Using decadal predictions to identify risks for the energy-sector

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Summary

- As the power system transitions to use more variable renewable energy sources, the system becomes more sensitive to changes in weather and climate.
- There is skill in decadal forecasts for temperature, solar irradiance, precipitation, and the North Atlantic Oscillation (NAO), over Europe and the North Atlantic.
- A large ensemble of decadal predictions can be aggregated to create an event set of physically plausible extremes, such as multi-year wind droughts.

Background

As the deployment of intermittent renewable energy technologies increases, so does the need for long-duration, large-scale electricity storage to ensure security of supply (The Royal Society, 2023). As decadal predictions sample the uncertainty from both internal climate variability and climate change, these predictions allow us to estimate the potential for risks to the power system on these longer timescales. Decadal predictions can be used to identify risks to the energy-sector in two ways:

1. Forecasts can be used to try to **predict** how a variable of interest (e.g. precipitation) may vary over the next year to decade (Hermanson et al., 2022).
2. Predictions can be aggregated to **explore physically plausible extremes**, such as winter wind droughts, in a very large synthetic event set (Kay et al., 2023).

As previous work has demonstrated the value of these methods on seasonal timescales (Clark et al., 2017, Kay et al., 2023), there is potential for applying similar techniques to explore applications for the energy-sector on multi-annual to decadal timescales.

Prediction skill

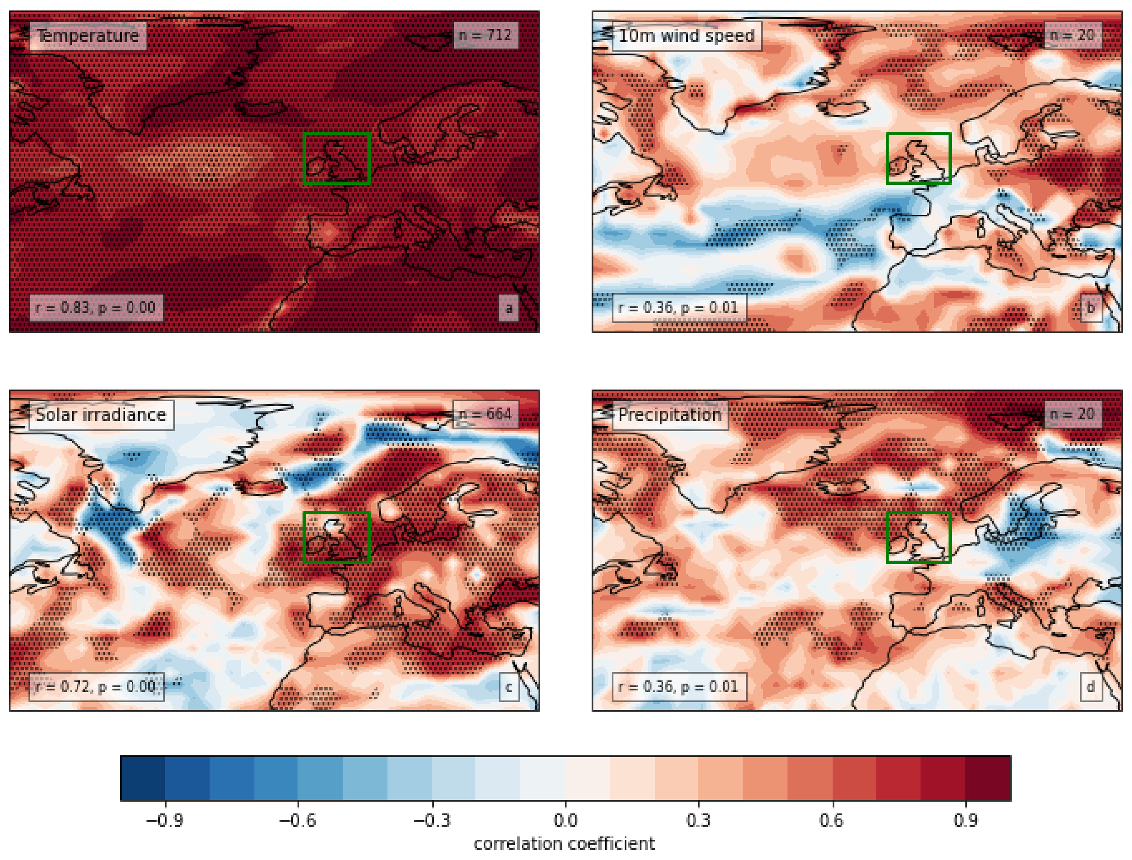

Figure 1 – Correlation skill for ensemble mean decadal forecasts for years 2-9, extended winter (ONDJFM), for temperature (**a**), 10m wind speed (**b**), solar irradiance (**c**), and precipitation (**d**). Stippling shows where correlations with observations are significant at the 95% confidence interval. Correlation coefficients are shown for the UK grid box mean.

There is significant skill over broad regions of Europe for temperature, solar irradiance, precipitation, and wind speed (**Fig. 1**) during the extended winter (ONDJFM). There is significant skill for these variables over the UK. Less skill is found for 10m wind speeds over North-Western Europe, however, there is significant skill over much of Eastern Europe.

There is significant skill for predicting the extended winter NAO (**Fig. 2**). When compared to a shorter winter period, such as DJF or DJFM (not shown), the extended winter period better captures the recent period of more positive NAO conditions (around 2005-2015 initialisation).

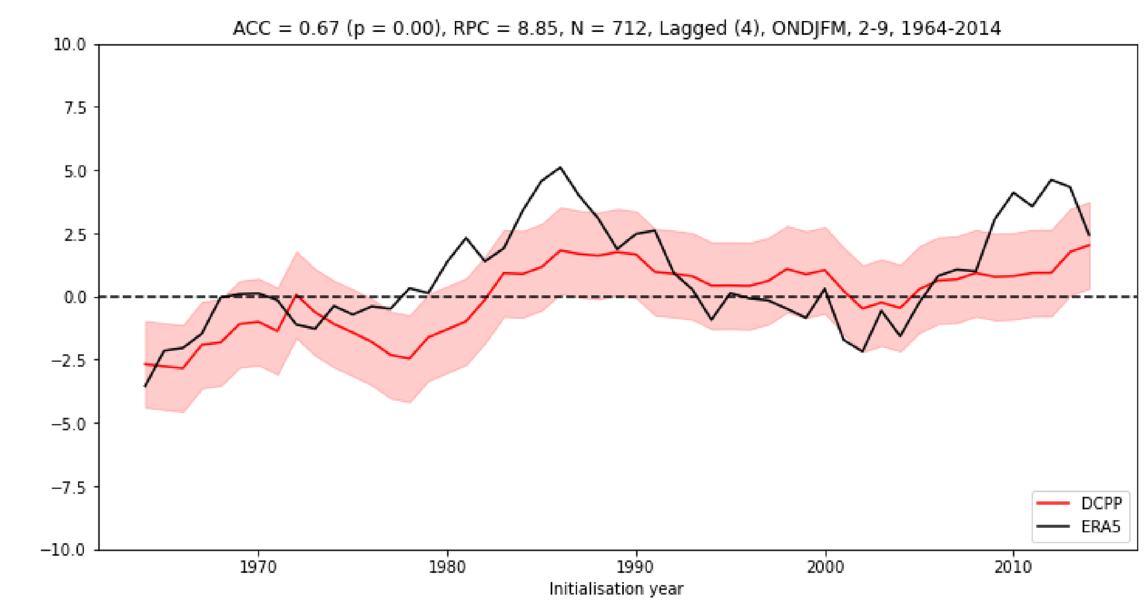

Figure 2 – Observed (black, ERA5) and model-forecast (red, DCPP-A) 8-year running means for the extended winter (ONDJFM) NAO index, using a multi-model ensemble initialised from 1961 to 2014 (valid 1966-2019).The ACC of the lagged ensemble mean, its significance and the RPC are shown.

Exploring extremes

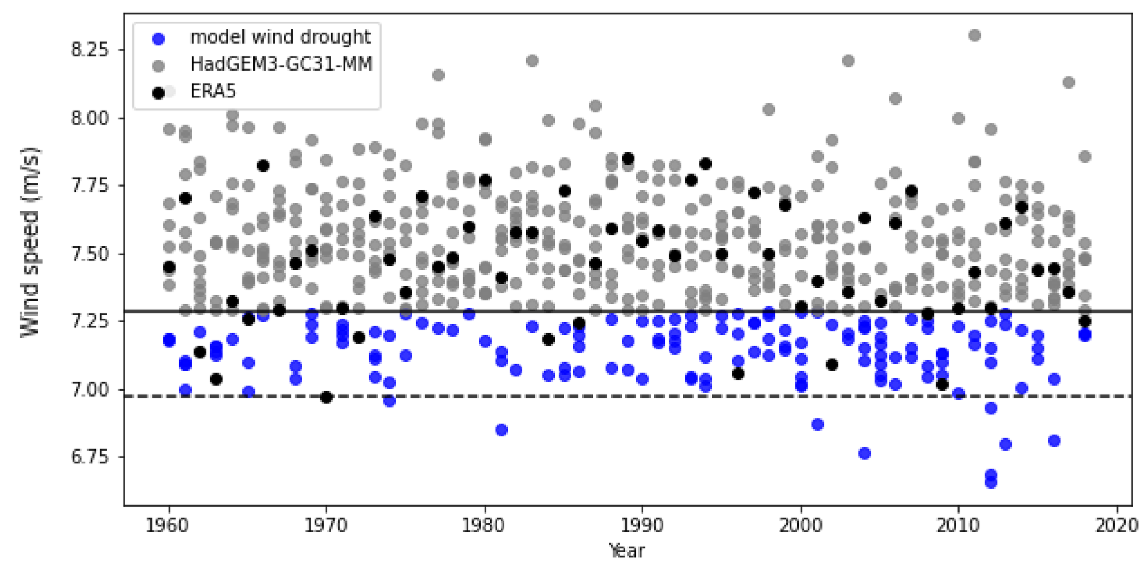

Figure 3 – Observed (black, ERA5) and model simulated (grey and blue, HadGEM3-GC3.1-MM) 12-month means (December to November) for 10m wind speed over the UK, using a single model initialised from 1960 to 2018. The solid line shows the 20th percentile of the observed wind speeds and the dashed line shows the minimum 12-month mean wind speed in the observational record.

The decadal predictions produce many more realizations of years with mean wind speeds below the 20th percentile of the observations than have occurred (**Fig. 3**). They also simulate a sample of years where mean wind speeds are lower than the lowest recorded year in 58 years of observations. The model therefore generates unprecedented extremes.

Next Steps

- Consider the potential applications of decadal forecast skill.
  - For example, predicting precipitation for hydropower over Norway, or wind speeds for wind power capacity factors over the UK.
- Quantify the impacts of unprecedented weather extremes, such as multi-year wind droughts, on the power system by converting meteorological variables through to power system variables.
- Consider the physical drivers of unprecedented extremes to identify sources of predictability for power system stress periods.
- Quantify how shifts in the forecast mean relate to the likelihood of experiencing potential extremes.
  - To help power system operators to understand the potential risks associated with forecast conditions.

References

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3. Kay, G., et al. (2023). Variability in North Sea wind energy and the potential for prolonged winter wind drought. *Atmospheric Science Letters, 24*, e1158.

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