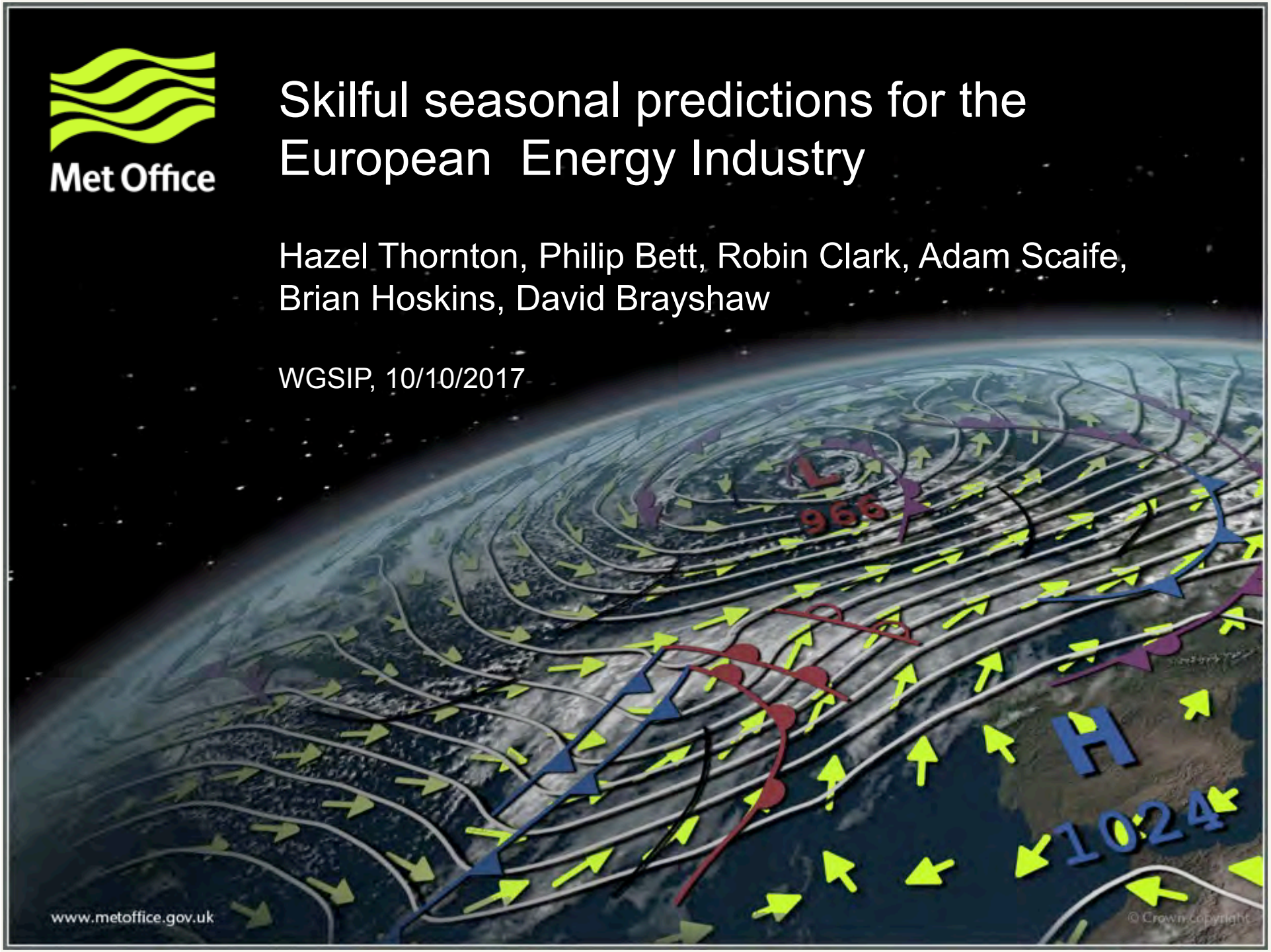
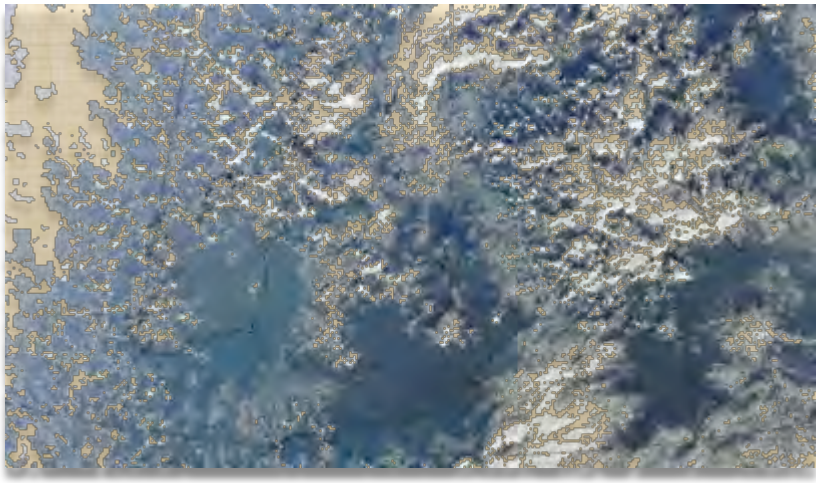
Skilful seasonal predictions for the European Energy Industry

Hazel Thornton, Philip Bett, Robin Clark, Adam Scaife, Brian Hoskins, David Brayshaw

WGSIP, 10/10/2017



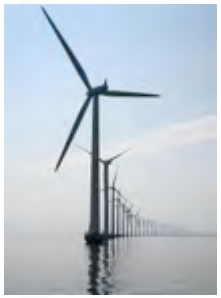
Outline



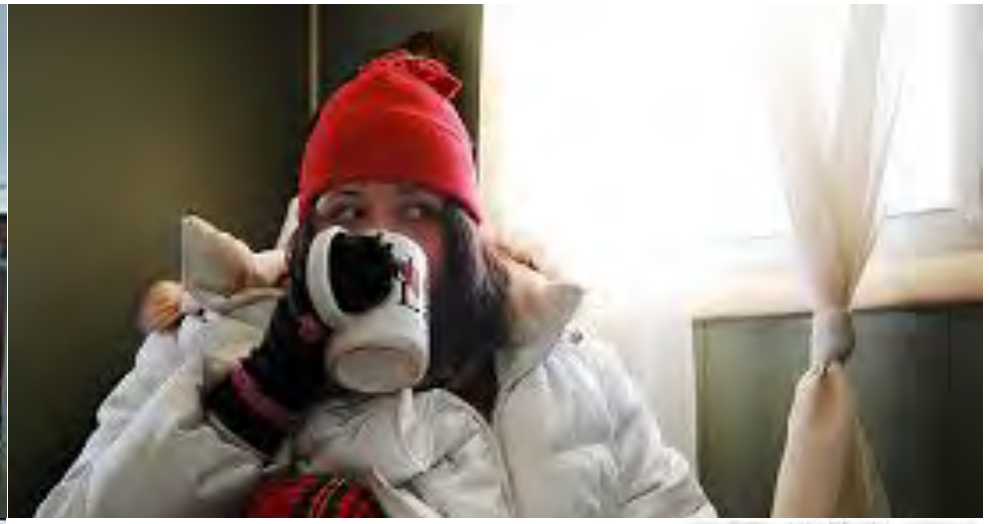
- Energy industry and climate
- Application of seasonal forecasts
  - UK case study
  - Other activities
- Winter outlook for the energy industry

Energy Industry and Climate

The energy system

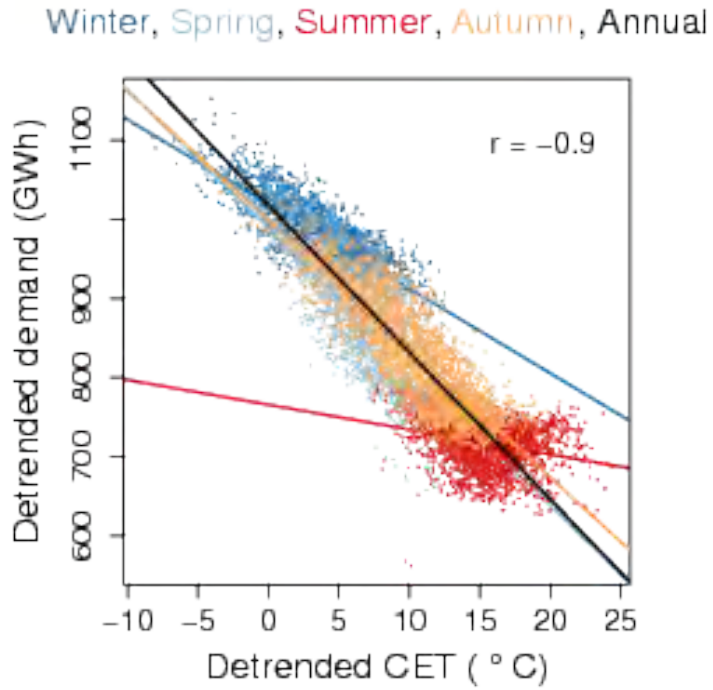


Impacts of weather

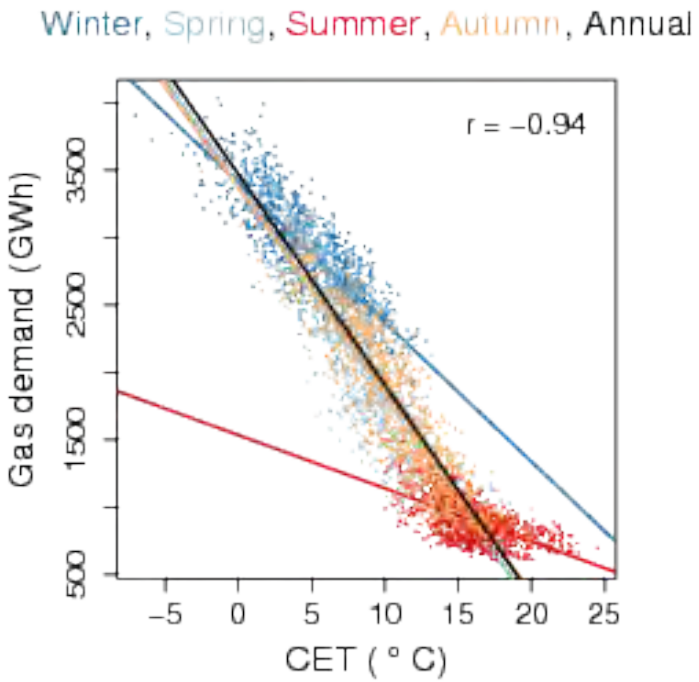


Strong anti-correlation between energy demand and temperature

Electricity demand



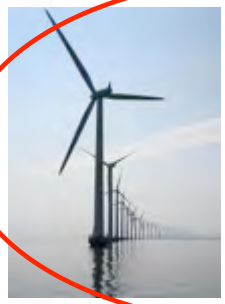
Gas demand



In winter: a 1°C reduction in daily T =>
~1% increase in daily electricity demand
3% - 4% increase in gas demand

Thornton et al, 2016 ERL

The energy system



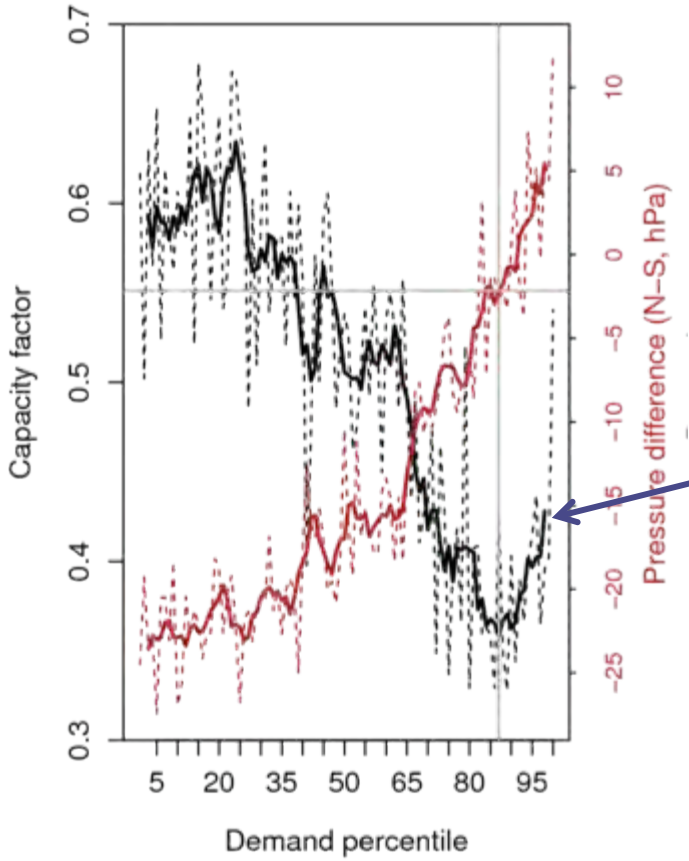
Newspaper Headlines

- ‘Wind farms produced "practically no electricity" during the cold snap which manufacturers' groups say could lead to severe winter energy shortages.’ The Telegraph 11/01/2010

- ‘Wind farms don't work in the cold: Why it's no use waiting for turbines to keep us warm as the snow returns.’ Daily Mail, 08/01/2011

- ‘Electricity demand hits highest this winter - as wind power slumps to its lowest.’ The Telegraph, 15/01/2015

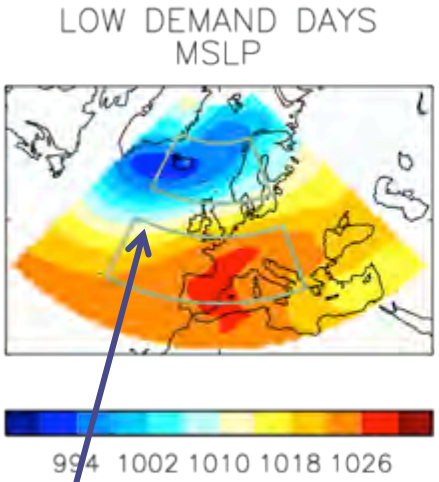
Electricity – wind power relationship in winter

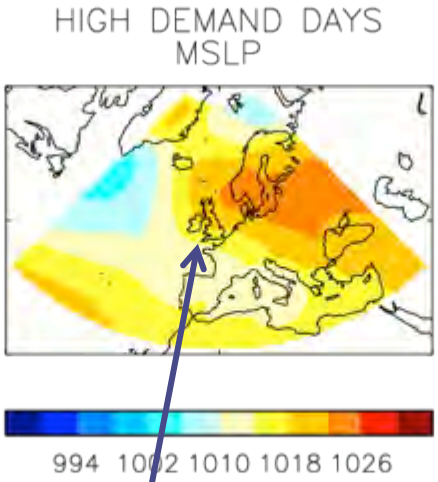


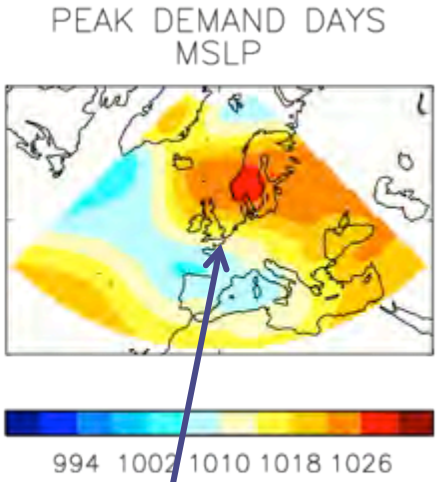
- Average wind power reduces by a third between lower and higher demand.
- During the highest demand average wind power starts to recover.

Thornton et al, 2017, ERL

Average pressure pattern for different demand conditions







Westerly flow regime

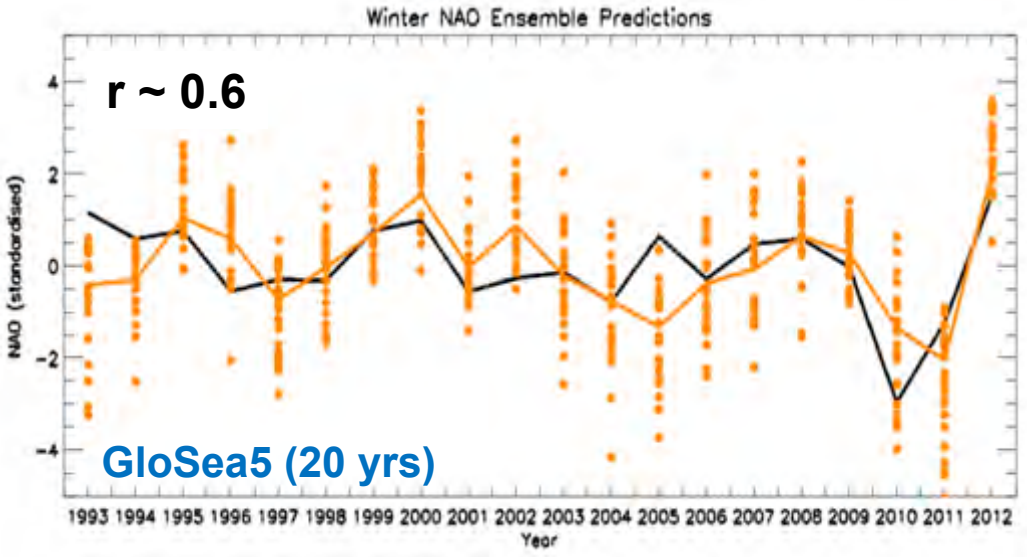
Easterly flow regime

Strengthened easterly flow regime

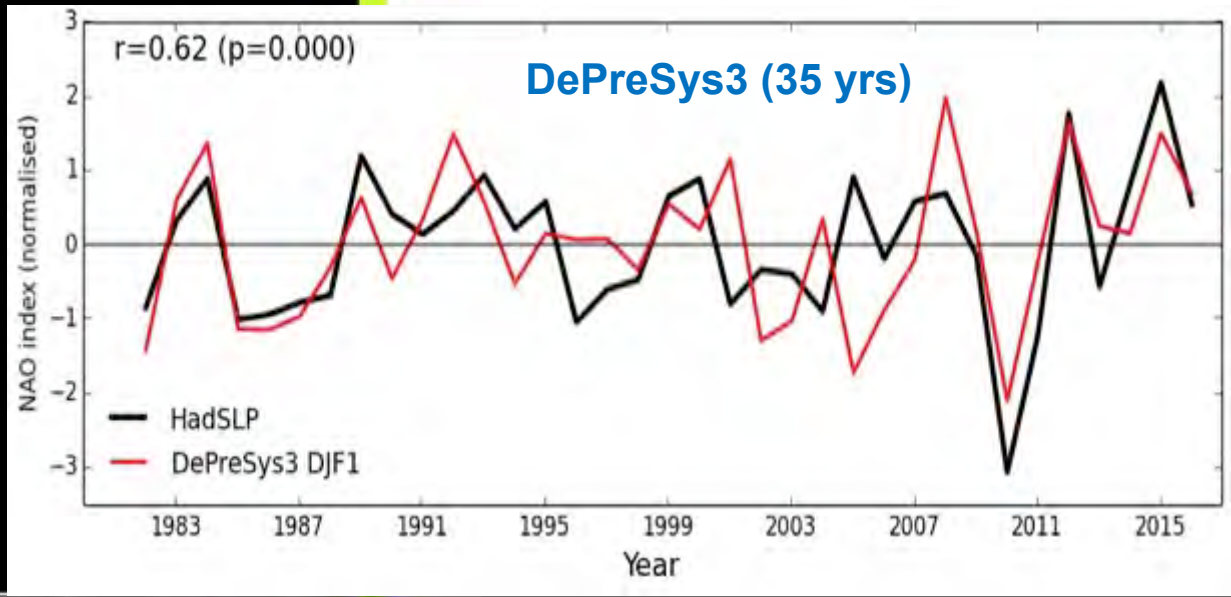
Thornton et al, 2017, ERL

Using seasonal forecasts, UK case study

Seasonal skill in winter NAO



Scaife et al 2014

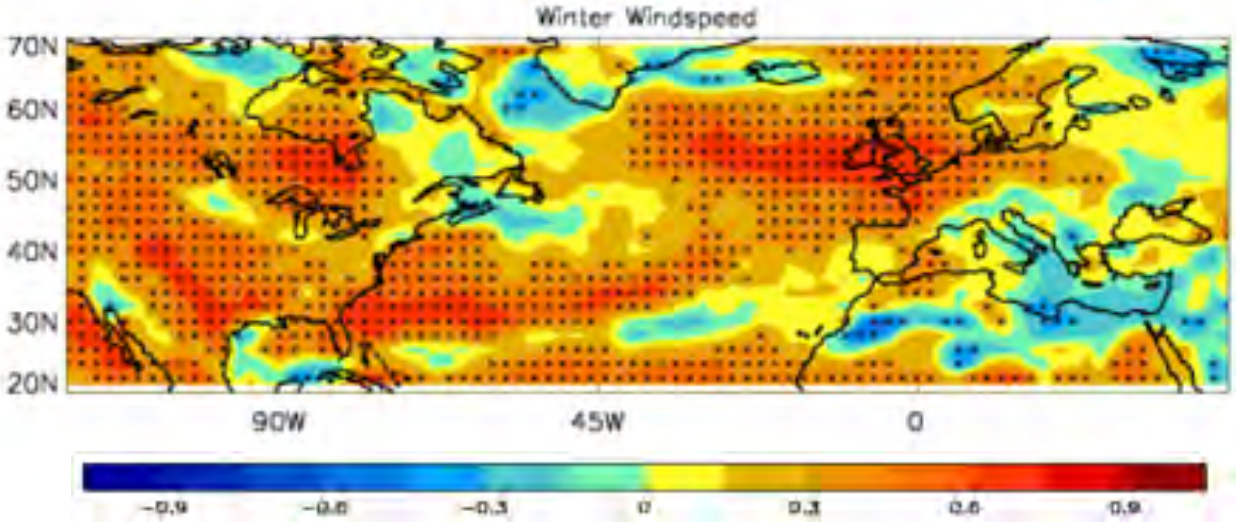


- DePreSys3 has skill for the NAO (r=0.62) similar to GloSea5 but over 35 years

- NAO predictability is robust from a one month lead time

Dunstone et al 2016

Winter wind speed skill



Correlation of ERAI wind speed and GloSea5 wind speed, 1993-2012

Good skill over UK

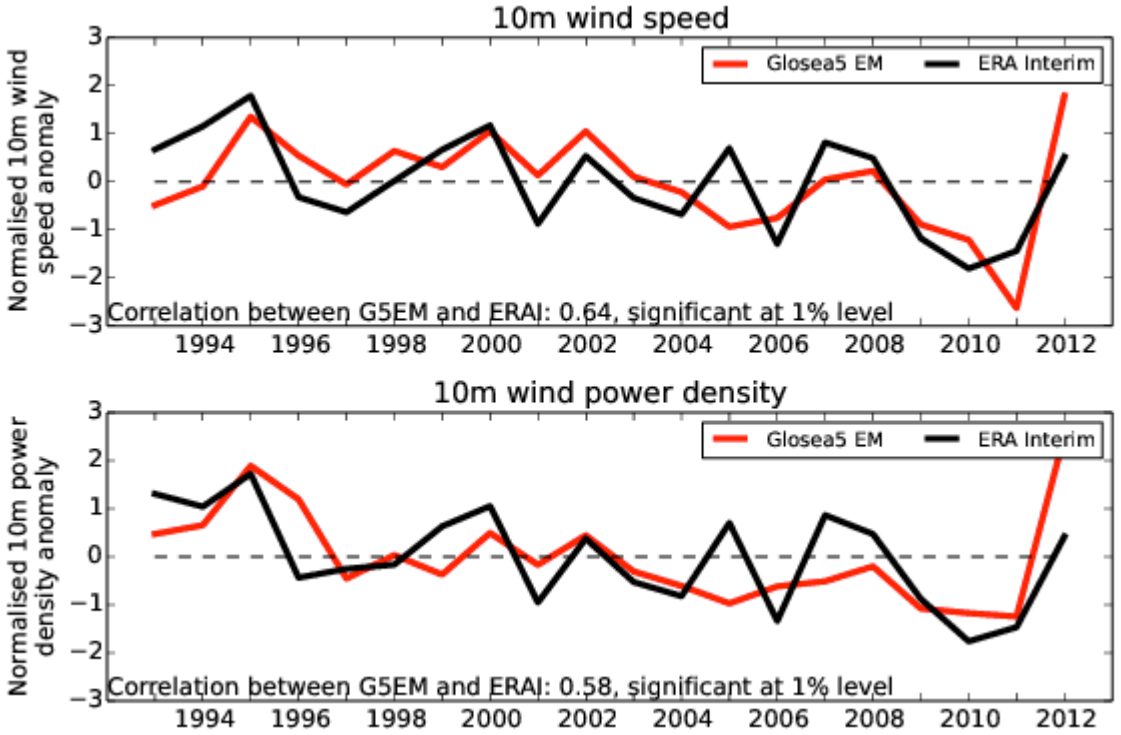
Scaife et al, 2014

Winter wind speed skill, UK

Obs (ERAI) GloSea forecast

Wind speed
r = 0.64

Wind power density
r = 0.58

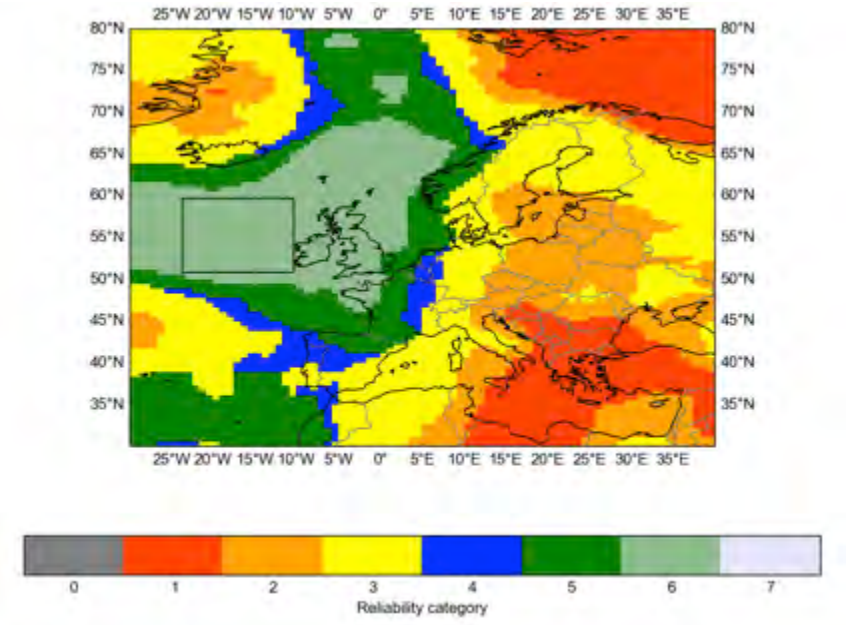


Clark et al, 2017, ERL

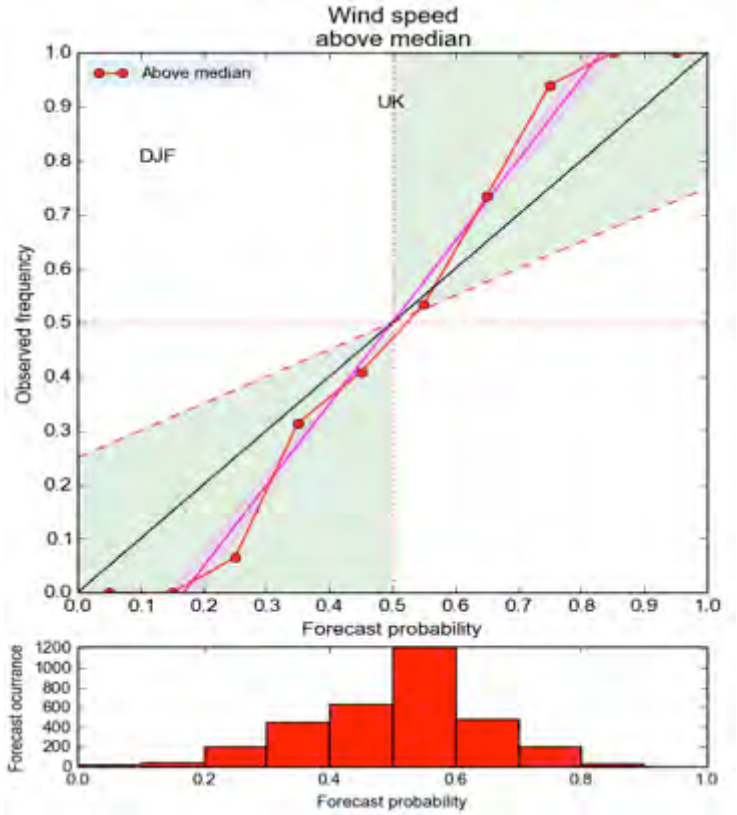
Reliability

Under-confident wind speed forecasts.

When model predicts above median wind speed with a probability of 70% it actually occurs 80% of the time.



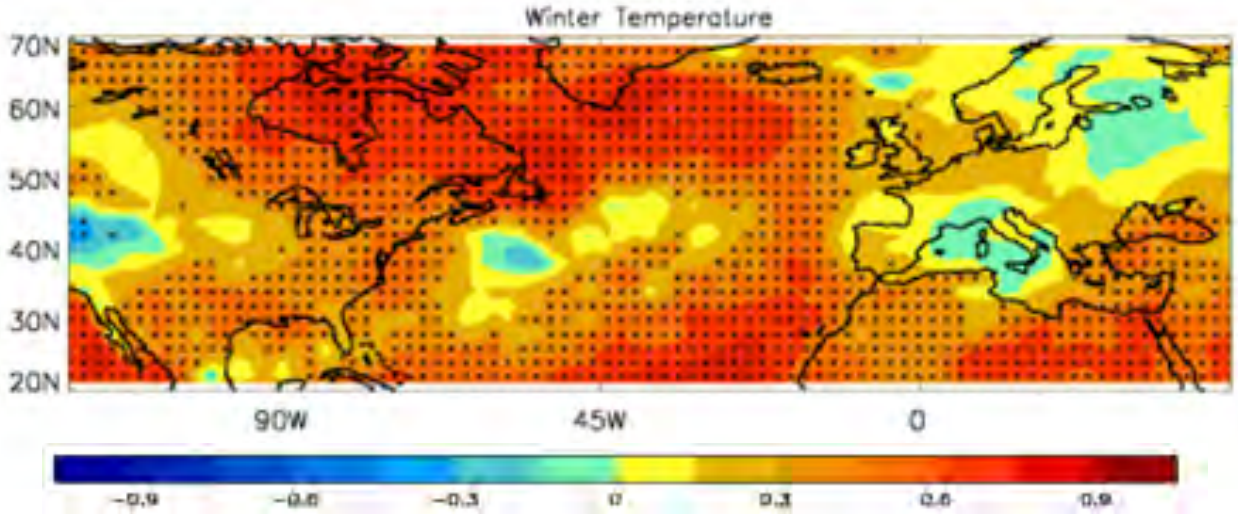
Reliability diagram



Forecasts would benefit from calibration if giving operationally.

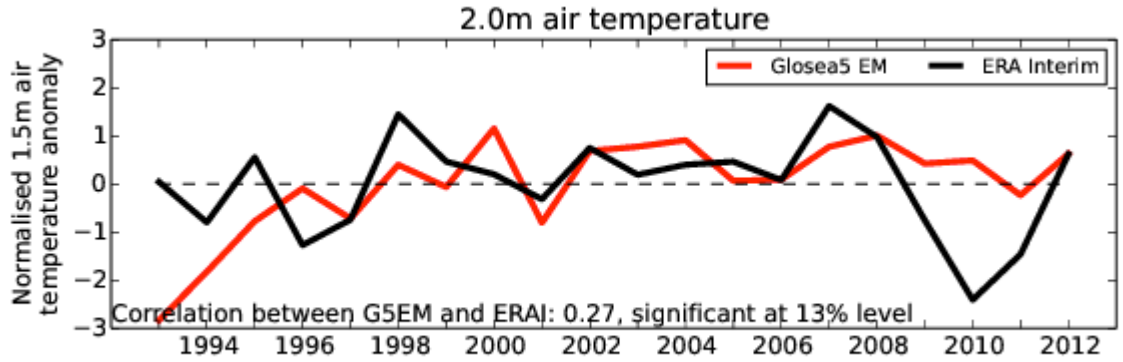
Clark et al, 2017, ERL

Winter temperature skill



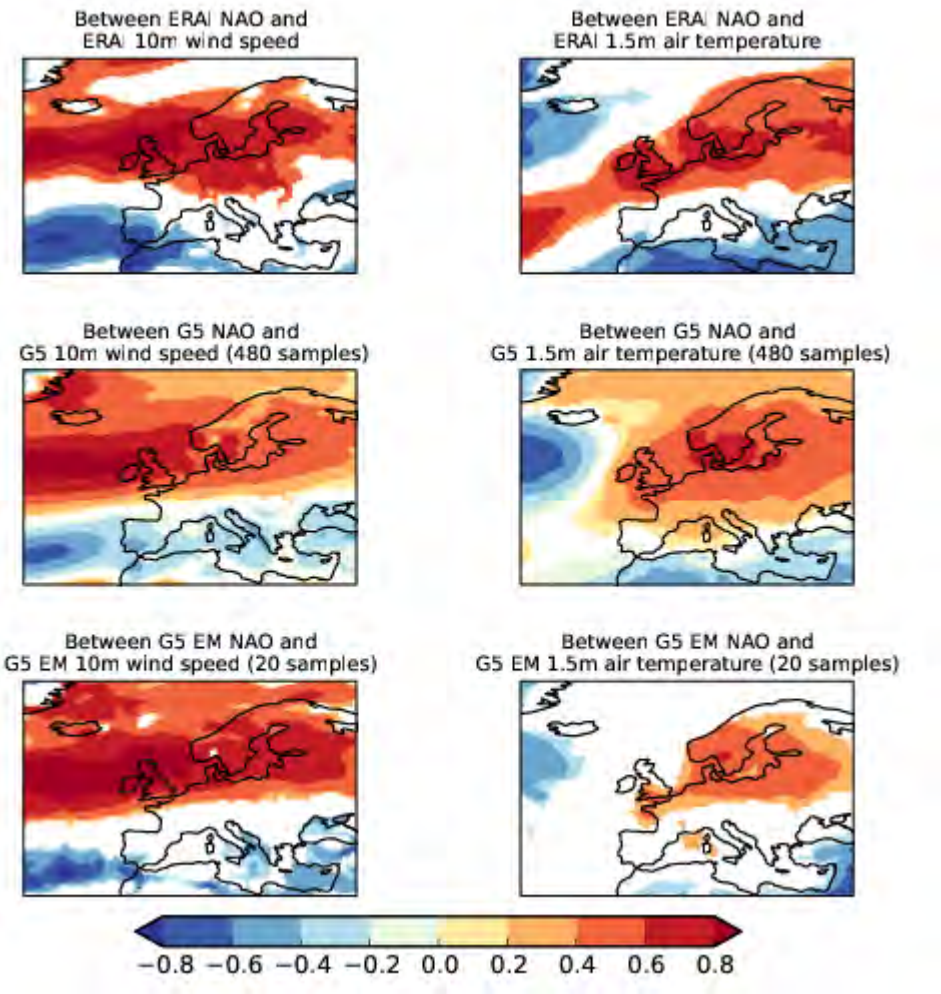
Scaife et al, 2014

Over UK: $r < 0.3$



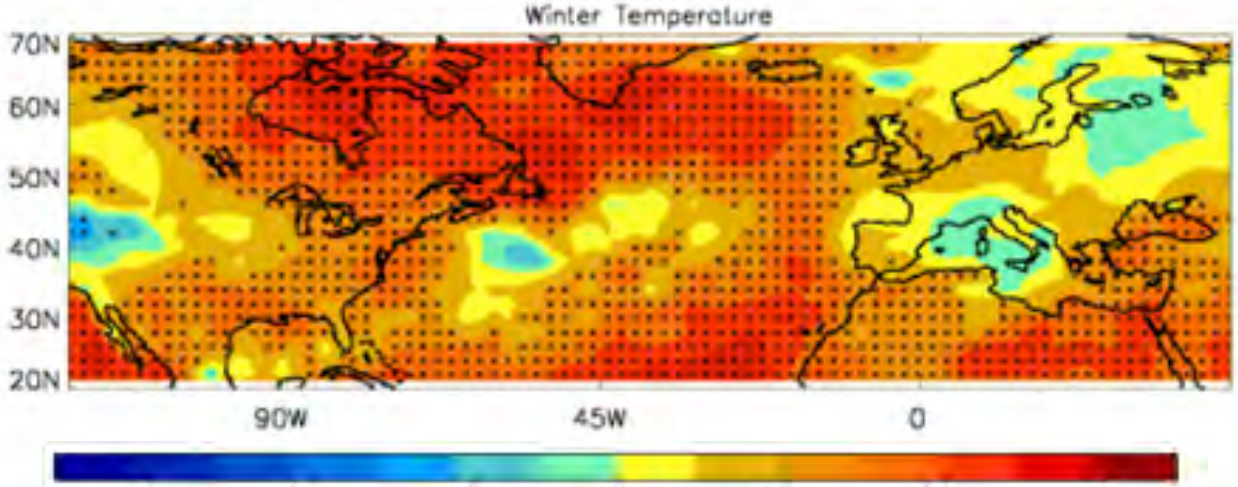
Clark et al, 2017

NAO – temperature relationship



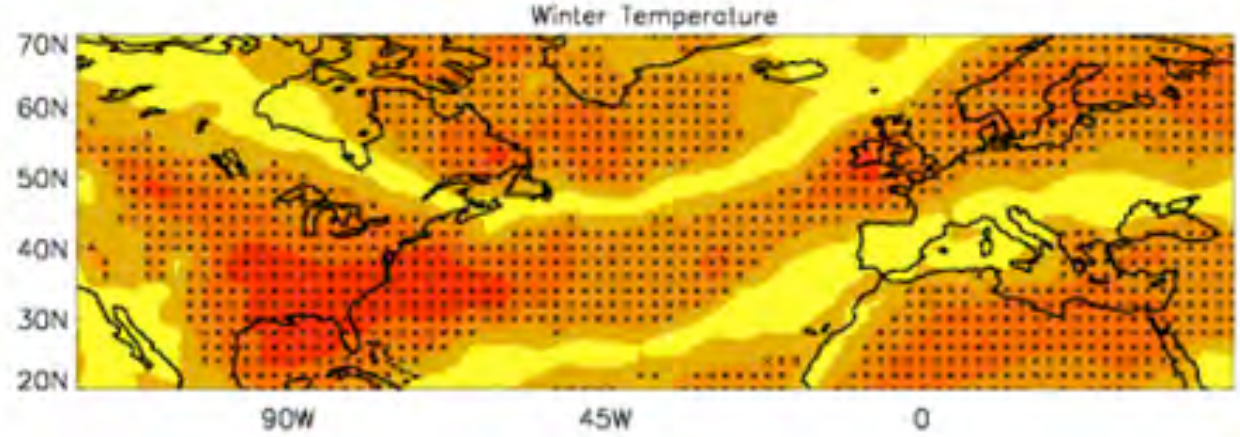
Temperature response represented in model, but not well over the UK

UK temperature forecast is better when using NAO as predictor



Cor (Obs T, Fcast T)

UK $r < 0.3$

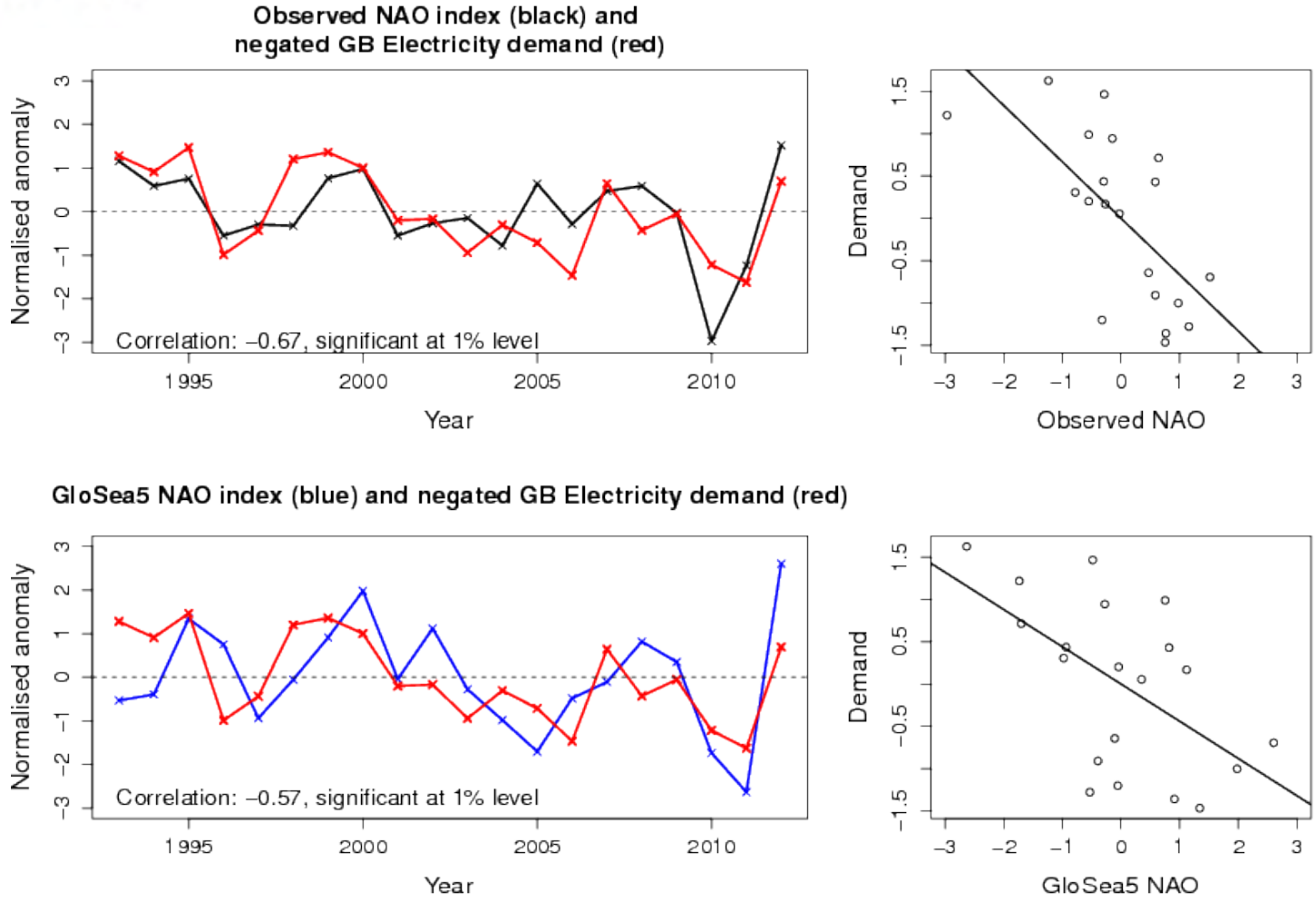


Cor (Obs T, Fcast NAO)

$r > 0.4$

Scaife et al, 2014

Potential for Electricity demand forecasts

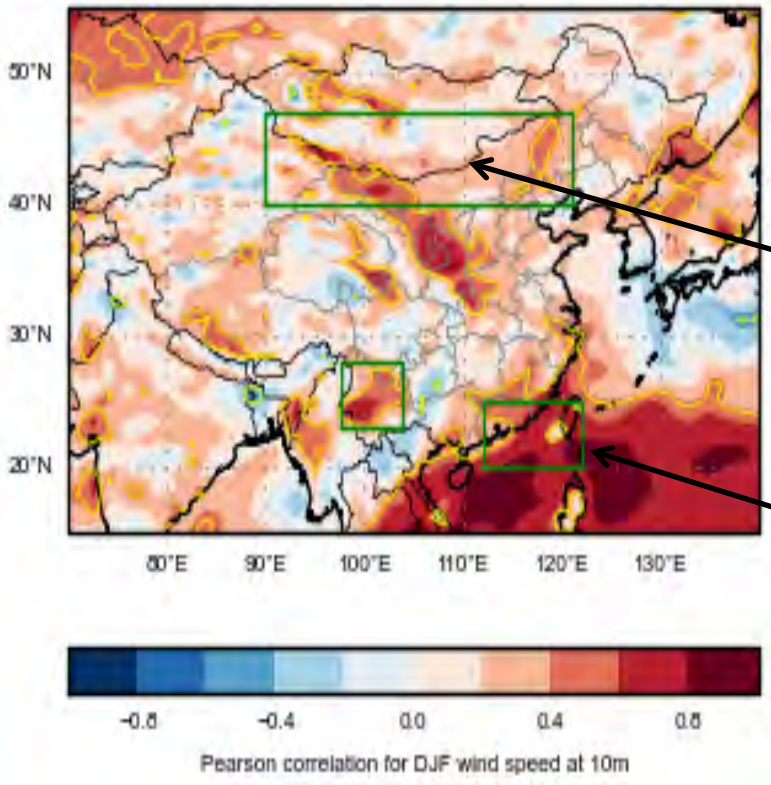


Skilful predictions of demand possible

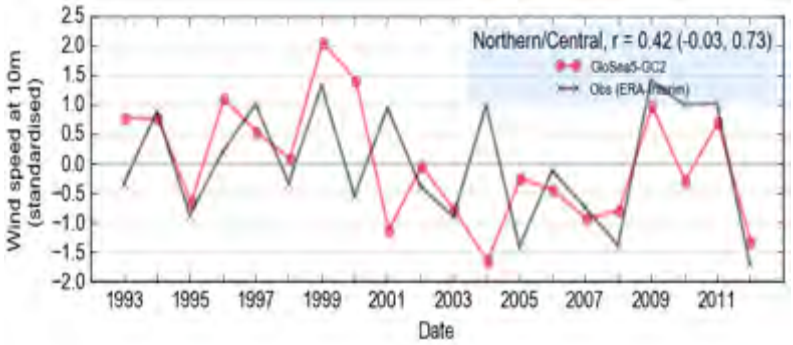
Clark et al, 2017, ERL

Other projects, regions of world

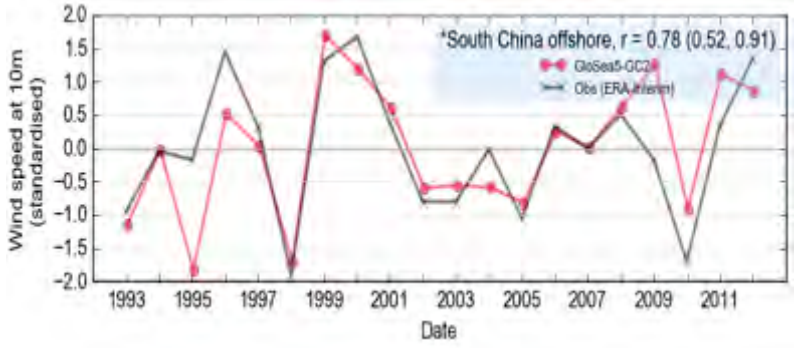
Winter wind power over China



North Central China



South – eastern China



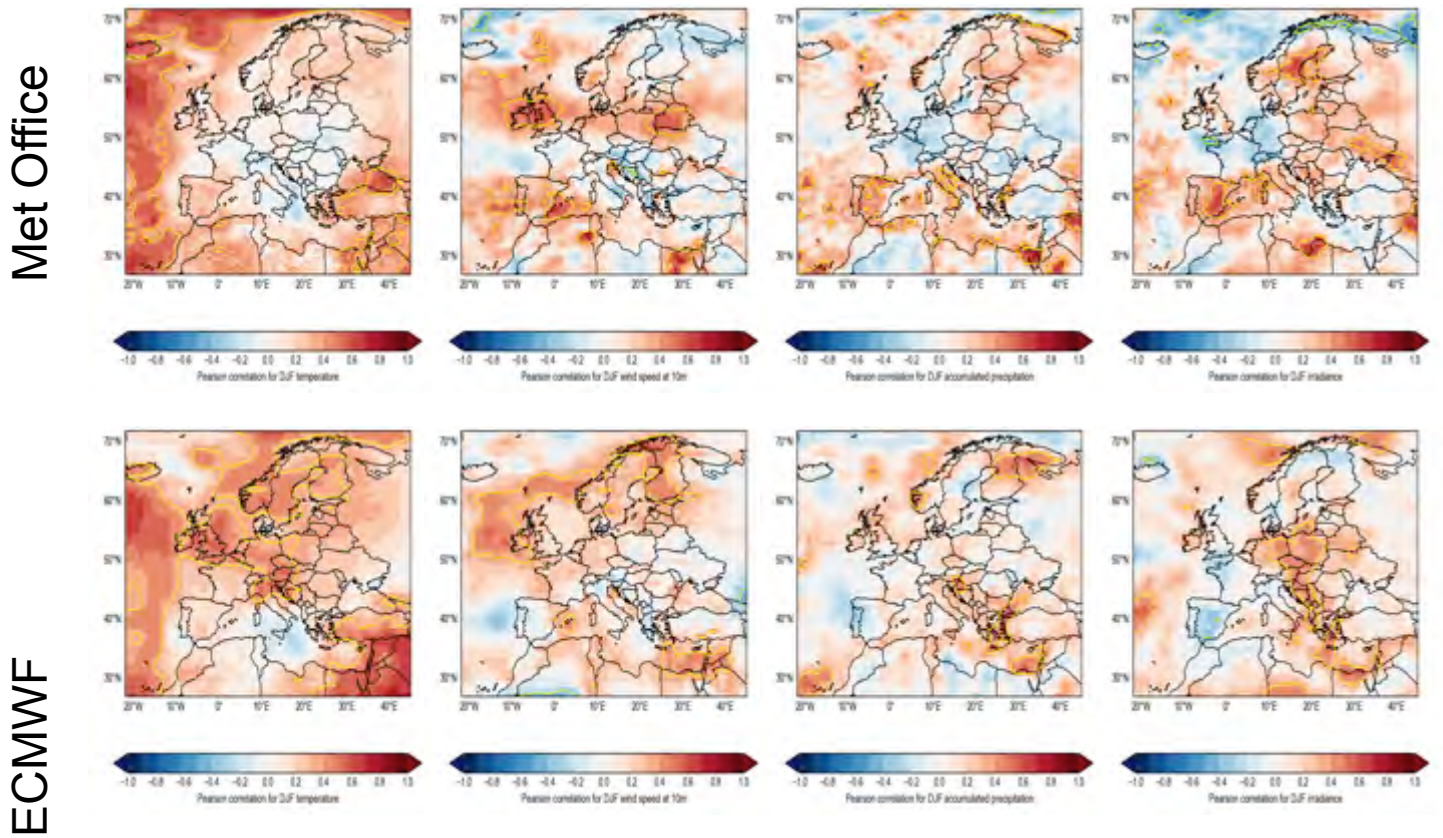
In some regions we have good skill:
North – related to the AO, middle eastern jet stream
South – related to ENSO

Bett et al, 2017, Lockwood et al, in prep.

ECEM project: Assessing seasonal forecast skill

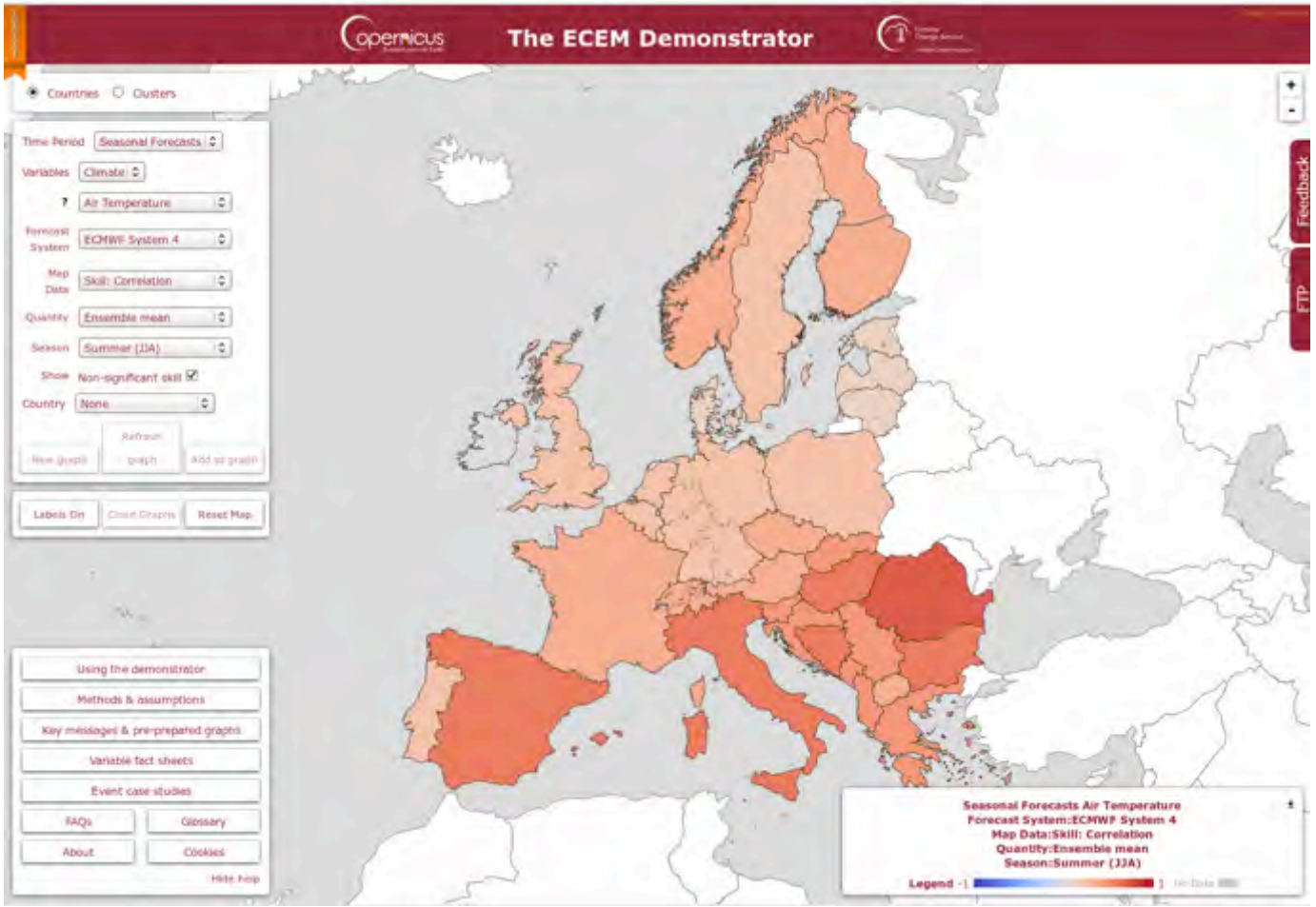
Winter skill

Skill is diverse across models and variables.



ECEM demonstrator

Summer temperature skill



Met Office

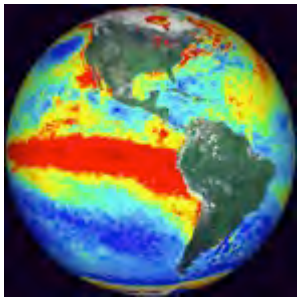
Winter outlook for the energy industry

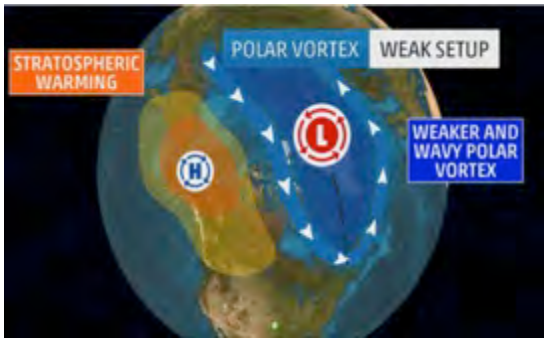
www.metoffice.gov.uk

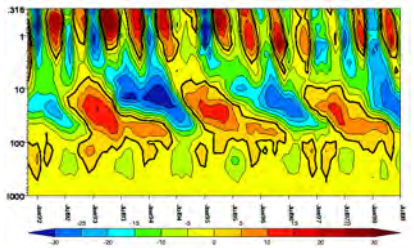
Winter briefing for the energy industry

- Monthly briefings from September 2016 to February 2017 by webinar
- Gave forecast for the coming month and 3 month period.
    - E.g. from Sept: forecast for Oct and then an average for Oct - Dec
    - From Oct: forecast for Nov and then an average for Nov - Jan
- Coordinated by the national transmission operator → invited their Electricity Forum group.
- Users included:
    - government organisations
    - Energy companies
    - consultancies and traders

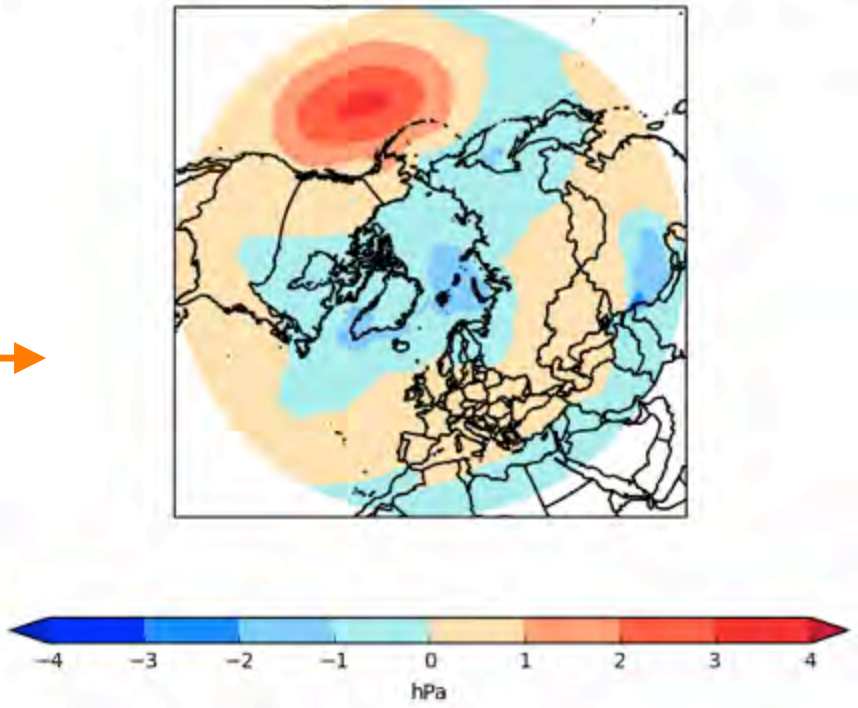
Climate drivers & model signal





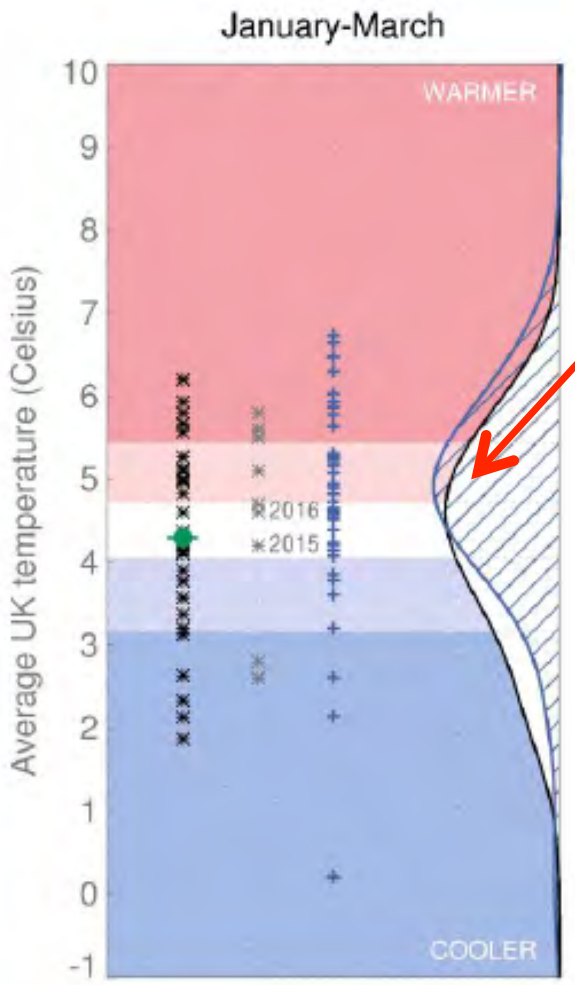


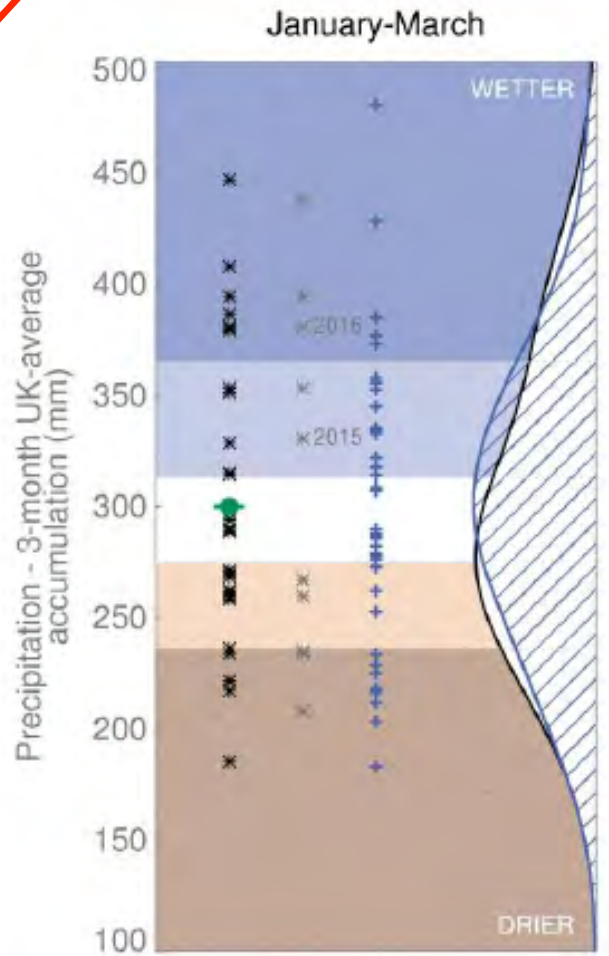
Met Office: Ensemble mean anomaly : mean sea level pressure : Jan/Feb/Mar



Also consider other modelling centres' forecasts:
ECMWF, Met. France, NCEP, KMA

Slight increase in the probability of milder-than-average but .....





Drier and wetter than average conditions evenly balanced

Same also shown for the 1 month ahead forecast – so for January in this case

Contingency Planners Forecast

January-February-March

- In January the chance of prolonged spell of cold weather is similar to normal (i.e. no higher than the climatological risk)

- The probability of a prolonged spell of colder weather decreases later in the winter.

- Therefore, we consider the greatest risk of cold weather impacts, such as snow and ice, to be in January.

- Spells of windy weather slightly higher than normal, particularly in late winter (February).

Were the briefings useful?

94% of respondents found the briefings to be useful or very useful.

100% of respondents would like to see the briefings repeated this year.

The types of activities which the briefings helped inform were:

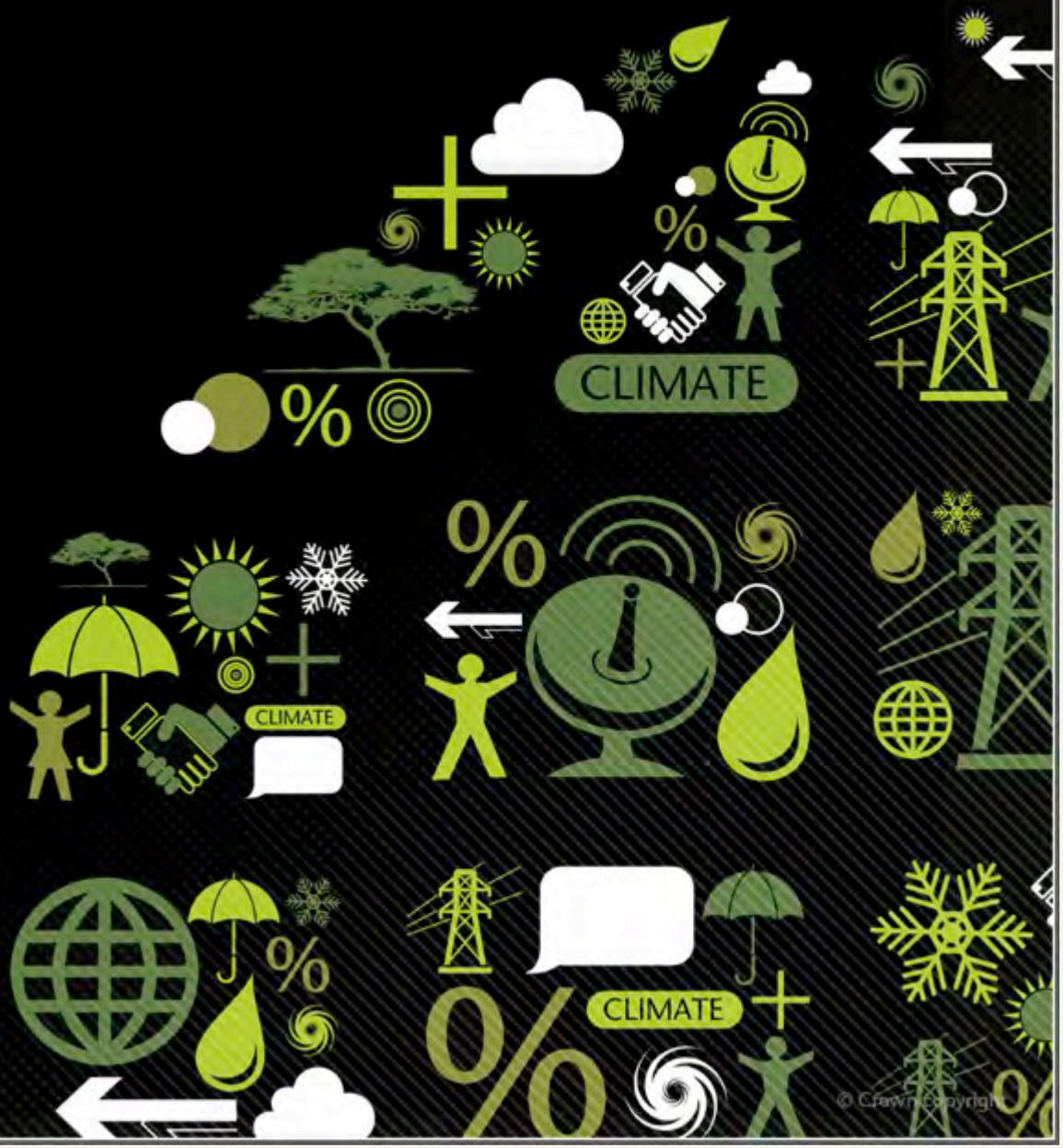
- Energy demand forecasting
- Triad management (forecasting and budgeting)
- Anticipating conditions that could mean volatile or high energy prices
- Contributed to trading/risk mitigation decisions and hedging strategy

Summary

- An indication of winter conditions ahead of time is very useful for the energy industry
- Met Office model can skilfully predict winter:
    - wind power availability
    - Electricity demand – through use of the NAO forecast
- Seasonal briefings for the energy industry were well received.
- Many developing climate services across the world.
    - Solar, hydro, wind, wave power.

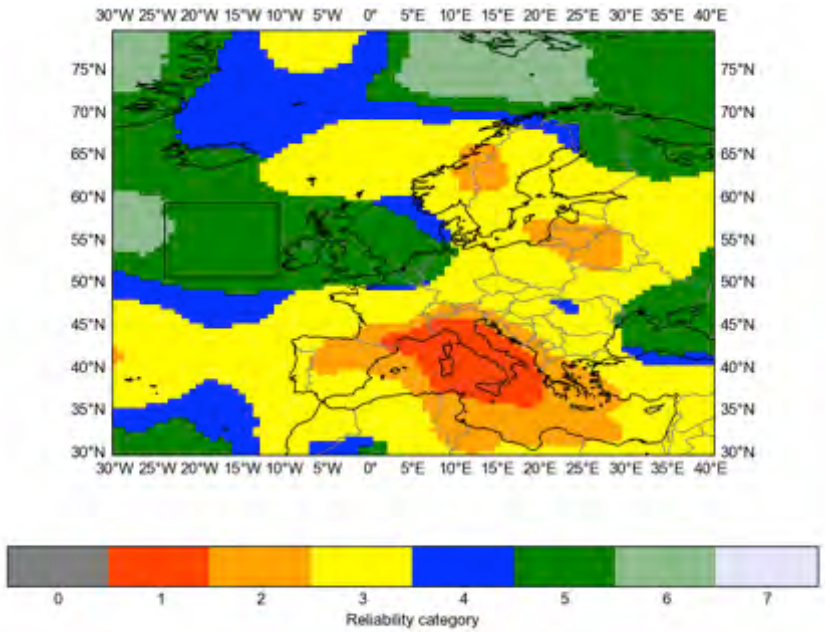
Met Office

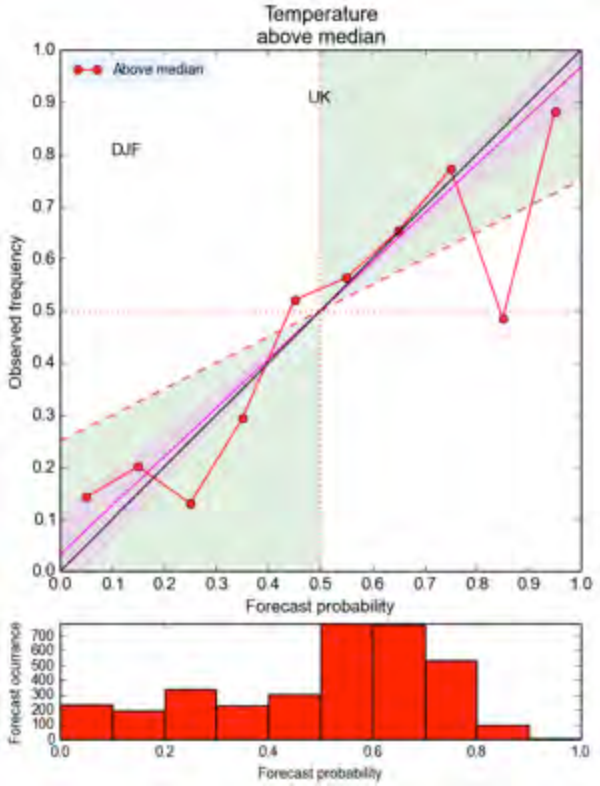
Questions?



Temperature Reliability

Reliable temperature forecast over UK, poor reliability over S. Europe





Clark et al, 2017, ERL

Research questions

- What is the relationship between electricity demand and wind power in Britain?

- How much wind power is available when electricity demand is very high?

- What role does atmospheric circulation play?

Data

- Electricity demand data:
  - GB daily total (GWh), between 1975-2013
  - Long term socio-economic trend removed (see Thornton et al, 2016, ERL)
- Idealised wind power model: 6 hourly estimate of grid point level wind power capacity factor.

$$\text{Capacity factor} = \frac{\rho U^3}{\rho_c U_r^3}$$

ρ = air density, ρ = typical air density

U = wind speed, U_r = rated wind speed

Average to daily mean then to regional mean (all UK, onshore and offshore regions, different regions of UK).

MSLP skill map

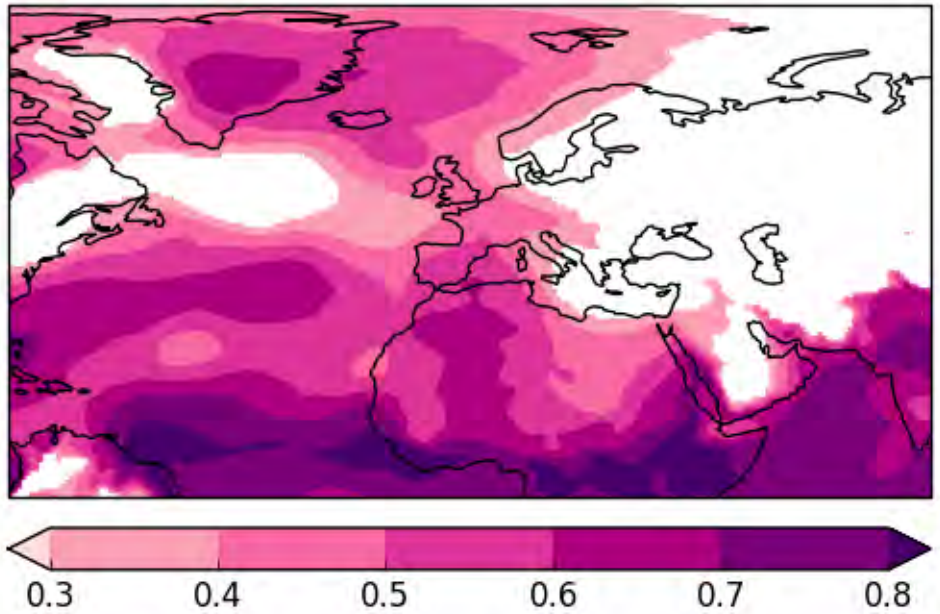


Figure 1. Correlation between GloSea5 ensemble mean and ERA Interim sea level pressure for DJF compiled from 20 years of simulation. Mask (white areas) applied to correlations not significantly greater than zero at 10% level.