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Influence of changes in large-scale circulation on surface wind projections for wind power over Europe

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Wind power accounts for a large portion of the European energy mix (∼17% of total power capacity) and, in consequence, European power systems have a significant - and growing - exposure to changes in near-surface wind speeds. Despite this, there is scant process-based research on the impact of climate change on European wind climate, and the limited studies that do exist show inconsistent responses between different general circulation models (GCMs). This work therefore seeks to explore the potential drivers of change - both large-scale and local - in European wind climate in the 21st Century.

The contribution to variations in near-surface wind speed changes from the large-scale circulation (associated with the North Atlantic jet) is therefore quantified in both reanalysis (ERA-Interim) and the CMIP5 ensemble. By isolating the fraction of the variations in surface wind speed that are explained by changes in the North Atlantic jet, we found that the connection between wind and the large-scale is stronger in the cold season than in the warm season, and can be captured reasonably well by the first two empirical orthogonal functions (EOFs) of North Atlantic zonal wind. Such connection is stronger over Western Europe, where the influence of the North Atlantic jet is greater, and weakens towards central Europe.

The raw projected changes in wind speed over Western Europe are then decomposed into two components: one associated with the large-scale changes in the North Atlantic jet, and a 'residual'. The component associated with the large scale circulation can explain the windiness projections in the free troposphere over Western Europe, with the changes reflecting the poleward shift of the North Atlantic jet. However, we find that large-scale circulation changes are unable to explain the projected windiness change near the surface, where the residual is negative in the majority of GCMs. This analysis therefore suggests that projected 21C wind speed-changes over Western Europe are potentially the result of two distinct processes. The first is associated with changes in the large-scale atmospheric circulation, while a second process is likely to be more 'local' in its connection to the near-surface boundary-layer structure. An improved process-based understanding of both components is important for improving confidence in wind-power projections on multi-decadal timescales.