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Understanding the impact of meteorological variability on the European power system

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As the weather-dependence of power systems increases it is becoming increasingly important for power system operators/traders to have information on timescales of weeks to months ahead. For this to be possible, the impact of climate variability on the power systems (and our ability to predict these variations) must be quantified and understood. European climate variability is often viewed in terms of meteorological patterns, generally derived using principal component analysis or clustering techniques on large scale meteorological fields. Such approaches therefore represent meteorological variability well, but they do not necessarily capture the circulation patterns that best explain the impact of weather on a geographically diverse and inhomogeneous power system. As part of the H2020 Subseasonal to Seasonal predictability for Energy project (S2S4E), a novel and alternative approach is proposed, whereby “impact patterns” - derived directly from simulated power system data – are used to identify the meteorological characteristics which drive the greatest power system response.

MERRA2 and ERA5 re-analysis are first used to calculate national-aggregate weather-dependent demand, wind power generation, and solar power generation time series from 1980-2018 for each European country. From this simulated power system data, impact patterns are calculated using k-means clustering and principal component analysis techniques, which are then projected back onto the corresponding meteorological fields (e.g., circulation and surface variables).

As expected, the impact pattern methodology reproduces features consistent with traditional meteorological pattern analysis. However, the impact patterns have much stronger connections to the surface variables of interest than the traditional weather regime methods. The impact patterns also highlight that not all meteorological patterns are equally useful in forecasting the power system impact of weather on a European scale. Moreover, additional and novel atmospheric circulation patterns emerge from the impact pattern analysis compared to standard meteorological analyses.
Impact patterns therefore provide a complementary view to traditional meteorological analyses, highlighting the patterns of weather which most strongly characterise variations in the properties of the impacted system (in this case electricity). Results concerning the predictability of the European power system using these impact-patterns are also be presented.