CALIBRATED EUROPEAN HISTORICAL AND NEAR-FUTURE ENERGY-METEOROLOGY VARIABLES FOR ENERGY SYSTEMS MODELLING

Hannah Bloomfield

Matt Deakin, David Greenwood, David Brayshaw, Ilias Sarantakos & colleagues at AFRY

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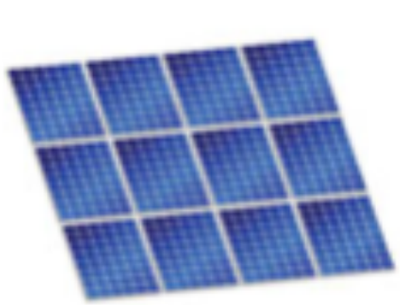
MOTIVATION

- To meet government targets power systems are becoming increasingly weather-dependent
- This weather-dependence results in increased power system variability on numerous timescales from seconds-decade

Temperature
Wind Chill
Relative Humidity

Wind Speed



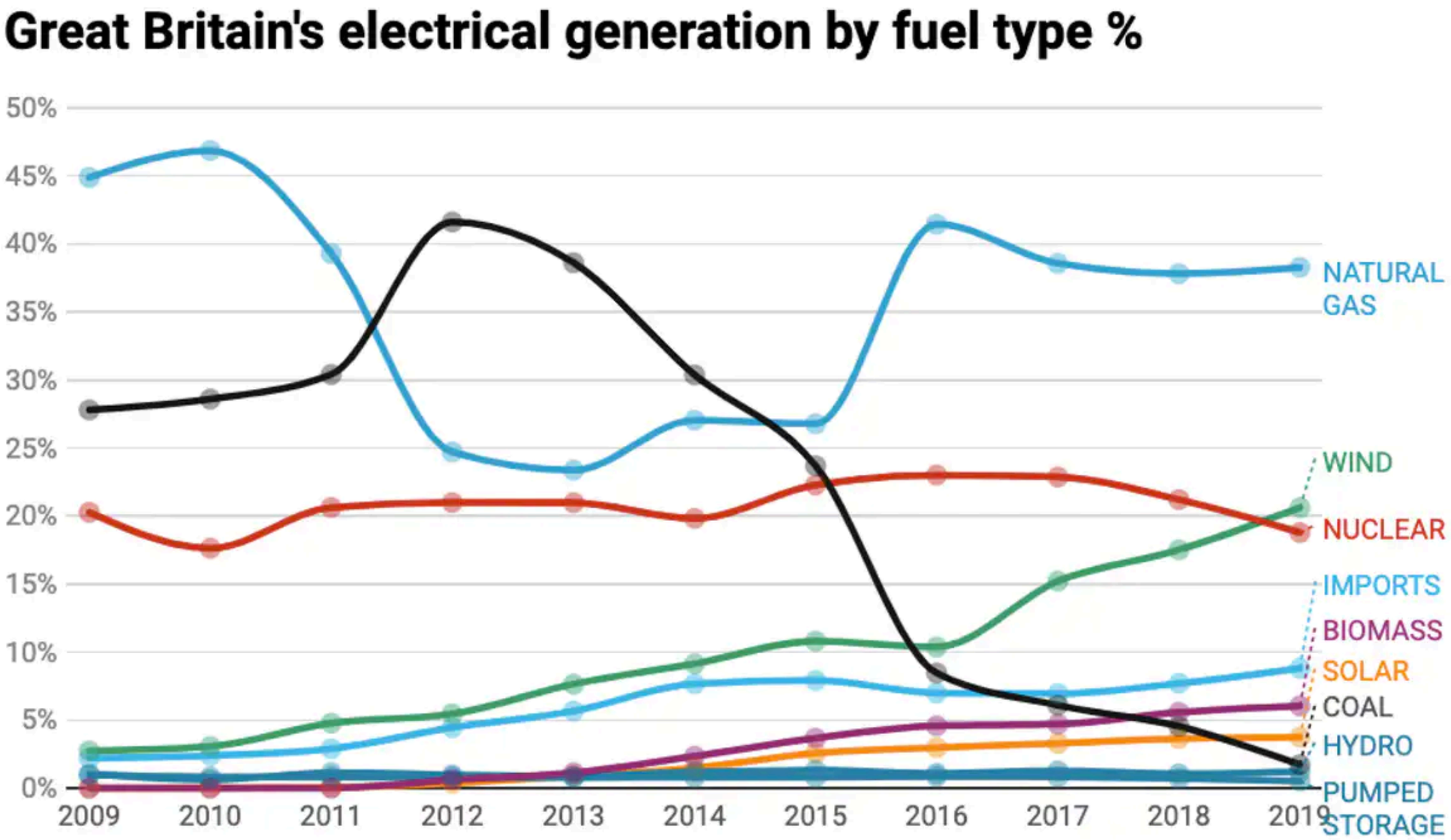
Shortwave Irradiance
Temperature

Precipitation
River Run-off

Precipitation
Snowfall
Wind Speed
Temperature

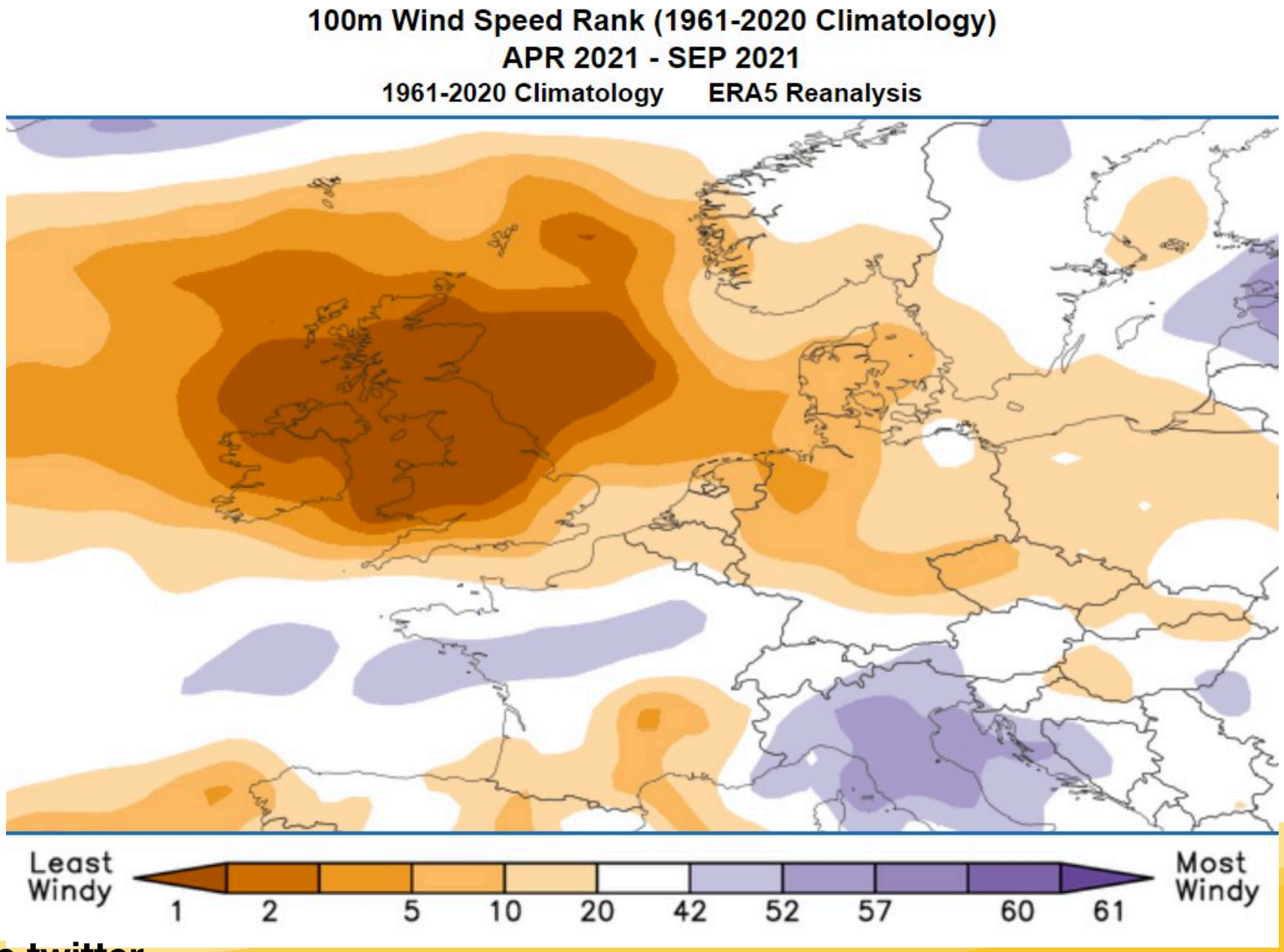
WHY DO I NEED METEOROLOGICAL DATA?

- Energy systems are rapidly changing to meet climate mitigation targets, so metered data contains large trends, and past years data are less useful



TOPICAL SITUATION

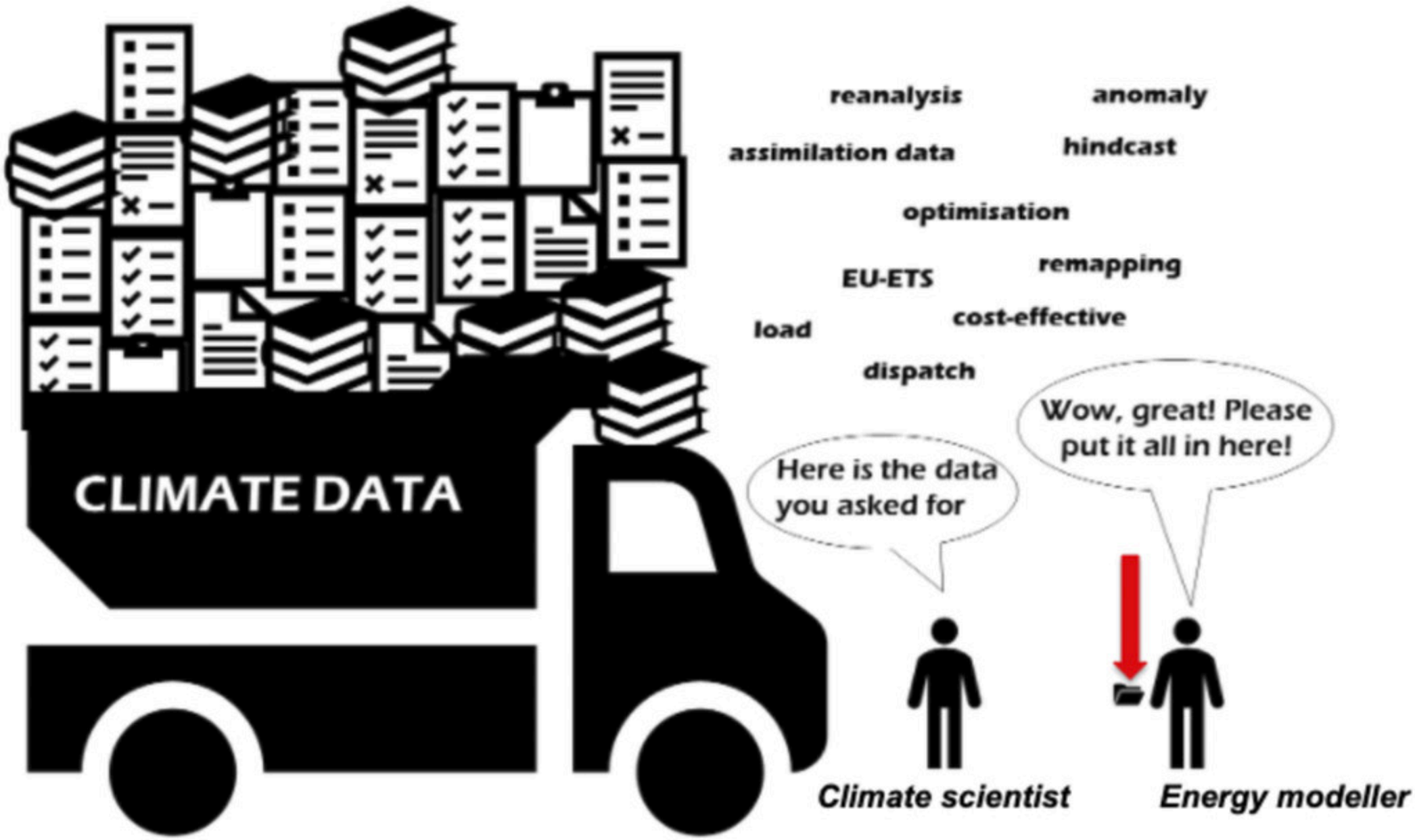
- European wind drought summer 2021
- Lowest wind period in the last 60 years. - A challenge when you come to rely heavily on renewable generation!



Summer was bad, will that happen again next year?

Source: World Climate Service twitter

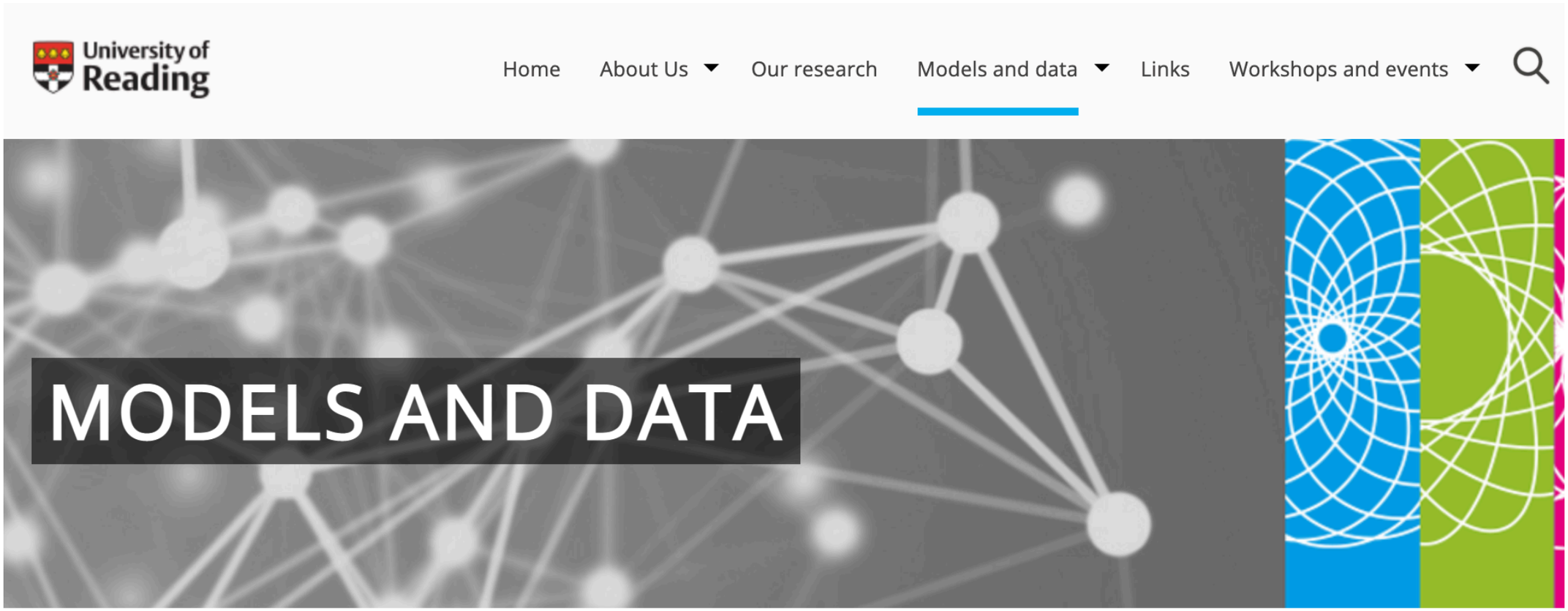
BRIDGING GAPS BETWEEN DISCIPLINES



Citation: Bulletin of the American Meteorological Society 102, 1; 10.1175/BAMS-D-20-0256.1

DATA AVAILABLE THROUGH VARIOUS PLATFORMS

https://research.reading.ac.uk/met-energy/data/



TWO-WAY DEVELOPMENT

Your datasets are nice but…
- **Can we have a bespoke area?**
- **Can we separate onshore and offshore wind?**
- **Can we include the most recent winter?**

ELSEVIER

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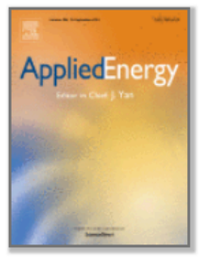


Impacts of heat decarbonization on system adequacy considering increased meteorological sensitivity

Matthew Deakin [a], Hannah Bloomfield [b], David Greenwood [a], Sarah Sheehy [c], Sara Walker [a], Phil C. Taylor [d]

TWO-WAY DEVELOPMENT

Your datasets are nice but…

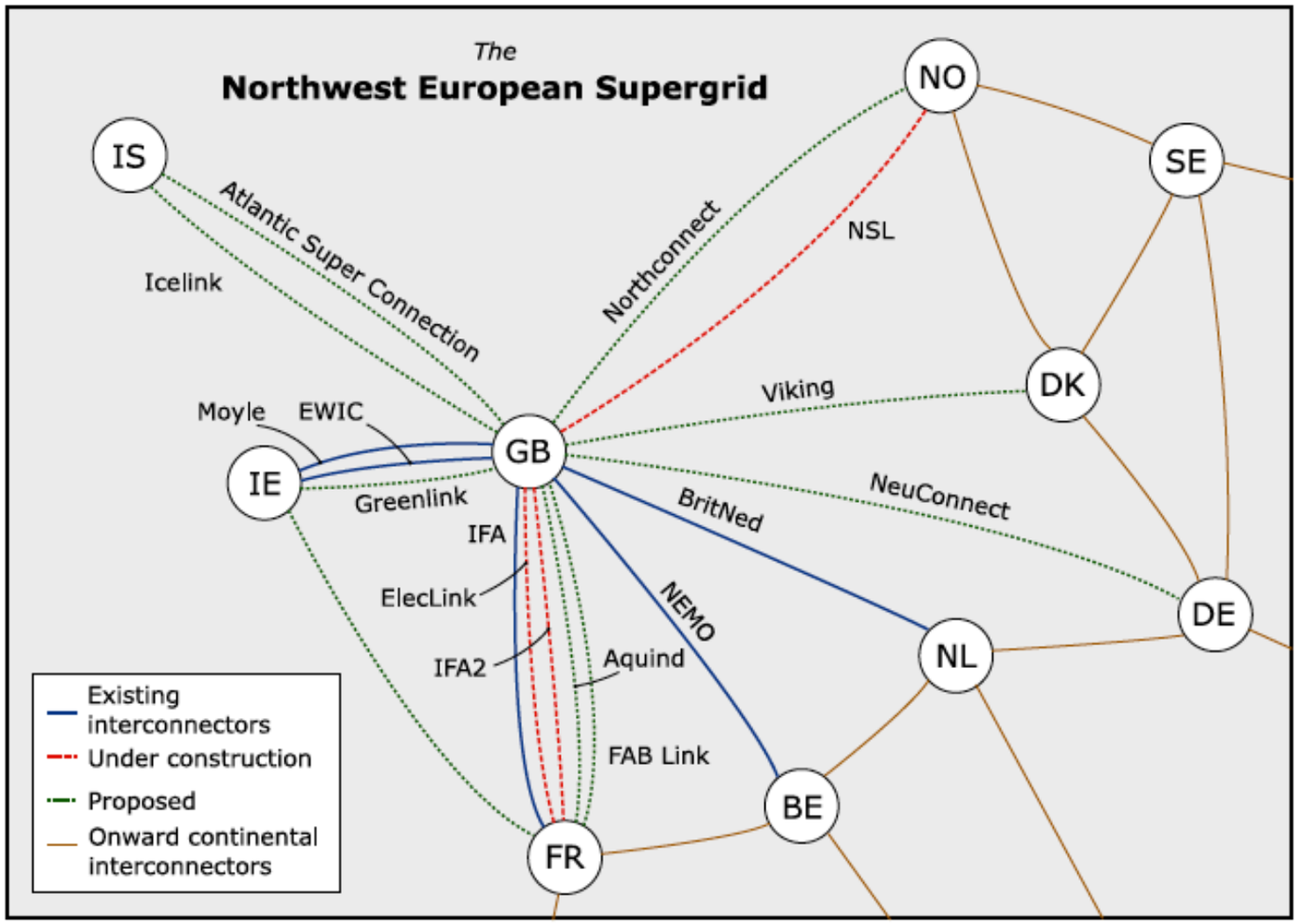
- Can we have a bespoke area?
- Can we separate onshore and offshore wind?
- Can we include the most recent winter?

- Could we do this for the whole of Europe?
- Could we think about interconnections?
- What about climate change?

CLEARHEADS

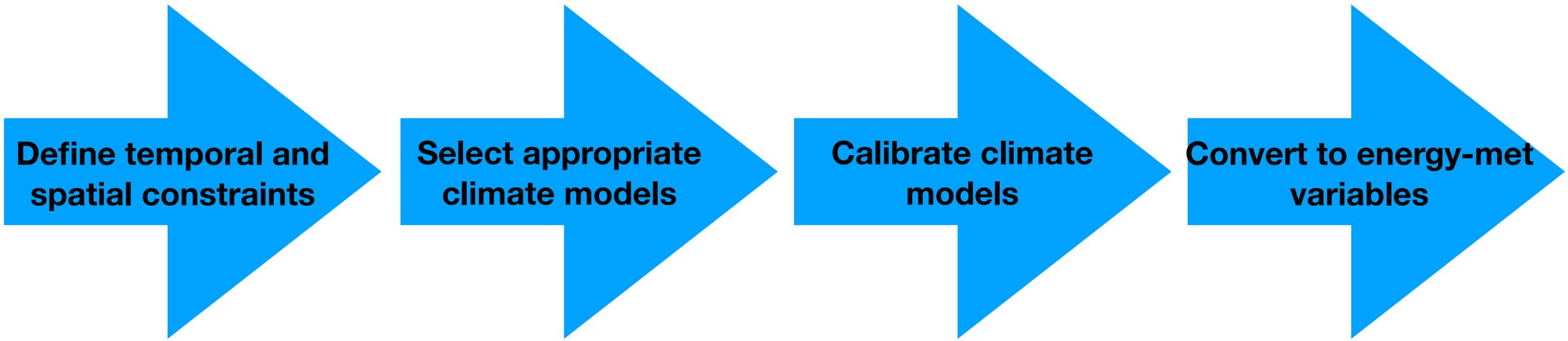
- **CLimate-Energy modelling for Assessing Resilience: HEAt Decarbonisation and the Northwest European Supergrid**
  - Many countries.
  - Interconnection.
  - More years of past climate.
  - Impacts of climate change.
  - Multiple decarbonisation scenarios.

- **Publicly available datasets.**
- Scripts for processing weather data.
- Python libraries for calculating useful energy indices (e.g. outages).



Focus of this talk is on the meteorological data provision

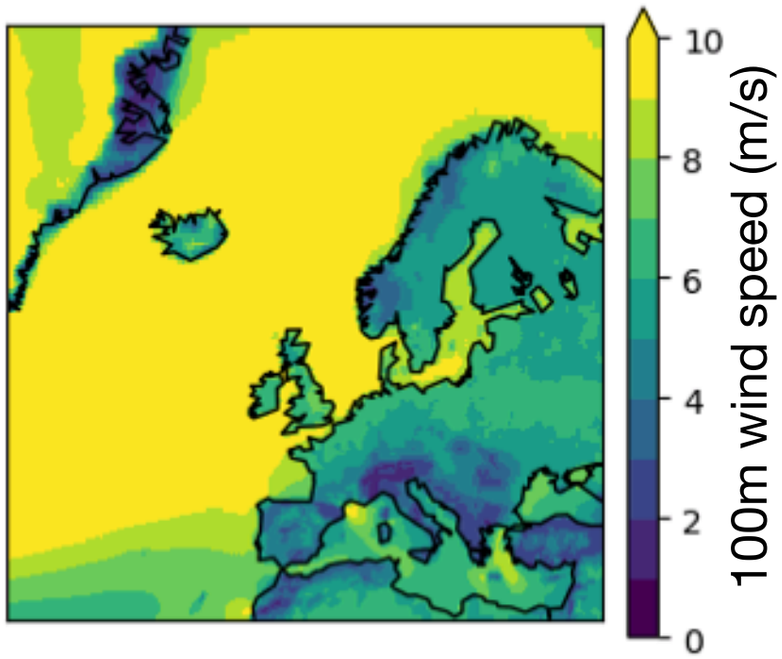
FOUR STEP PROCESS



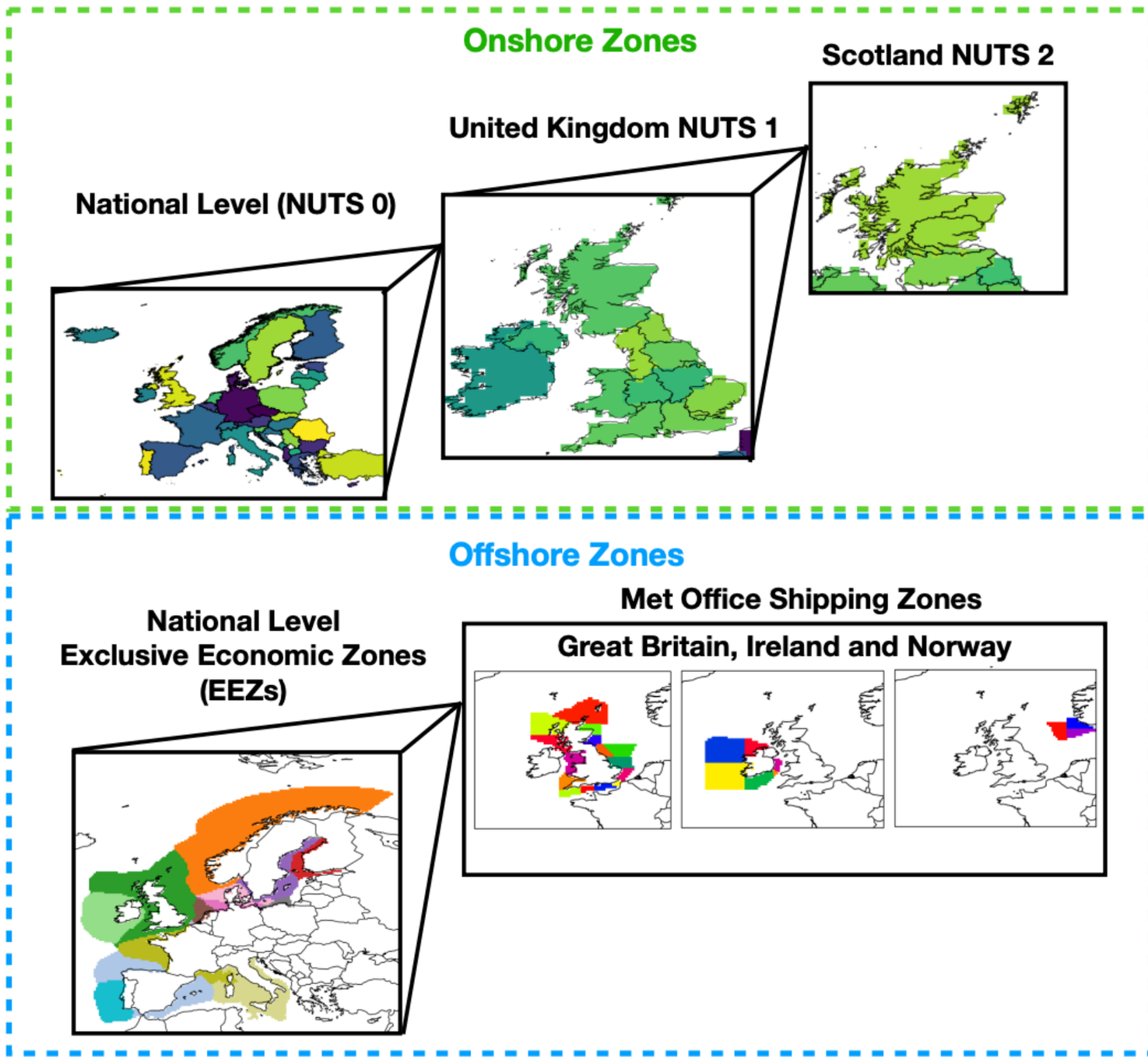
DEFINE CONSTRAINTS

Hourly data
High spatial resolution
Historical 1950-2020. near-future 2020-2050

Gridded meteorological data

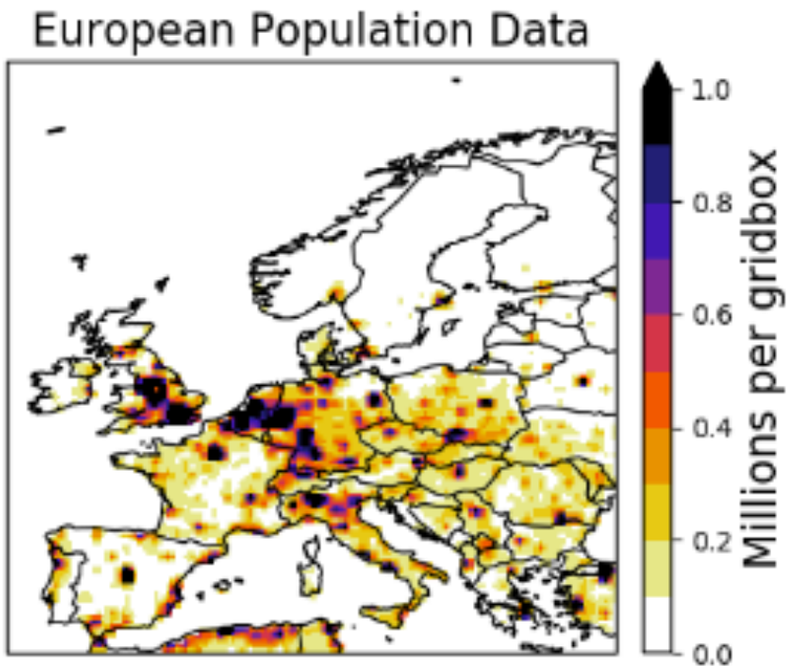


Spatially aggregated time series

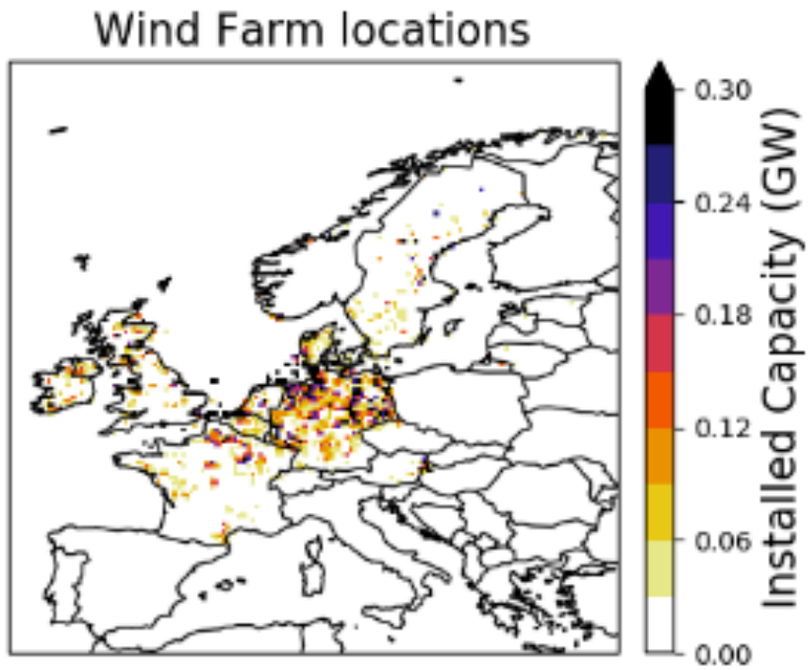


FIELDS TO CREATE

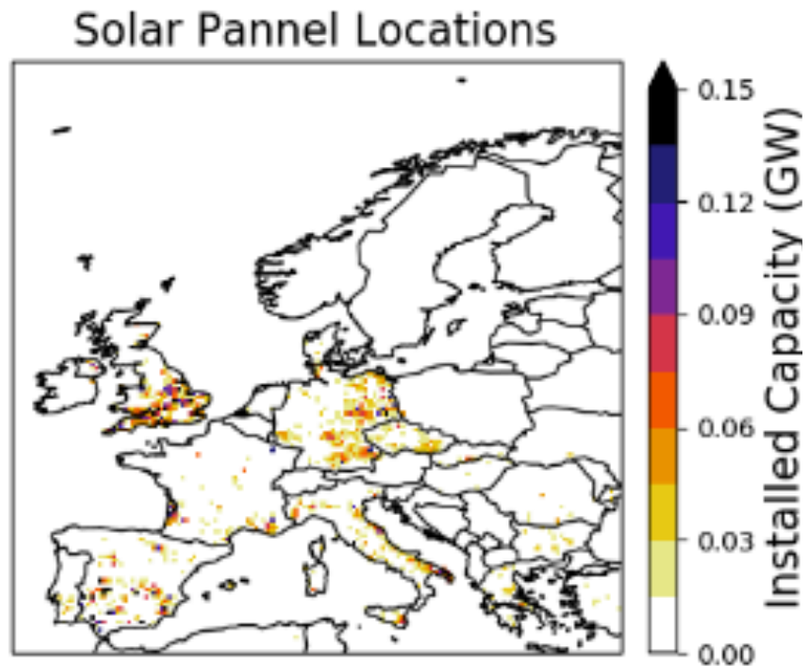
- National (and sub-national) calibrated meteorological variables: T2m, speed10m, speed100m, surface radiation.
- National (and sub-national) wind power and solar PV capacity factors.
- Heating degree days, cooling degree days.



Doxey-Whitfield et al., (2015)



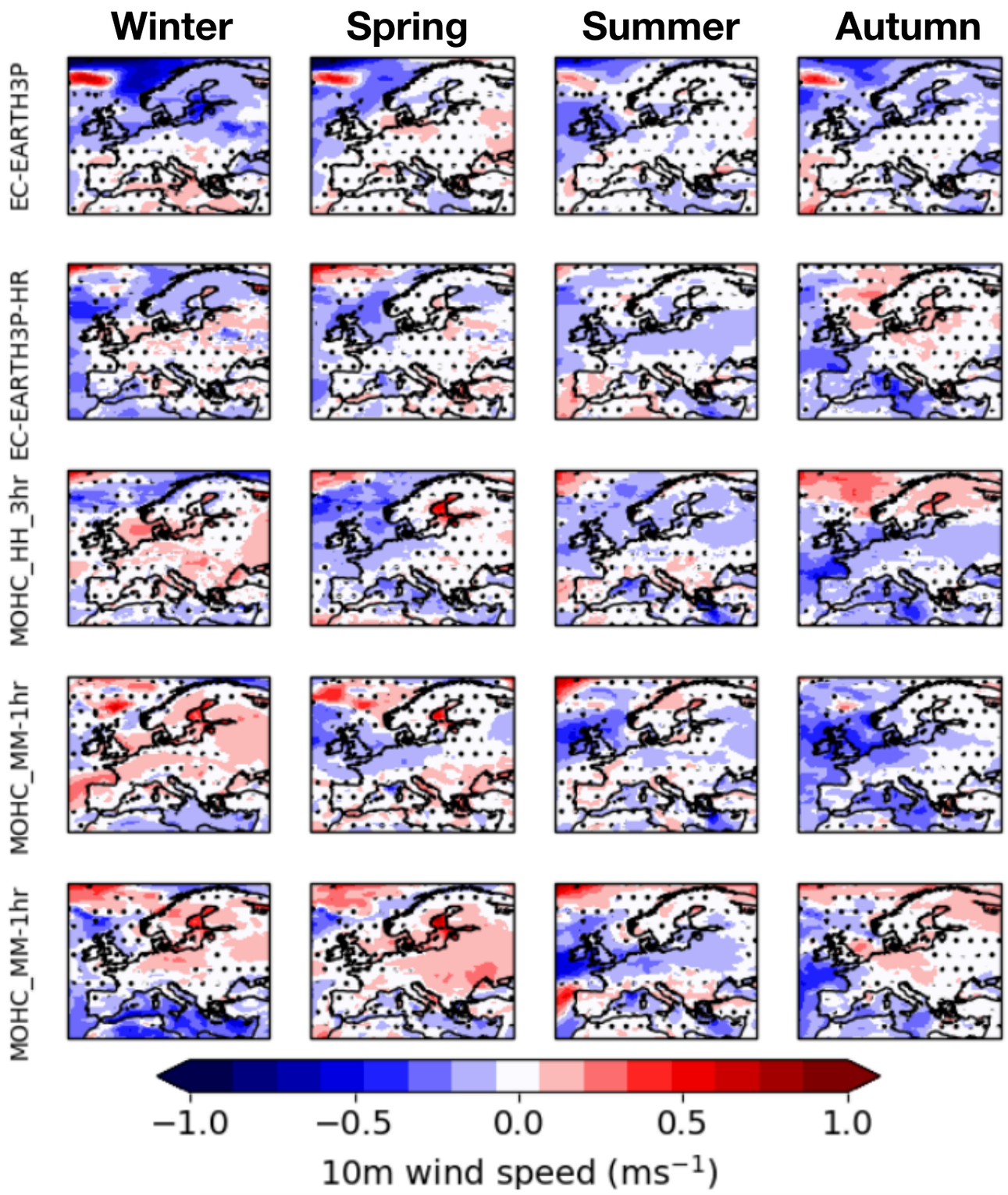
thewindpower.net database



Dunnett et al., (2020)
Stowell et al., (2020)

SELECT CLIMATE MODELS

- The **ERA5** meteorological reanalysis datasets contain **>70 year reconstruction** of hourly gridded weather variables at multiple heights through the atmosphere.
- **High resolution climate model data:** new generation of well-evaluated high resolution global climate models.
- available through the CEDA data catalogue or on the JASMIN supercomputer.
- Around 4TB of data processed during this project



CALIBRATE CLIMATE DATA

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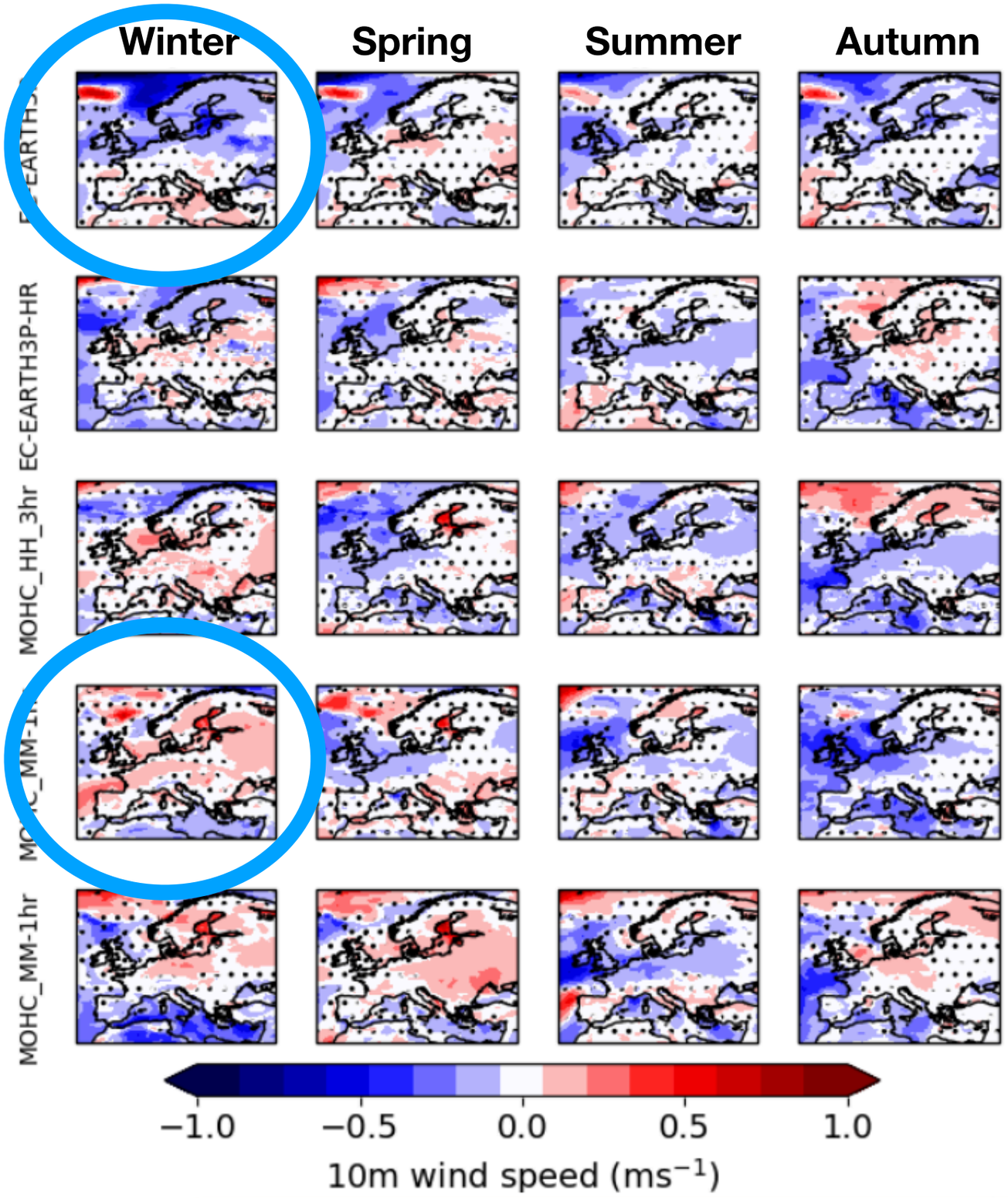

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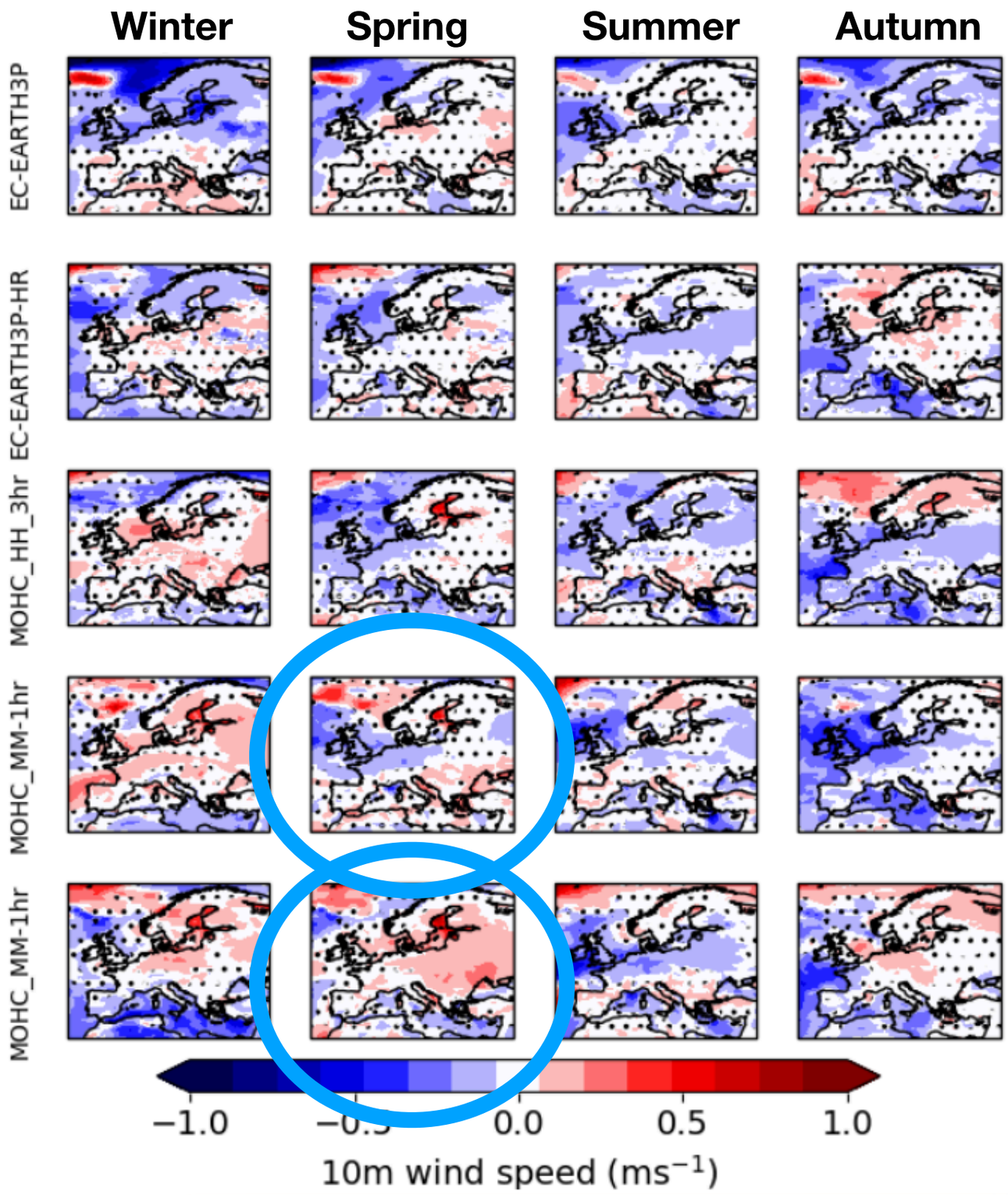


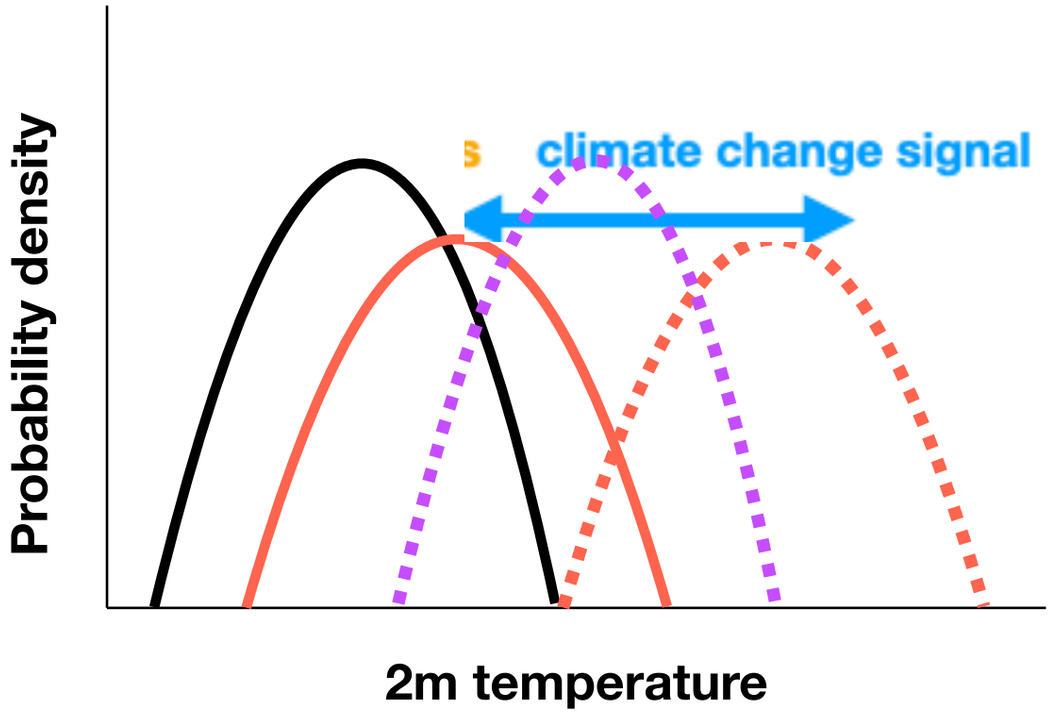
CALIBRATE CLIMATE DATA

ERA5

clim model

present

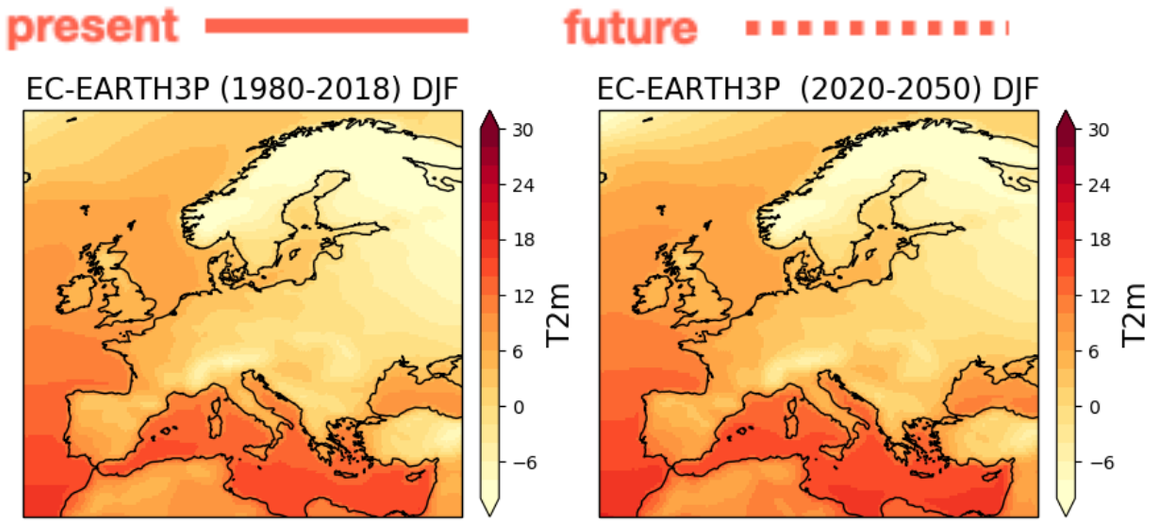
future

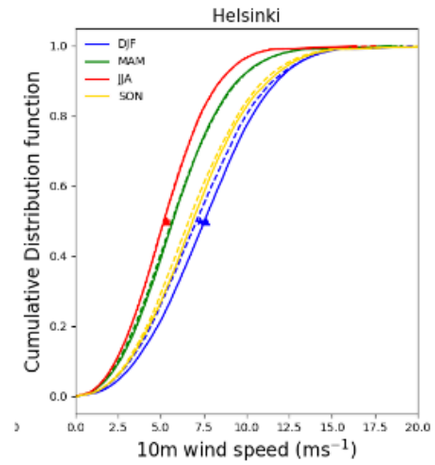


delta future clim = ERA5 + climate change signal

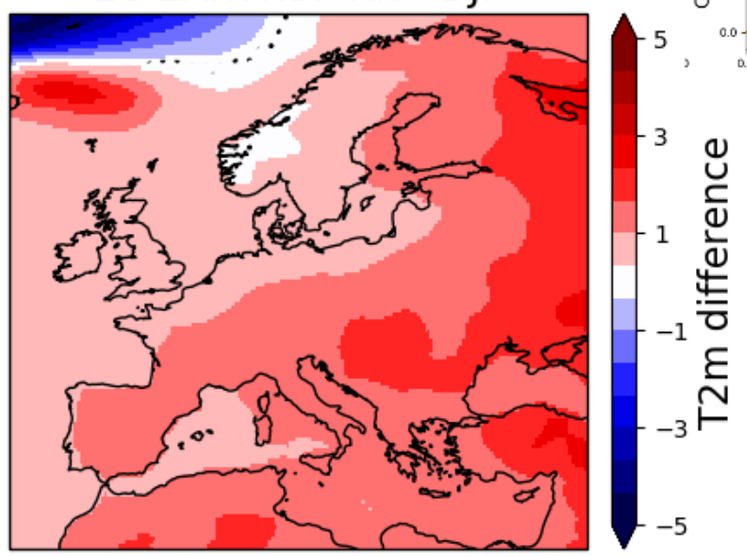
present

future





climate change signal



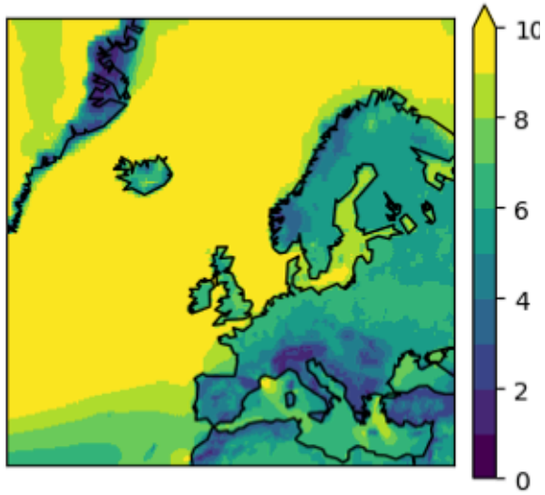
WIND POWER GENERATION

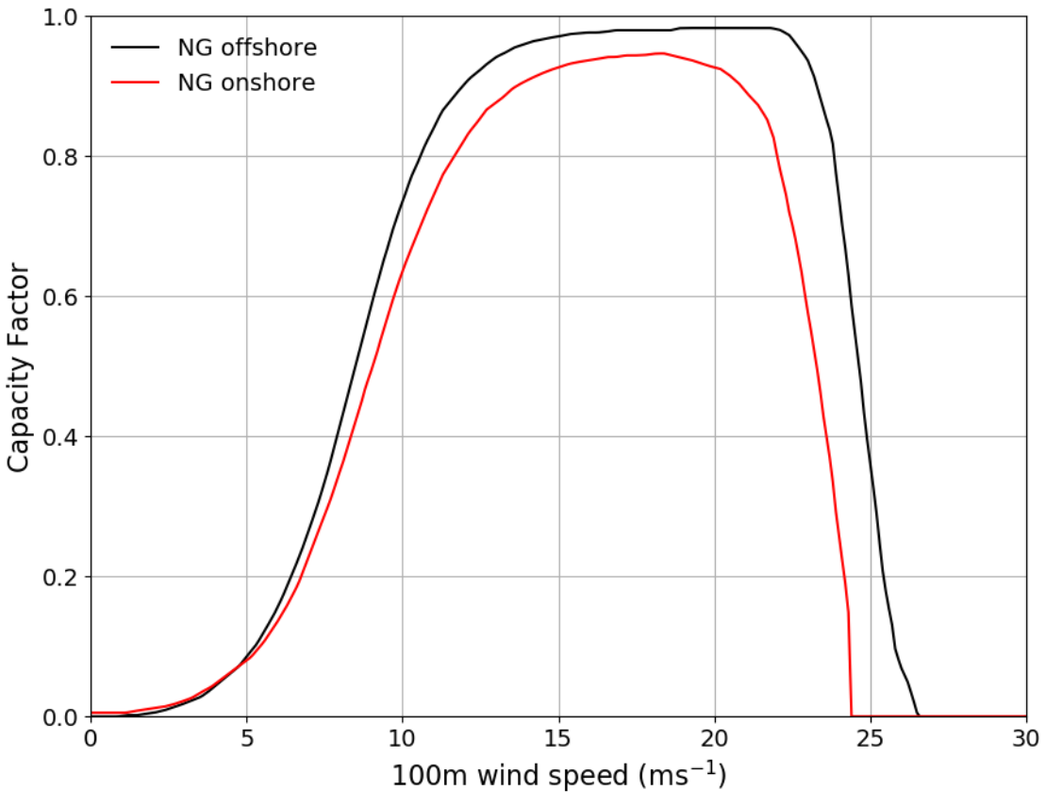
Input: hourly calibrated 100m wind speeds. Extrapolate to average hub-height

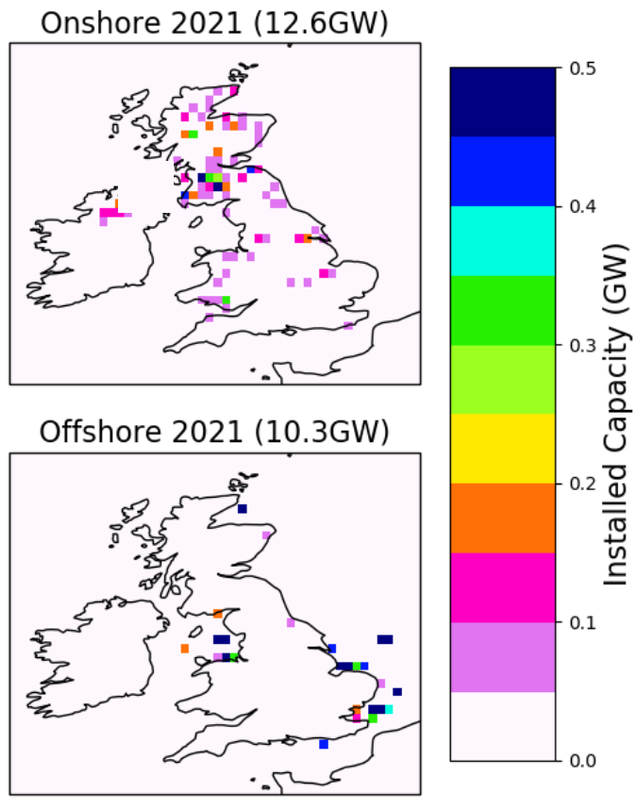
- Pass through onshore/offshore power curve to produce capacity factor time series at each grid box.
- Aggregate to national level based on amount of installed wind power in each grid box.

Output: Hourly national capacity factor time series

ERA5 100m winds (1980-2018)







SOLAR PV MODELLING

- Take gridded 2m temperatures and surface solar radiation and calculate CF using empirical model.
- Efficiency of panels declines with increasing temperatures.

relative efficiency factor

Irradiance

$$CF = \frac{Power}{Power_{STC}} = \eta_{rel}(G,T)\frac{G}{G_{STC}}$$

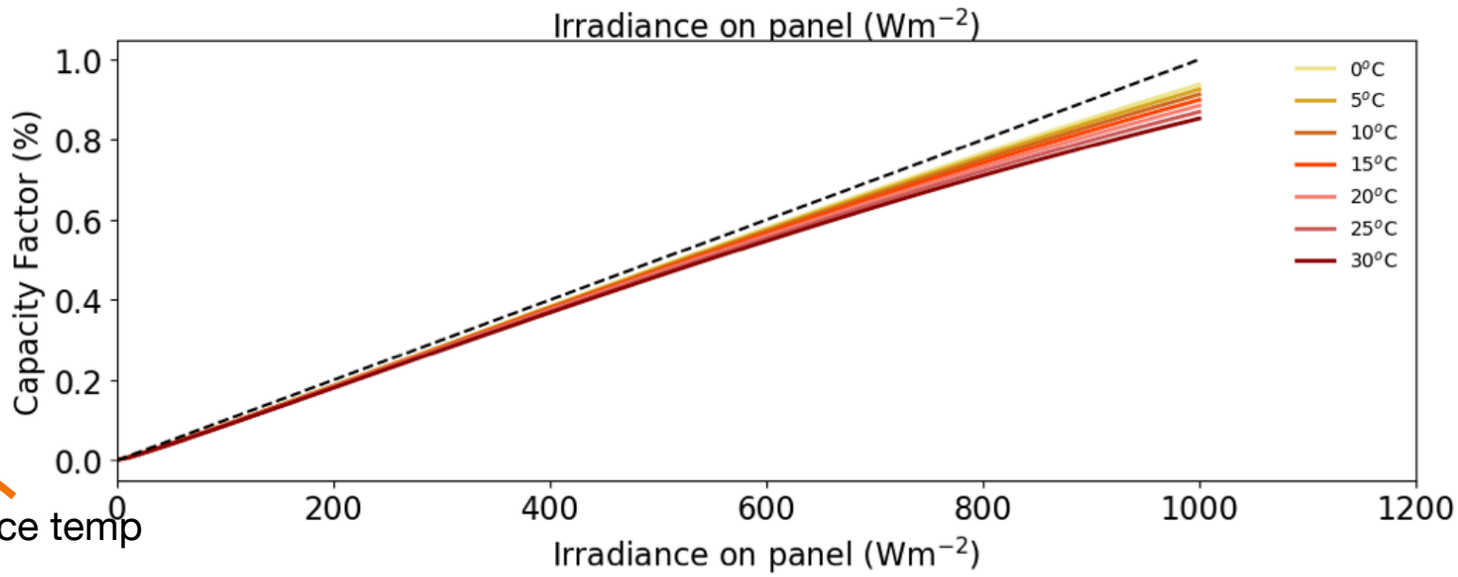
$$\eta_{rel}(G,T) = \eta_r[\,1 - \beta_r(T_c - T_r\,)]$$

efficiency at reference temp

decrease in efficiency per unit temp

cell temperature

reference temp



See Bloomfield et al., (2020) and Bett and Thornton (2016) for further details

EXAMPLES OF THE DATA

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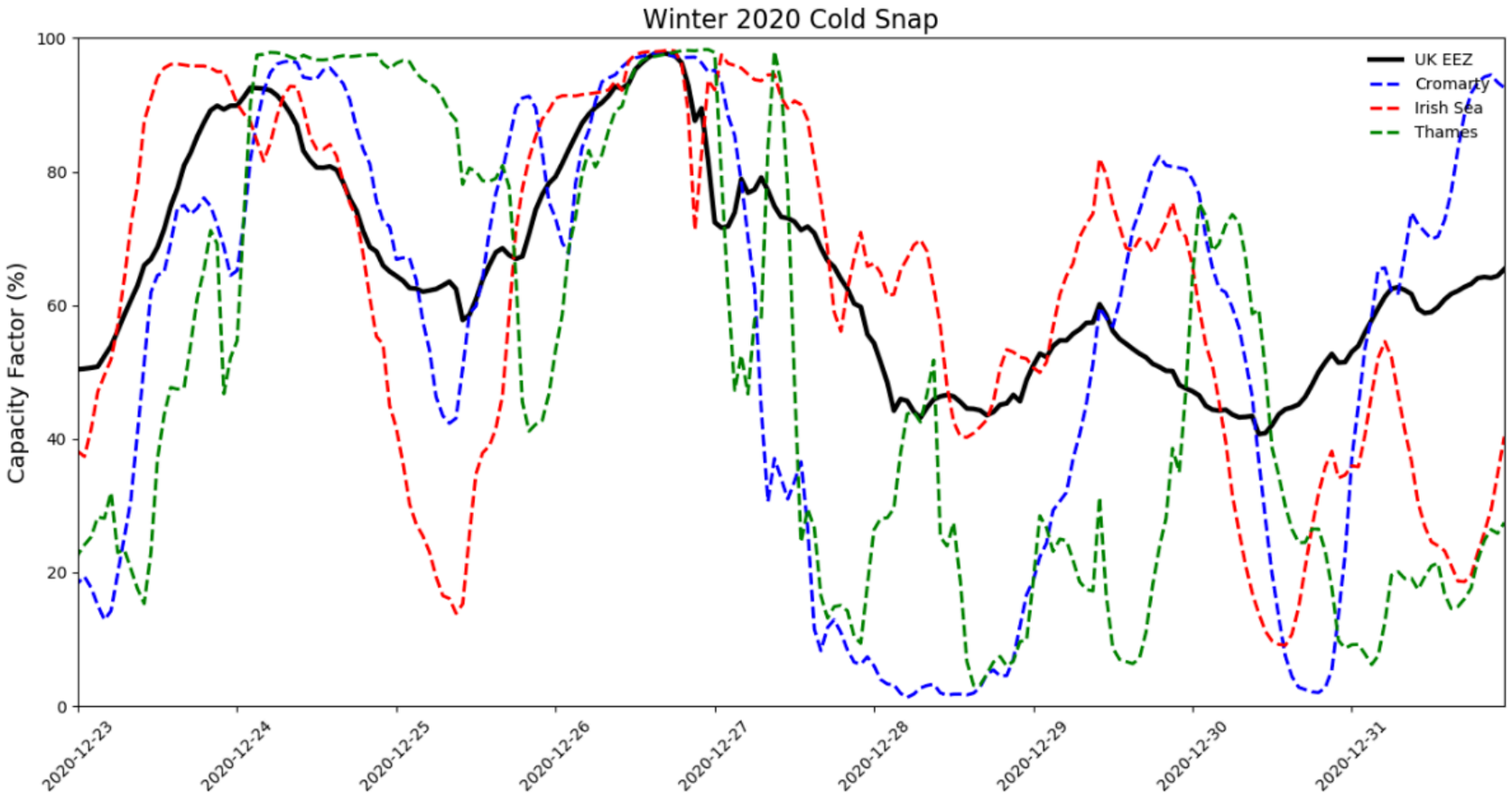
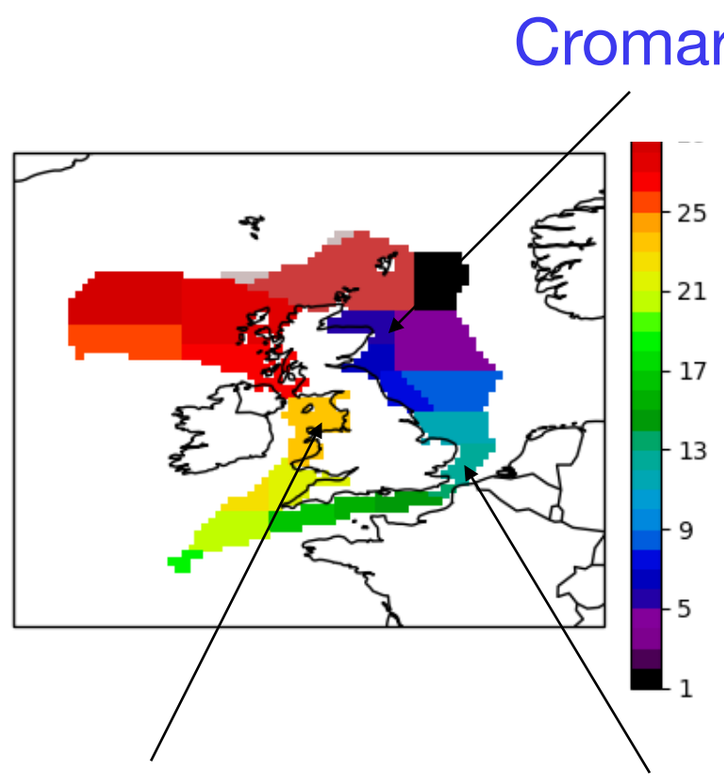
- Case study period of variable capacity factor (December 23rd - 31st 2020)
- We are able to pick up the larger ramps experienced in regions with a lot of wind power generation





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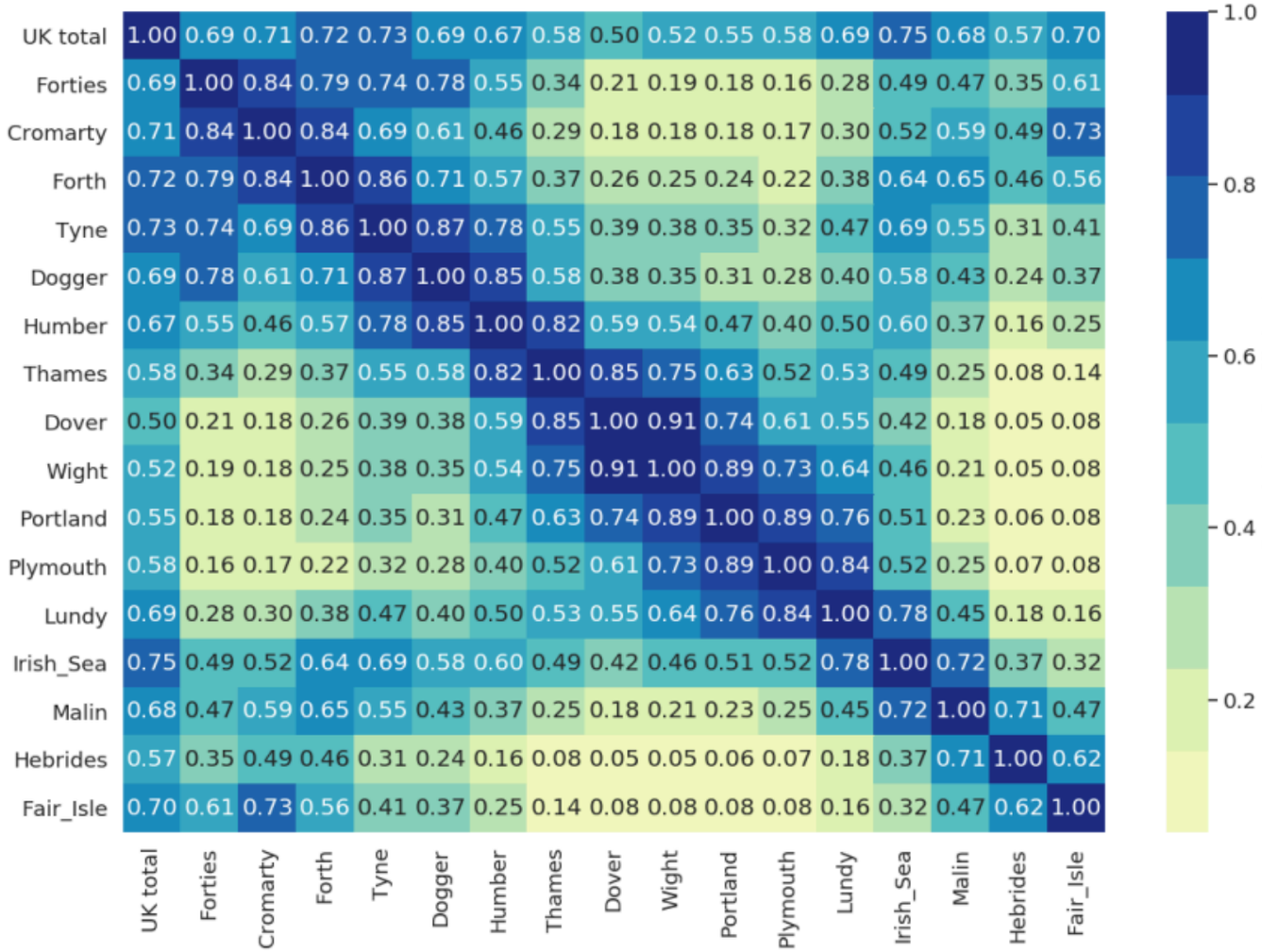
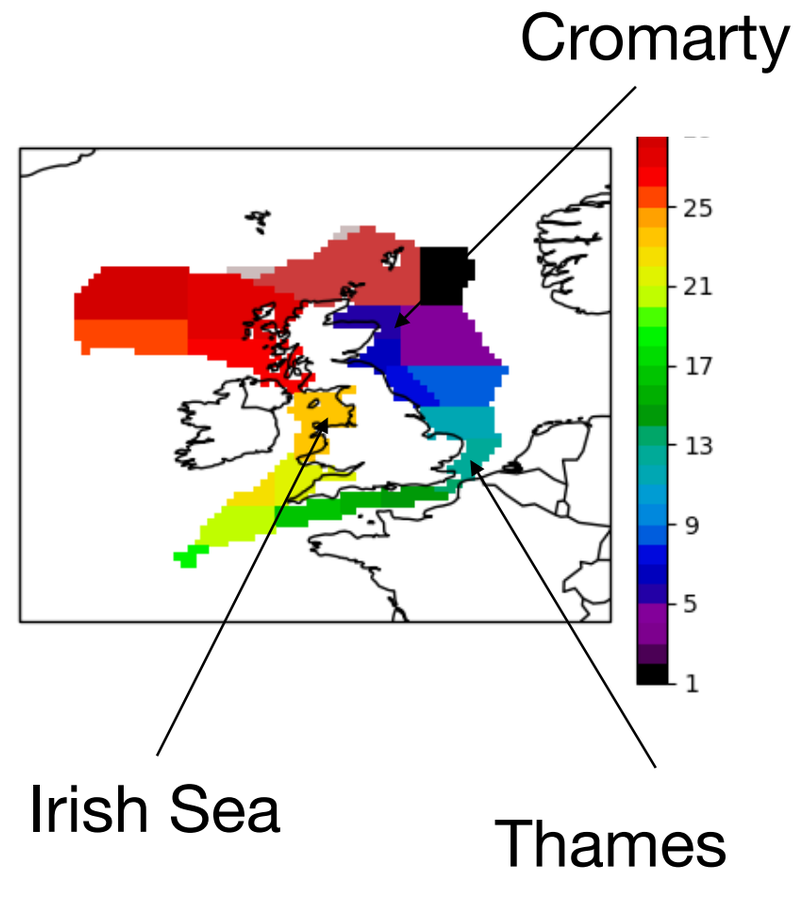
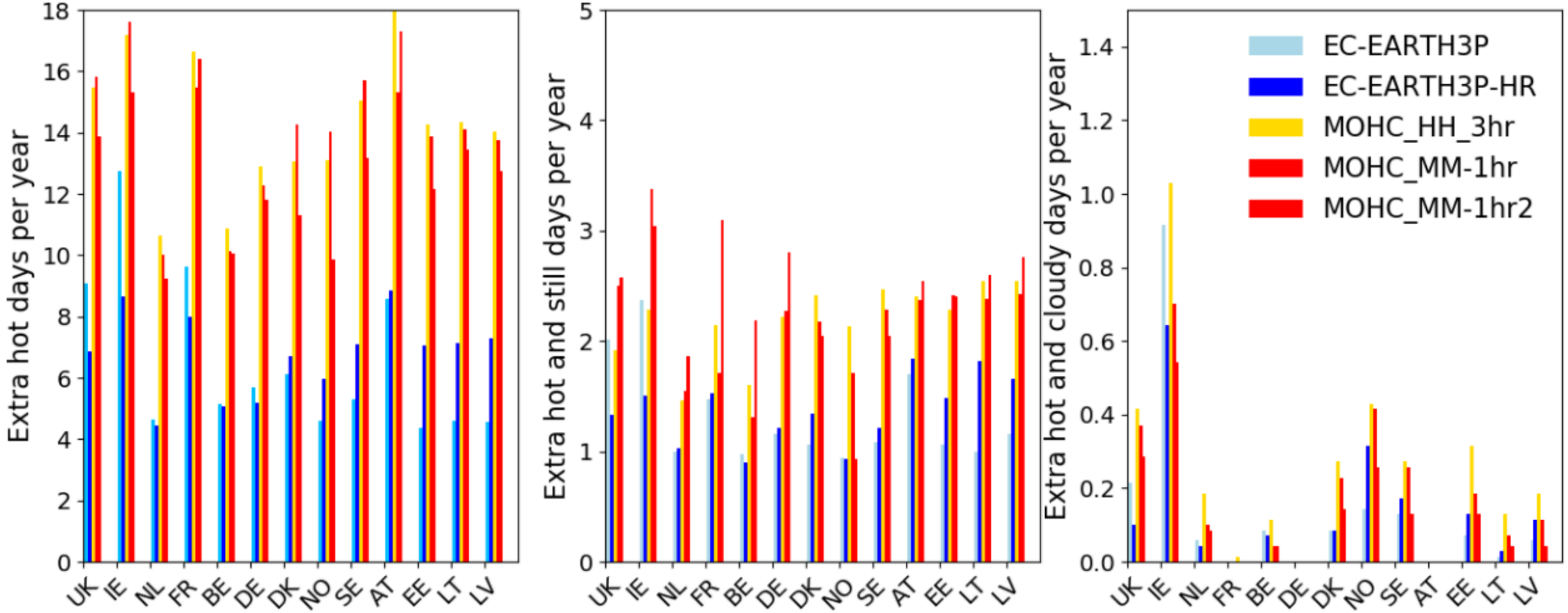




EXAMPLES OF THE DATA

- Dataset can be used to think about the changing frequency of extremes and compound extremes.
- Many more hot days in summer, but not as many that are both hot and still.
- Minimal changes in hot and cloudy days.



EXAMPLES OF THE DATA

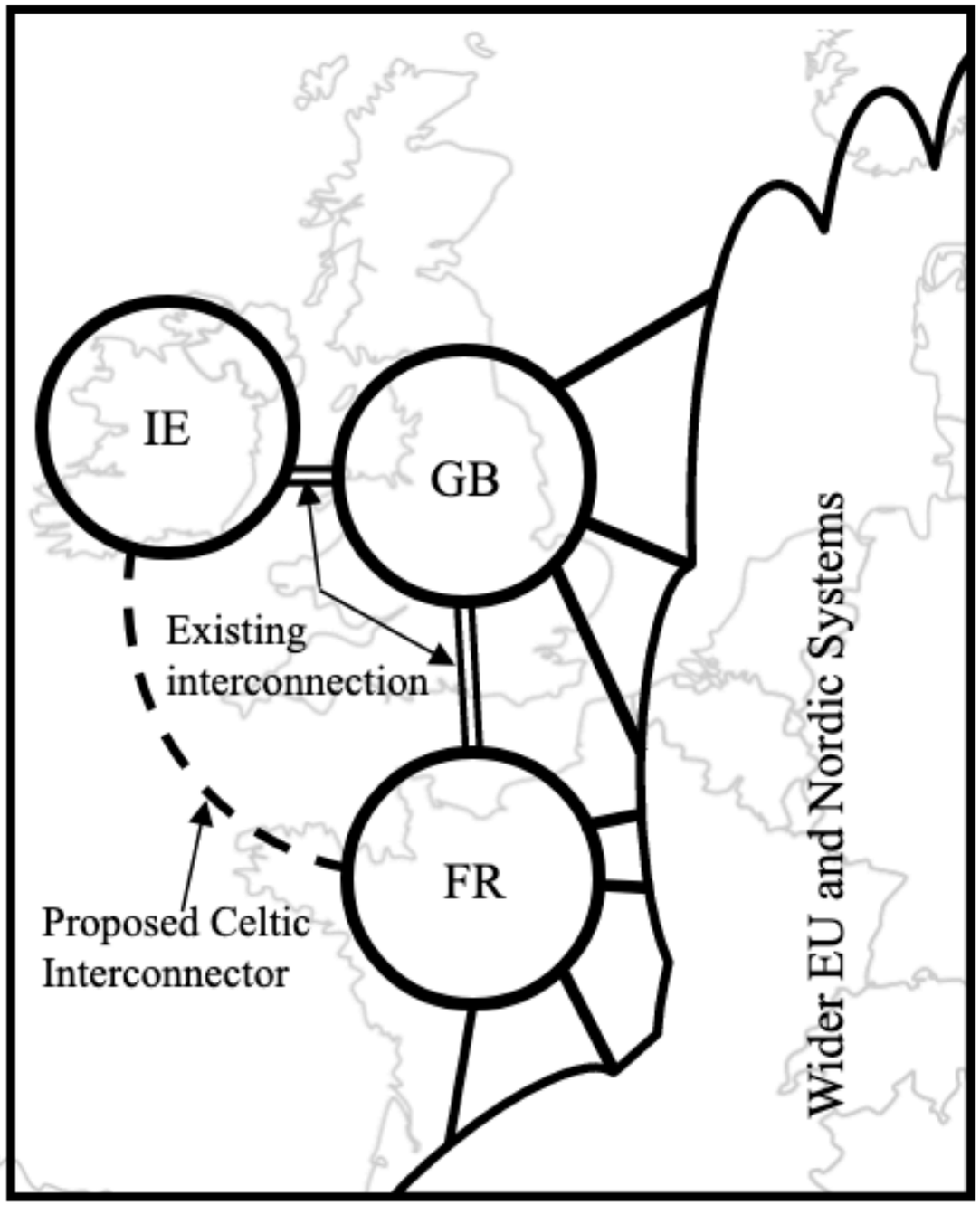
- Capacity Value of Interconnectors for Resource Adequacy Assessment in Multi-Region Systems

- See David Greenwoods talk in the adequacy session!

09:47–09:53 | EGU22-11692 ★ | **ECS**

Climate-resilient planning of renewable energy systems in North-West Europe

Marianne Zeyringer, Hannah Bloomfield, David Brayshaw, and James Price



WHERE TO ACCESS THE DATA

Just the historical data (1950-2020)

Bloomfield, Hannah and Brayshaw, David (2021): ERA5 derived time series of European aggregated surface weather variables, wind power, and solar power capacity factors: hourly data from 1950-2020.
University of Reading. Dataset. https://researchdata.reading.ac.uk/id/eprint/321

The historical data and delta corrected climate model simulations

Bloomfield, Hannah and Brayshaw, David (2021): Calibrated, hourly historical and near-future surface weather variables, wind power and solar power capacity factors. University of Reading. Dataset. https://researchdata.reading.ac.uk/id/eprint/331

Citation: Bulletin of the American Meteorological Society 102, 1; 10.1175/BAMS-D-20-0256.1

SUMMARY

1. The CLEARHEADS project has created a dataset of national and sub-national level weather variables, wind and solar capacity factors which can be used for energy system modelling.
2. These datasets include 70 years of historical climate (1950-2020) and the impact of climate change, using 5 state-of-the-art climate model simulations.
3. The datasets are available via the Reading Research Data Archive. **https://researchdata.reading.ac.uk/**
4. Please feel free to use them and give us feedback :)

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matthew.deakin@newcastle.ac.uk