



University of
Reading



University of
BRISTOL

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

Hannah.bloomfield@bristol.ac.uk

Increased weather dependence

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



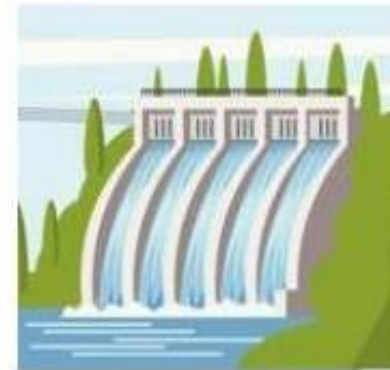
Temperature
Wind Chill
Relative
Humidity



Wind
Speed



Shortwave
Irradiance
Temperature



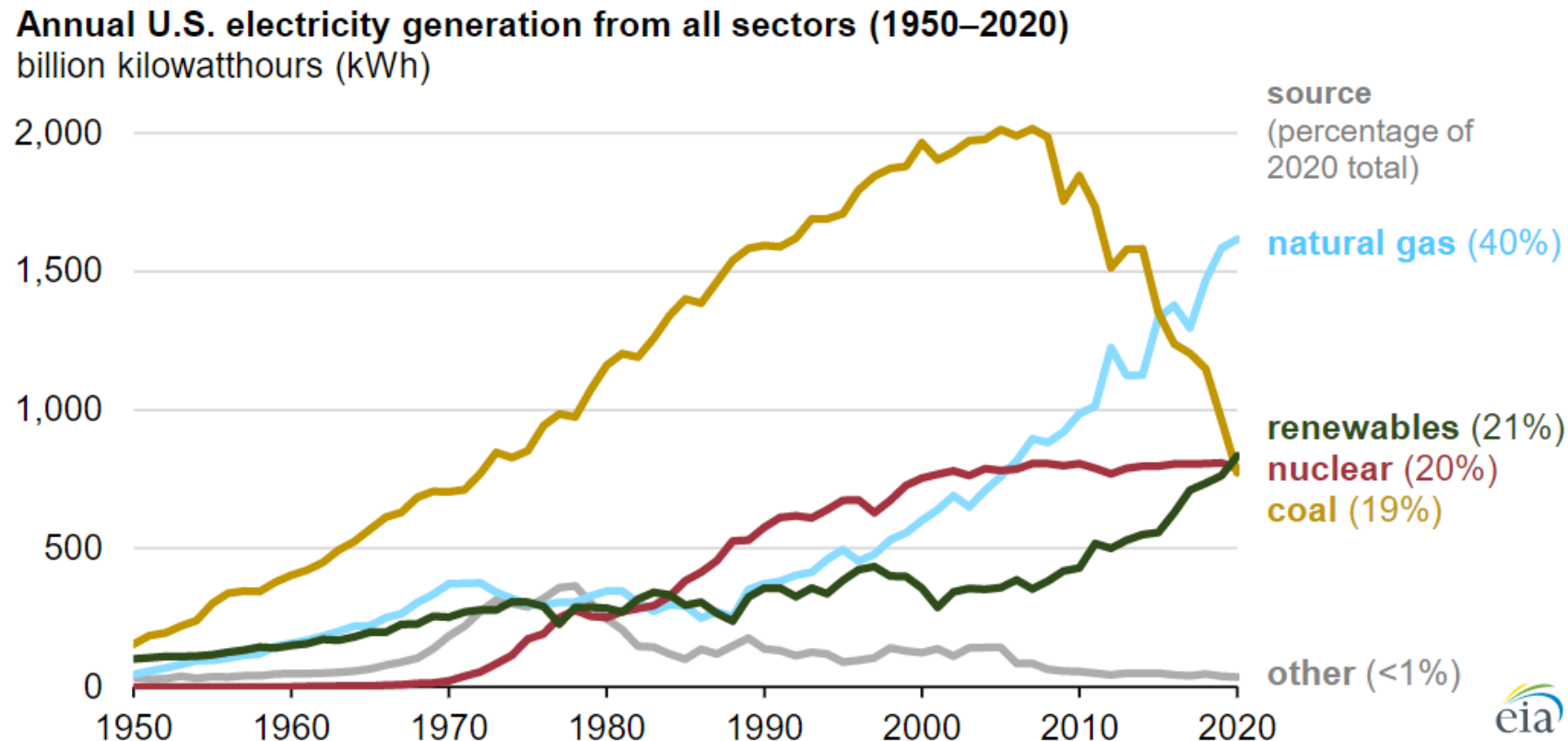
Precipitation
River Run-off



Precipitation
Snowfall
Wind Speed
Temperature

Metered data contains large trends

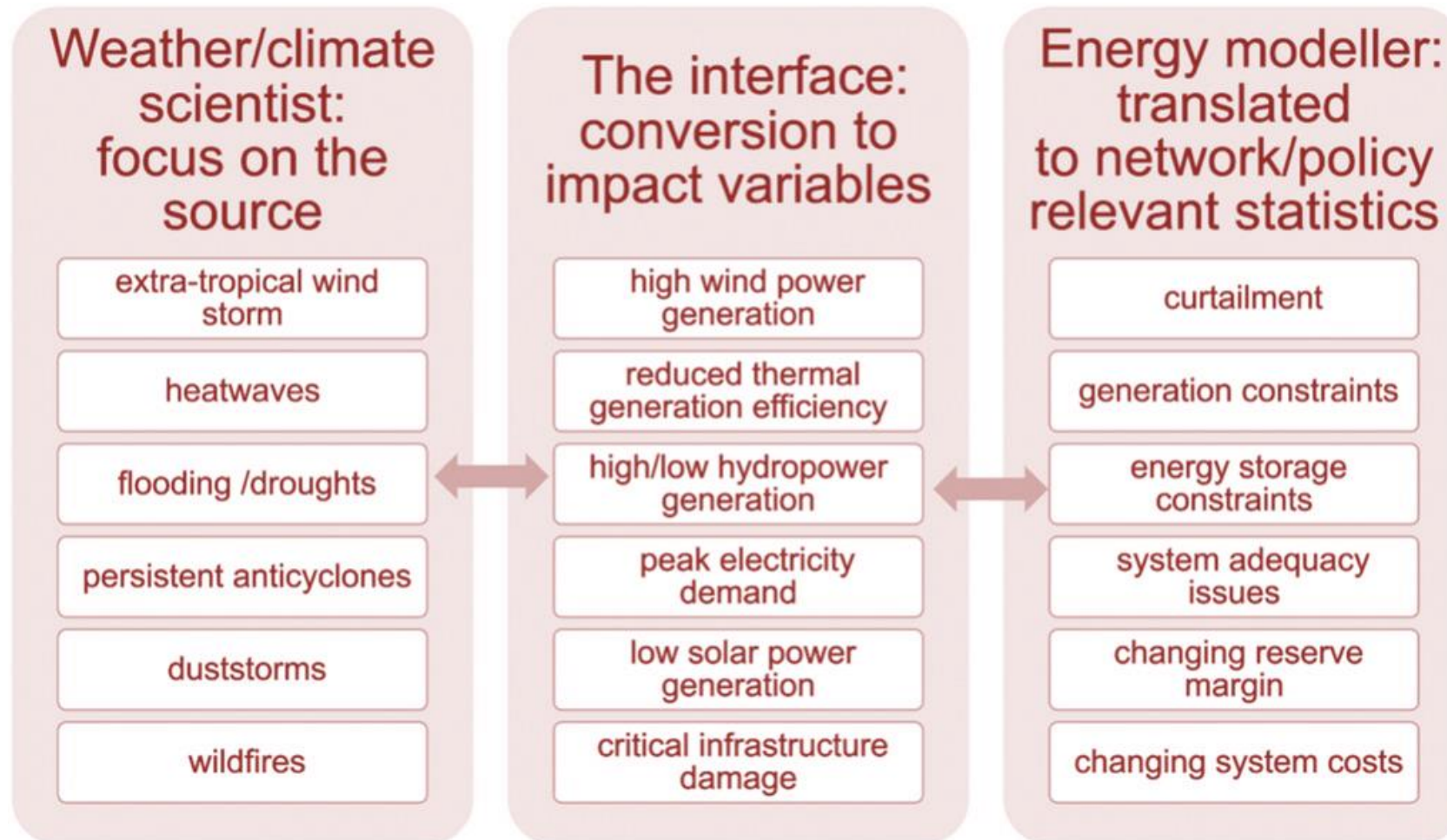
- Past years metered data are less useful.
- Year to year variations in weather can cause large differences in power system modelling results.



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.

Interdisciplinary problem

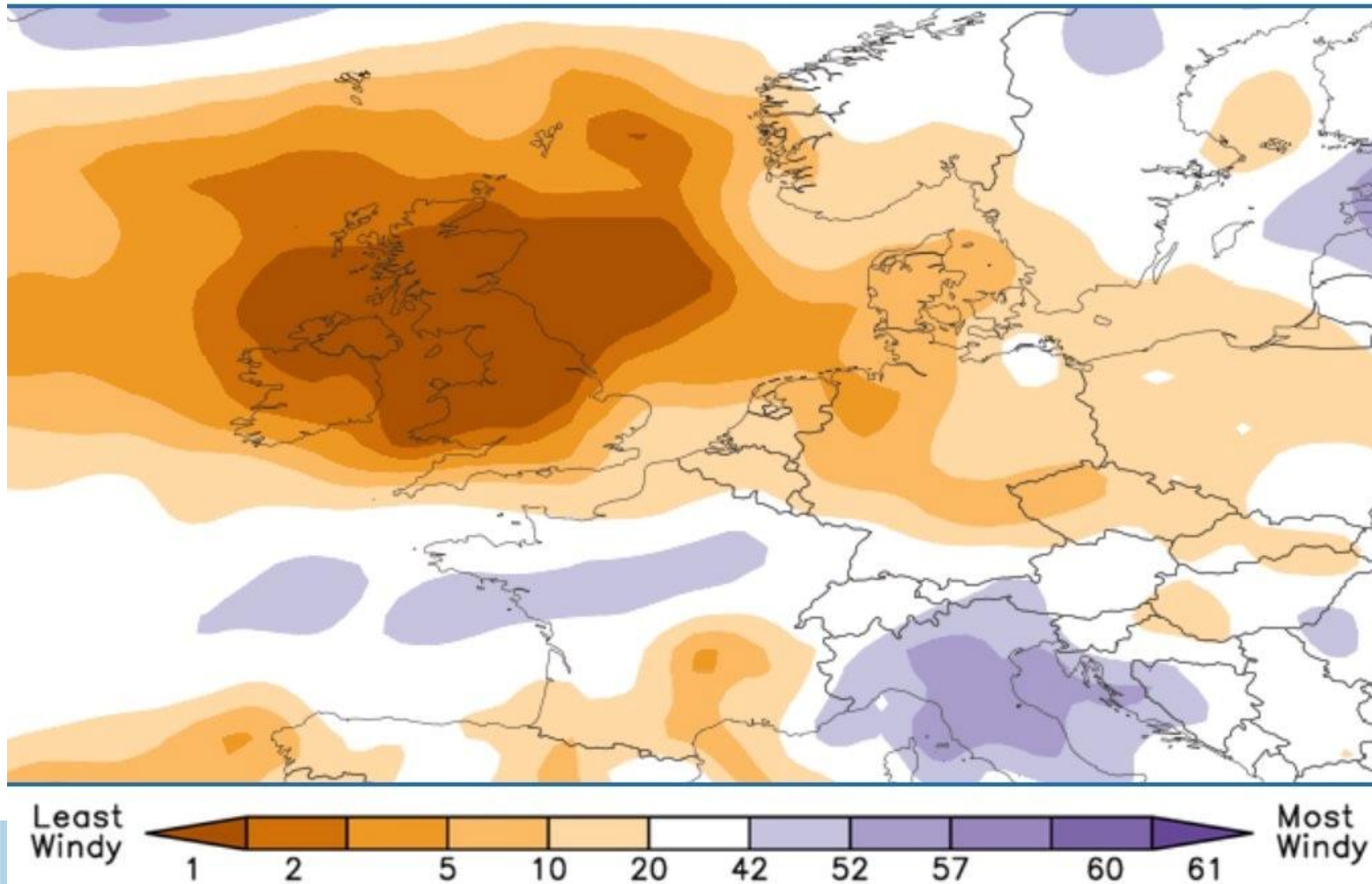


A recent example

100m Wind Speed Rank (1961-2020 Climatology)

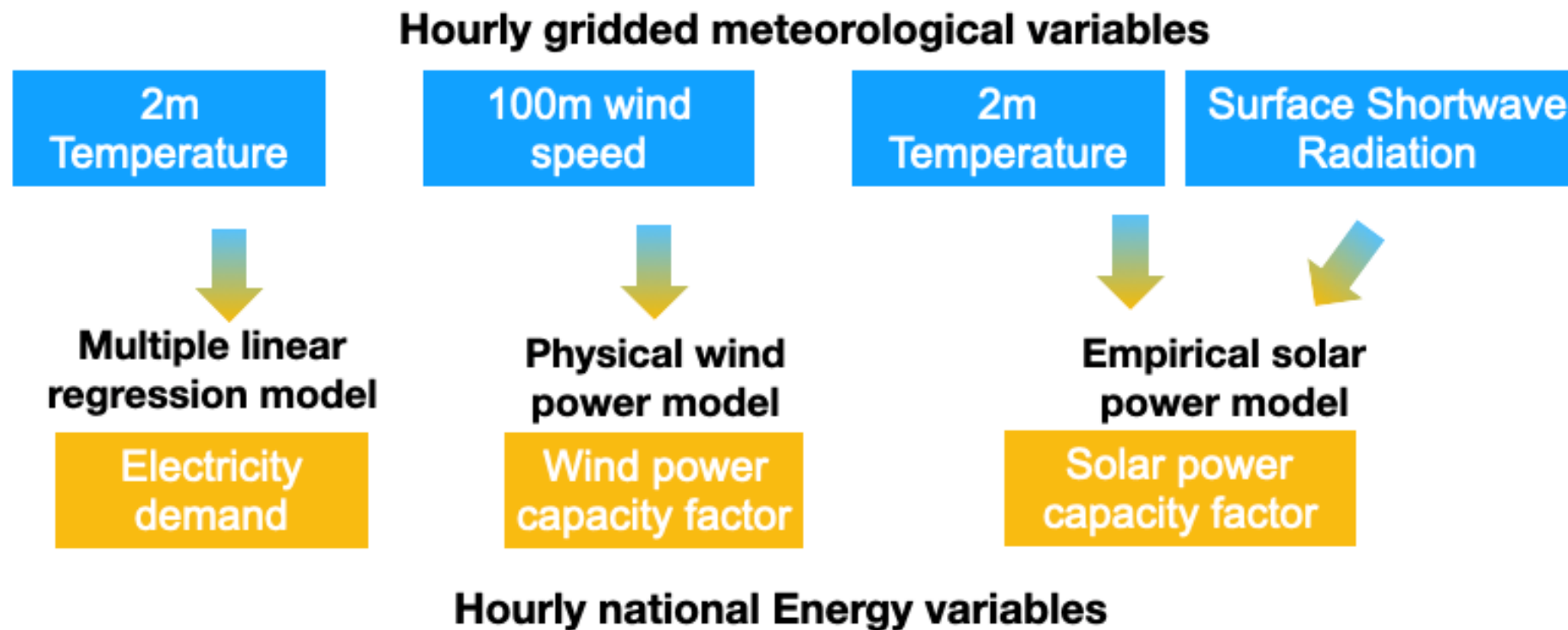
APR 2021 - SEP 2021

1961-2020 Climatology ERA5 Reanalysis



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/>

Historical Assessment: Peak demand

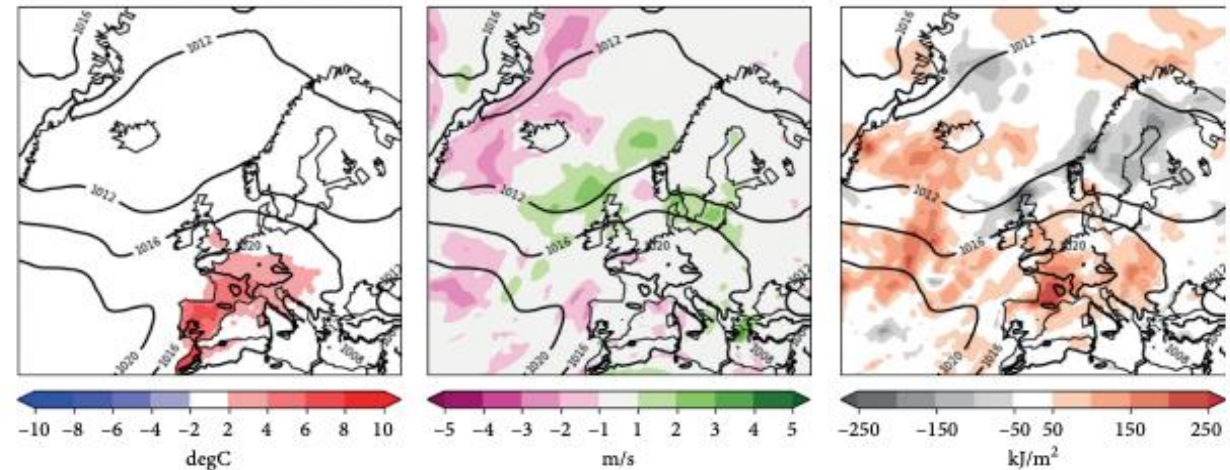
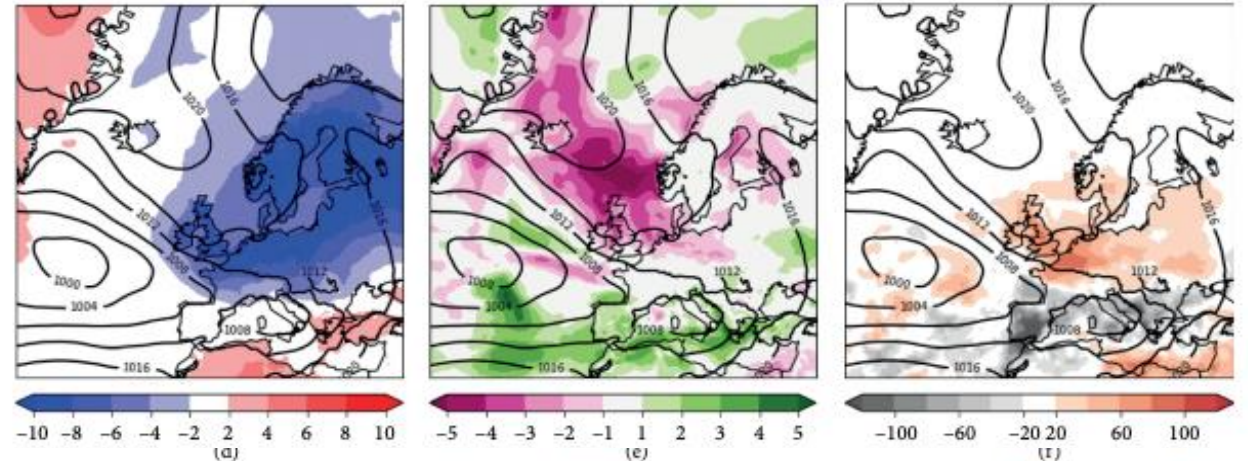
Composites of top 10 events

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



surface temperature
anomalies

surface wind speed
anomalies

surface solar radiation
anomalies

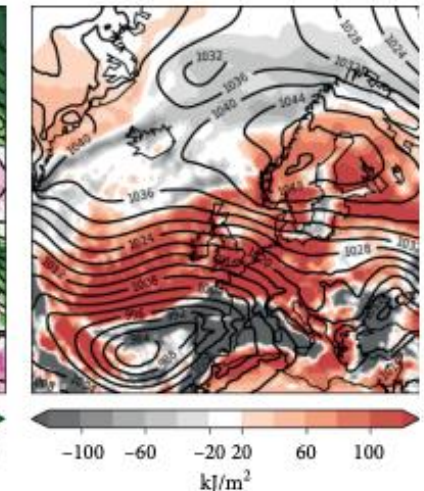
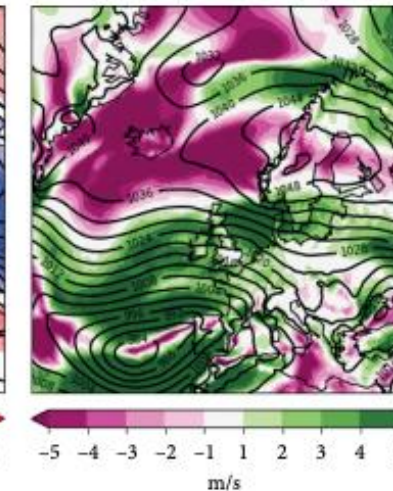
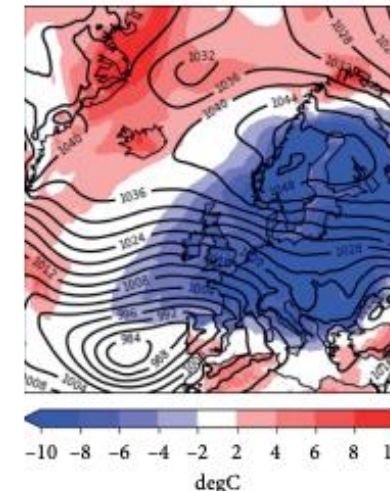
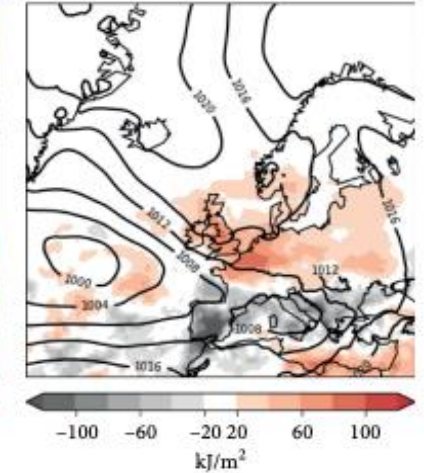
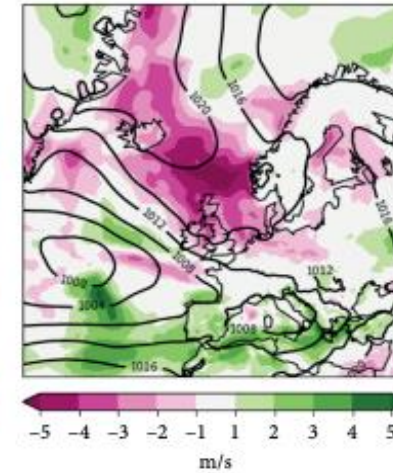
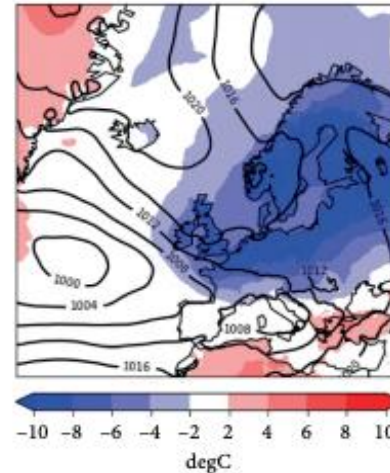
The 'Beast from the East' 2018

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



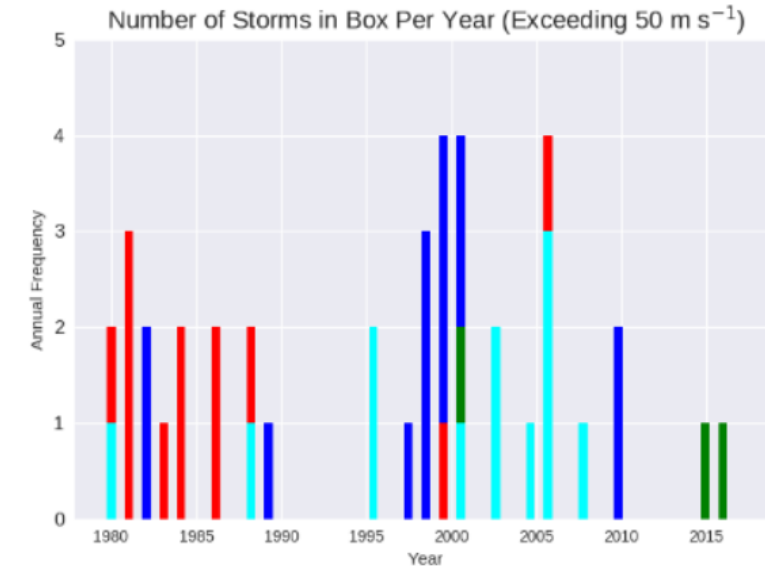
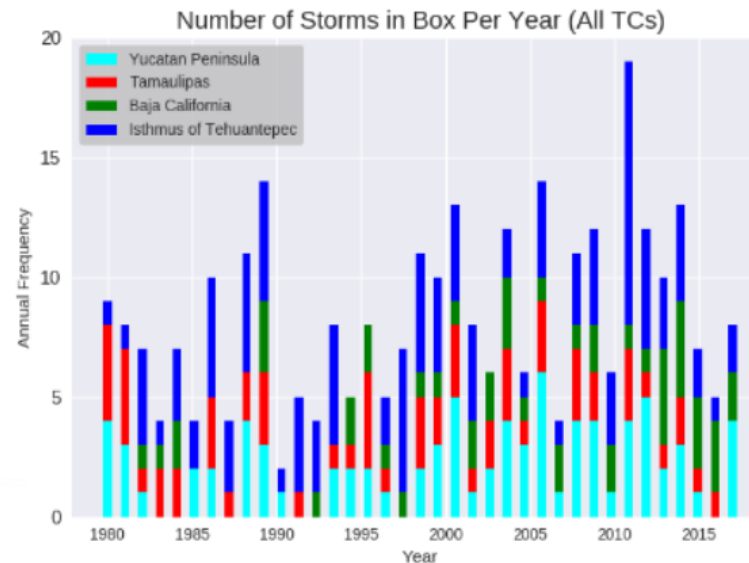
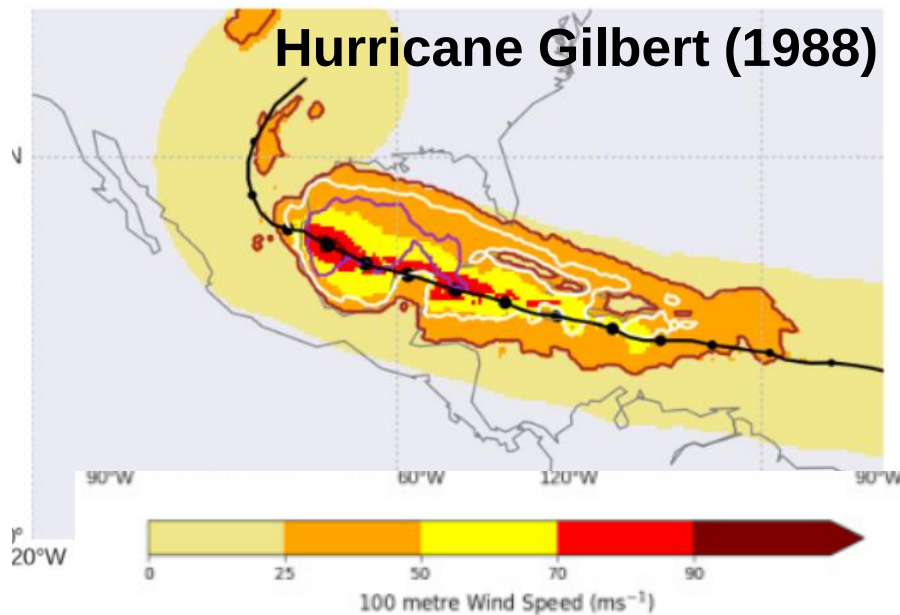
anomalies

anomalies

anomalies

Historical Assessment

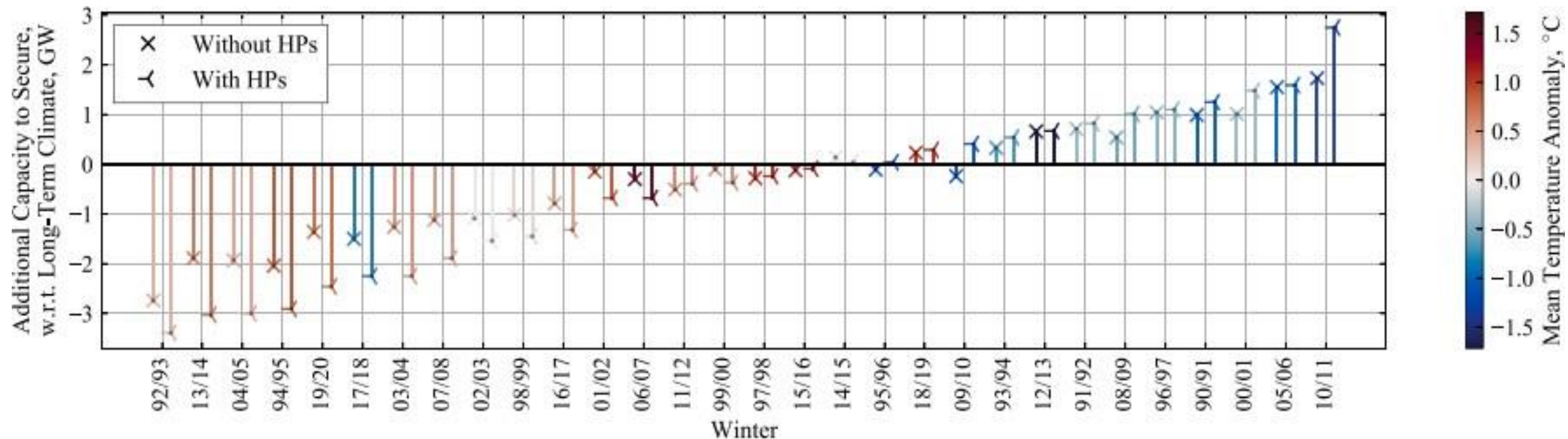
- Using reanalysis data to assess the potential damage of historical tropical cyclones on proposed wind farm locations.
- Around 10 storms a year at wind farm locations
- Far less potentially damaging storms, but possible for multiple in one year.



Looking towards the future (energy)

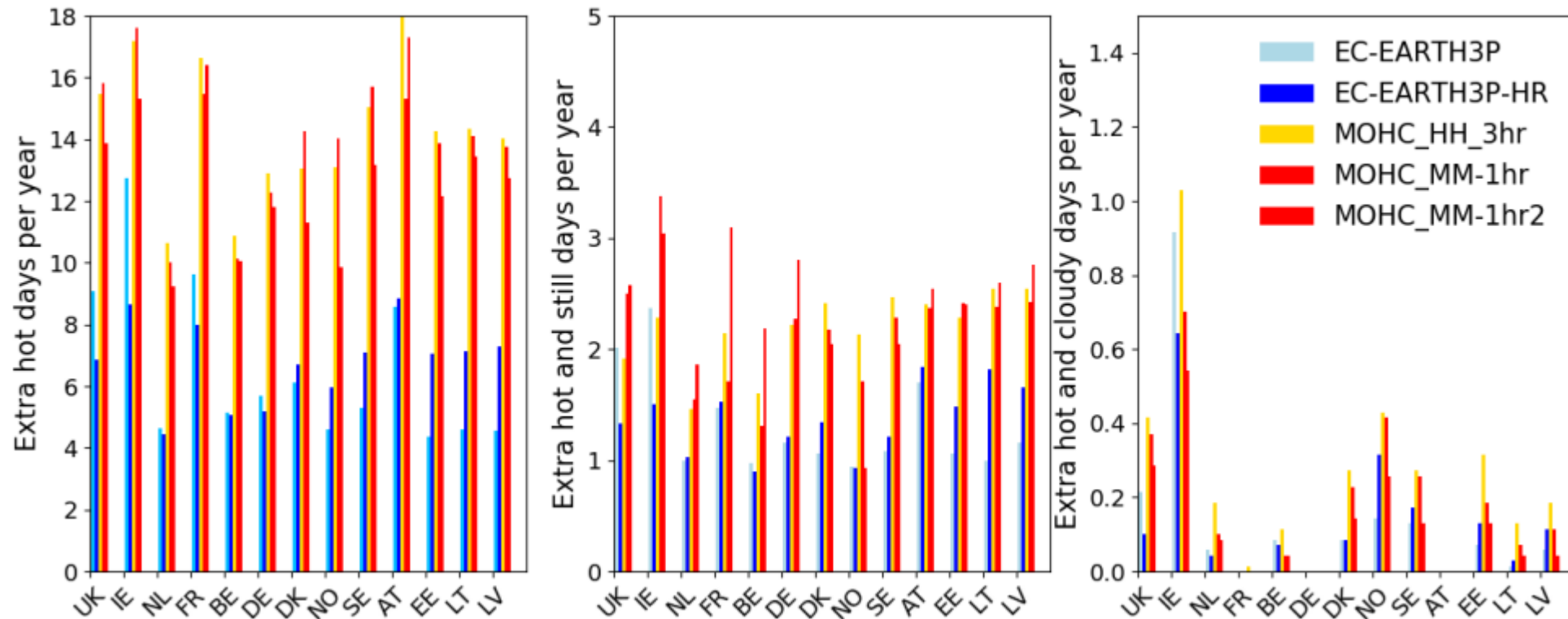
UK is planning substantial heat-pump roll-out. With increases temperature sensitivity of demand

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



Looking towards the future (climate)

How many
more
extreme
events in the
future?

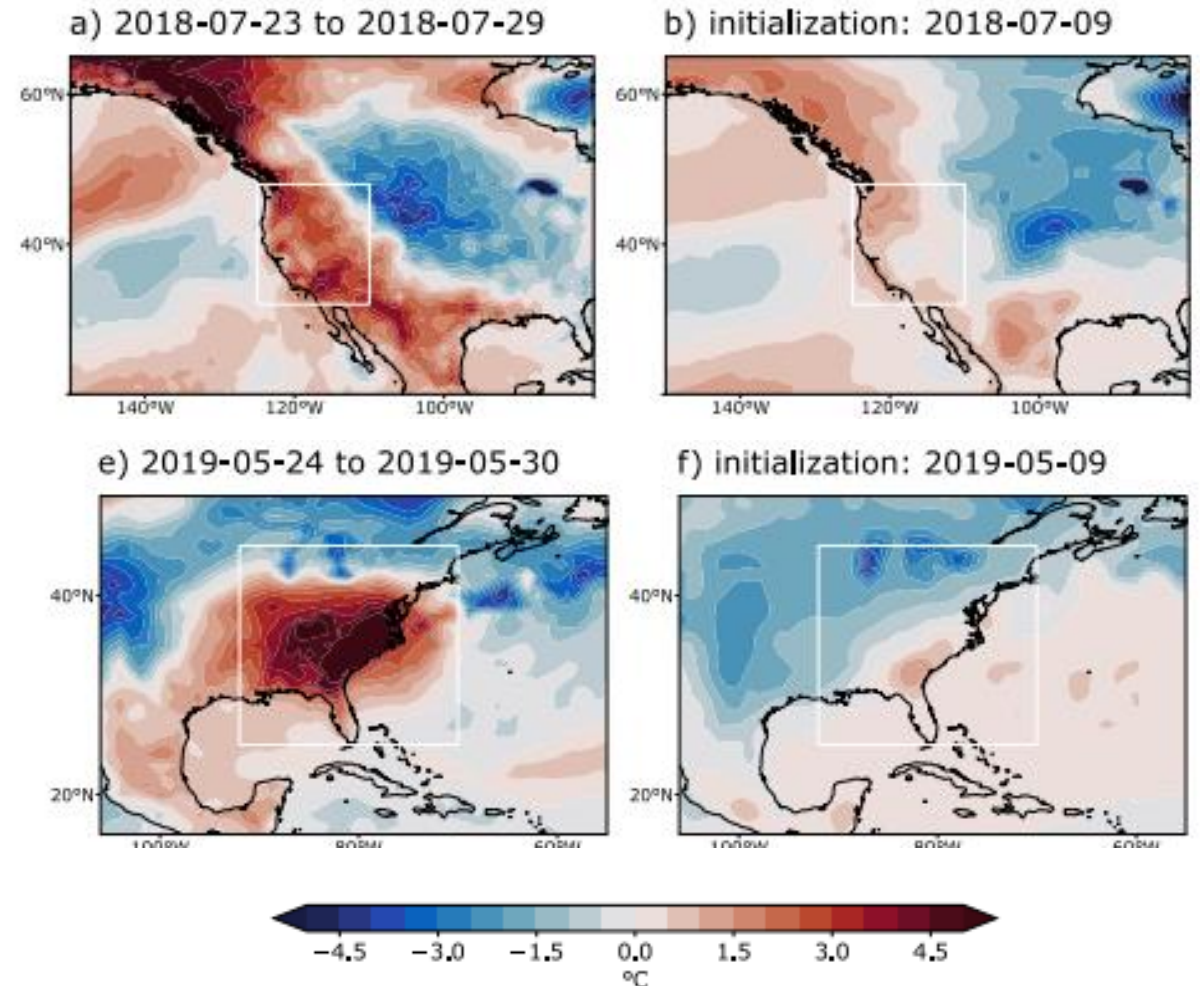


Predictability is increasing

How far ahead
can we see these
extreme events
coming?

Case studies

Heatwaves ~ 3 weeks
Coldwaves ~ 2 weeks
heavy precip ~ 1 week



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.

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.

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