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Met Office UK monthly and seasonal forecasts

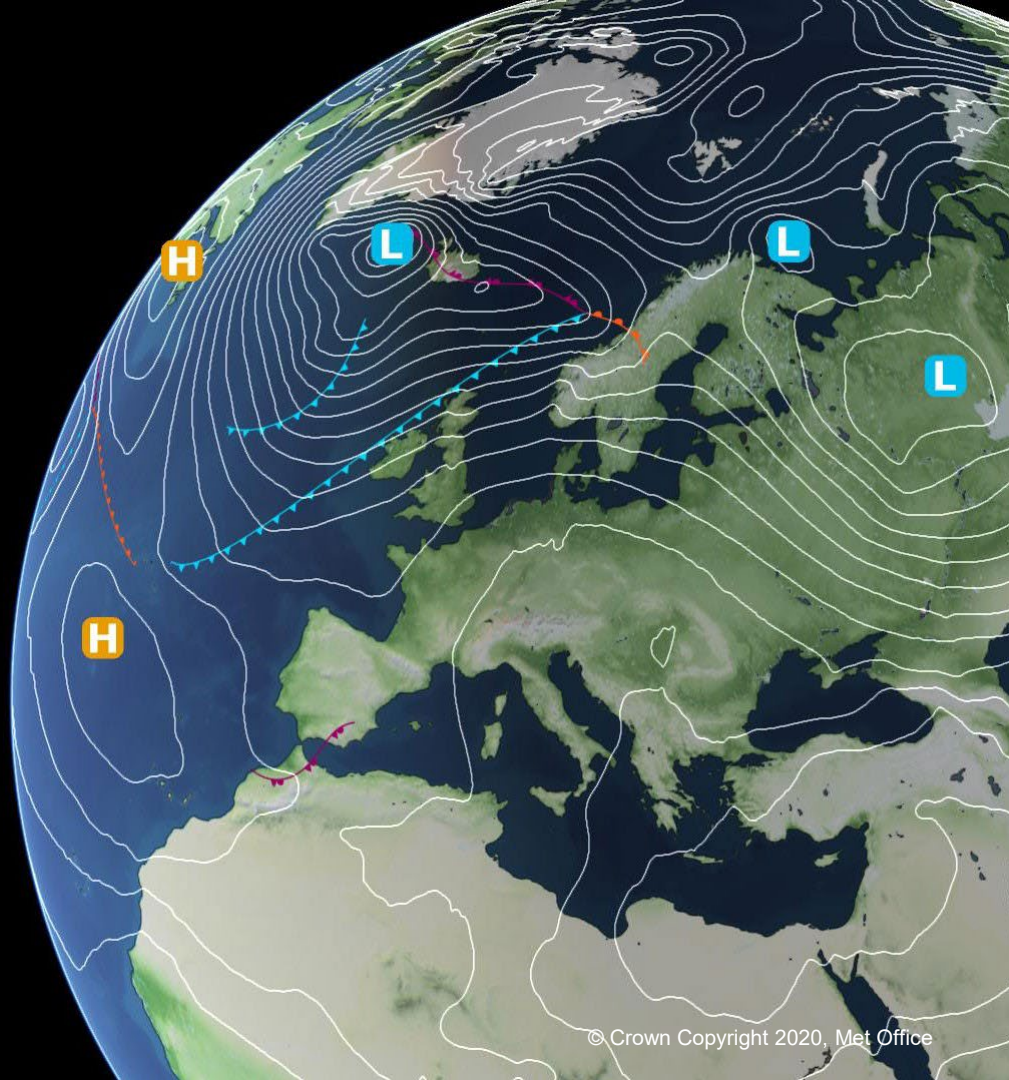
Exploiting ensembles for studying wind droughts in the North Sea

Nicky Stringer and Gillian Kay

18th May 2023

Seasonal Forecasting for the Weather Driven Energy System

University of Reading



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- UK monthly and seasonal outlook.
  - A look a last winter.
  - North Atlantic Oscillation
  - Drivers of predictability
  - How did it go?
  - Adding wind to the outlook
- Exploiting ensembles to improve understanding of extremes:
  - Potential for prolonged winter wind drought in the North Sea

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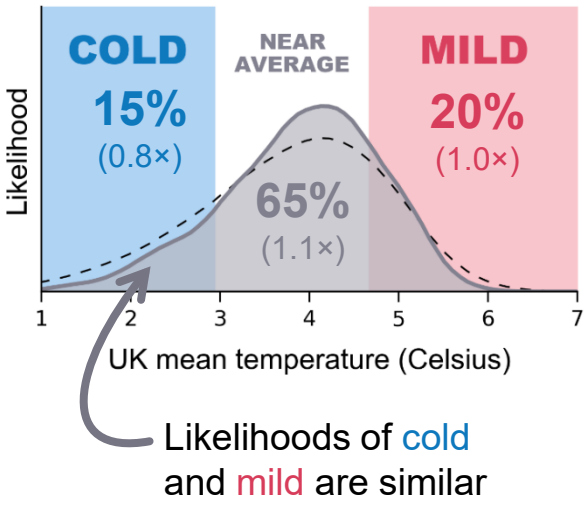
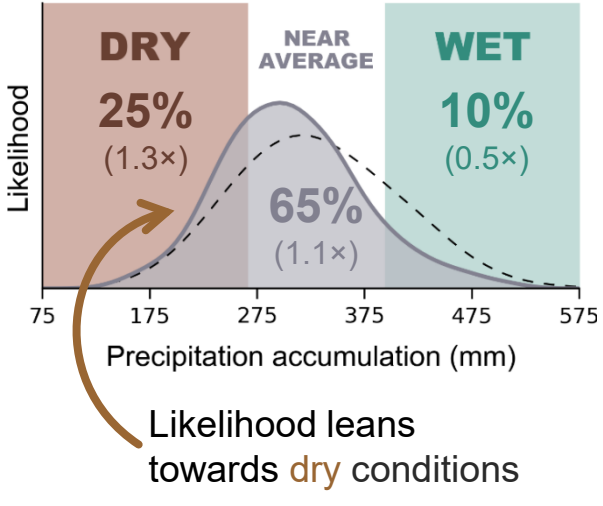
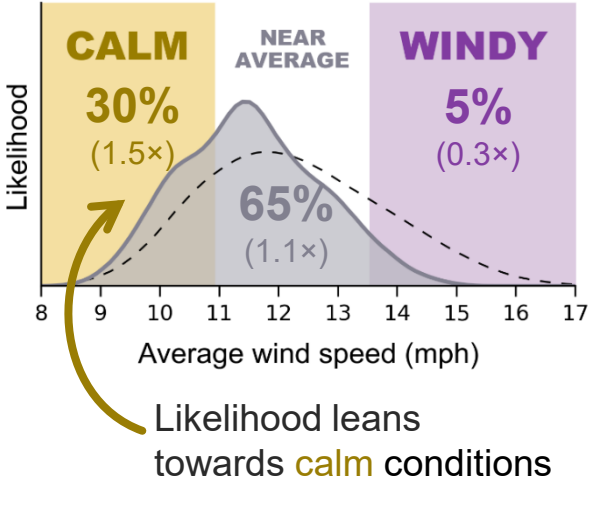
Forecasts for Dec–Jan–Feb







Coloured categories occur 20% of the time in the 1991–2020 period.
"Near-average" occurs 60% of the time.

DJF 2022–23 outlook

Normal likelihood (1991–2020)

DJF categories for the last 10 years:

2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22
NEAR AVERAGE	MILD	NEAR AVERAGE	MILD	MILD	NEAR AVERAGE	MILD	MILD	NEAR AVERAGE	MILD
NEAR AVERAGE	WET	NEAR AVERAGE	WET	DRY	NEAR AVERAGE	DRY	WET	WET	NEAR AVERAGE
NEAR AVERAGE	WINDY	NEAR AVERAGE	WINDY	NEAR AVERAGE	NEAR AVERAGE	CALM	WINDY	NEAR AVERAGE	NEAR AVERAGE

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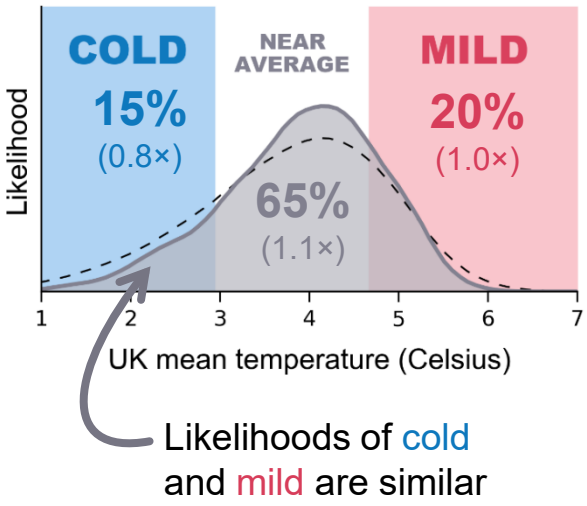
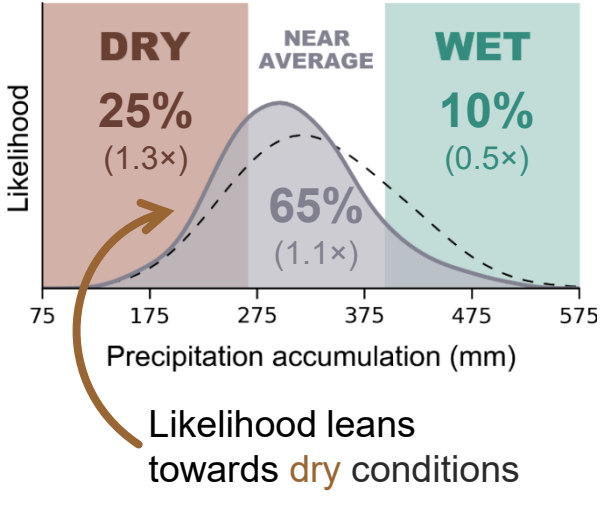
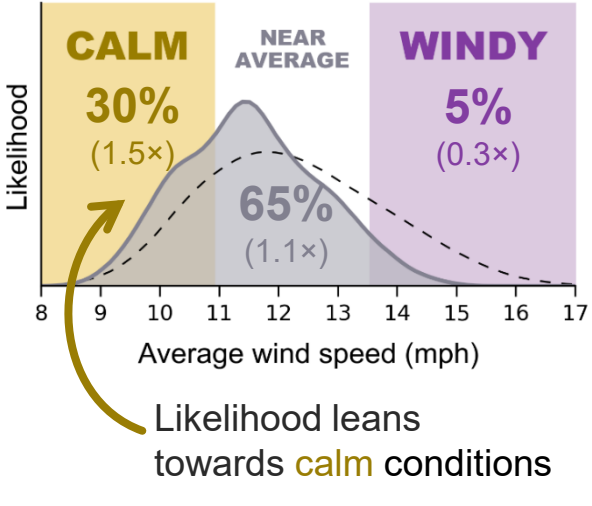




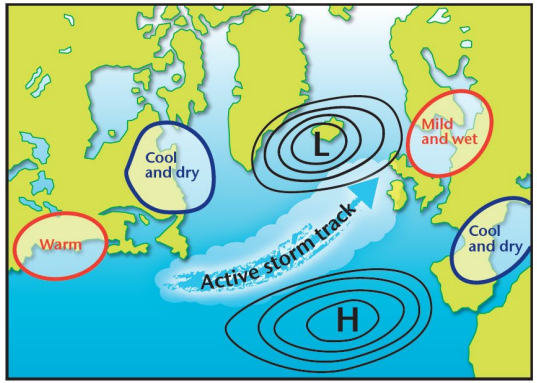


- Greatest chance of impacts from cold weather are in early winter
- There is a reduced chance of wet conditions and impacts from heavy rainfall
- Chances of dry conditions are greater than normal
- Stormy conditions, and impacts from high winds, are less likely than normal

https://crudata.uea.ac.uk/cru/data/nao/, plot updated from Osborn (2011)

The North Atlantic Oscillation (NAO)

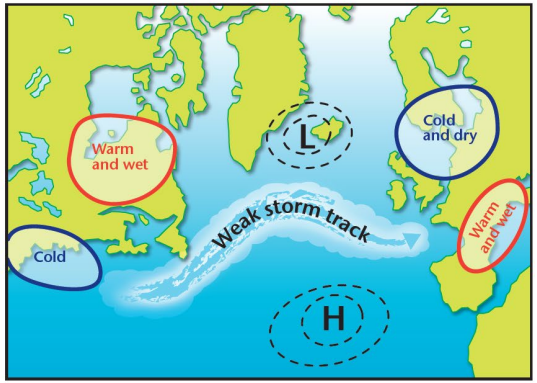
Positive phase



- Enhanced winds from the west
- Milder and wetter conditions
- Higher frequency of wind storms
- Lower frequency of snow

- e.g. winter 2015–2016

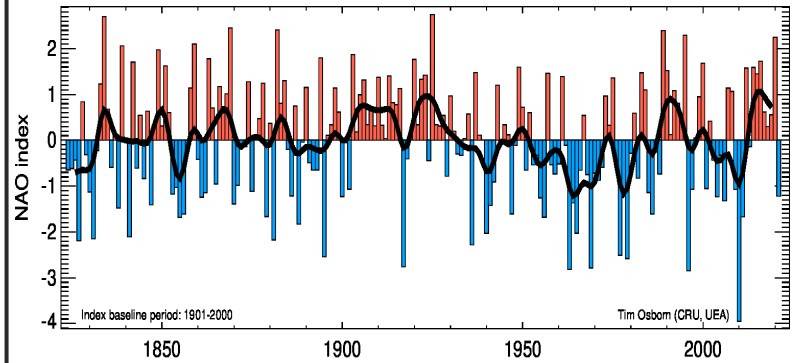
Negative phase



- Reduction in winds from the west
- Colder and drier conditions
- Lower frequency of wind storms
- Higher frequency of snow

- e.g. winter 2009–2010

DJF NAO index (final value: 2020/2021)



- Explains much of the variability of winter weather in the North Atlantic region.
  → **Single most important factor for UK winters**
- Seasonal prediction systems, like Met Office GloSea6, have skill in predicting the NAO phase several months ahead.
- Correlation with obs in DJF is ~0.6

The NAO is clearly related to UK energy: by impacting **wind speeds** and **temperatures**, it affects **energy supply** and **demand**, as well as risks of **infrastructure damage**.

More on climate drivers:
https://www.metoffice.gov.uk/services/government/contingency-planners/seasonal-forecasts-and-climate-drivers-resources

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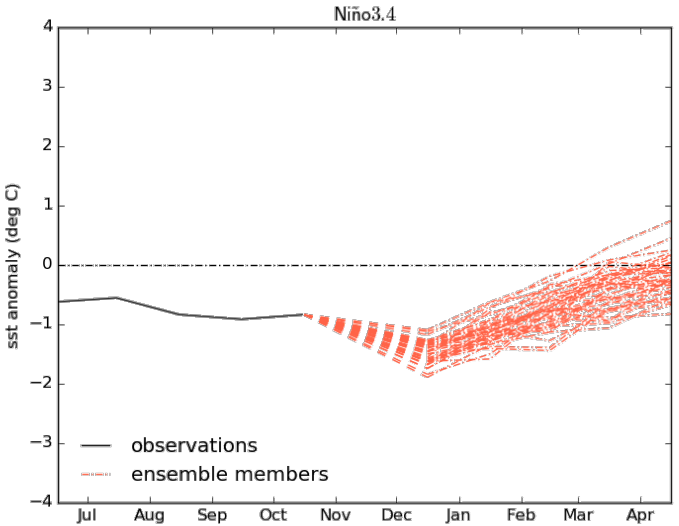
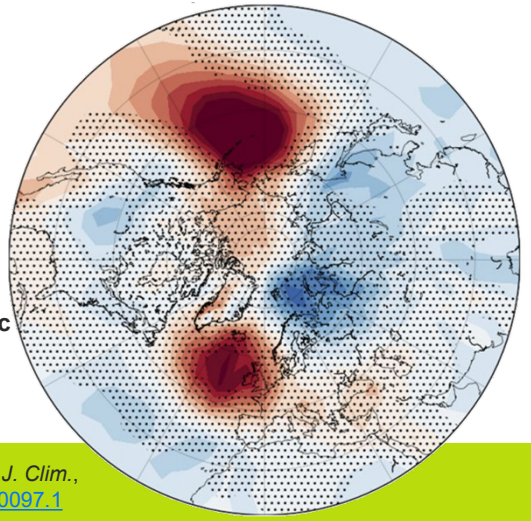
Summary of teleconnections

- **Negative NAO**
  - **La Niña conditions (impact in early winter)**
    → Can bring higher pressure regimes to the north and west of Europe during later autumn/early winter
  - Madden–Julian Oscillation (MJO) phase 6–7
    → Increases chance of northerly or easterly winds in early Dec., and therefore an early winter cold snap.
- **Positive NAO**
  - La Niña conditions (impact in late winter)
    → Increases likelihood of westerly winds
  - Quasi-biennial Oscillation (QBO) in westerly phase
    → Stronger stratospheric polar vortex particularly in early winter





Observed PMSL anomaly responses to La Niña in **Nov–Dec**

PMSL map: Ayarzagüena et al. (2018), *J. Clim.*, **31**, 8861-8873, doi:10.1175/JCLI-D-18-0097.1

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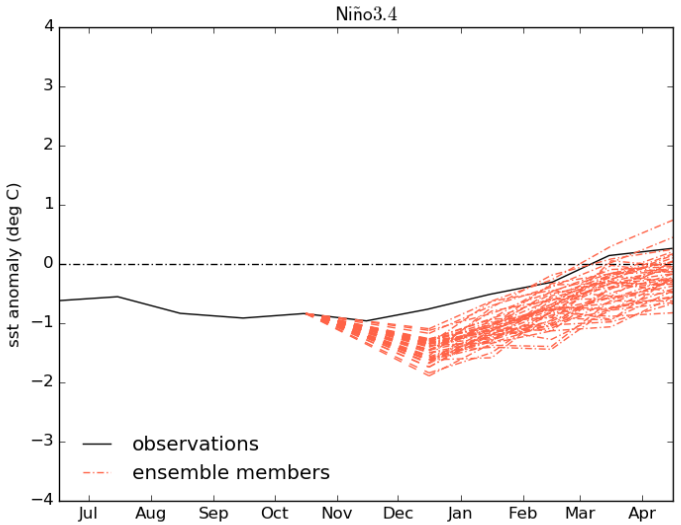

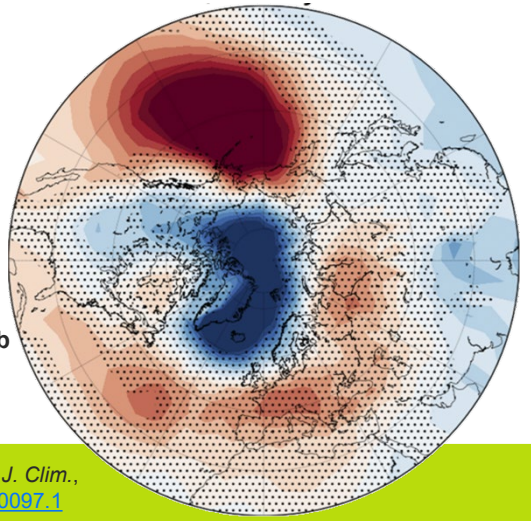

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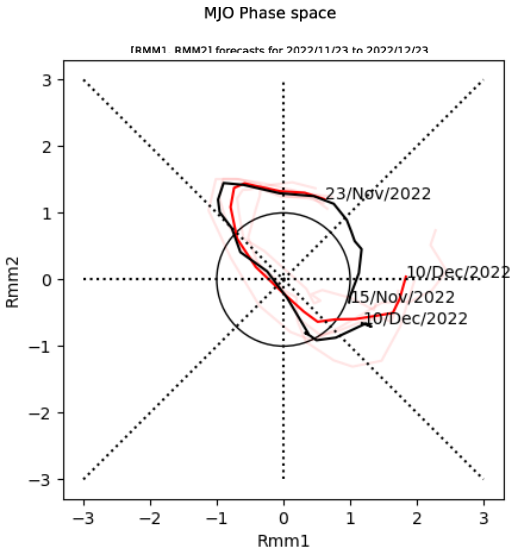

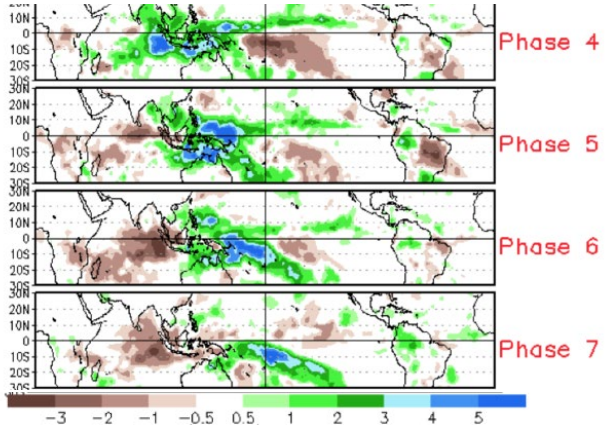

Historical average rainfall anomalies in different MJO phases (1979-2012)
https://www.climate.gov/news-features/blogs/enso/what-mjo-and-why-do-we-care

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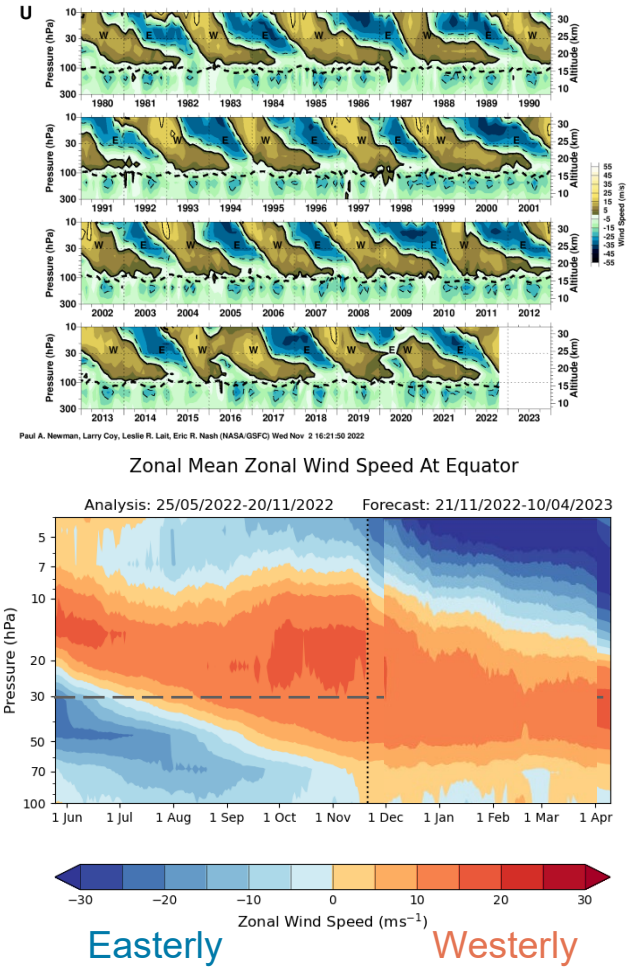
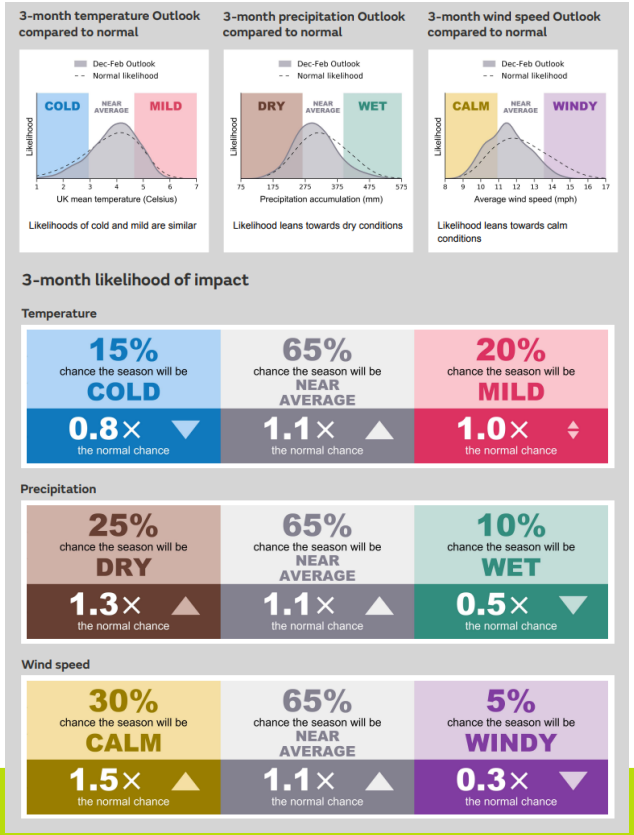
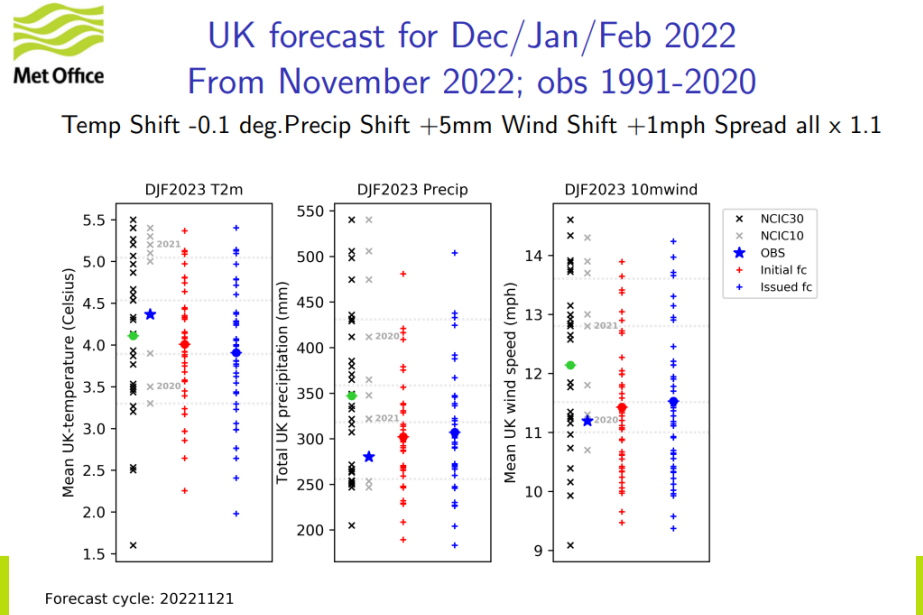


https://acd-ext.gsfc.nasa.gov/Data_services/met/qbo/#singau

November Forecast for DJF 2022/3



- Near average temperature
- Slightly increased chance of dry
- Decreased chance of a windy/stormy season (first winter we included wind)



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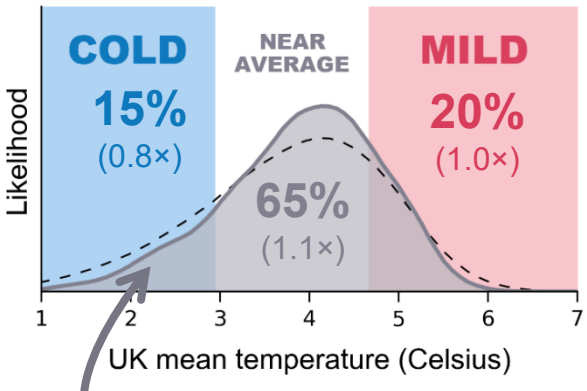
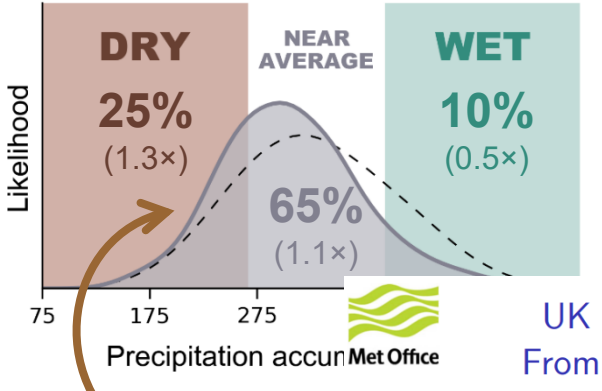
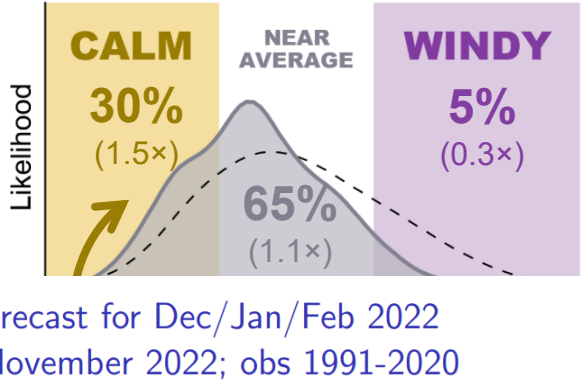


Likelihoods of cold and mild are similar



Likelihood le towards dry



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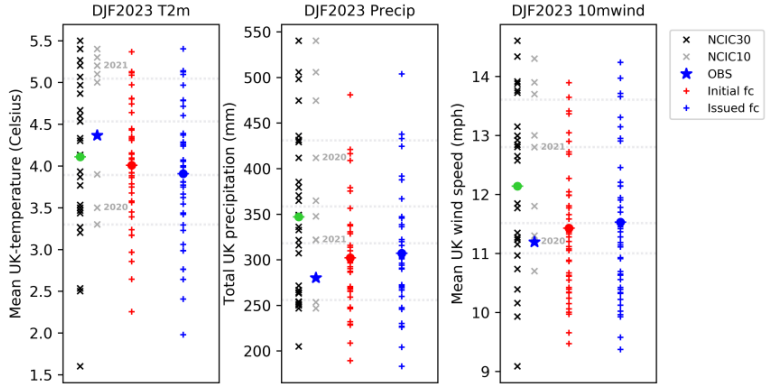
UK forecast for Dec/Jan/Feb 2022
From November 2022; obs 1991-2020

Temp Shift -0.1 deg.Precip Shift +5mm Wind Shift +1mph Spread all x 1.1



Forecast cycle: 20221121

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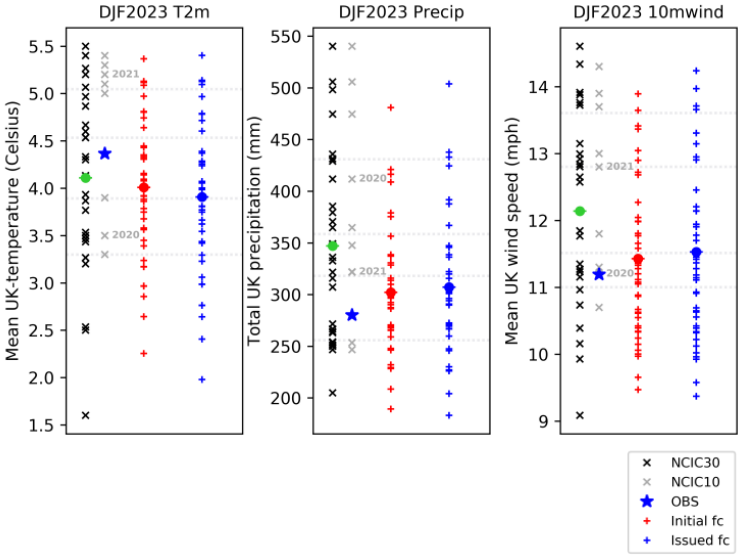

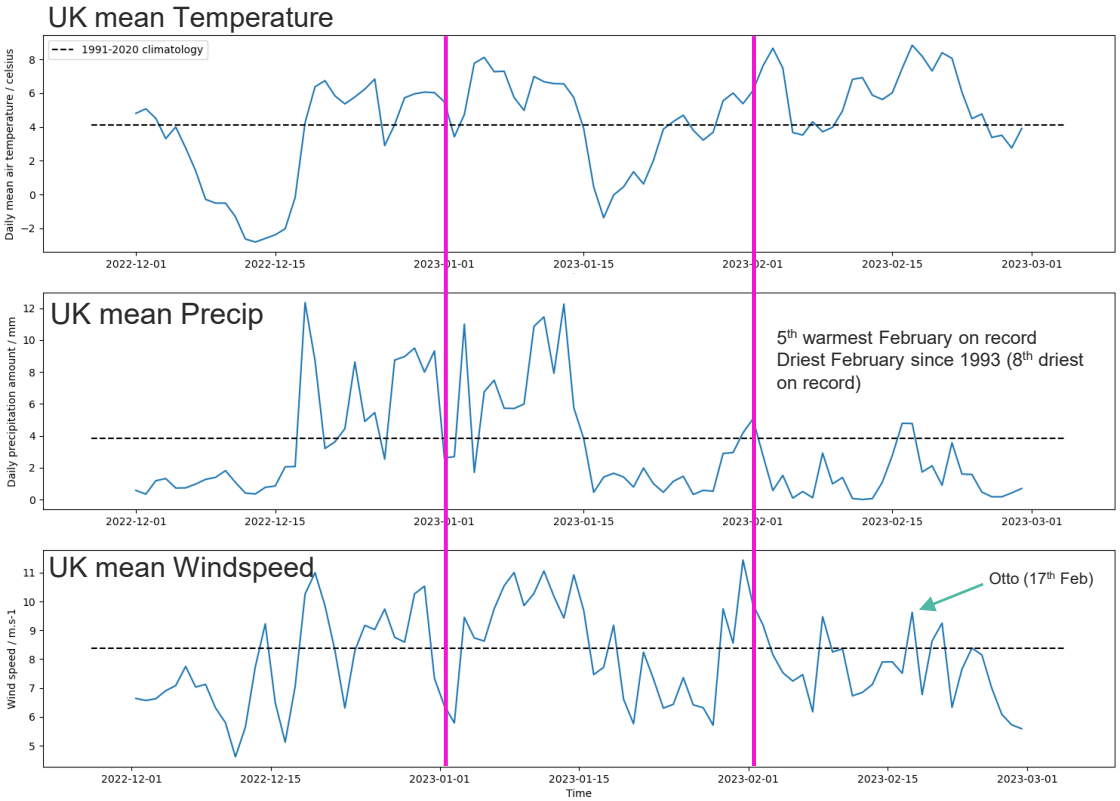

- Greatest chance of impacts from cold weather are in early winter
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Potential for prolonged winter wind drought in the North Sea

Gillian Kay, Nick Dunstone, Anna Maidens, Adam Scaife, Hazel Thornton, Doug Smith, Laura Dawkins, Stephen Belcher

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Increasing reliance on (offshore) wind energy

- UK has committed to decarbonising the energy system by 2035
- Rapid growth in wind energy in recent years: 24.6% of total electricity generation from wind in 2022; 13.8% from offshore
  - 2.7% (0.8% from offshore) in 2010
- Wind power is variable – growing challenge to security of supply

How well are we able to characterise wind variability?

Image credit: Shutterstock

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How well are we able to characterise wind variability?

UNSEEN (UNprecedented Simulated Extremes using ENsembles*) approach:

Using a large ensemble as a synthetic dataset of the current climate that better samples extremes and allows exploration of their dynamics.

Image credit: Shutterstock

*Thompson et al. 2017. High risk of unprecedented UK rainfall in the current climate. *Nat Commun* 8:107.

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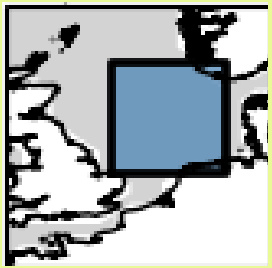
Study domain: North Sea; Season: winter

Image credit: Shutterstock

The North Sea is a global hotspot of current and planned offshore wind farms that serve the UK and other European countries.



In winter, periods of **higher demand** tend to coincide with **lower wind power**.

Related to the large-scale weather patterns that affect Northern Europe:

Stronger, warmer, westerly winds

Weaker, colder, easterly winds

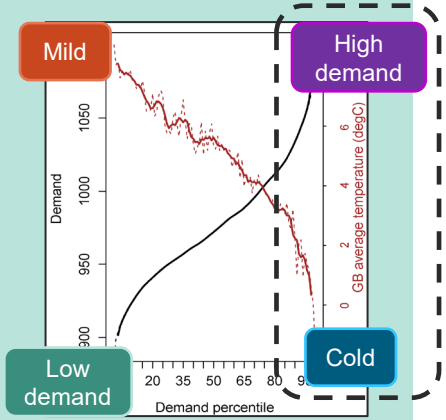


Figure credit: Thornton et al. 2017

Thornton, H.E. et al. 2017. The relationship between wind power, electricity demand and winter weather patterns in Great Britain. *Environ. Res. Lett.* 12 064017

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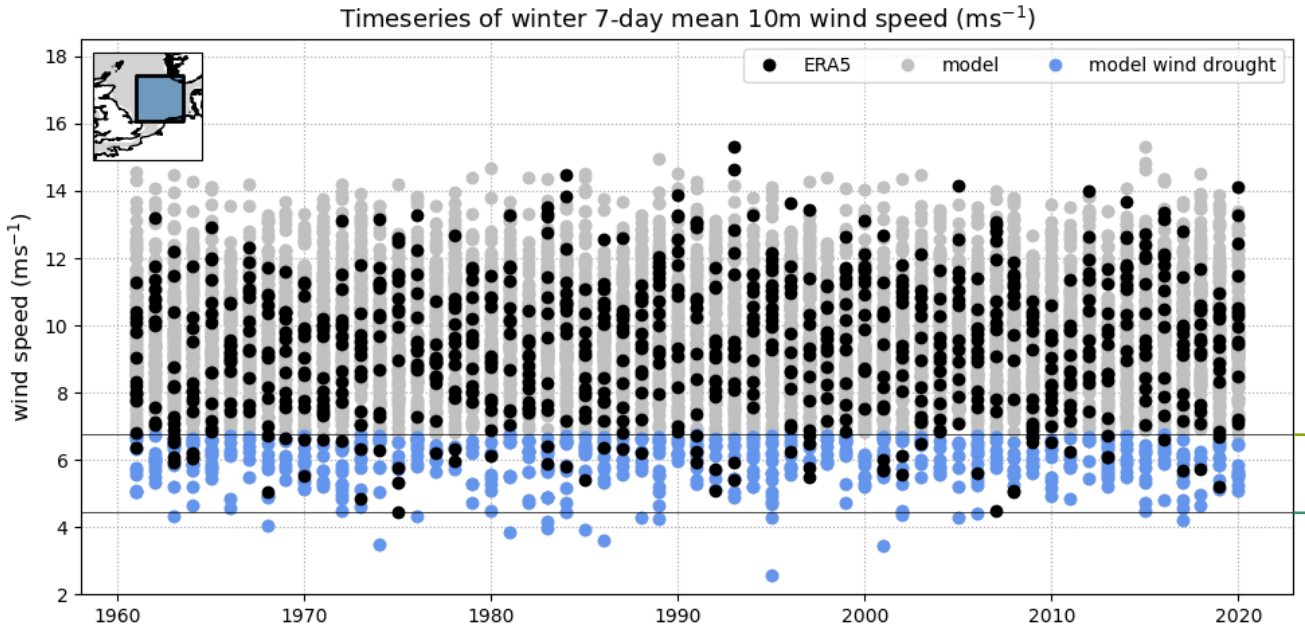
Weekly mean 10m wind speeds



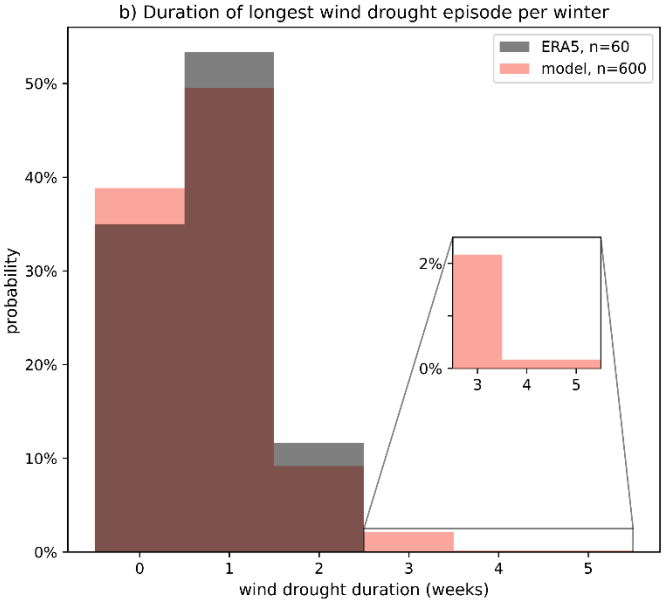
Wind drought threshold: 20th percentile of ERA5 daily 10m wind speeds.

During wind drought weeks there is a large reduction in power generated compared with a typical winter week

Weekly mean wind speeds below the lowest yet recorded are possible

Persistent wind drought events

- Up to 5 weeks of wind drought possible in a single winter. 4 in the reanalysis.
- Most likely: single-week events.
- Chance of consecutive weeks with very low wind speeds.
- Maximum of 2 weeks seen in ERA5 so far.
- 1-in-40 chance of three or more continuous weeks.
- Worst case: 5 continuous weeks.



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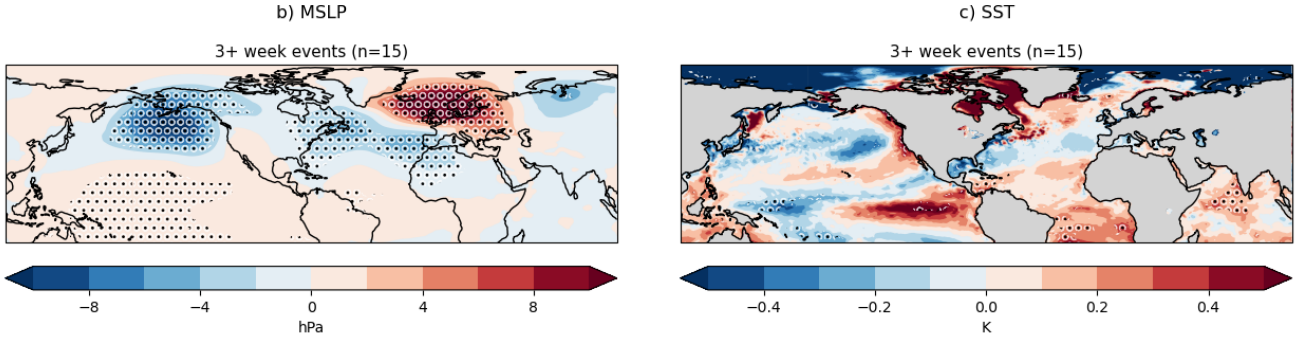
Dynamics of prolonged wind drought



Prolonged (3+ week) wind drought events are associated with El Niño-like SST anomalies in the tropical Pacific and an intensified Aleutian Low.

Chance of persistent wind drought events doubles during El Niño.

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Section summary

- Better information on characteristics of wind variability will be useful in planning a resilient energy system, especially as proportion of wind in the energy mix increases.
- Weeks with winds below the recorded minimum are possible in the current climate.
- The model indicates a 1-in-40 chance of three or more continuous weeks of wind drought each winter, with a worst case of five.
- There is a doubling of the likelihood of these prolonged wind drought events during El Niño.
  - Monitoring and predicting the state of the tropical Pacific may be useful in assessing the risk of wind drought events in an upcoming winter.

Image credit: Shutterstock

Kay, G. et al. 2023: Variability in North Sea wind energy and the potential for prolonged winter wind drought. *Atmos. Sci. Lett.* e1158. https://doi.org/10.1002/asl.1158