Utrecht University

PENTA forum

Climate change in adequacy assessments

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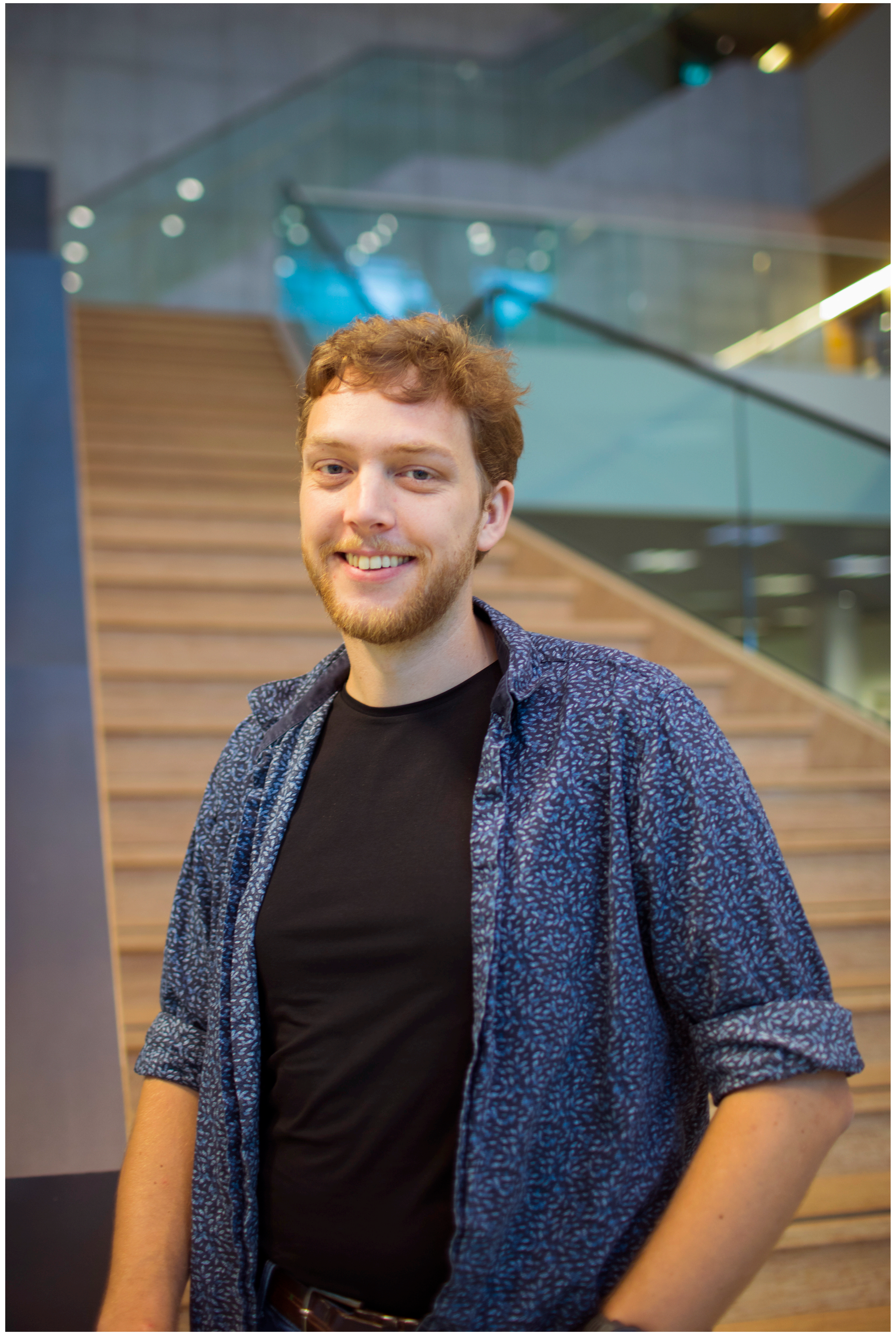


Overview

ACER's options to account for the climate change (CC) in Regional Adequacy Assessment (RAA)

i. Rely on a best forecast of future climate projection

ii. Weight climate years to reflect the likelihood of occurrence (taking future climate projection into account)

iii. Rely at most on the 30 most recent historical climatic years included in the PECD

Near term effects and simple adjustment

Research with Ines Haran & Fabian Heymann (ENTSO-E)

Incorporating climate change effects into the European power system adequacy assessment using a post-processing method - doi.org/10.1016/j.segan.2020.100403

Extreme events & distribution changes

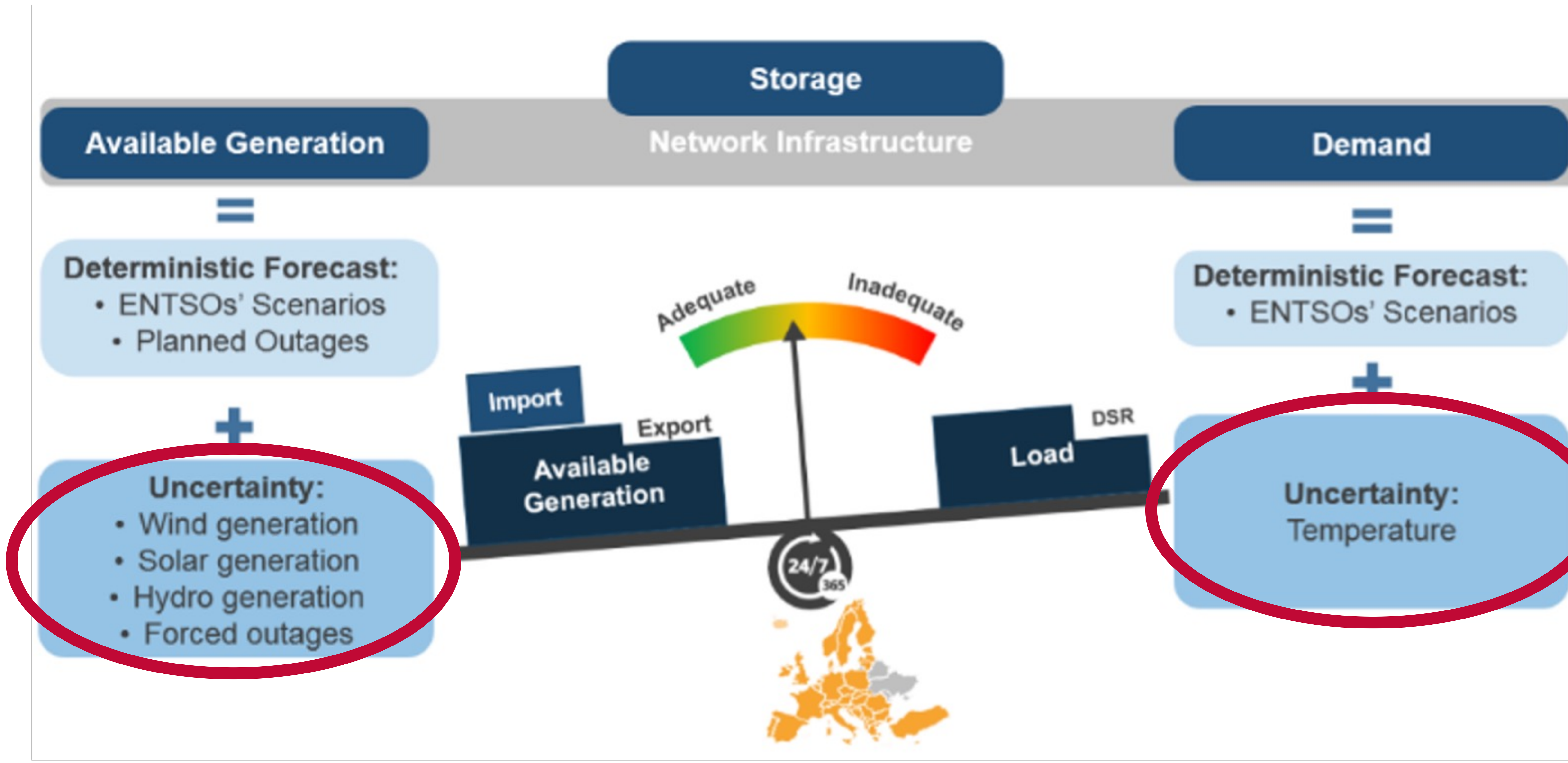
Research with Karin van der Wiel (KNMI) & others.

Meteorological conditions leading to extreme low variable renewable energy production and extreme high energy shortfall – doi.org/10.1016/j.rser.2019.04.065

Incorporating CC in adequacy assessment

Midterm Adequacy Forecast (MAF)
Uncertainty in system due to the weather

Climate is weather over longer periods of time

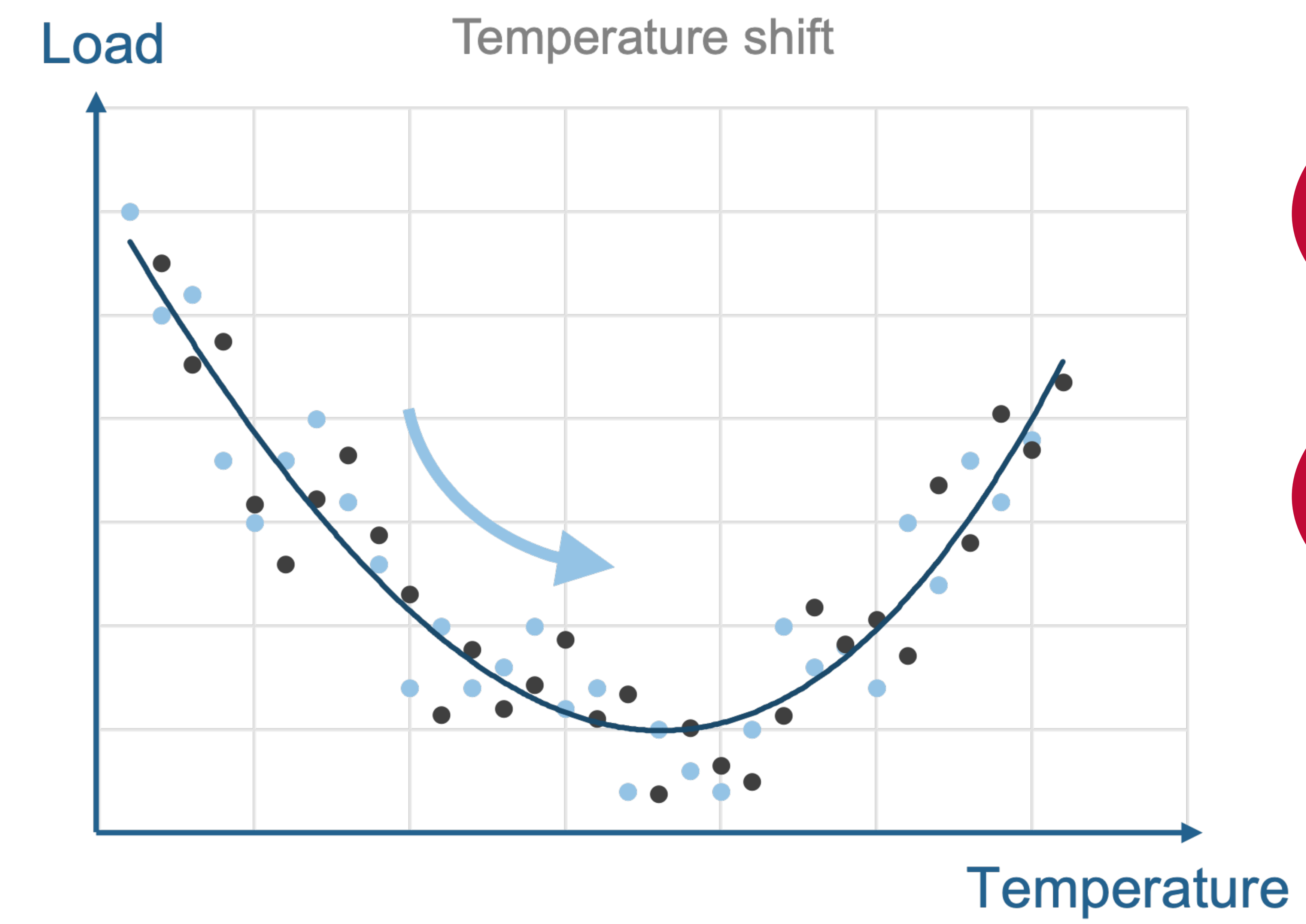


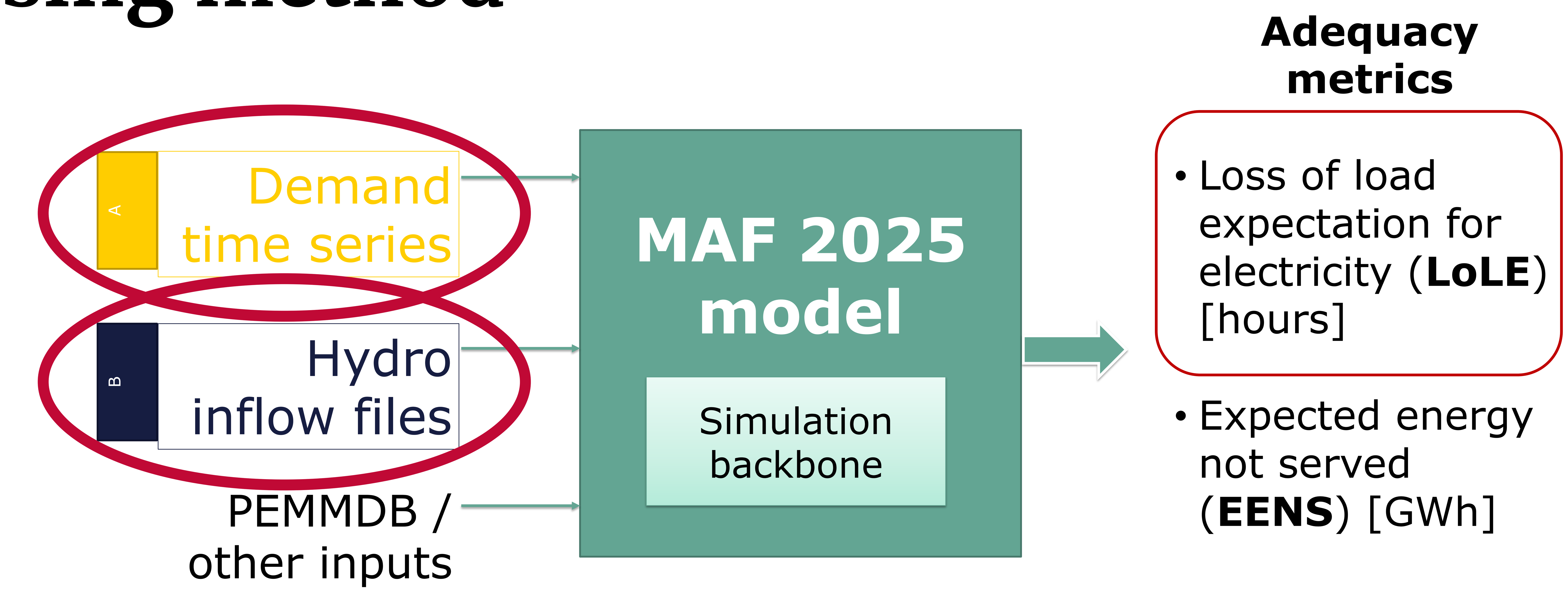
The impact of the change in **temperatures** on electricity demand in Europe

The impact of the change in **water inflow** on hydroelectric generation

The impact of climate change on adequacy study

Using a Post-processing method





a) Original profile b) Extracted profile c) Reprofiling d) Rescaling

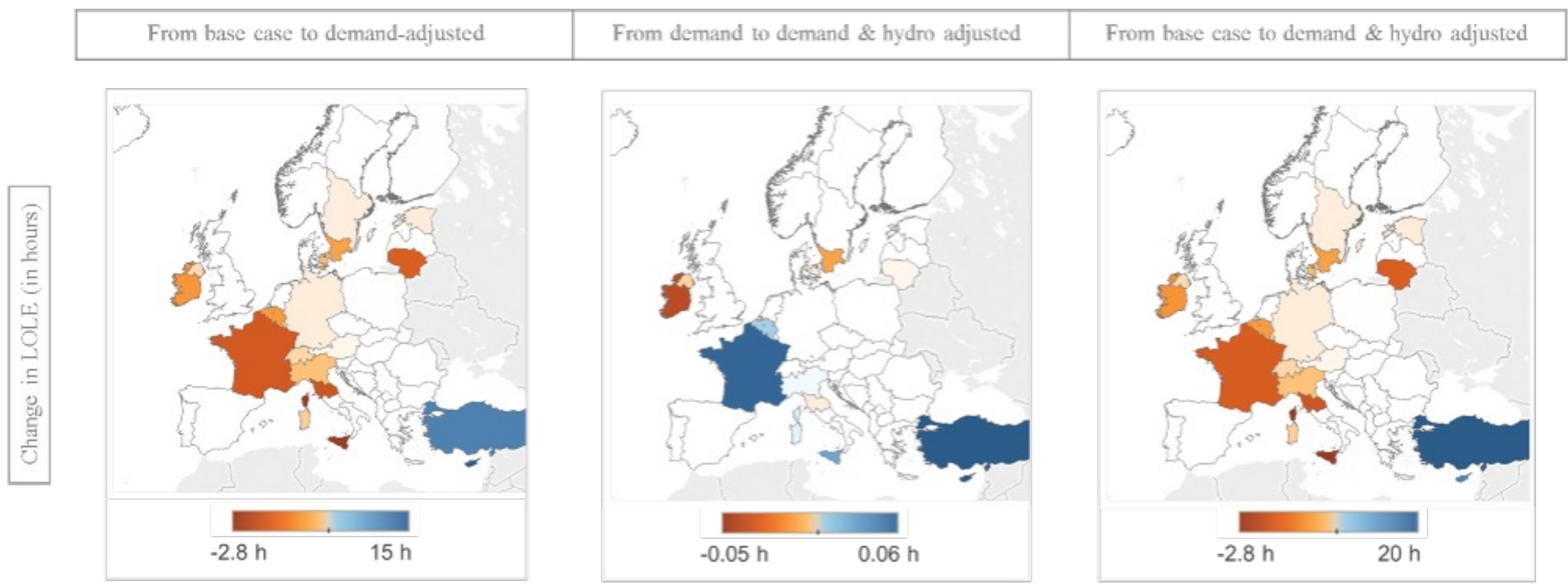
Near term effect of CC on adequacy

Inputs are no longer correlated!

Climate change had a significant effect on LOLE

1. Temperature effect generally reduces LOLE – due to reduced wintertime demand
2. Inflow changes increase LOLE – due to expected changes in precipitation
3. Combined effect reduces LOLE

Regional differences in the size and sign of change! Only significant changes shown

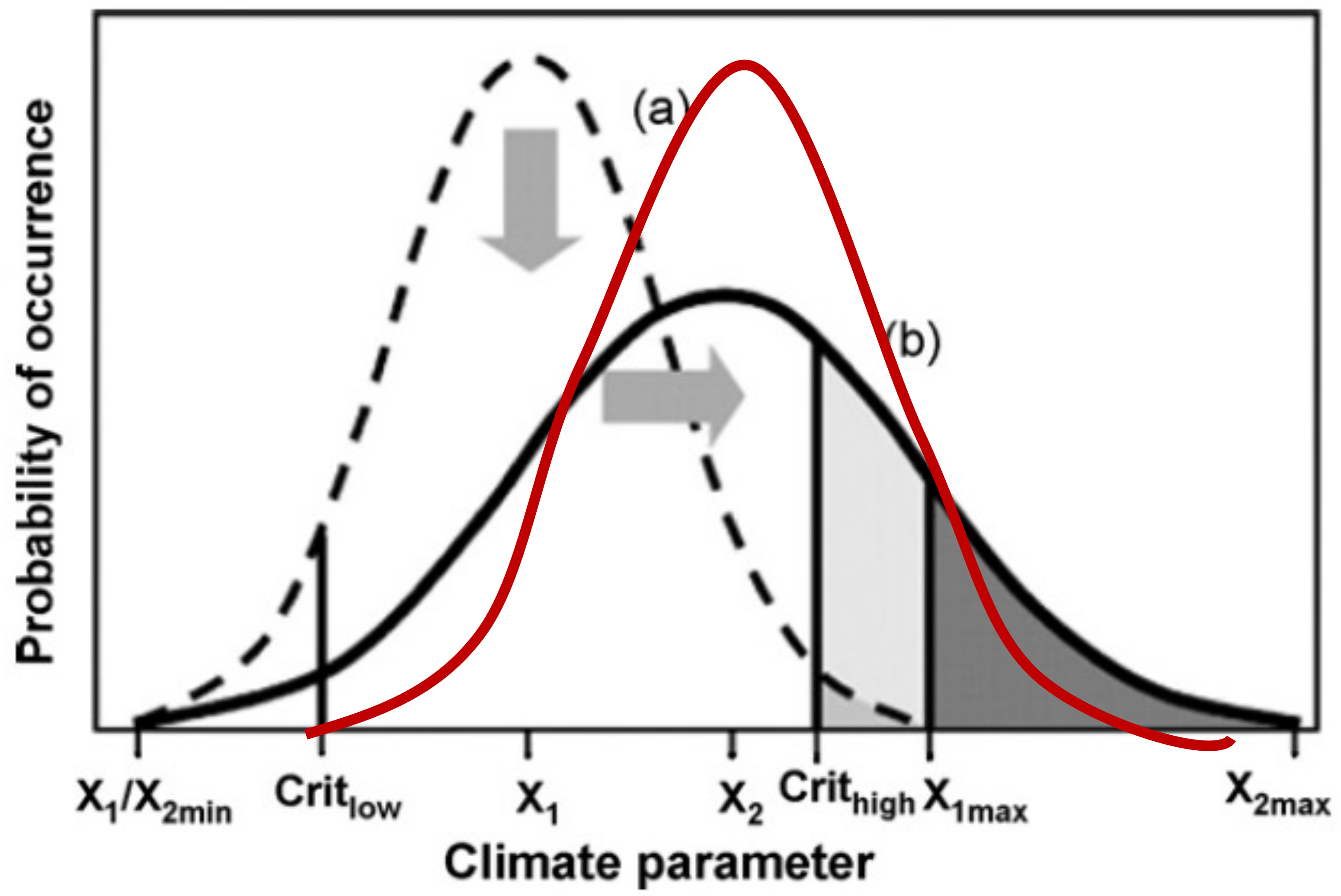


Issues with using post-processing

The impact of the change in **temperatures** on electricity demand in Europe

The impact of the change in **water inflow** on hydroelectric generation

The impact of climate change on adequacy study



CC effects on non-hydro RES

CC effects on network operation

CC effects on extreme events frequency

CC effects on compound high impact events

”Future work should when possible be based on a consistent set of assumptions to better capture linkages in climate change effects”

Projected future impact of changes in climate

Compute large ensemble climate data
climate model

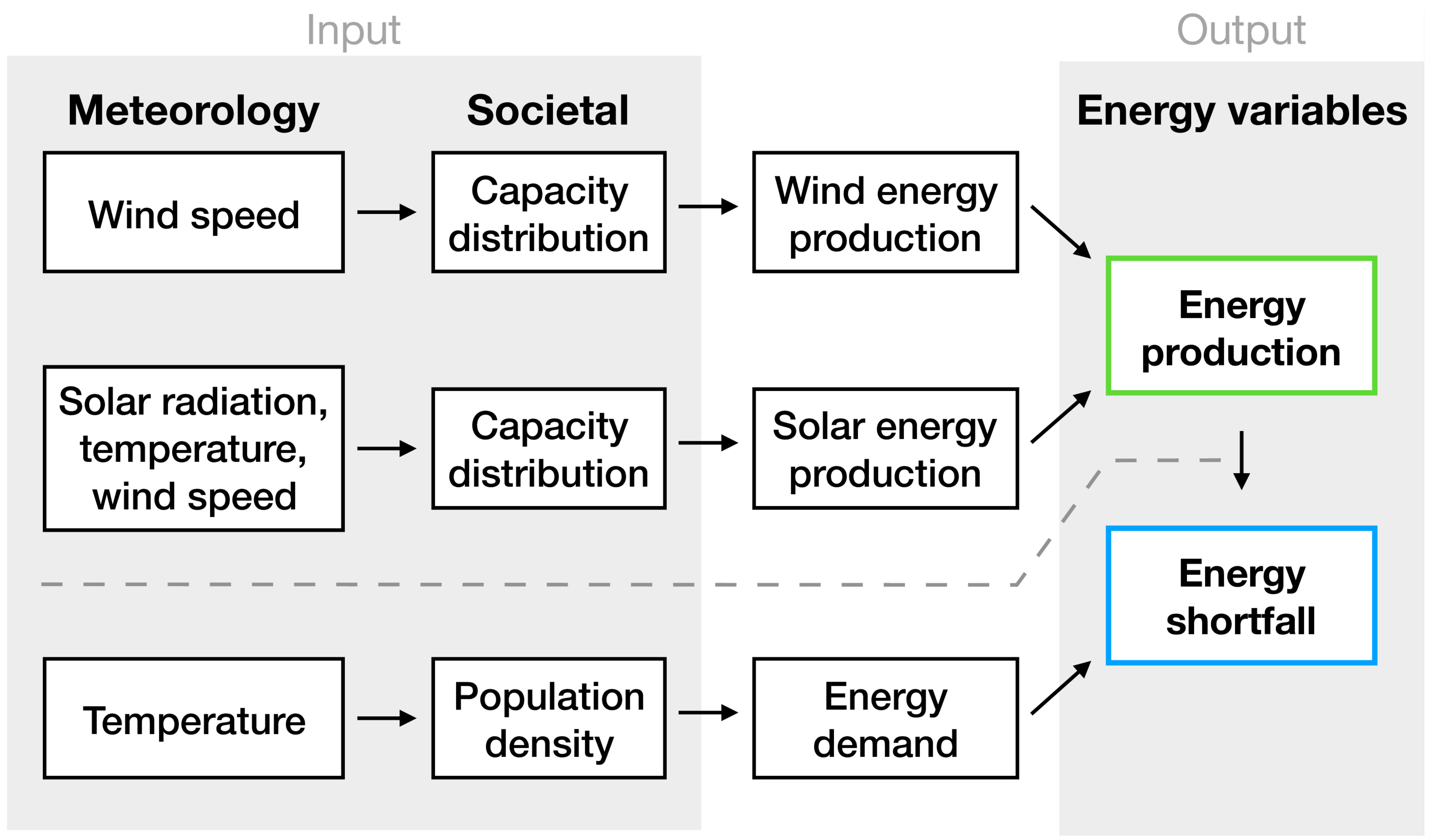
Wide sectoral range possible

Application determines impact model

- Crop yields – doi.org/10.5194/esd-12-151-2021
- Large scale drought – doi.org/10.1016/j.wace.2021.100350
- Extreme river discharge – doi.org/10.5194/nhess-21-961-2021

Method applied to European power system

- Production from Wind & Solar
- Electricity demand



Meteorological conditions leading to extreme low variable renewable energy production and extreme high energy shortfall – doi.org/10.1016/j.rser.2019.04.065

Kalte-Dunkelflaute

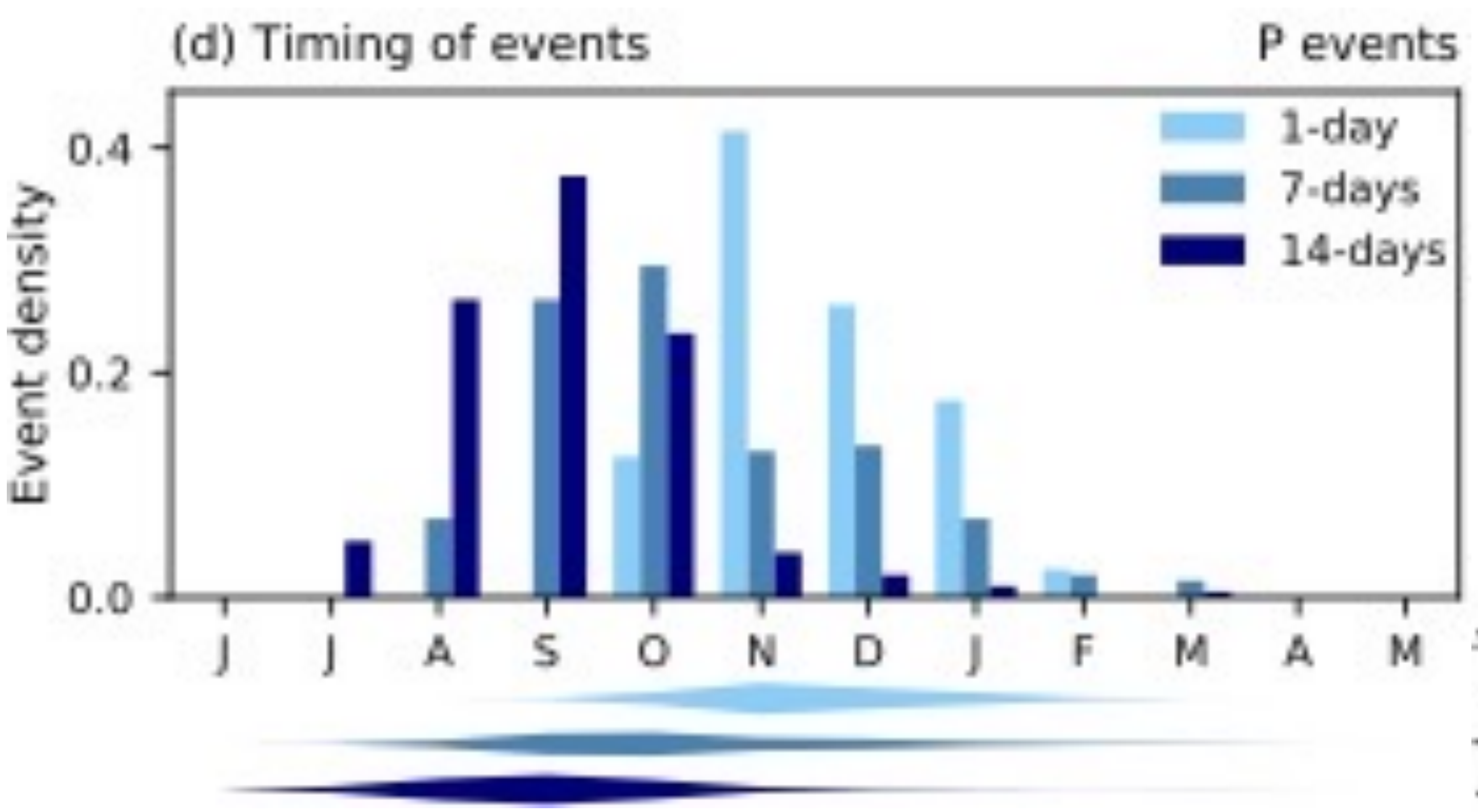
Correlation of input is required!

Dark Doldrums – an extreme high impact event

- Low production from wind & solar
- Increased demand due to cold

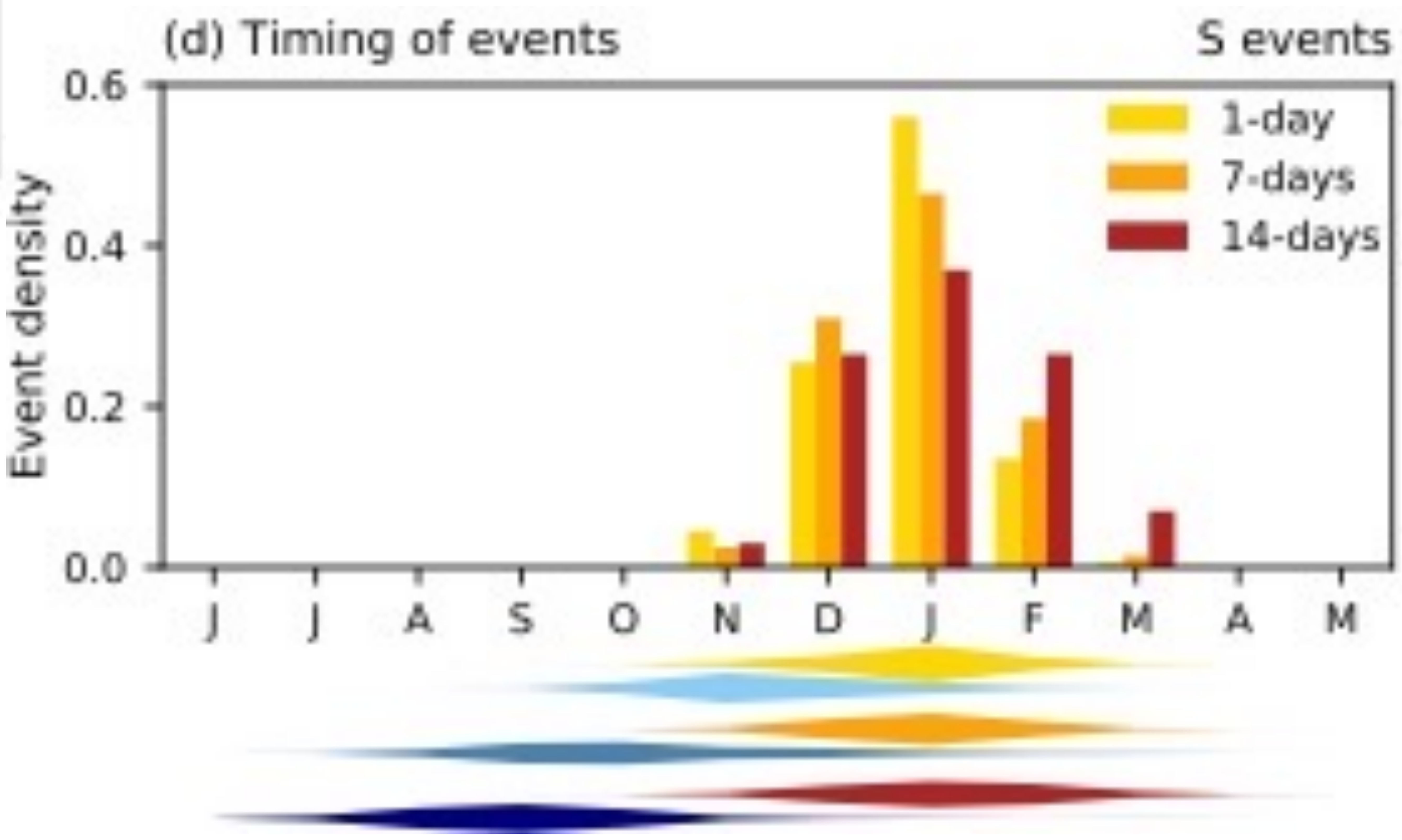
2000 years of daily data!

Timing of high impact events



High shortfall (kalte dunkelflaute) events

- Both short & long events mid-winter
- Require continues time series to capture



Low production events

- Short events in late autumn
- Longer events near end of summer

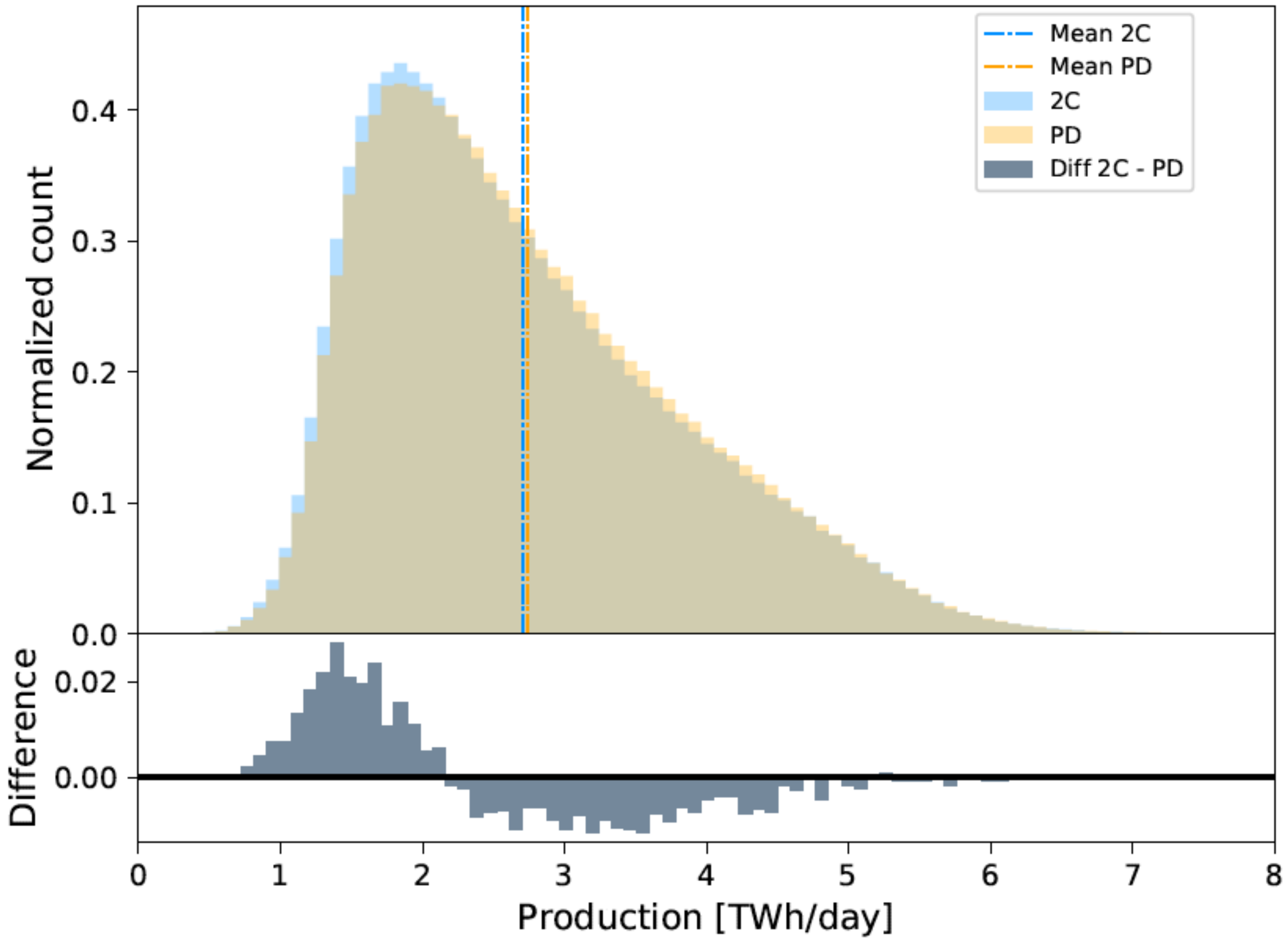
Influence of Climate Change on distribution

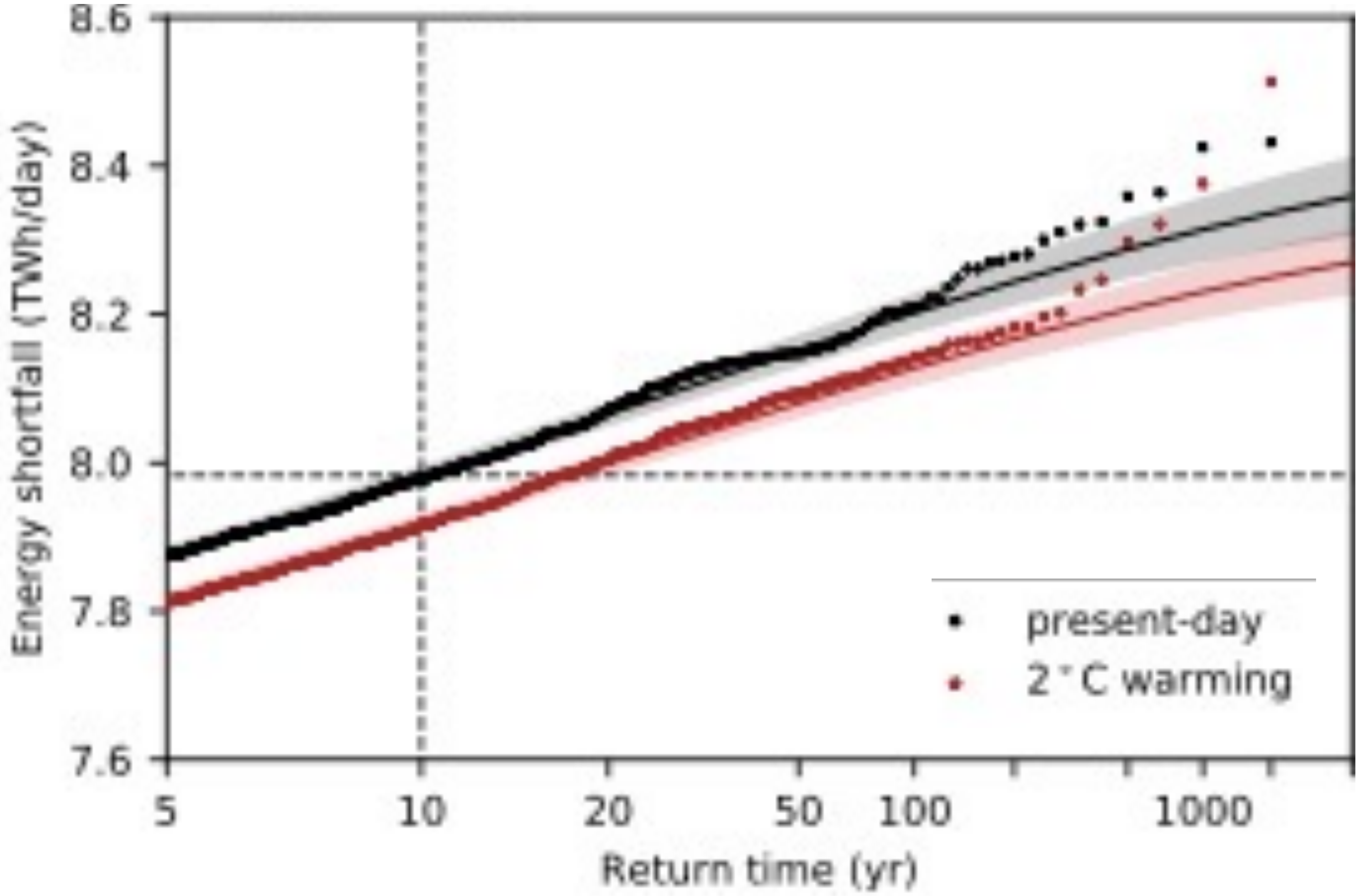
Change from Present Day (PD) to 2C

Same ensimble, but 2C warming w.r.t. pre-industrial

Effect of CC on distribution

- Small change in mean
- Climate change reduces the severity of high impact events





Summary

ACER's options to account for the climate change in RAA

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ii. Weight climate years to reflect the likelihood of occurrence (taking future climate projection into account)

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Likely allready near-term effects of CC

Distribution changes hard to capture
&
High impact events occur in winter period

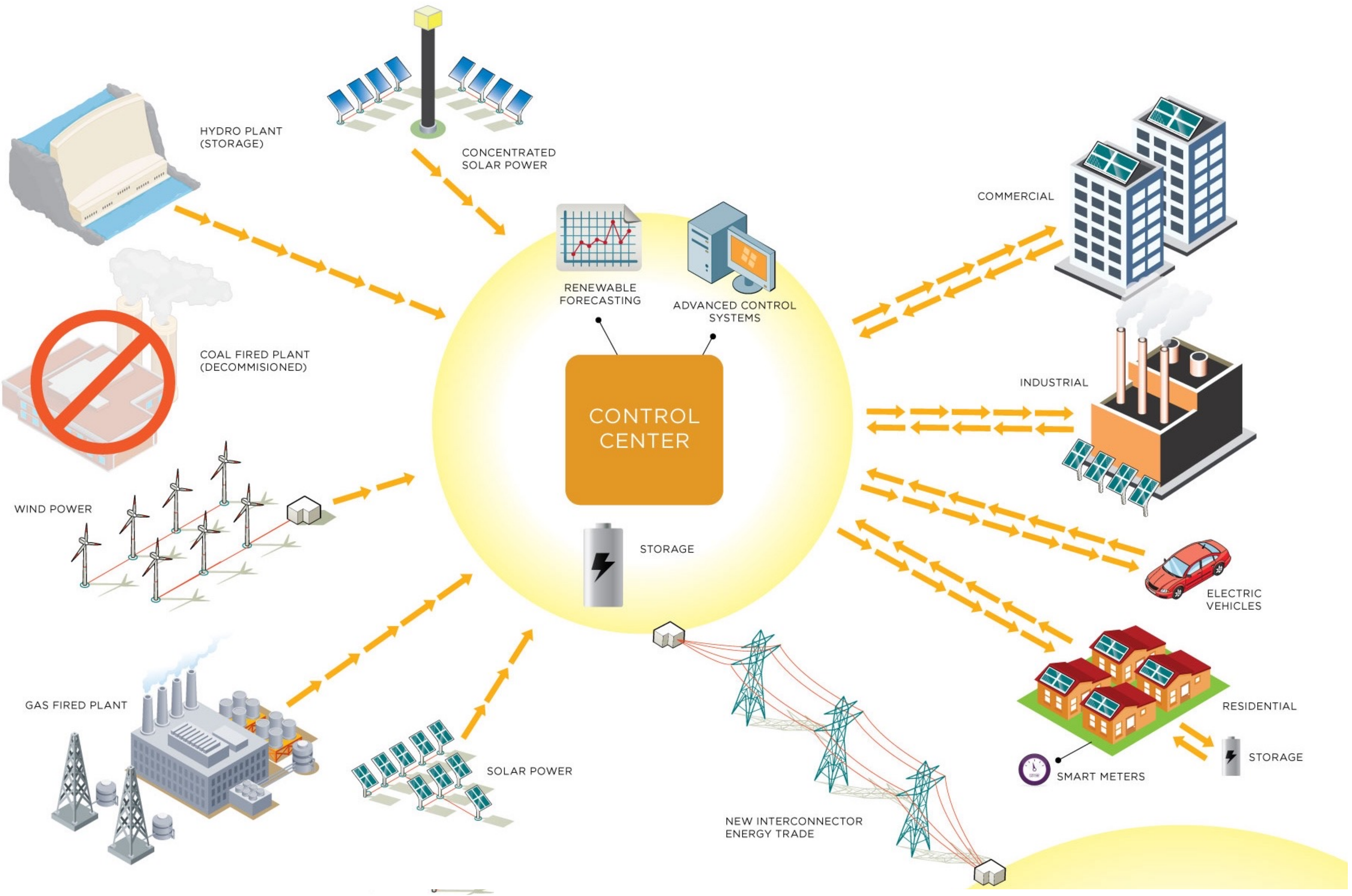
ACDC—ESM project

Algorithmic Computing and Data-mining for Climate integrated Energy System Models

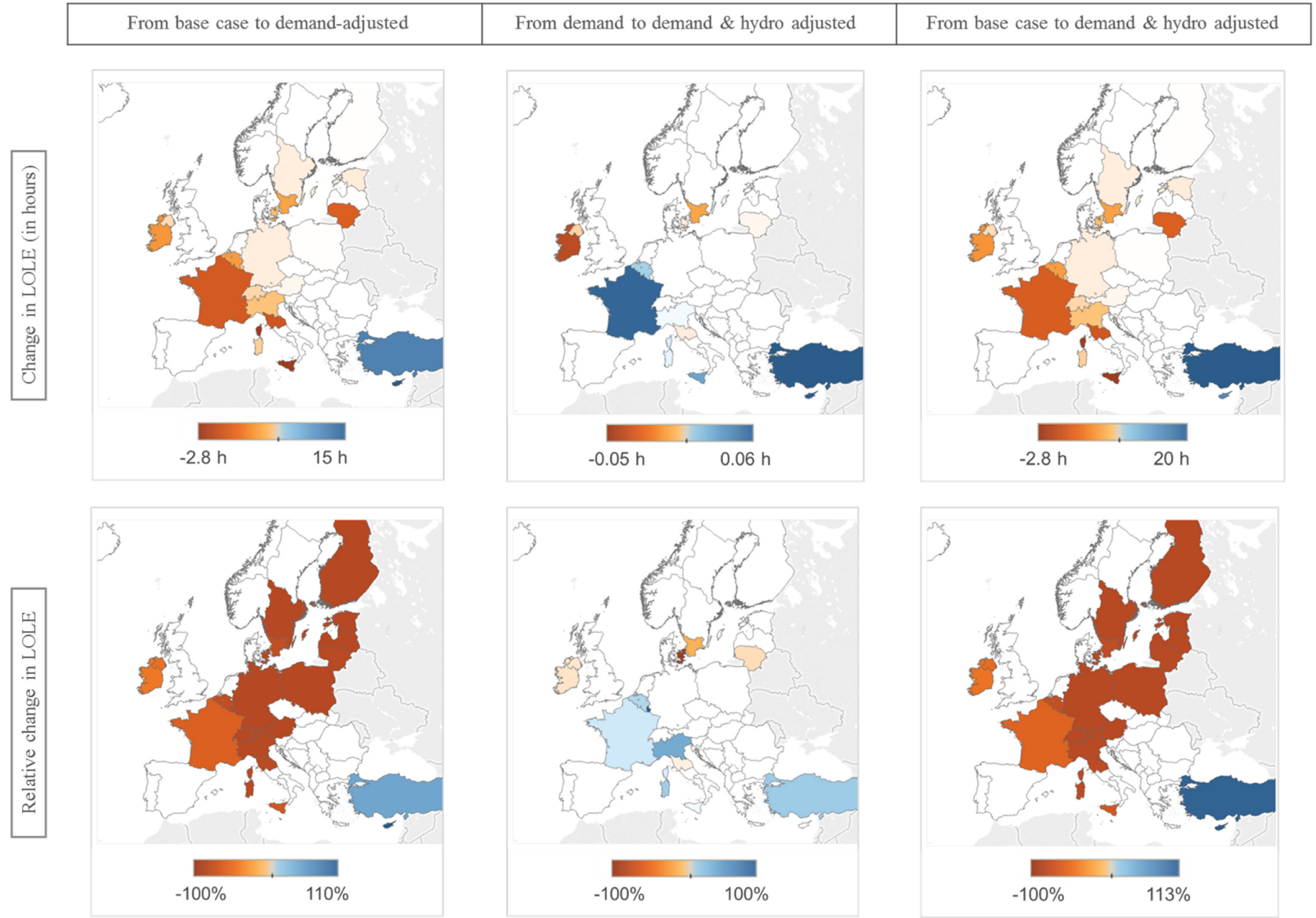
Transition to renewables

Increased weather dependence

Adverse circumstances disrupt the grid

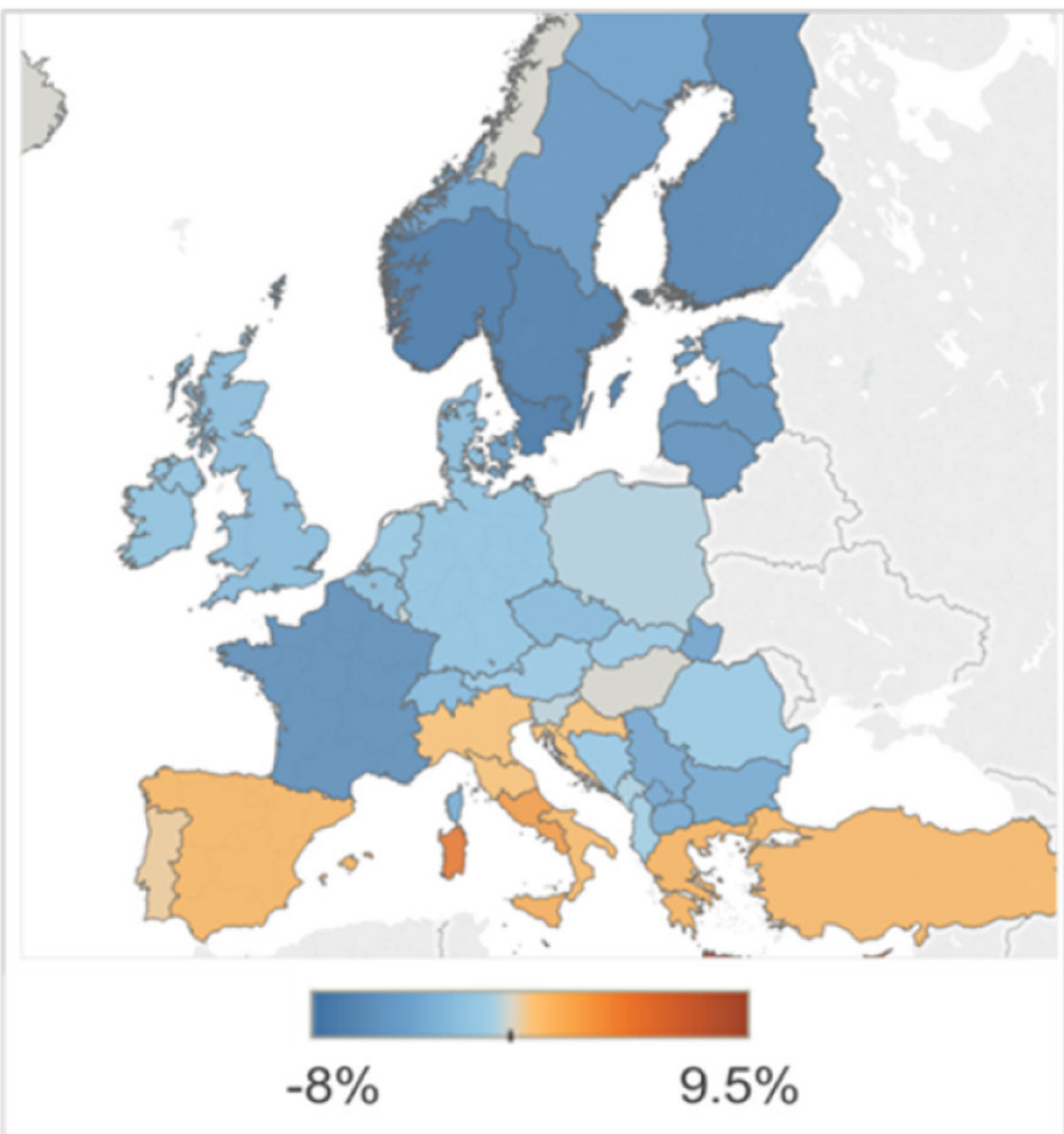


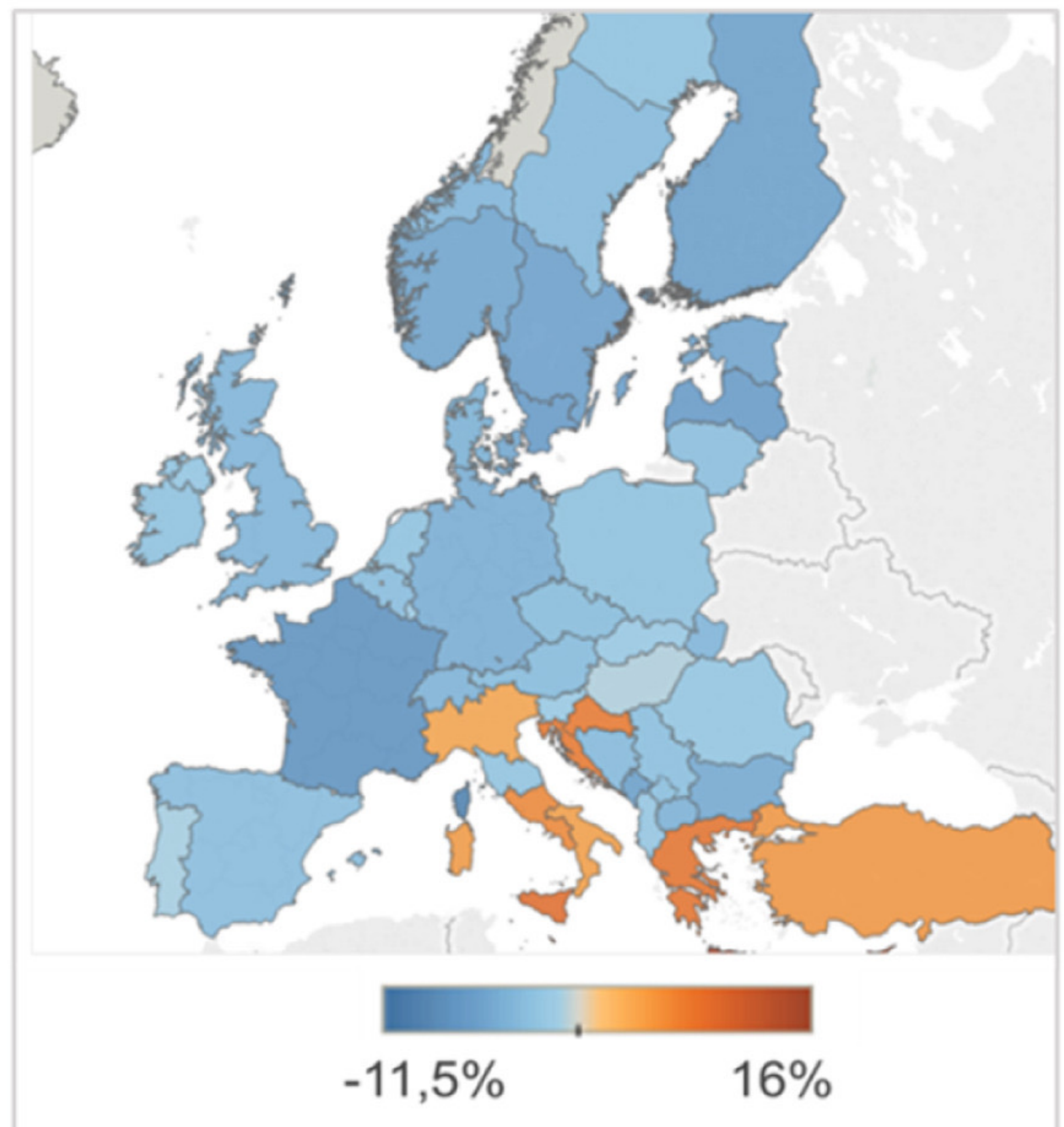
Relative change in LOLE

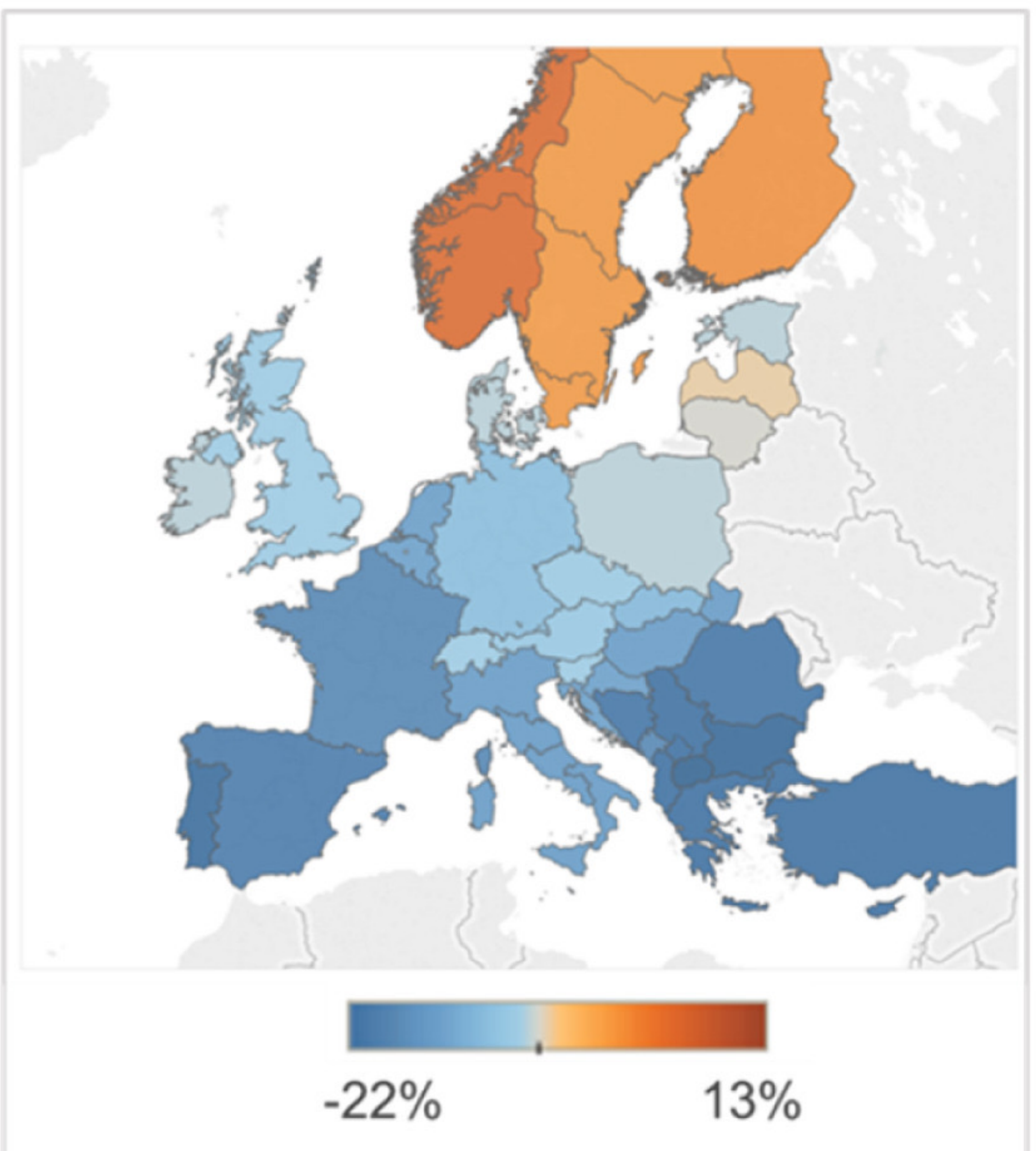


CC effect on variables

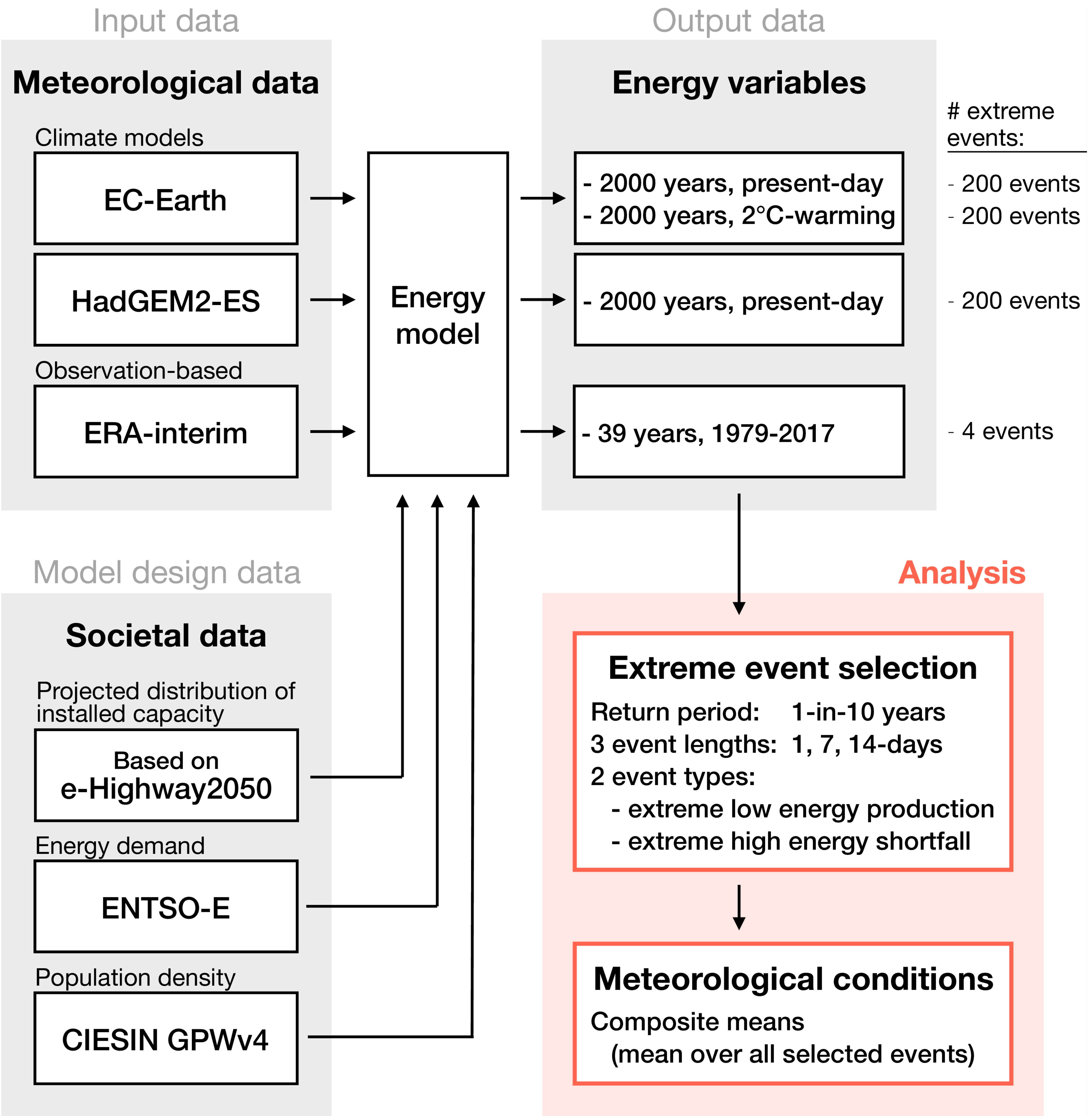
Relative change in electricity consumption	Relative change in peak loads	Relative change in hydro inflow





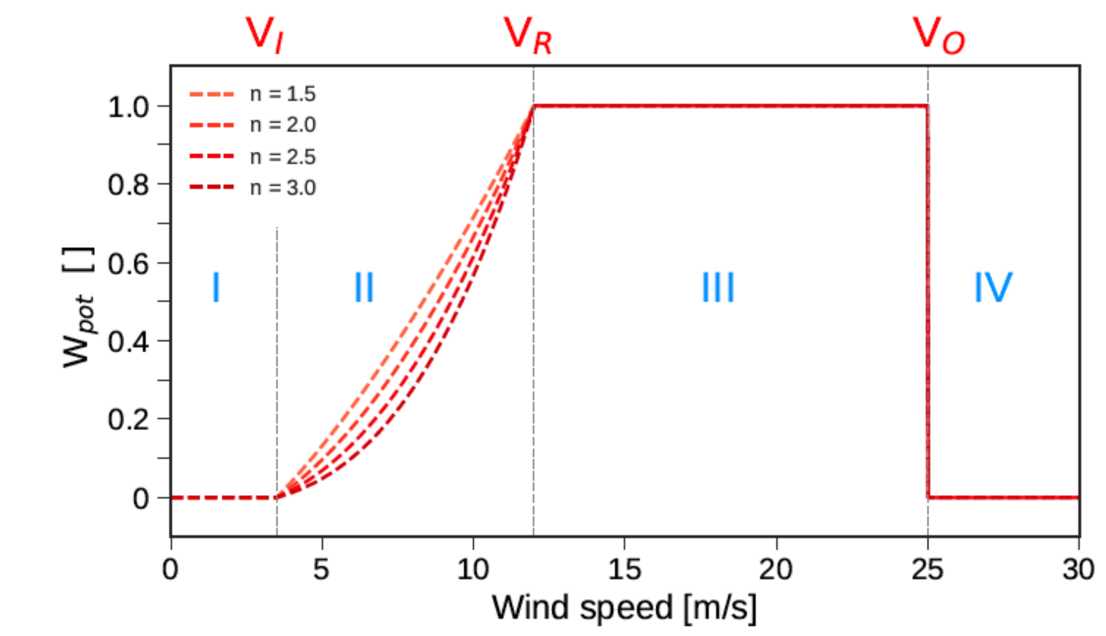


Data model



$$W_{pot} = \begin{cases} 0 & \text{if} \quad V < V_I, \\ \frac{V^n - V_I^n}{V_R^n - V_I^n} & \text{if} \quad V_I \leq V < V_R, \\ 1 & \text{if} \quad V_R \leq V < V_O, \\ 0 & \text{if} \quad V \geq V_O \end{cases} \quad (2)$$

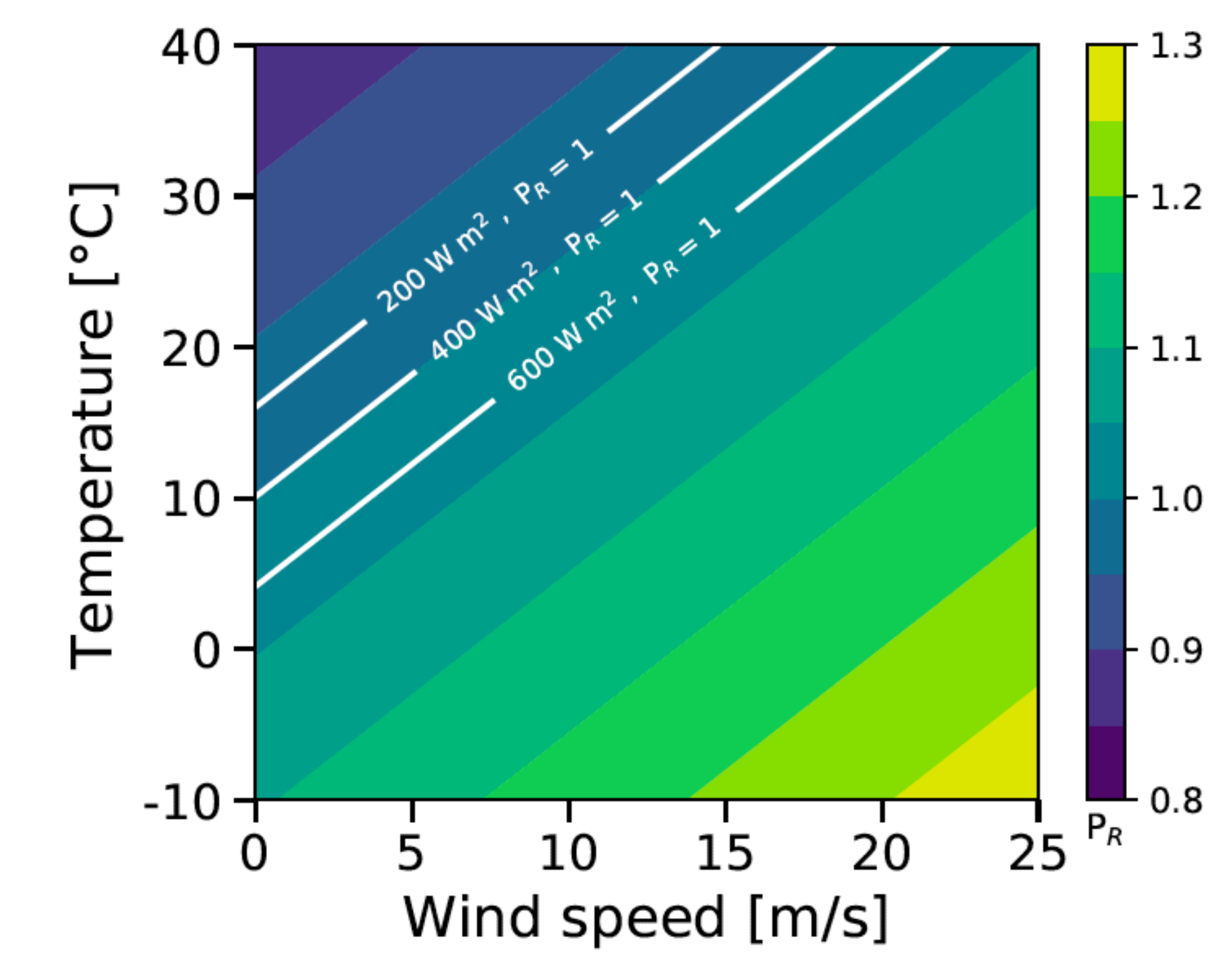
Power scaling factor $n = 3$



$$PV_{pot} = P_R \frac{I_{day}}{I_{std}} \quad (3)$$

$$P_R = 1 + \gamma \left(T_{cell} - T_{ref} \right) \quad (4)$$

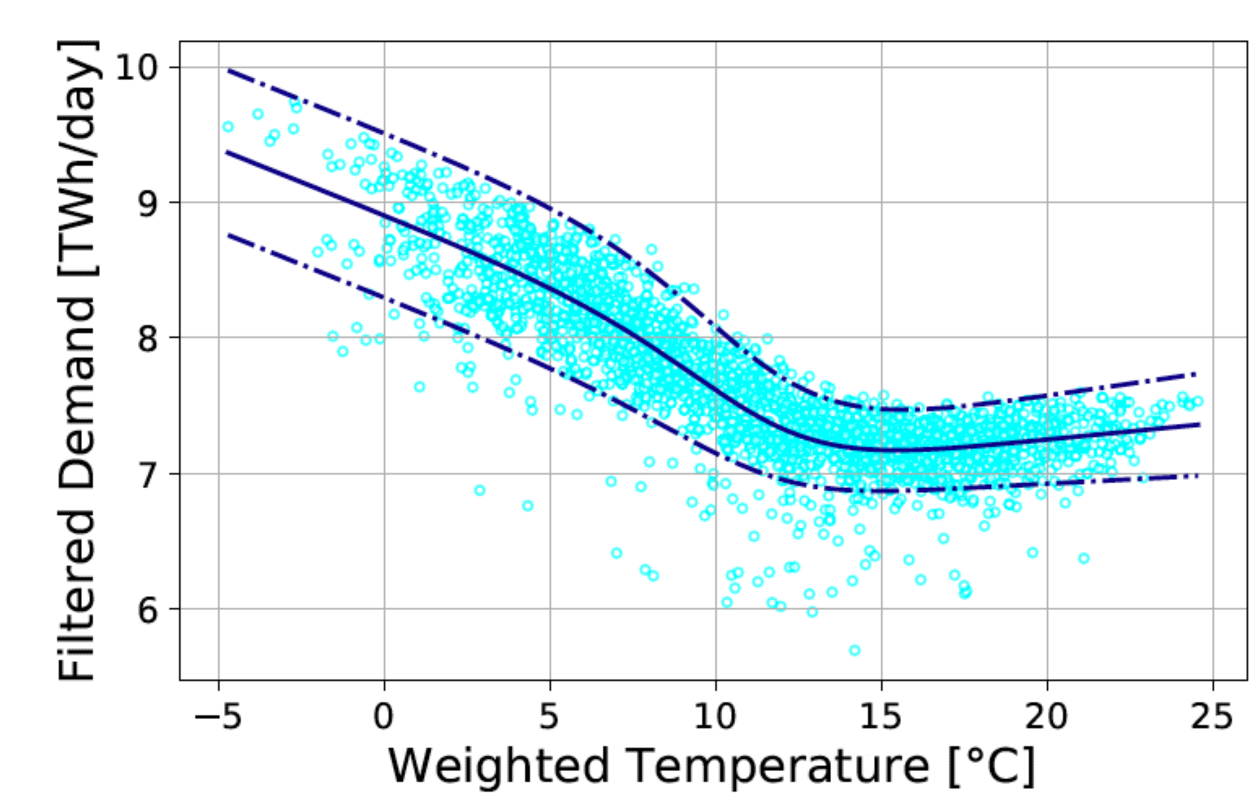
$$T_{cell} = c_1 + c_2 T + c_3 G + c_4 V \quad (5)$$



$$E_{fil.} = [\alpha_1 + \beta_1 T] \times (1 - G) \quad (5)$$

$$+ [\alpha_2 + \beta_2 T] \times G \quad (6)$$

$$G = (1 + \exp[\gamma])^{-1} \quad (7)$$



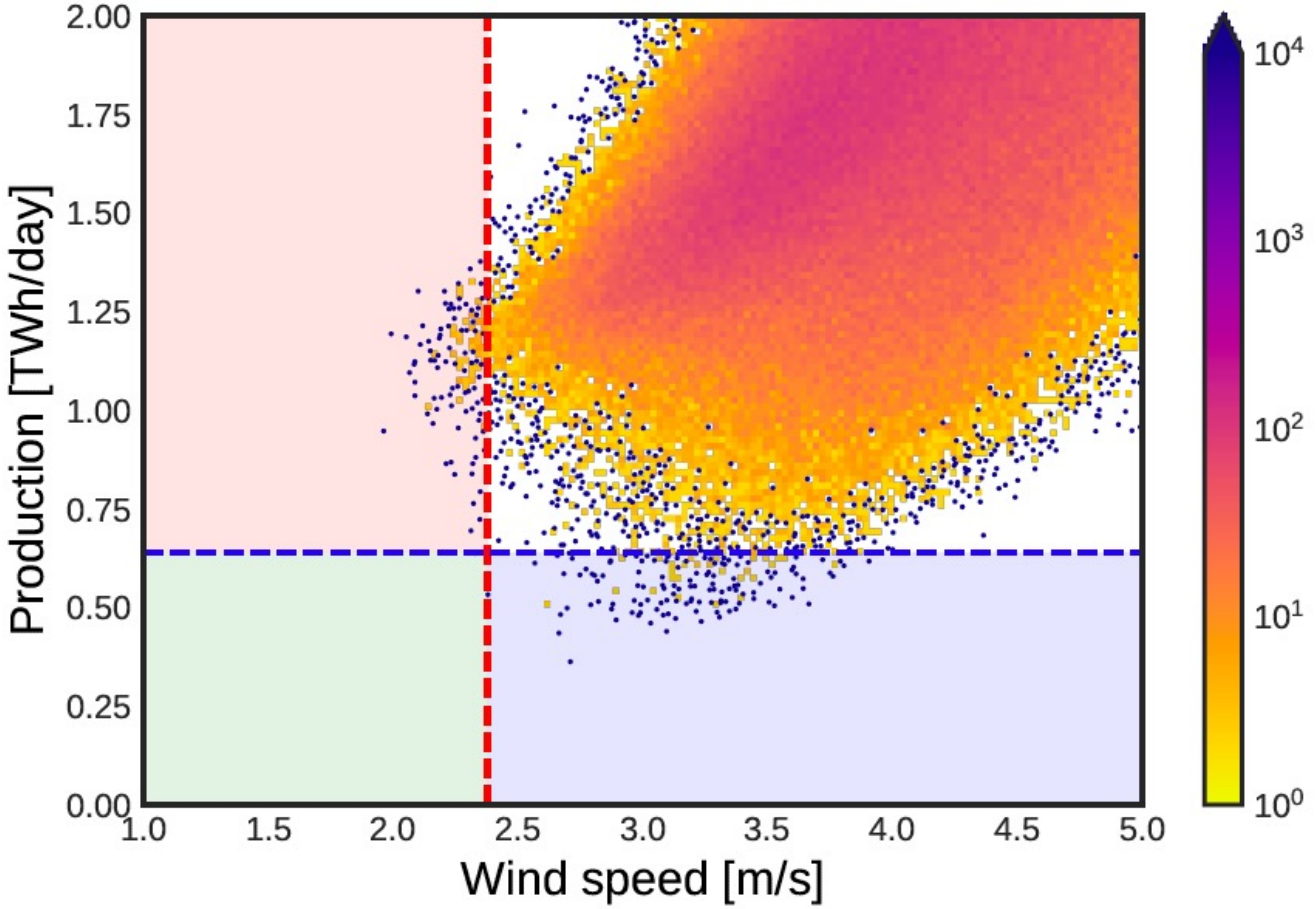
Large ensemble design

Meteorological conditions leading to extreme low variable renewable energy production and extreme high energy shortfall – doi.org/10.1016/j.rser.2019.04.065

High impact events

Climate model ensemble generates 2000 years
Apply a conversion model for wind energy generation

Select all 1-in-10 year events
- 200 low wind energy production events
- 200 low wind speed events

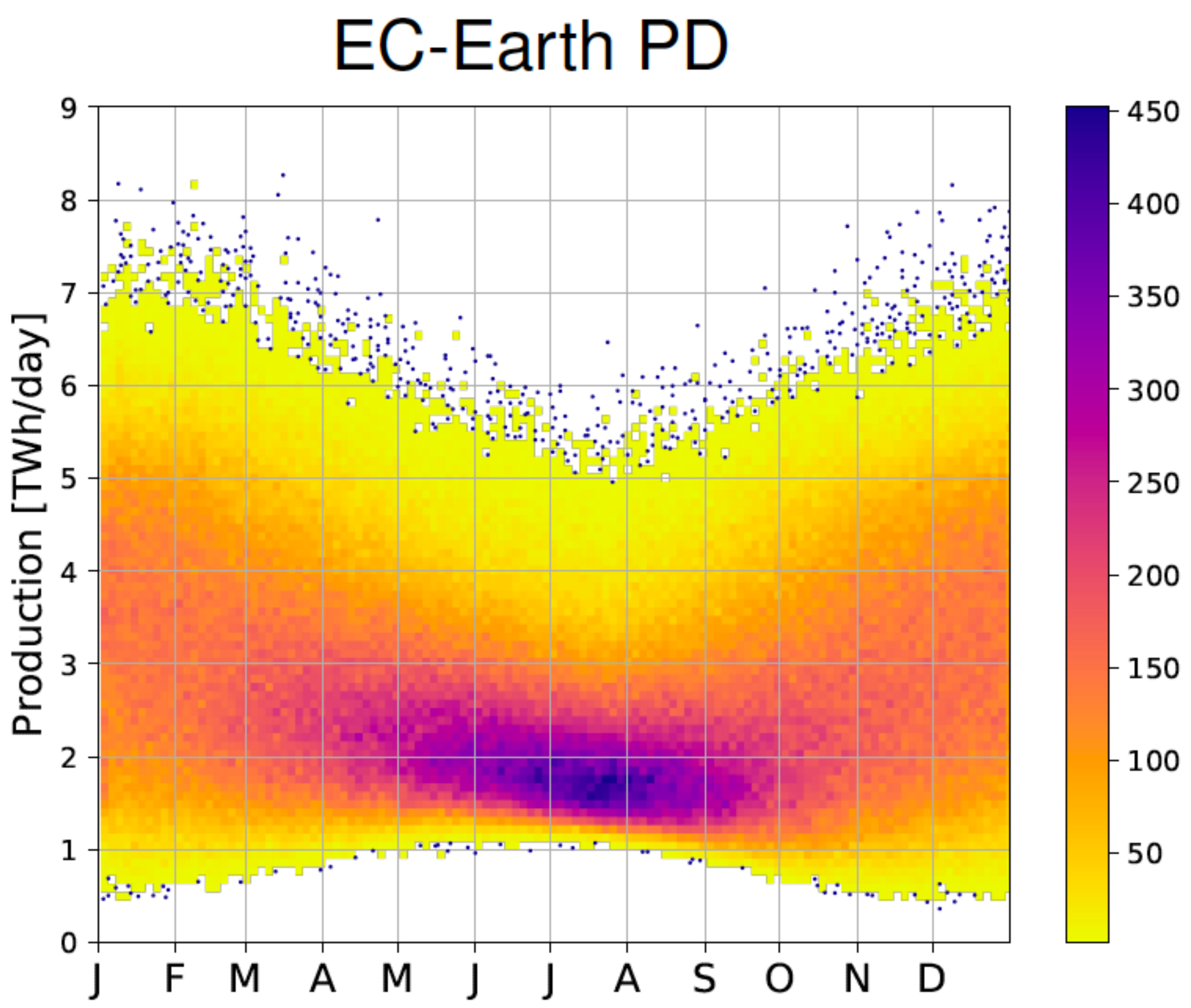


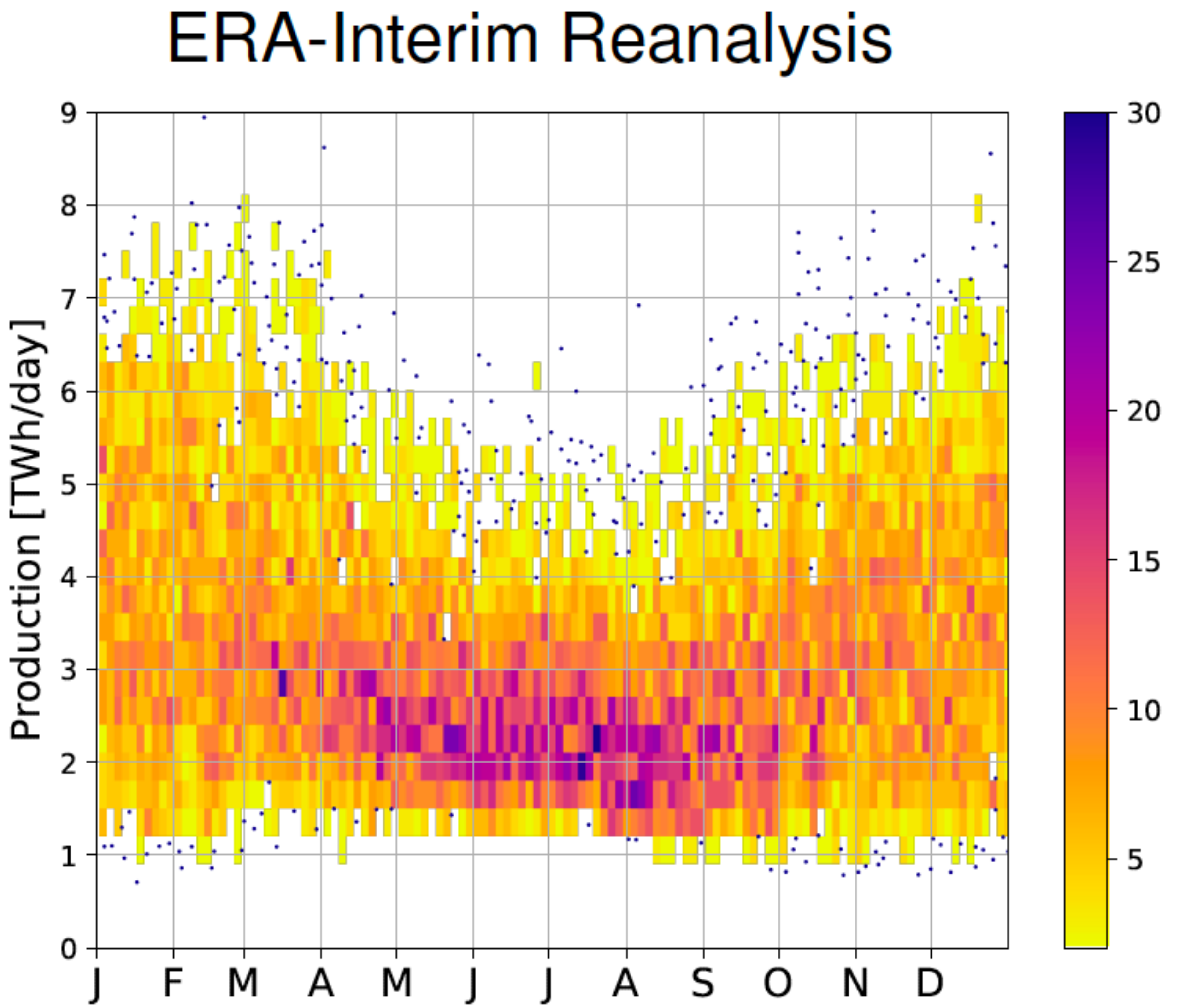
Annual cycle of low production events

Modelled results vs observed events

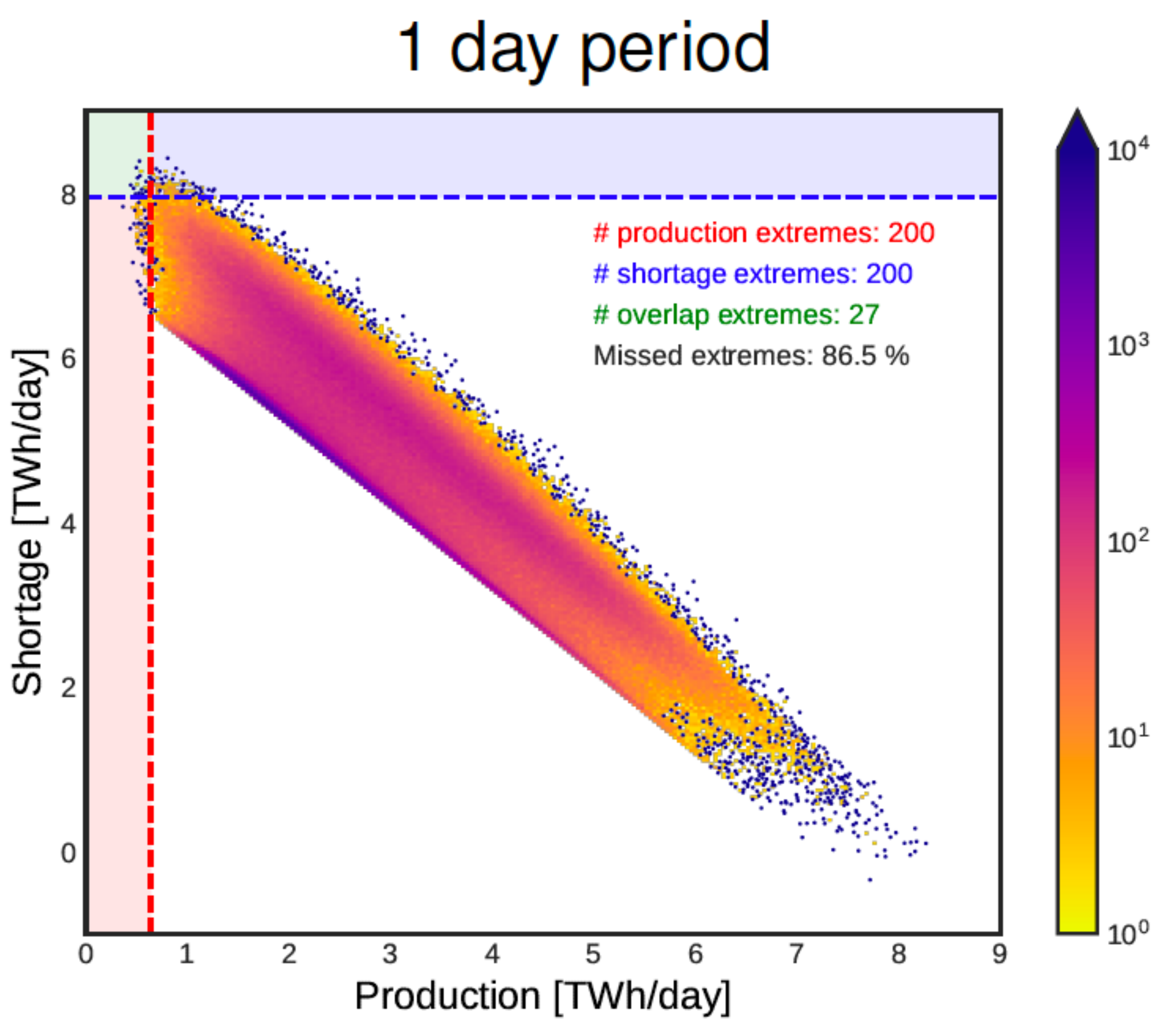
- Observed shortfall events fall in the distributions of modelled shortfall events

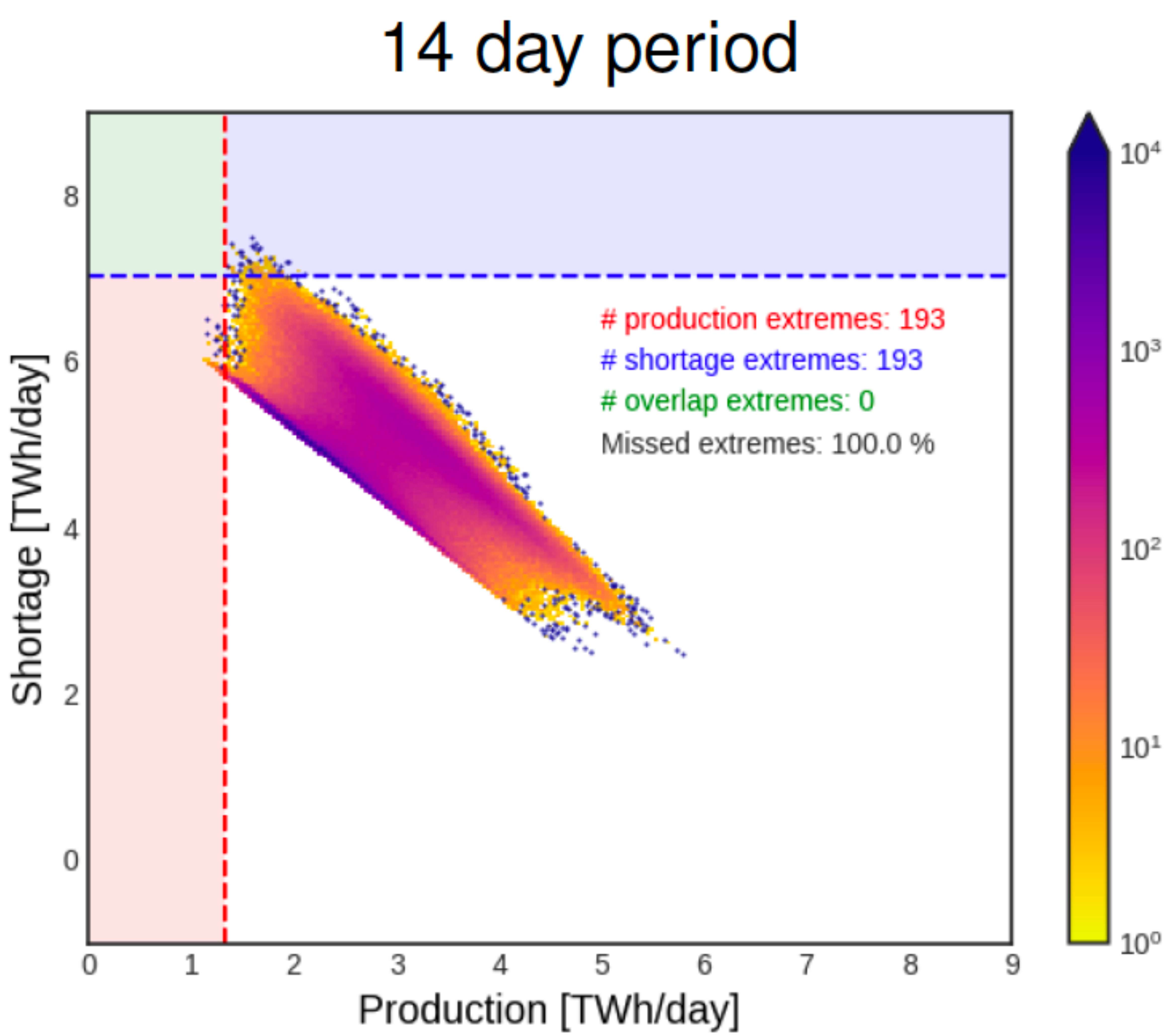
Biases in data & sampling size difference





Production vs Shortage events





Changes in distribution & probability ratio