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Large scale atmospheric circulation patterns and solar energy resources in the UK and Ireland

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Increased penetration of variable and intermittent renewable energy sources such as wind and solar poses a major challenge for the design and stability of power systems globally. Successful further large scale integration of variable renewable energy sources will depend on a much improved understanding and quantification of the spatiotemporal variability of these renewable energy resources. Here we focus on the links between large scale atmospheric circulation patterns and solar energy resources in the Euro-Atlantic sector; specifically in the UK and Ireland. In this sector, teleconnections such as the North Atlantic Oscillation (NAO), the East Atlantic (EA) and Scandinavian (SCAND) patterns reflect large scale sea level pressure (SLP) anomalies. Recent work has assessed the impact of the NAO, EA and SCAND modes on several meteorological variables in the region, such as air temperature, precipitation amount, cloud cover (solar radiation), wind speed, wind direction and ocean wave characteristics, especially in winter. Some of these patterns (mainly the NAO), have been linked to output variability in renewable power systems on various time-scales, although recent work has shown that atmospheric low frequency variability is best explained when considering the combined action of various variability patterns.

Taking advantage of meteorological observations (pyranometers) and recently available reanalysis datasets (MERRA2) we have evaluated the contribution of the climate patterns to cloudiness variability throughout the UK and Ireland. Station observations of irradiance were used to check the accuracy of the MERRA2 re-analysis data, the latter being a gridded dataset that enables an extensive geographical cover that is essential for our analysis. Our results confirm known biases in the MERRA2 reanalysis. Importantly however, our analysis also confirms that a previously identified zonal gradient in the correlation coefficient between the winter NAO index and the winter surface clearness index (a cloudiness index) in the UK sector extends westwards into, and across the island of Ireland. The SCAND pattern exerts an important effect, particularly in some northern locations, but the EA pattern appears to have relatively little influence on winter surface clearness throughout the UK-Ireland region. These findings have important implications for estimates of inter-seasonal and inter-annual variability in surface irradiance and therefore expected solar power output. There is considerable potential to use this information to help balance the regional scale renewable power capacity, with implications for the optimisation of west-east interconnection between the UK and Ireland, particularly when the solar and wind resources are considered together in the context of NAO variability and recent advances in its predictability.