Skillful Prediction of U.K. Seasonal Energy Consumption Based on Climate Information

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1. Background

- The winter seasonal mean energy demand can vary strongly from year to year.
- Skillful predictions of energy demand ensure the security of energy supply and help protect vulnerable populations from the dangers of extreme cold weather.
- **Objective**: Develop a statistical model for prediction of the winter seasonal electricity consumption over the UK based on climate information.

2. Data and Methods

- Climate data: the North Atlantic Oscillation (NAO) time series from the NOAA PSL, the UK 2-meter temperature (T2m), 2-meter dewpoint (TDD), 10-meter wind speed from the ERA-5 reanalysis.
- Predictand: detrended winter UK electricity consumption data from Thornton et al. (2019).
- Predictors: Sea ice concentration, 70-hPa geopotential height, sea surface temperature during 1979-2012 Dec-Feb, which were used to construct a skillful model for the NAO prediction by Wang et al. (2017).
- Statistic method: a multiple linear regression model
- Validation: the prediction is assessed by the anomaly correlation coefficient btw the observed and predicted energy consumption using the leave-one-out method.

3. Skillful Prediction of Electricity Consumption

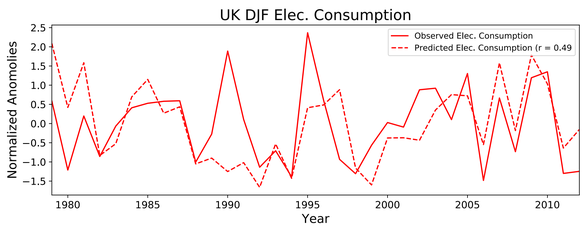

Fig. 1. The observed (red) and predicted (dashed) winter seasonal mean electricity consumption anomalies, normalized by the corresponding means and standard deviations.

- The simple model skillfully predicts the UK energy consumption
- The ACC during 1979-2012 is 0.49

4. Climate conditions and Electricity Consumption

Table 1. Correlation between the observed UK electricity consumption and T2m, TDD, 10-m wind speed and NAO.

	T2m	TDD	10mws	NAO
Corr.	-.570	-0.367	-0.407	-0.698
P-value	0.000437	0.0327	0.0168	4.47e-06

- The UK electricity consumption is also closely related to the T2m, 10-m wind speed and 2-m TDD.
- The correlation between the NAO and electricity consumption is stronger than the correlation of electricity consumption with any individual climate condition index.

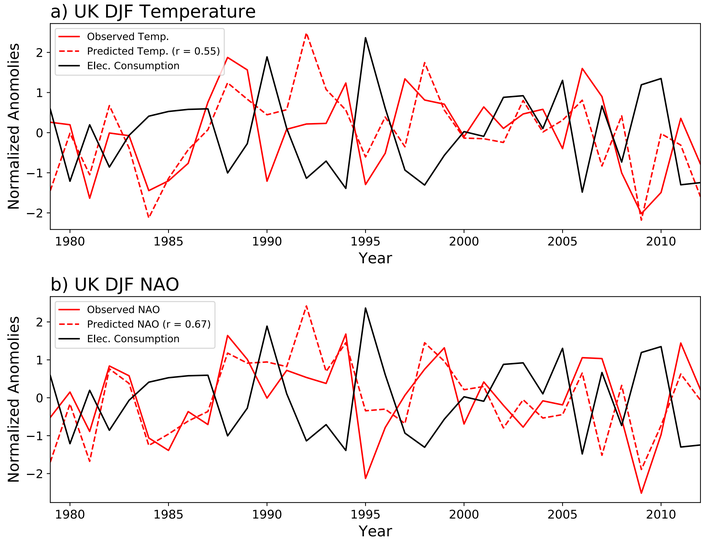

Fig. 2. The time series of the observed electricity consumption (black) and the observed (red) and predicted (dashed) T2m (a) and NAO (b). The ACC between the predicted and observed time series is shown in each panel legend.

- T2m and NAO are skillfully predicted using multiple linear regression models with the same predictors.
- Predictable climate conditions provide useful information to predict energy consumption.

5. Potential Application to Other Regions

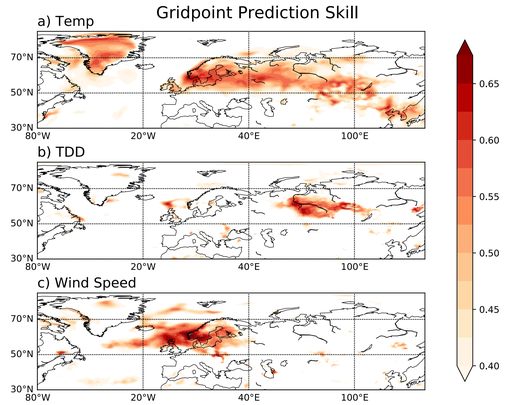

Fig. 3 The prediction skill of T2m, TDD, and wind speed over Eurasia. Only areas with statistically significant anomaly coefficients are shown.

- Skillful prediction of T2m and 10-m wind speed are obtained over northwestern Europe using a MLR with the same predictors.
- Energy consumption in northwestern Europe is likely predictable given the close link btw weather conditions and energy consumption.

6. Summary

- A simple statistical model is developed to predict the UK winter energy consumption.
- The model skillfully predicts UK electricity consumption as well as UK temperature, surface wind speed and dew point depression.
- The NAO is highly correlated with electricity consumption because it contains T2m, TDD, and windspeed information.
- Gridpoint analysis shows skillful prediction of T2m and TDD across northwestern Europe using the same predictors and indicates the predictability of energy consumption in the region.

References

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