Next Generation Challenges in Energy-Climate Modelling

Online workshop 22nd-23rd June 2020

Supported by the H2020 PRIMAVERA project
*A 5-year €15M programme across 14 leading climate research institutions to develop a new generation of **advanced high-resolution global climate models***
www.primavera-h2020.eu

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Programme

Day 1 (22nd of June):

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H. Bloomfield, M. Zeyringer, J. Browell

Perspective talks:
- Jan Wohland (ETHZ, Switzerland)
- Matteo de Felice (JRC, EU)
- Keith Bell (Strathclyde, UK)

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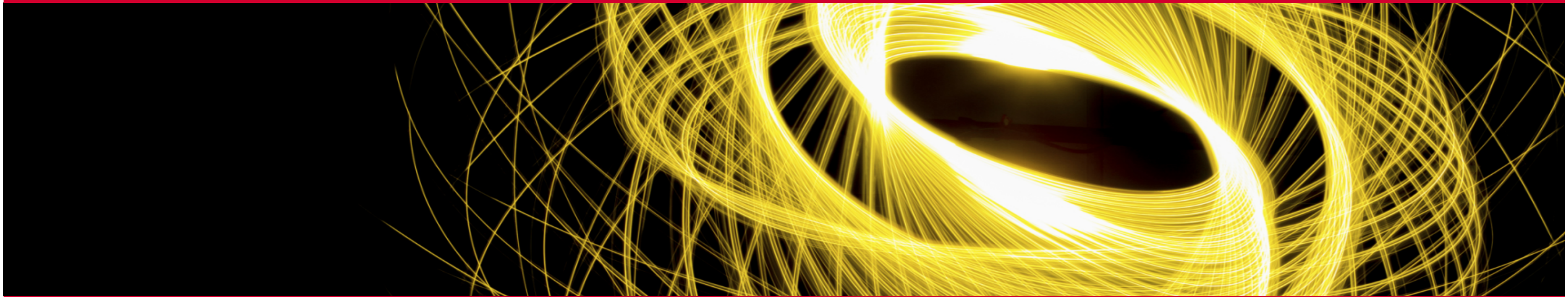
Department of Meteorology
School of Mathematical, Physical and Computational Sciences

NEXT GENERATION CHALLENGES IN ENERGY-CLIMATE MODELLING



David Brayshaw
Associate Professor in Climate Science and Energy Meteorology

Welcome

- Thank you to everyone for coming!
  - Exceptional interest in the workshop
  - Anticipating up to 100 participants from around the globe (original target 30-40)
  - Selected competitively for breadth of experience and background

- Special thanks:
  - PRIMAVERA
  - Hannah Bloomfield and Laurens Stoop (master-of-ceremonies with Zoom and google!)
  - Organising committee; session convenors; invited guest speakers

- Technology/format is experimental – we'd welcome feedback!

- This introduction:
  - Motivation and goals of the workshop
  - Programme
  - Rules of engagement

Motivation

(a very partial and personal perspective!)

- Energy sector has long been exposed to weather (extremes, demand) but:
  - Rapidly changing climate ➔ decarbonization (e.g., renewables)
  - Decarbonization ➔ increasing and changing the exposure of energy system to climate

- Historically weak connections between energy- and climate- research. Timely to build bridges in order to:
  - anticipate effects of future climate on energy (e.g., changes in wind, solar, temperature patterns/extremes)
  - ensure future energy system "solutions" (e.g., design, practice, policy) are robust to *climate uncertainty*

Energy-climate science in 2000's — 2010's — 2020's and beyond

Humber Bridge, near Hull in Yorkshire (UK). Formerly the longest single-span suspension bridge in the world, started construction 1973, opened 1981.

Images www.ioshmagazine.com/humber-bridge-open-all-hours; driventowrite.com/2019/10/06/bridge-across-the-humber/#jp-carousel-55246; historicengland.org.uk/listing/the-list/list-entry/1447321

Why future climate matters to energy

- Two main types:

1. **The ability of physical energy system and infrastructure to cope with climate change or variation**

Often associated with ”stress events” such as:

- Damaging weather extremes
- Compound impacts (e.g., low wind / high demand)

Climate change	Example impacts	Consequences
Temperature rise	Demand patterns for cooling / heating	Plant efficiency, permafrost melt
Sea level rise	Increasing sea levels, storm surges	Coastal plant; wave and tidal generators
Heat waves	More persistent, more extreme	Infrastructure tolerance, cooling demand
Storm frequency and intensity	Possible increases	Infrastructure damage
Precipitation / evaporation	Likelihood of floods and droughts	Hydropower, biofuels/crops
Wind and solar	Changes in resource	RE production

Table derived from Ebinger (2011).
Figure: pxhere.com/en/photo/1408472

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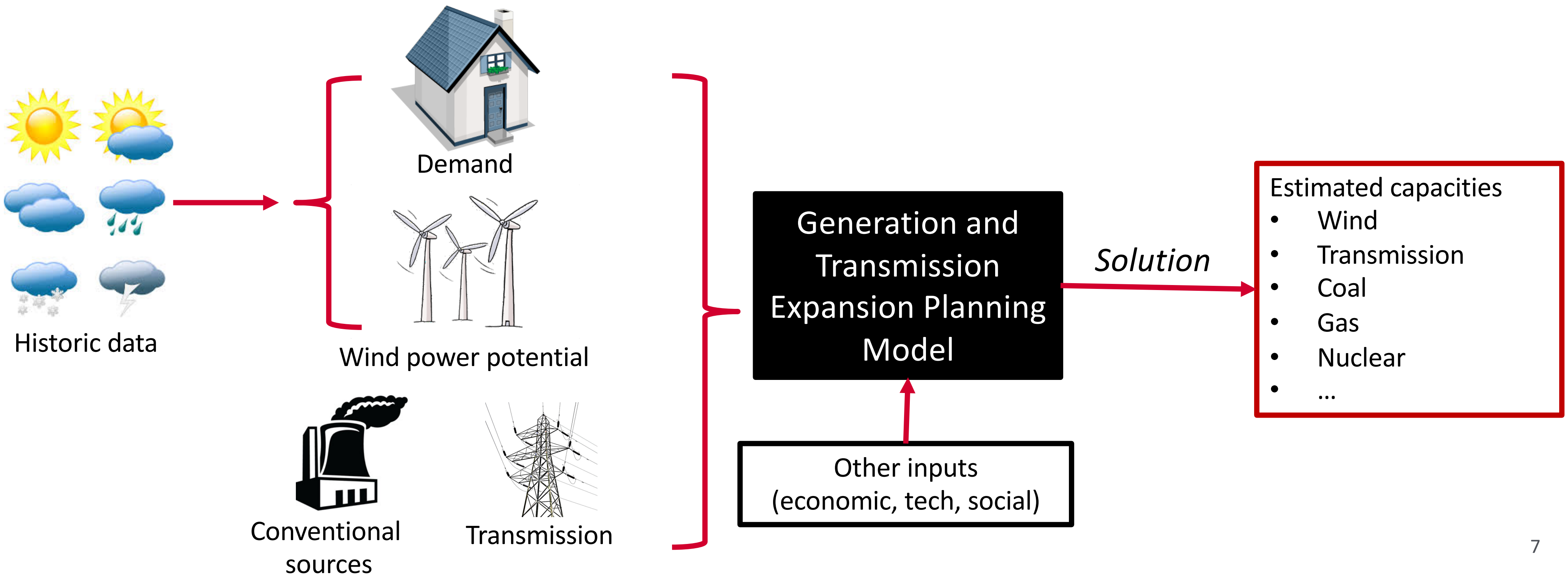
2. **The robustness of simulated “energy system solutions” to future climate uncertainties**

Relates to the modelling used to inform the operation or design of energy systems, e.g., consider simple GEP problem



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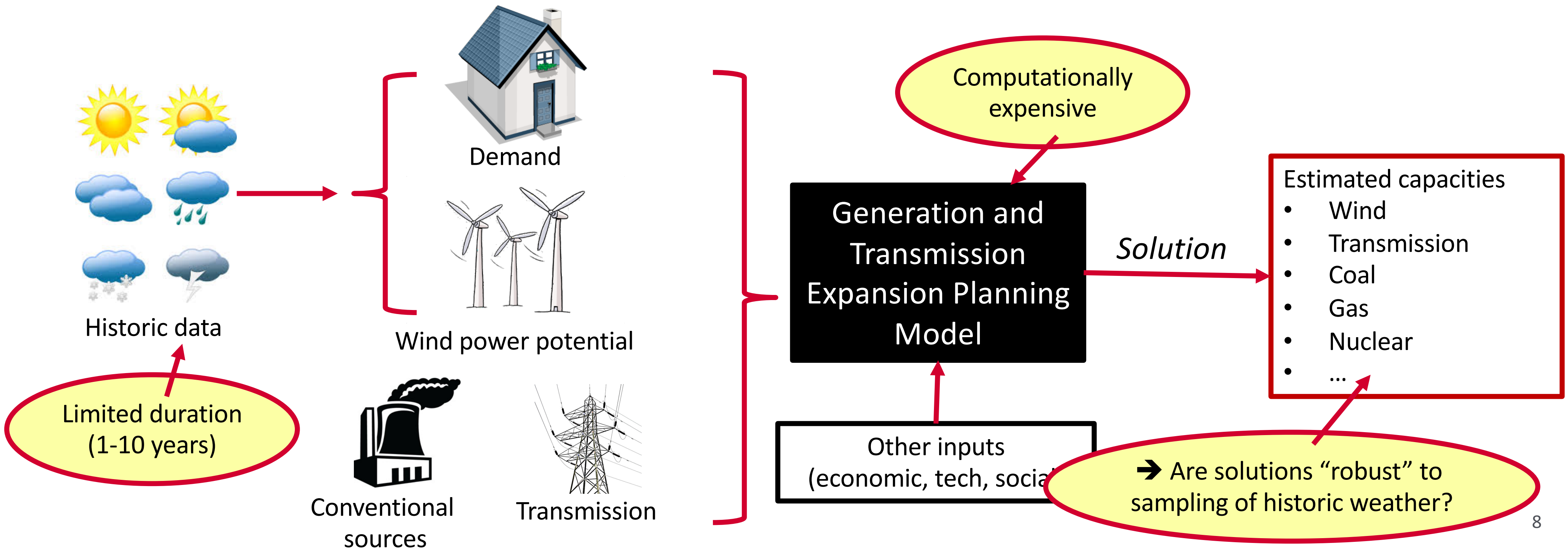

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- Are solutions "robust" to (poor) sampling of historic weather? ➔ **likely not!**

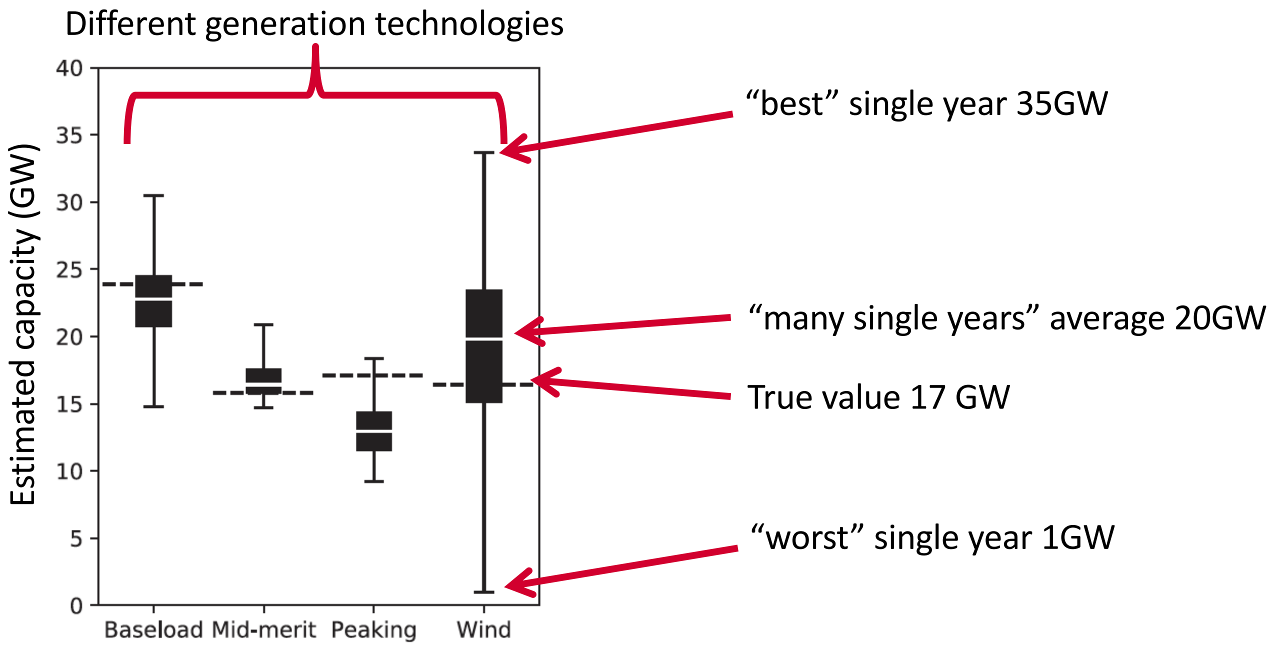

Figure: Hilbers et al (2019), builds on Bloomfield et al (2016, 2018).

See also, e.g., Zeyringer et al 2018; Collins et al 2018.

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- Are solutions "robust" to (poor) sampling of historic weather? ➔ **likely not!**
- Are solutions robust to **future climate uncertainty**? ➔ **only just beginning to be unexplored!**
  - Climate scenario uncertainty … how will GHG concentrations change?
  - Climate response uncertainty … how climate will respond to GHG increases?
  - Climate sampling uncertainty … how might climate differ from the short periods we observe or simulate?

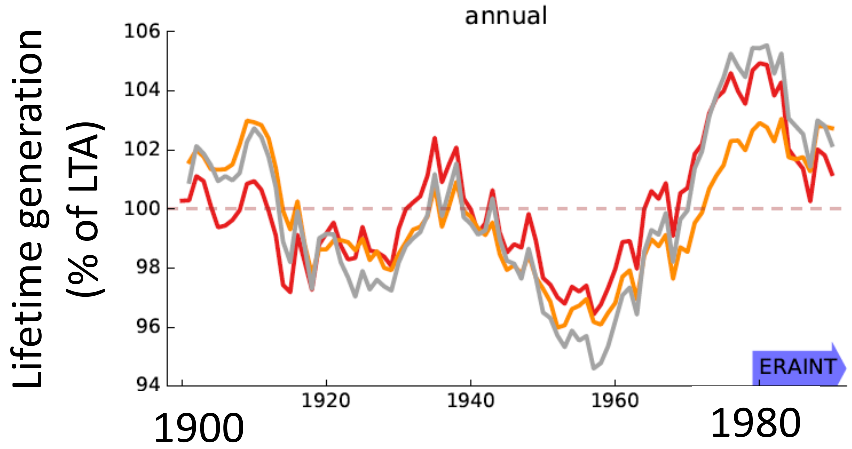
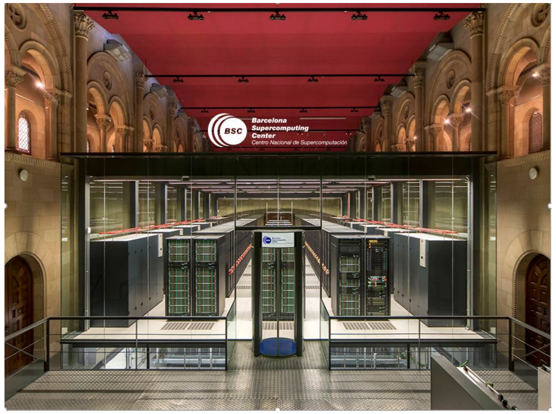


Figure: Wohland et al 2019

Climate data capabilities

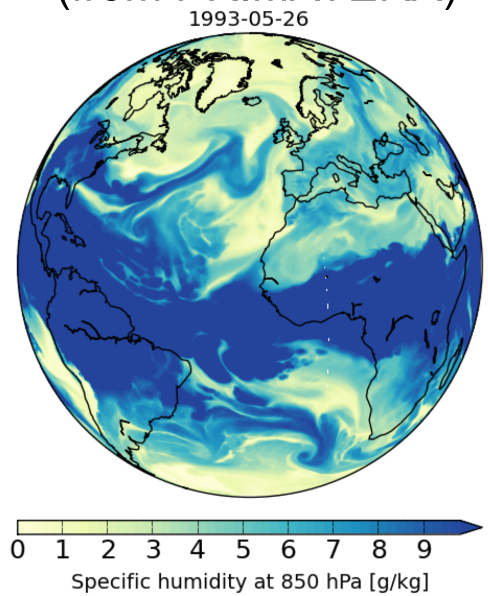
- Reanalyses spanning 40-100+ years (ERA5, JRA55, MERRA2, ERA-20C, 20CR, …)
- Climate models of increasing fidelity
- Huge international efforts with carefully designed protocols, curated data archives, and standardized data formats
- High frequency (1-6h) surface data becoming increasingly common (e.g., PRIMAVERA, CORDEX, CMIP6)
- Freely available for research (e.g., PRIMAVERA ~2.6PB on ESGF)



Mare Nostrum and ECMWF's Cray (just two of several leading HPC systems used for PRIMAVERA simulations)

https://www.bsc.es/news/bsc-news/the-bsc's-bid-host-one-the-largest-supercomputers-the-eu-strengthened-the-support-three-additional, https://www.ecmwf.int/en/computing/our-facilities/supercomputer

EC Earth, hi-res simulation (from PRIMAVERA)

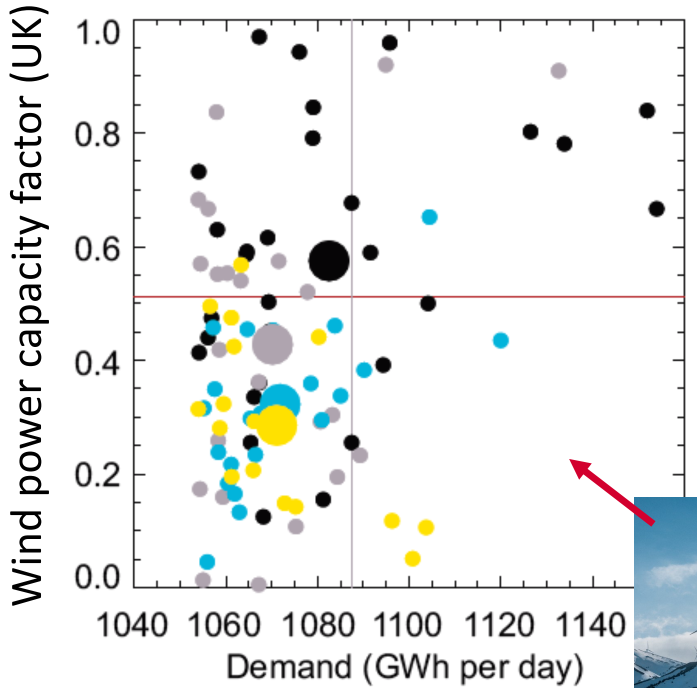


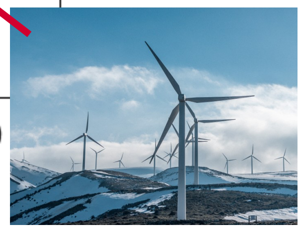
Substantial progress…

- **“Primary renewable energy” estimates from meteorological reanalyses now becoming common**
  - E.g., Ely et al 2013; Cannon et al 2015; Sharp et al 2015; Staffell and Pfenninger 2016; Bloomfield et al 2019; …
  - ECEM, renewables.ninja, EMHIRES, …

- Carrying through into:
  - Stress-event analysis (e.g., Thornton et al 2017, figure)
  - Energy system design (e.g., previous slides)

Top 5% of demand days (in UK)





IPCC AR5 WG2 SPM

A first step towards adaptation to future climate change is reducing vulnerability and exposure to present climate variability (*high confidence*).

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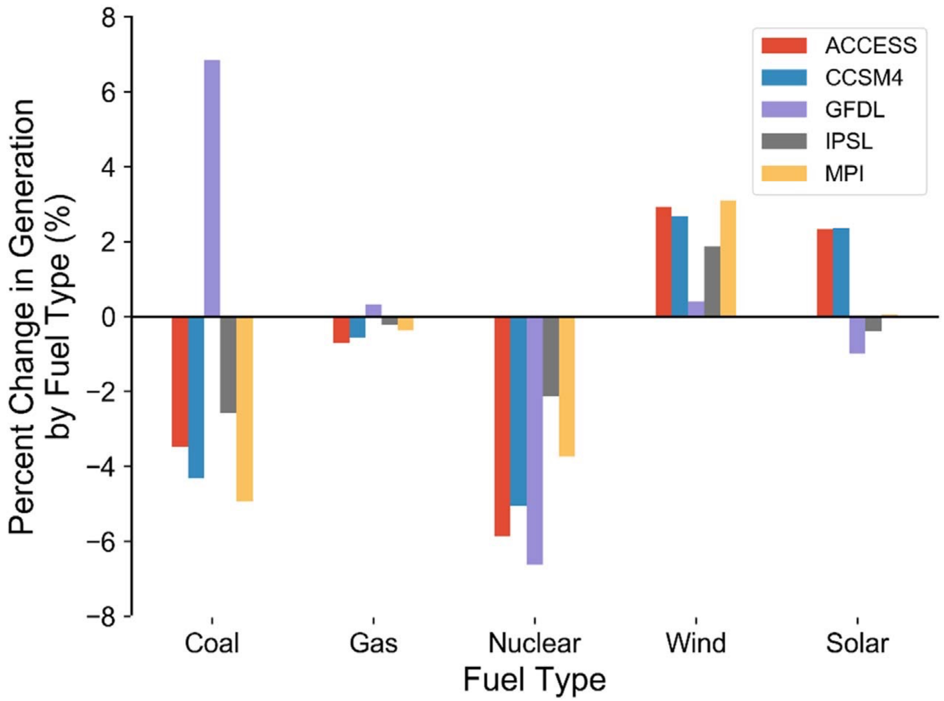
- **Beginning to use GCM data in detailed energy system analysis**

E.g., Craig et al 2019 (figure)

- Detailed power system model driven by data from 5 different GCMs
- Assessed how much the use of different types of generators would be effected under a future climate



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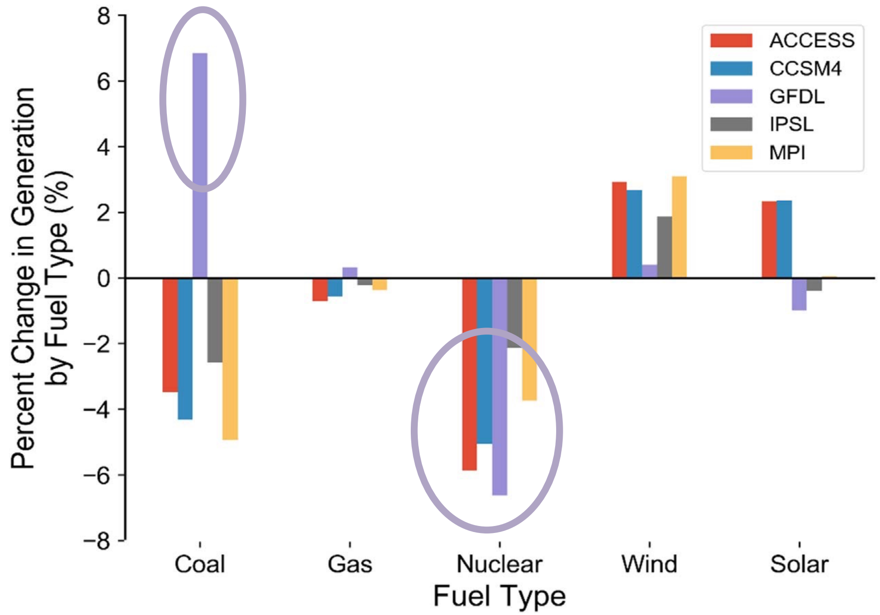
>
> Poor planning, overemphasizing short-term outcomes, or failing to sufficiently anticipate consequences can result in maladaptation (*medium evidence*, *high agreement*).

… but many challenges remain

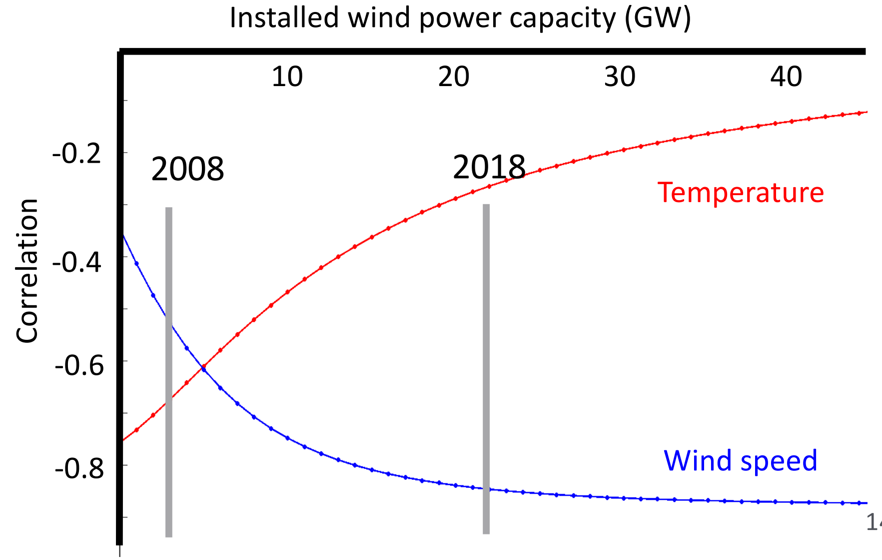
Questions around:

- multi-decadal variations in climate;
- computational feasibility of long power system simulations,
- differences between reanalyses;
- resolution, biases, deficiencies in climate models;
- imperfect short-range foresight and forecasting; and
- error propagation in modelling chains.



Upper figure (Craig et al, 2019):

- Why does one GCM give a completely different response?
- How should this impact our confidence in the result?



Lower: Bloomfield et al 2018, 2020

- Changes in the energy system impact it's weather sensitivity
- Will future "stress events" resemble past "stress events"?

Two messages

For climate scientists

- **Energy systems are more than just a set of inputs (or stress events) that can be directly calculated from weather.**

For energy scientists

- **Access to climate data is necessary but not sufficient to meaningfully address climate uncertainty.**

Need stronger interaction between the two disciplines!

Format

- Discussion-oriented workshop
  - Two sessions
  - Introductory reflections by active leading researchers
  - Facilitated breakout groups

Session 1 (Monday) – Use of historic climate data in energy system modelling

- To what extent are the implications of “present-day” climate risk/uncertainty in energy systems well characterised by existing methodological approaches?
- How can historic climate data be better used to estimate climate risk/uncertainty in energy system modelling?

Session 2 (Tuesday) – Climate change and energy system modelling

- To what extent does climate change affect our understanding of future risk/uncertainty in energy systems?
- What are the implications of using GCMs in the assessment of future energy-climate risk?

Goals, scope and outputs

- **Goal is to identify**
  - state-of-art (what doing now),
  - present opportunities (what could be done better using existing tools and know-how),
  - future research needs (where do we need to go next)
- **Scope**
  - Focus on the scientific and technical challenges
  - Try to avoid detailed discussion of particular location/technologies
  - Data access/availability is an important topic **but is NOT a priority here (other fora exist for this, e.g., OPENMOD)**
- **Outputs**
  - Networking and collaboration – joined up “energy-climate” research domain (**Workshop Booklet!**)
  - Intention to produce white paper or journal output(s)
- **Rules of engagement**
  - Please mute microphones and turn off video in plenary – raise hand or use chatbox if wish to ask a question
  - Please unmute microphones and turn on video in breakouts – or follow instructions from facilitator
  - Chatham house rules variant
  - Google docs / reporting

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Links and people

- Organising committee:
  - David Brayshaw (Univ Reading, chair)
  - Hannah Bloomfield (Univ Reading)
  - Jethro Browell (Univ Strathclyde)
  - Roger Dargaville (Univ Melbourne)
  - Matteo de Felice (JRC)
  - Paula Gonzalez (Univ Reading)
  - Katharina Gruber (BOKU)
  - Adriaan Hilbers (ICL)
  - Alex Kies (Univ Frankfurt)
  - Julie Lundquist (Univ Colorado)
  - Mathaios Panteli (Univ Manchester)
  - James Price (UCL)
  - Laurens Stoop (Utrecht University, TenneT, KNMI)
  - Hazel Thornton (UK Met Office)
  - Jan Wohland (ETH Zurich)
  - Marianne Zeyringer (Univ Oslo)

- PRIMAVERA project homepage: https://www.primavera-h2020.eu

- University of Reading Energy-Meteorology group: https://research.reading.ac.uk/met-energy/