Characterisation of Extreme weather events and Grid Impacts

DR HANNAH BLOOMFIELD

With thanks to: David Brayshaw, Paula Gonzalez, Matt Deakin, David Greenwood, Noelia Otero, Oscar Martinez-Alvarado Kanzis Mattu

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Increased weather dependence

- This results in increased power system variability which must be understood for reliable system operation.

Temperature Wind Chill Relative Humidity	Wind Speed	Shortwave Irradiance Temperature	Precipitation River Run-off	Precipitation Snowfall Wind Speed Temperature

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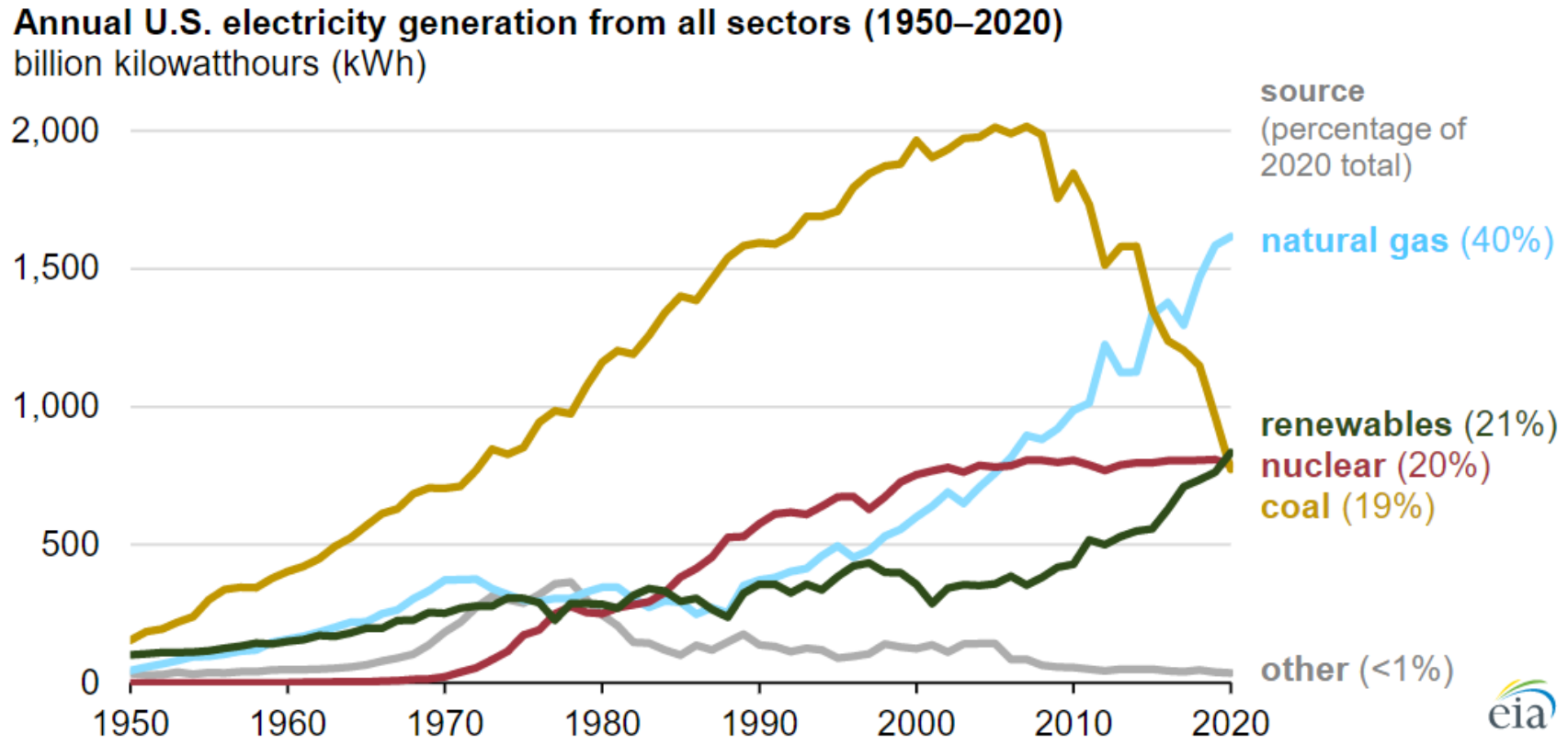
Metered data contains large trends

- Past years metered data are less useful.
- Year to year variations in weather can cause large differences in power system modelling results.



Source: U.S. Energy Information Administration (EIA), *Monthly Energy Review*
Note: This graph shows electricity net generation in all sectors (electric power, industrial, commercial, and residential) and includes both utility-scale and small-scale (customer-sited, less than 1 megawatt) solar.

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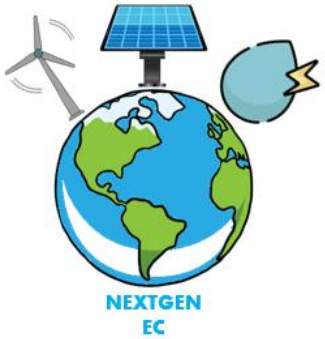
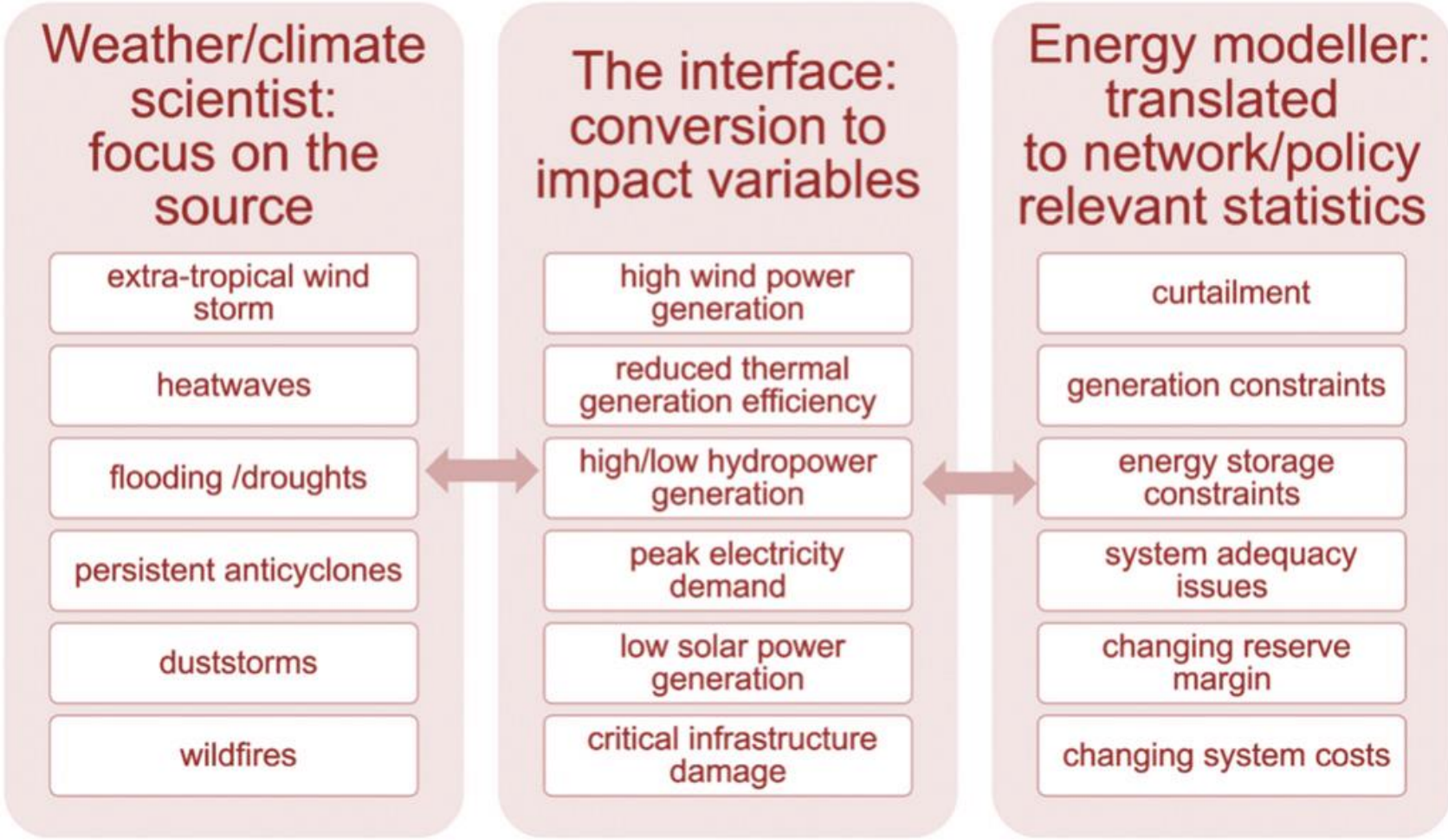
Interdisciplinary problem





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

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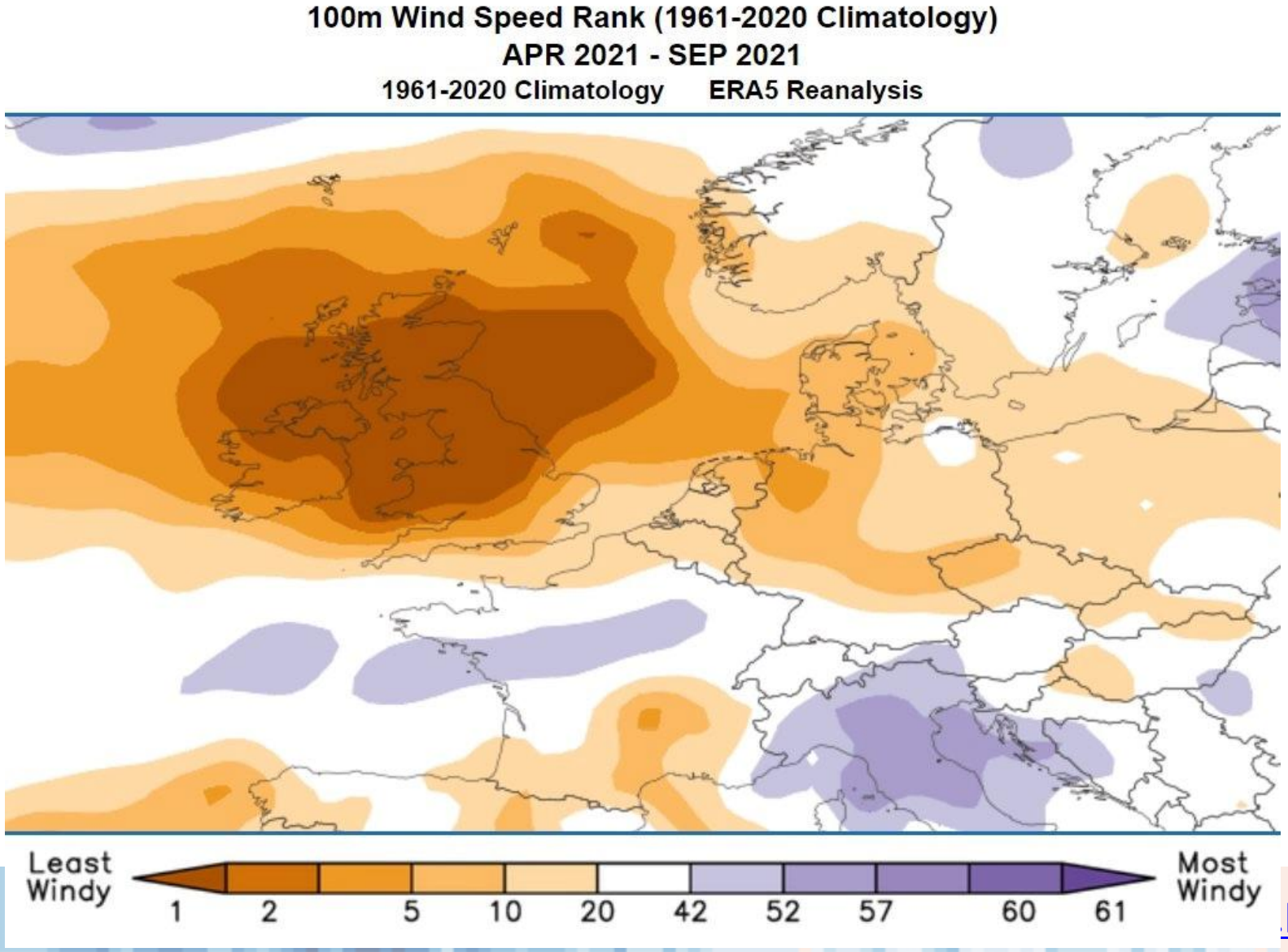
A recent example



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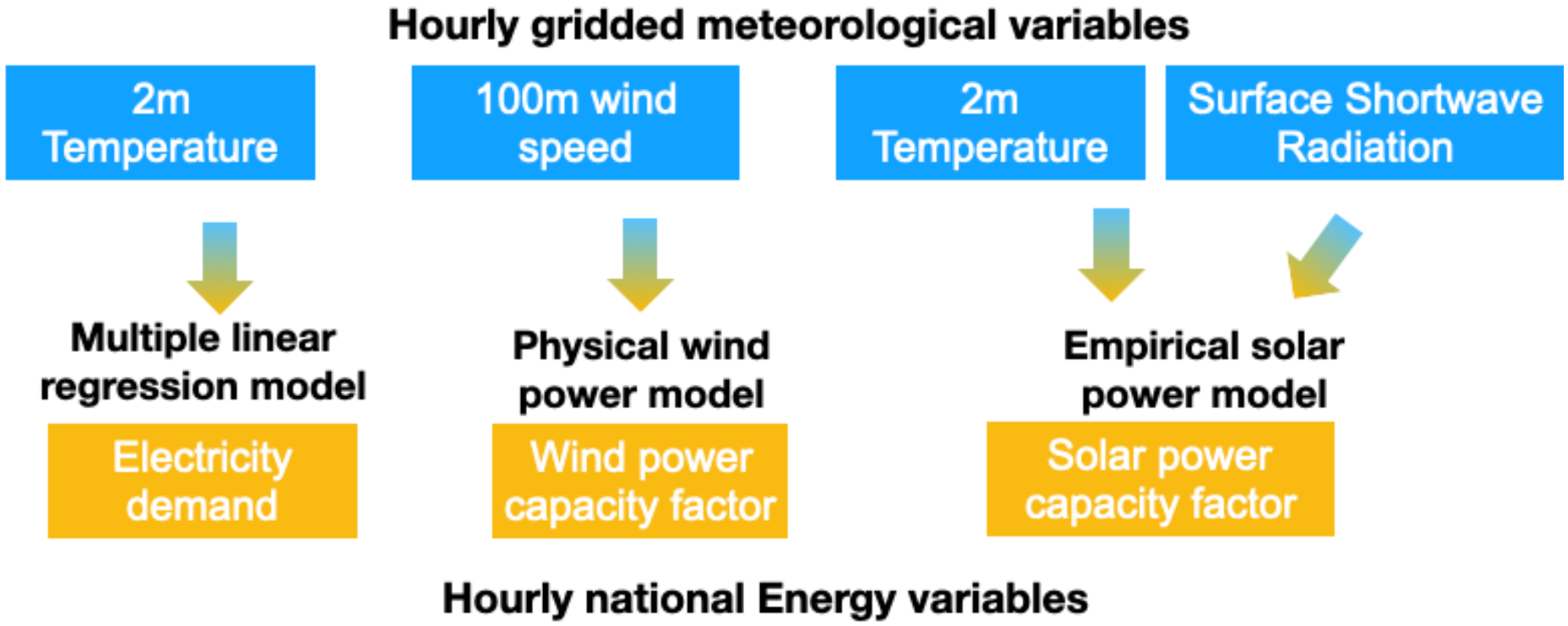
Weather → Energy

- Gridded weather and climate data can be converted into energy variables using statistical or physical models
- Fix the power system setup (e.g. 2021 levels of demand/wind/solar, or 2030 expectations of demand/wind/solar) and pass 40+ years of reanalysis through the demand/wind/solar models



Data available from the Reading Research Data Repository: https://researchdata.reading.ac.uk/

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Historical Assessment: Peak demand

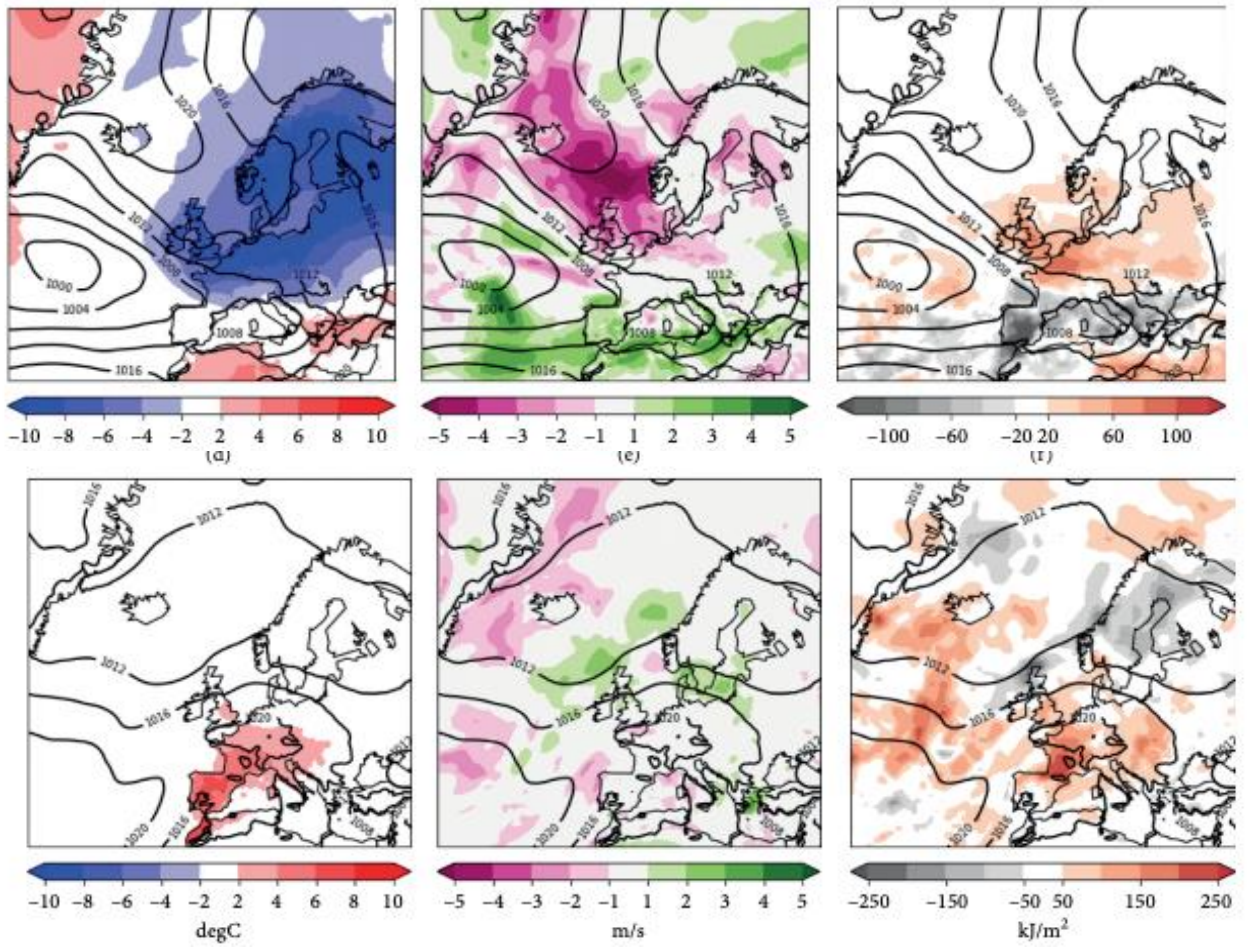
UK: winter cold snap

high pressure system cold temperatures over Europe quite low wind in the North Sea, sunny weather

Spain: Summer heatwave

Warm temperatures through Spain and France, average wind power generation, sunny weather

Composites of top 10 events



surface temperature anomalies

surface wind speed anomalies

surface solar radiation anomalies

Bloomfield et al., (2020) https://doi.org/10.1155/2020/5481010

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The ‘Beast from the East’ 2018

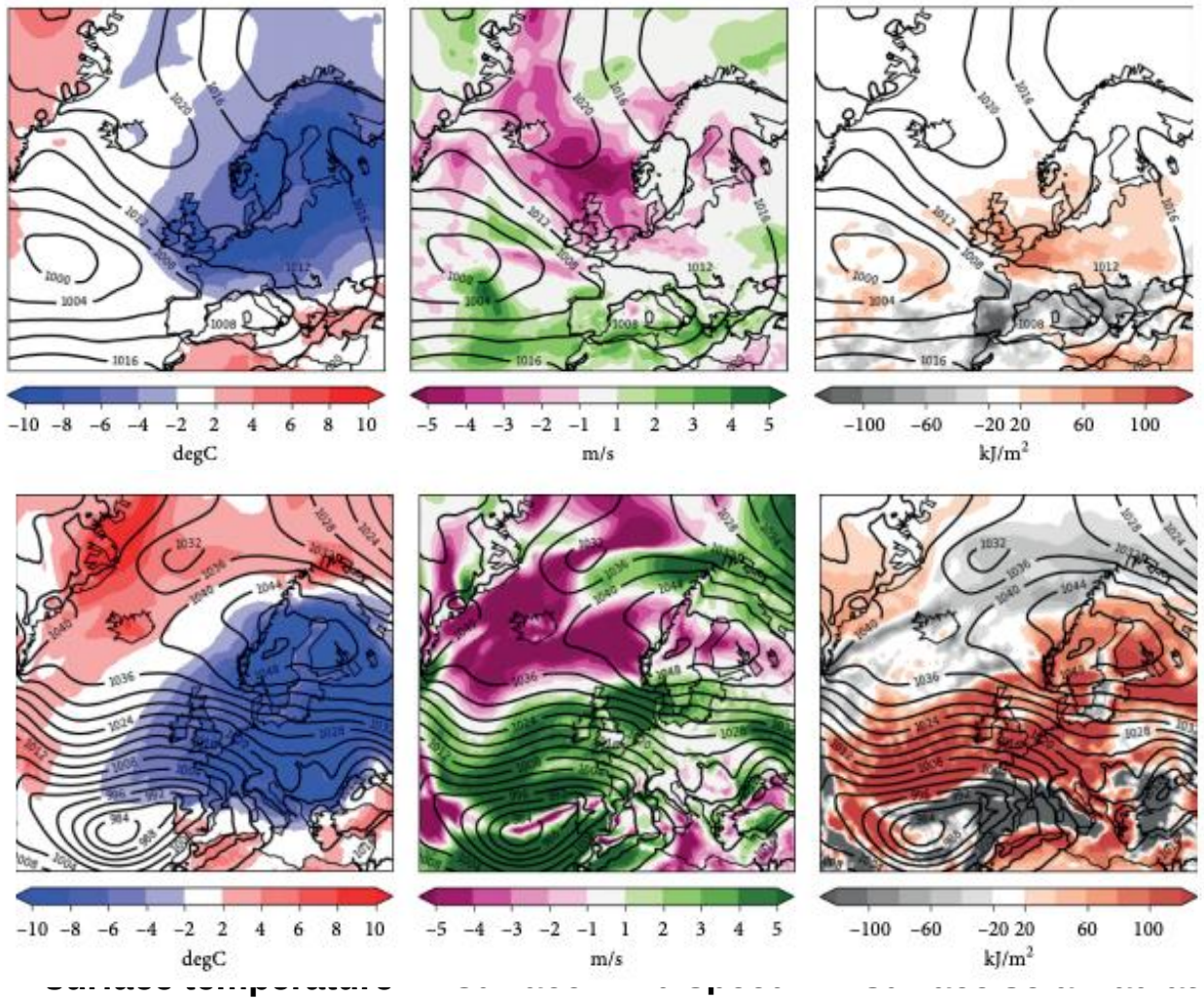
University of BRISTOL

This was hard work, is this as bad as it gets?

UK	
Demand	**DNR**
12 Jan87	**27 Dec 95**
10 Jan82	**20 Dec 10**
28 Dec95	10 Dec 81
20 Dec10	**21 Feb 86**
8 Jan 10	**8 Jan 10**
28 Feb18	23 Nov93
29 Dec85	31 Dec 08
12 Feb85	31 Jan 87
2 Jan 80	**12 Jan 82**
22 Feb86	30 Dec 03

UK

28 Feb 2018



anomalies anomalies anomalies

Bloomfield et al., (2020) https://doi.org/10.1155/2020/5481010

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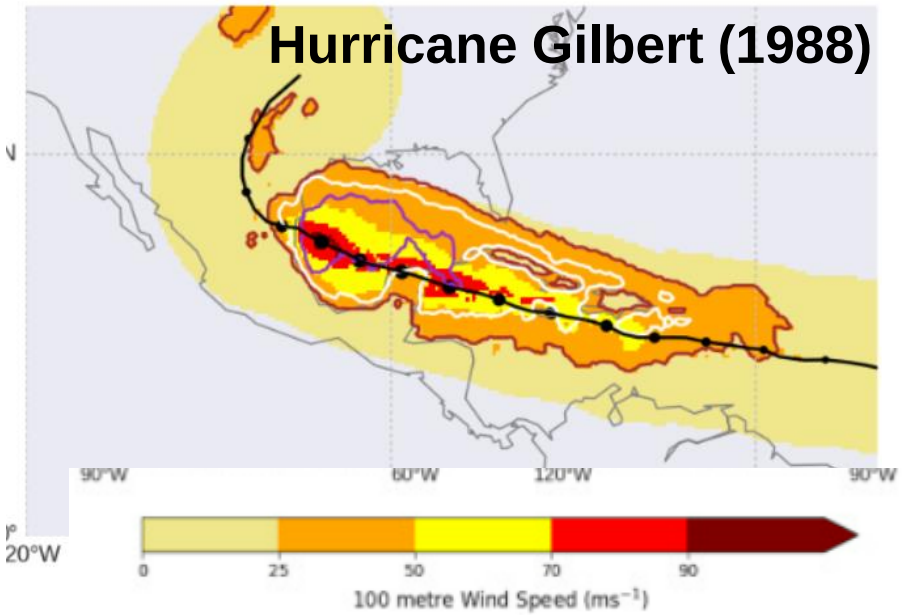
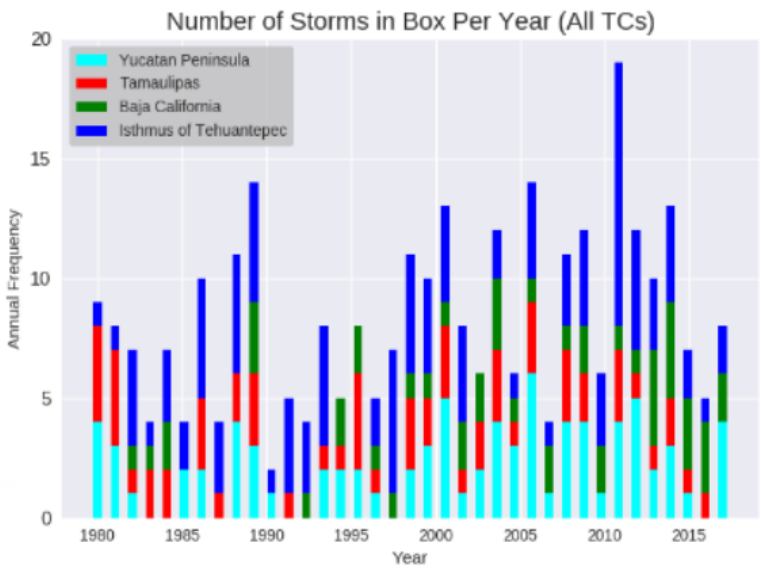
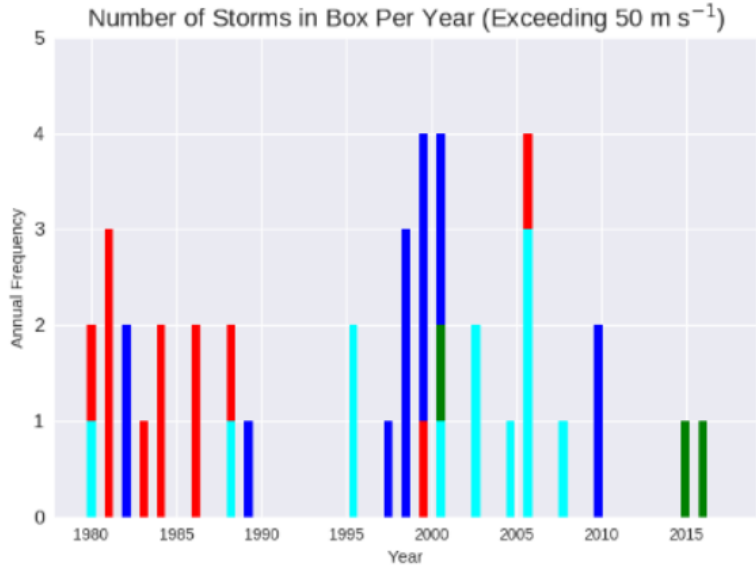
Historical Assessment

- Using reanalysis data to assess the potential damage of historical tropical cyclones on proposed wind farm locations.
- Around 10 storms a year at wind farm locations
- Far less potentially damaging storms, but possible for multiple in one year.







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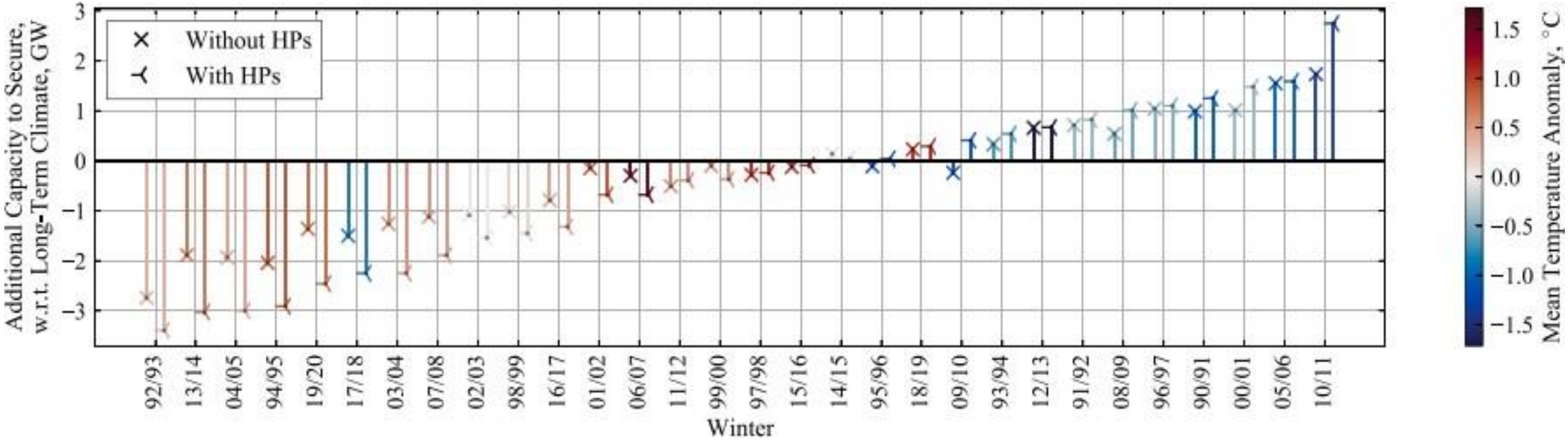
Looking towards the future (energy)

UK is planning substantial heat-pump roll-out. With increases temperature sensitivity of demand

More heat-pumps result in 'peakier' demand, and more additional capacity to secure.



Deakin et al., (2021) https://doi.org/10.1016/j.apenergy.2021.117261

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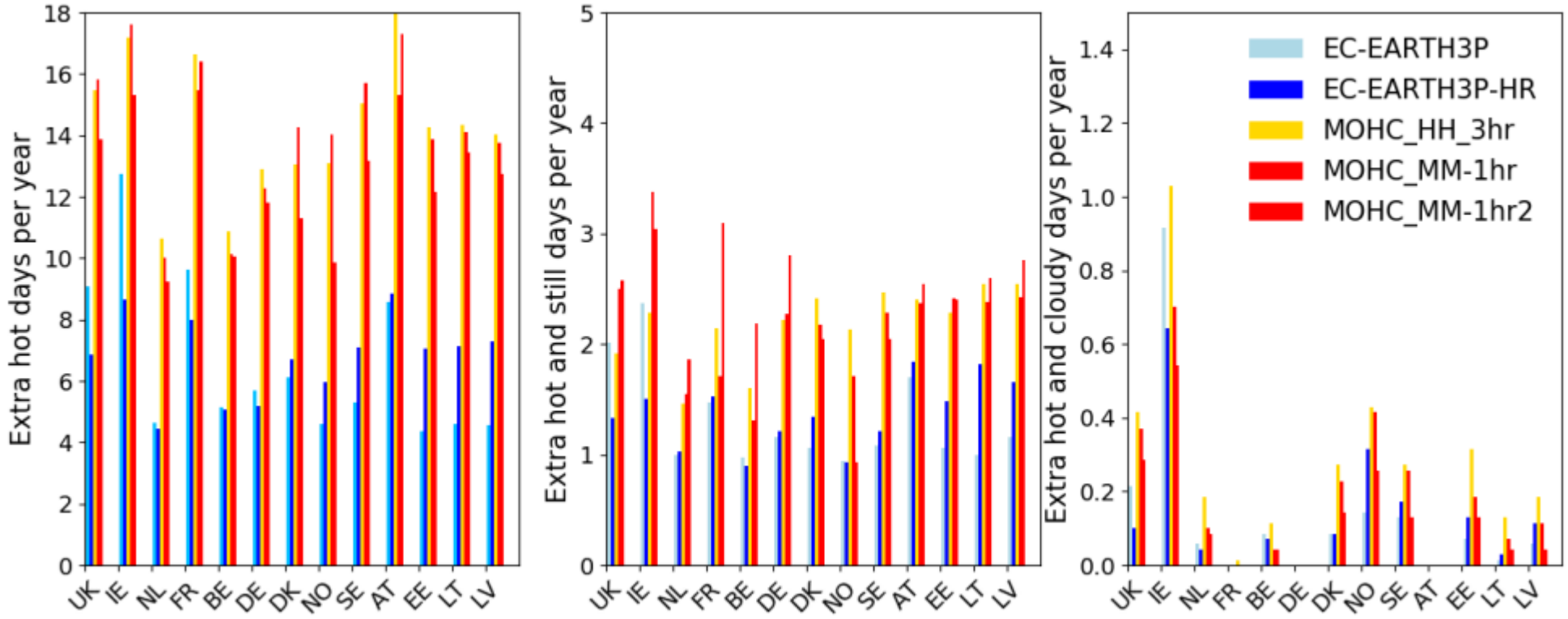
Looking towards the future (climate)

How many more extreme events in the future?



Bloomfield et al., (in review) https://doi.org/10.5194/essd-2021-436

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Predictability is increasing

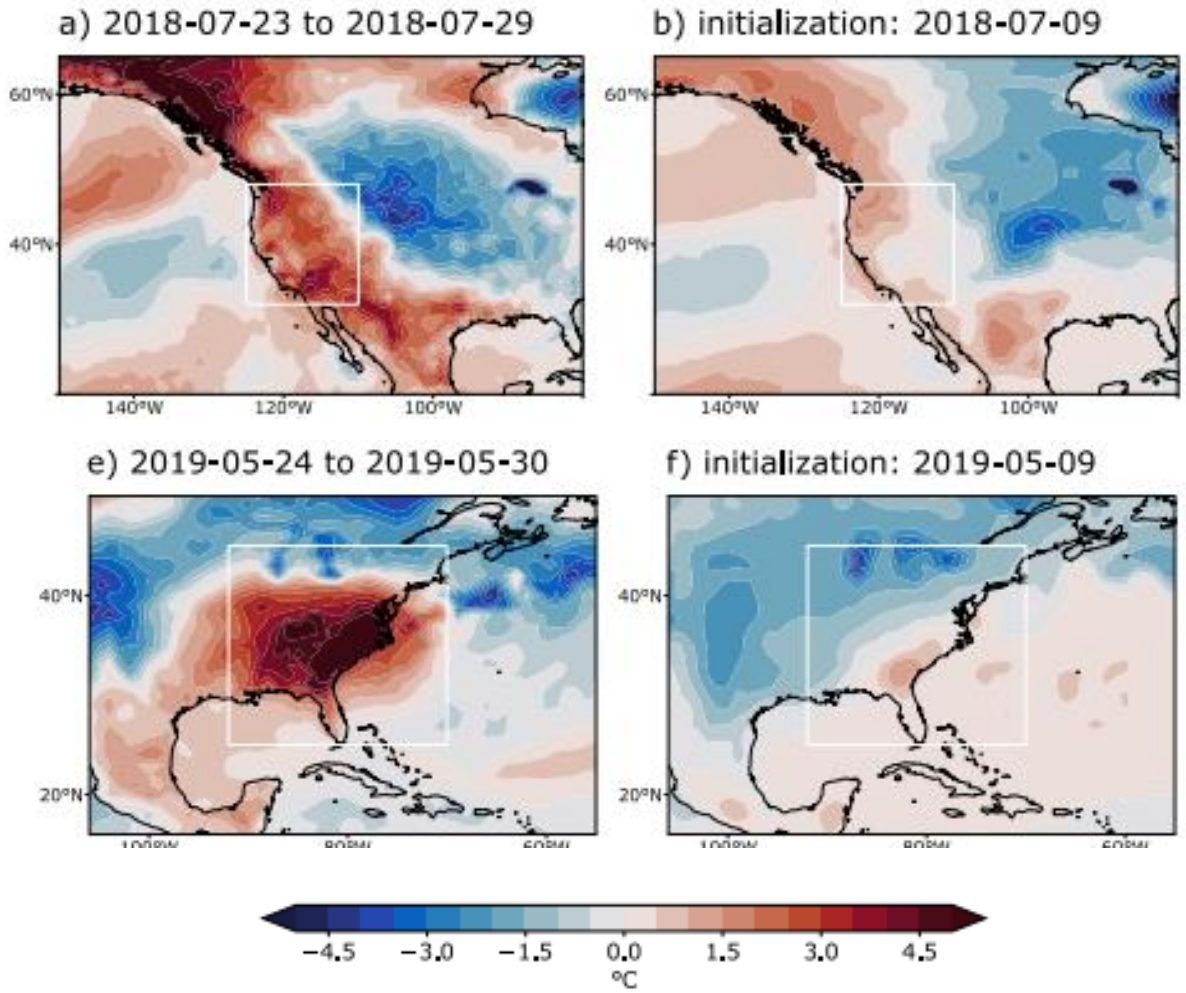
How far ahead can we see these extreme events coming?

Case studies

Heatwaves ~ 3 weeks

Coldwaves ~ 2weeks

heavy precip ~1 week



Domeisen et al., (2022) DOI 10.1175/BAMS-D-20-0221.1.

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Summary

1. With increasing amounts of renewable generation power systems become increasingly impacted by long-term climate variability.
2. Multi-decadal climate datasets can be used to understand the meteorological drivers of power system stress in present and near-future systems, and to contextualize recent stress events.
3. Climate model projections can be used to understand changing frequency of current extreme events.
4. Predicting these extreme events is challenging, but skill is increasing.
5. There is lots more work to do in this area! Collaboration with energy/power system modelers is particularly important for us to tailor our analysis/datasets.

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Thanks for listening! Please get in touch Hannah.bloomfield@bristol.ac.uk