planetary wave-breaking

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The present study analyses the long-term temporal variability of wintertime wave-breaking in the North Atlantic in reanalysis data and a 1000–year equilibrium simulation of the MPI-ESM model under constant pre-industrial forcing. Planetary wave-breaking can lead to large-scale atmospheric circulation anomalies and favour high-impact weather occurrences. For example, the simultaneous occurrence of anti-cyclonic wave-breaking to the south of the North Atlantic jet and cyclonic wave-breaking to the north, here termed double wave-breaking, has been linked to heightened frequencies of explosive cyclones in the Atlantic basin and destructive windstorms over Western and Continental Europe. We find a significant ultra-centennial variability in double wave-breaking frequency, which is largely mirrored in the variability of the NAO. The low-frequency wave-breaking variability is reflected in long-term anomalies in the large-scale circulation over the Euro-Atlantic sector. The 100-year periods with the most and least double wave-breaking occurrences display significant and opposite anomalies in both upper and lower-level wind, as well as in the frequency of extreme temperature events and in the magnitude of wind destructiveness over Europe. The latter broadly resembles the wind destructiveness anomalies associated with individual double wave-breaking instances in reanalysis data. The existence of low-frequency variability in an atmospheric pattern related to high-impact weather events has important implications for the study and interpretation of climate change projections.