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Port Moresby (PNG) 21 Aug 2018

What can European climate services offer to the energy (and water resource) sector?

Prof. Alberto Troccoli
World Energy & Meteorology Council and University of East Anglia, Norwich, UK

APEC Climate Symposium

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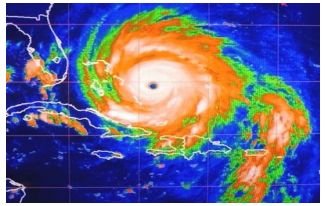
Outline

- The intimate relationship between Energy and Climate
- How Climate impacts Energy
- Climate Services and decision making in Energy Sector

Energy and meteorology go hand in hand

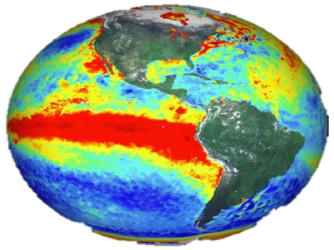
Passing clouds

Drop in solar power



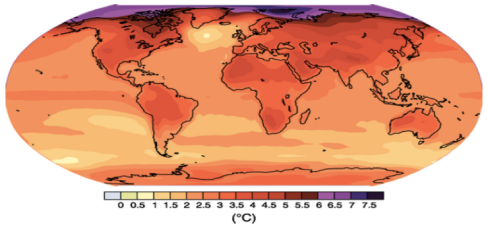
Hurricanes

Disruptions to oil rig operations



El-Niño

Changes in Demand Patterns



Long term changes

Renewable Resource Assessment

Seconds | Minutes | Days | Months | Seasons | Years | Decades

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Energy Decisions & Meteorological Forecasts

Paul Langrock

Klaus Rockenbauer

Operations	Maintenance	Management	Investment/Planning
‘Weather’ Forecast (hours-days ahead)	Monthly forecasts (weeks ahead)	Seasonal Climate Forecasts	Climate projections

Seconds Minutes Days Weeks Months Seasons Years Decades

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Peculiarities of Energy Systems

- Capital intensive with long life cycles (30+ years)
- Diversity of sources – each with different emissions, efficiency, reliability, etc.
- National (fragmented) energy markets, sometimes compounded by security issues

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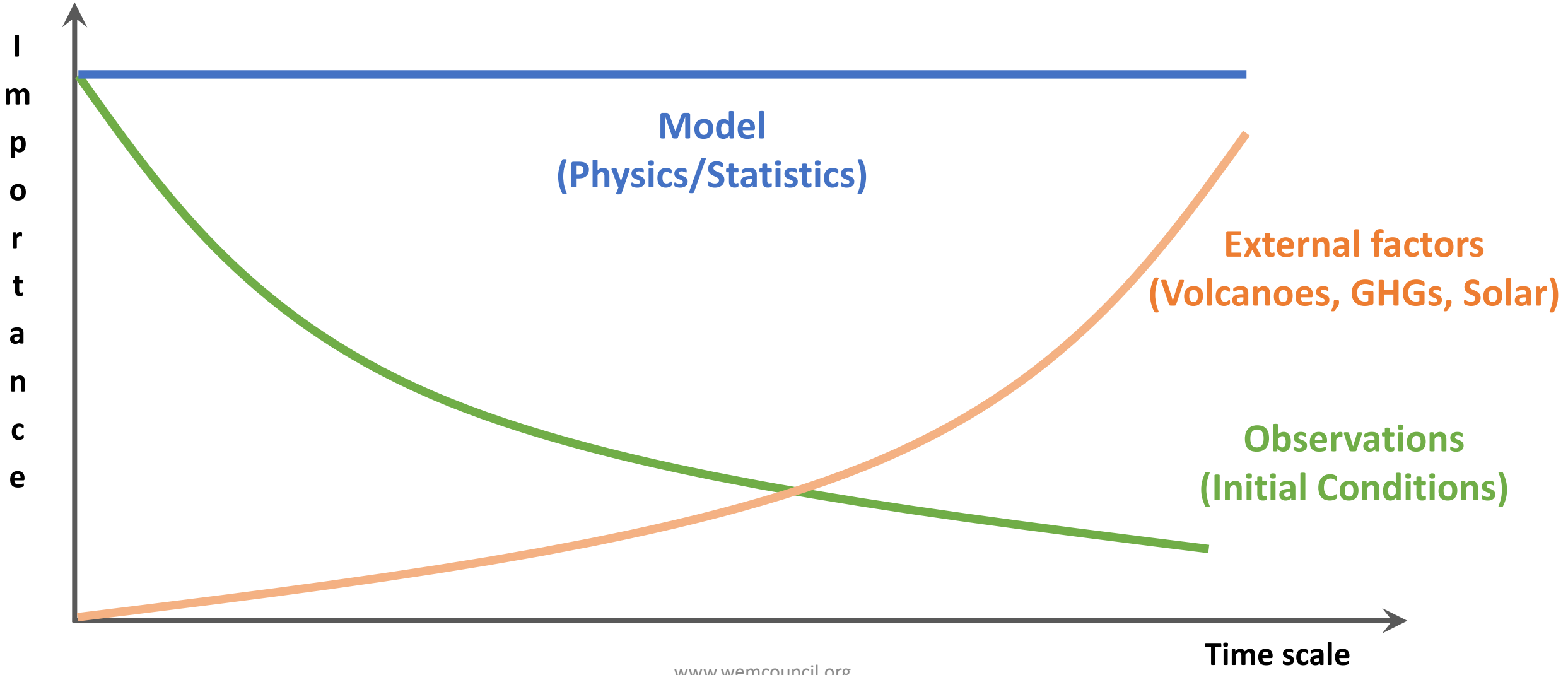
Critical components of a prediction system



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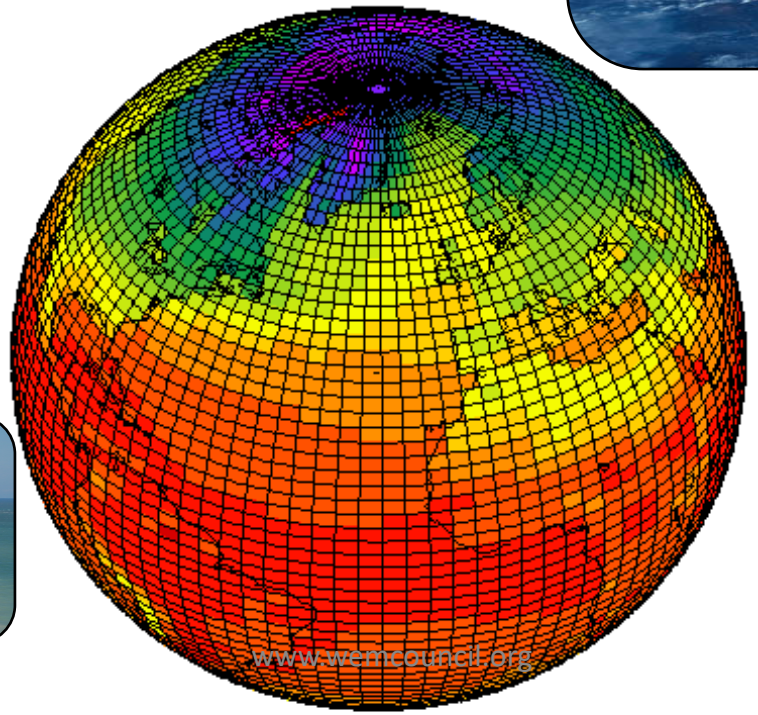
The complexity of the Earth System



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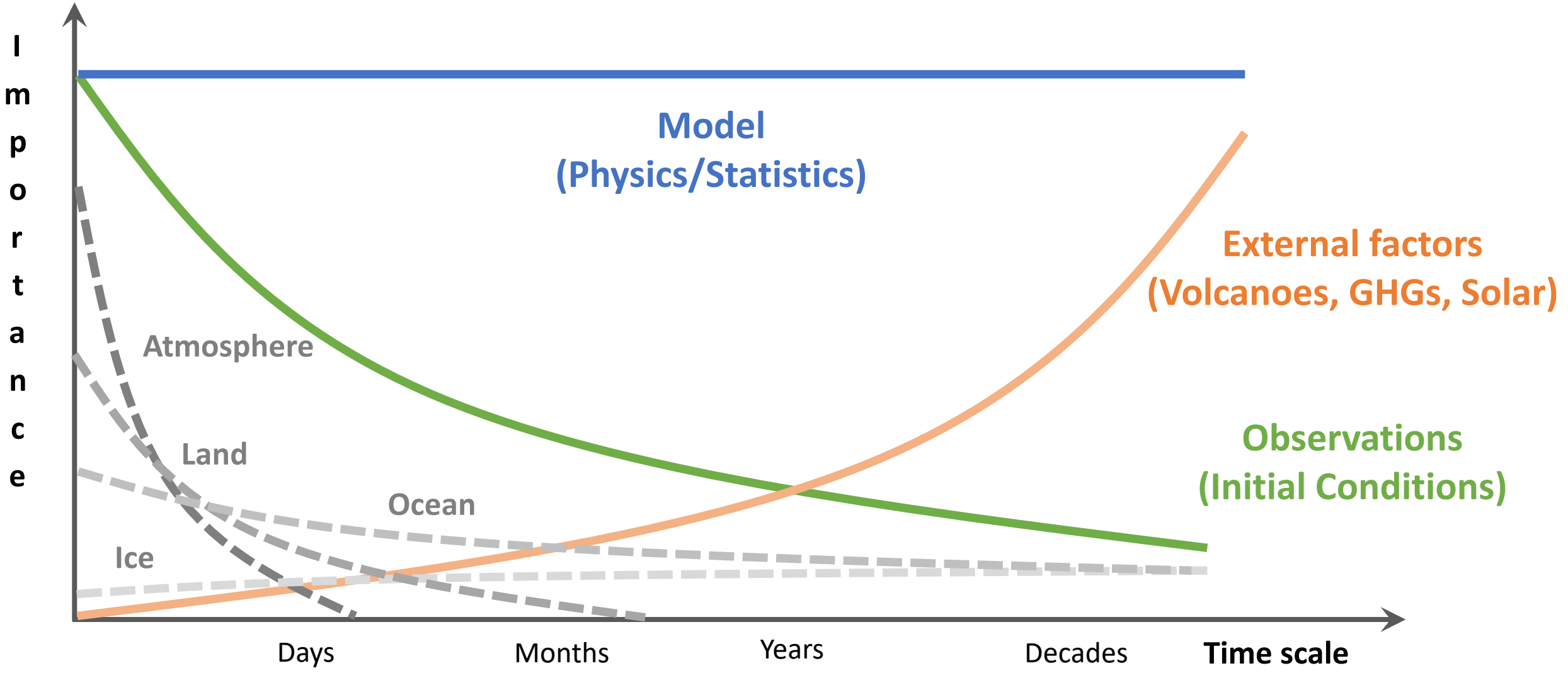
Critical components of a prediction system



The World Energy & Meteorology Council (WEMC)

WEMC primary goal is to enable improved

Sustainable energy

For a low carbon economy

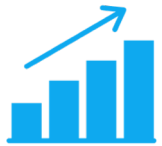
Resilience

Of energy infrastructures

Efficiency

Of energy systems





Under ever changing weather and climate

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Our Activities

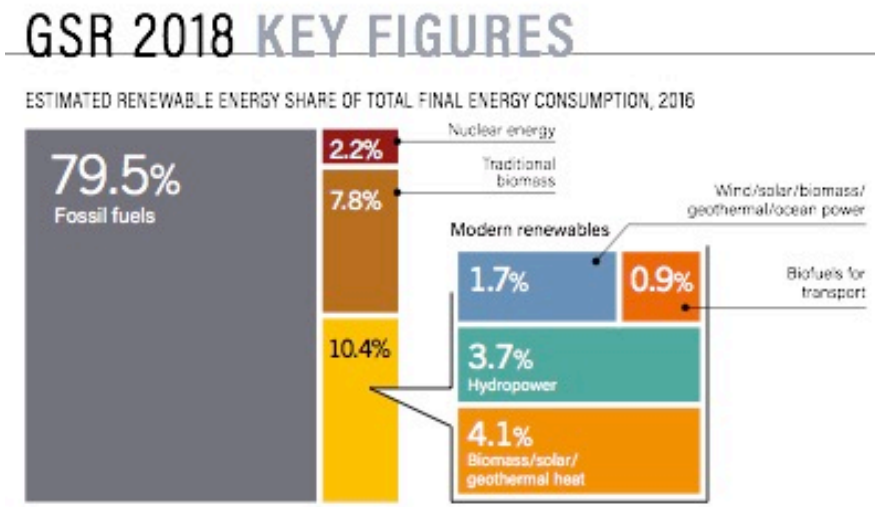
1. The **dissemination of information** on products, practices, and experiences in Energy & Meteorology including the promotion of our members' work

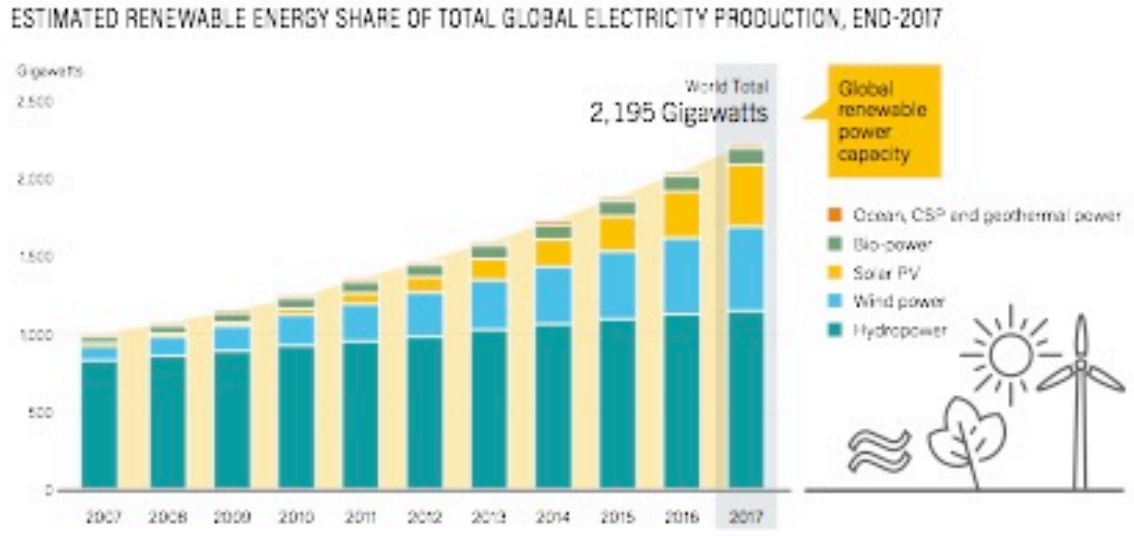
2. The **coordination of Special Interest Groups** leading to the production of reports, analyses and syntheses on key topics in Energy & Meteorology

3. The development and maintenance of **climate and energy demonstration tools** for the energy industry and the education of the general public

4. The **organisation of events** such as the International Conference Energy & Meteorology (ICEM), professional workshops, seminars and webinars

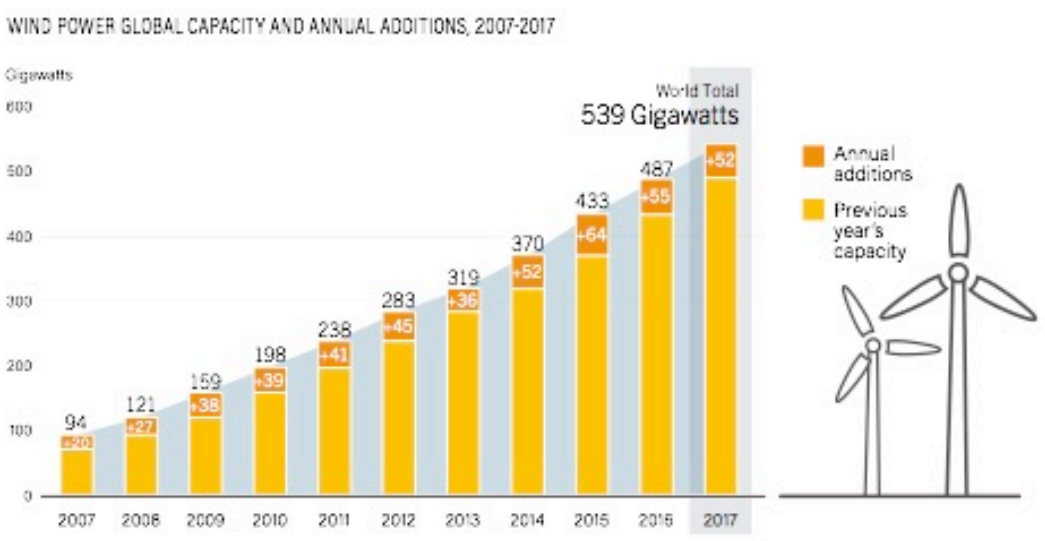
Strong growth in renewables

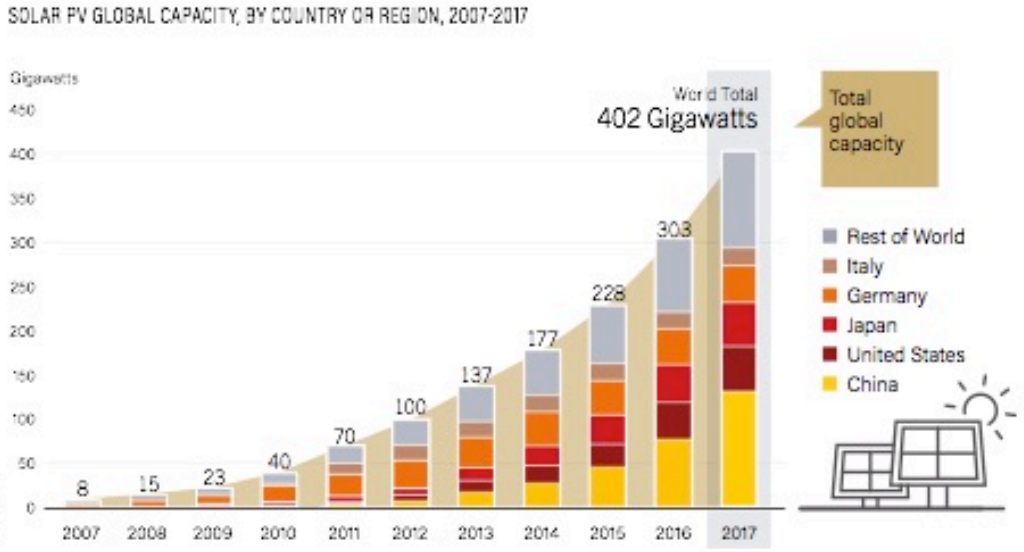




REN21 (2018)

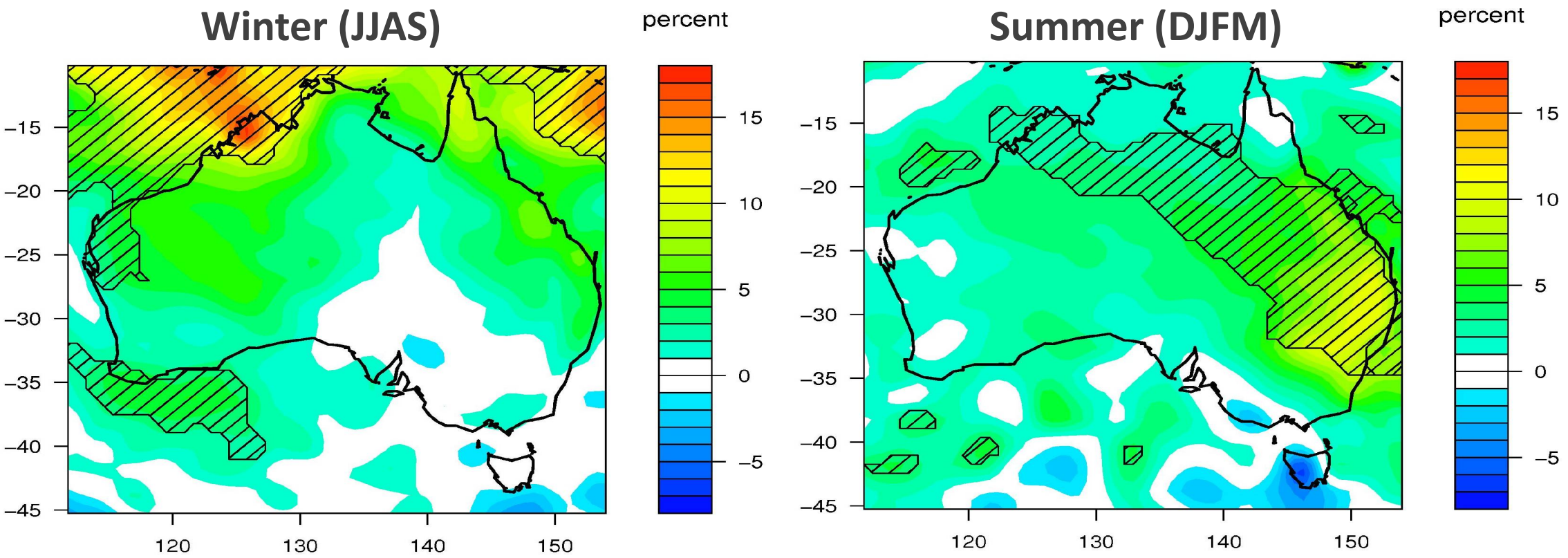
Impressive growth in Wind and Solar





REN21 (2018)

Solar Radiation Inter-annual Variability



Percentage difference in monthly solar radiation in El Niño relative to La Niña

Davy and Troccoli (2012)

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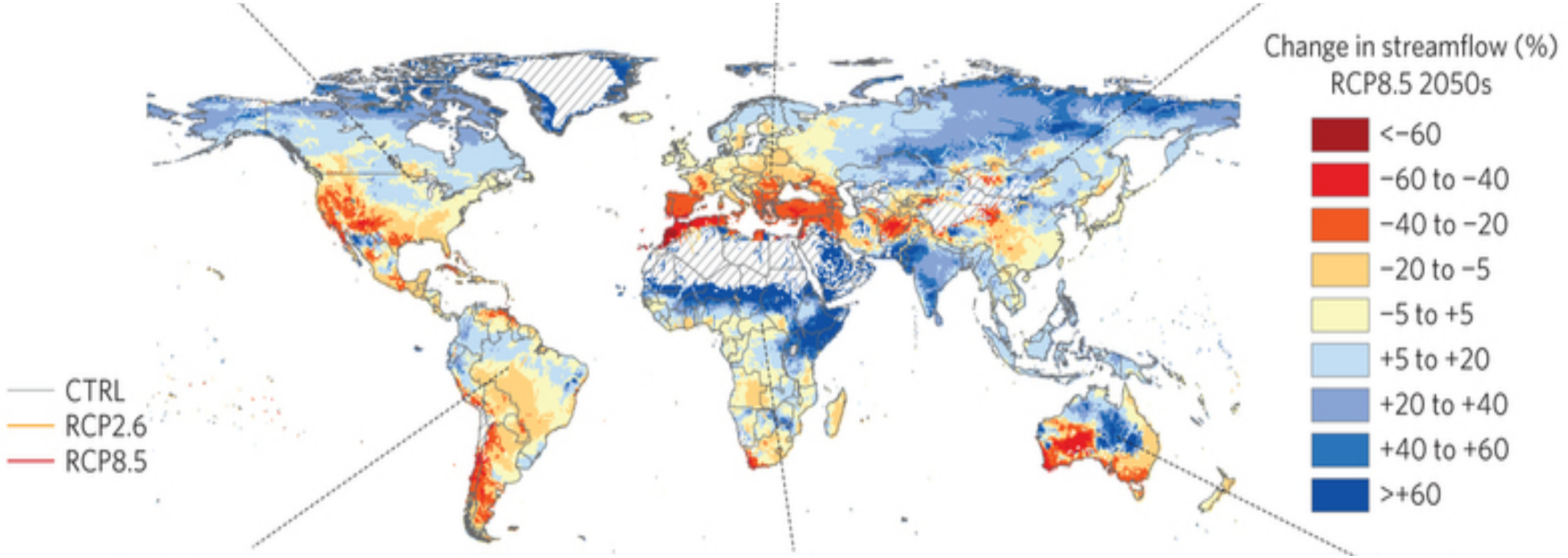
Global changes in streamflow projections



Change in streamflow for RCP8.5, 2040–2069 (2050s) vs1971–2000

Reductions in usable capacity for 61–74% of the hydropower plants

van Vliet et al. (2016)

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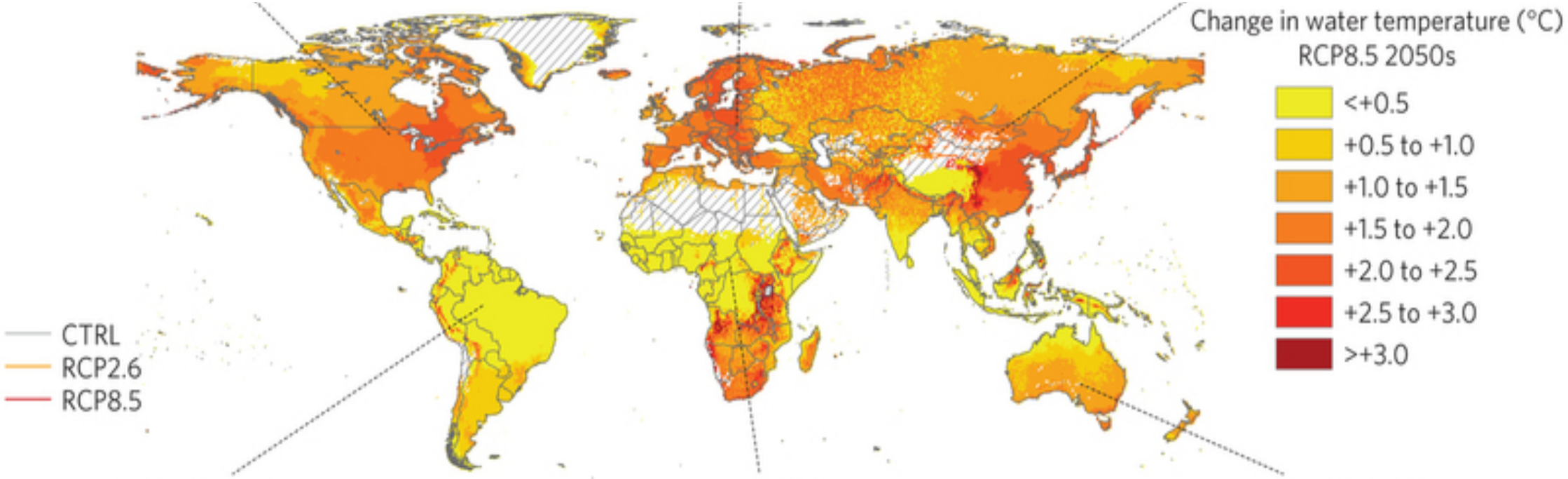
Global changes in water temperature projections



Change in water temperature for RCP8.5, 2040–2069 (2050s) vs 1971–2000

Reductions in usable capacity for 81–86% of the thermoelectric power plants

van Vliet et al. (2016)

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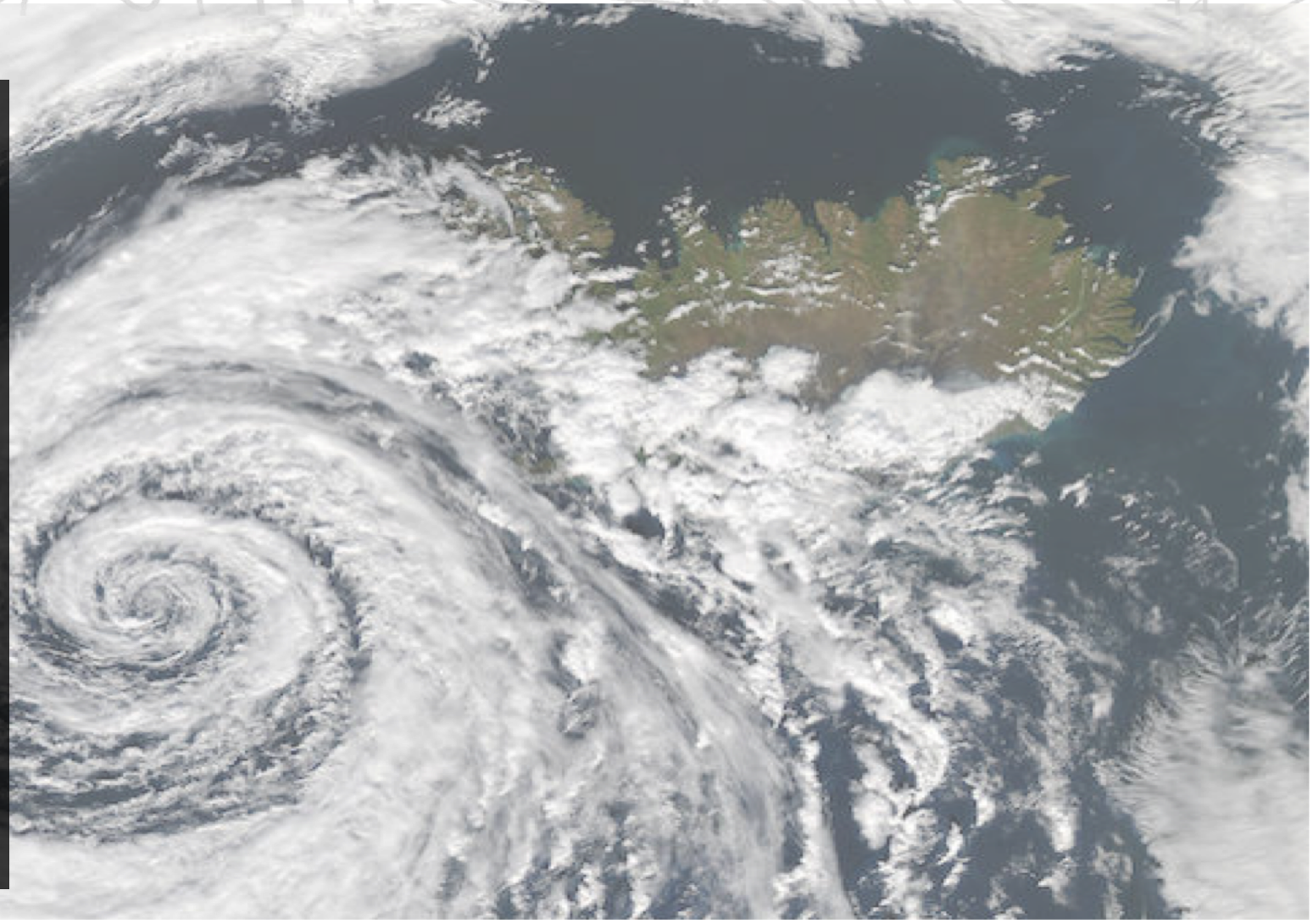
Addressing the ever variable nature of climate



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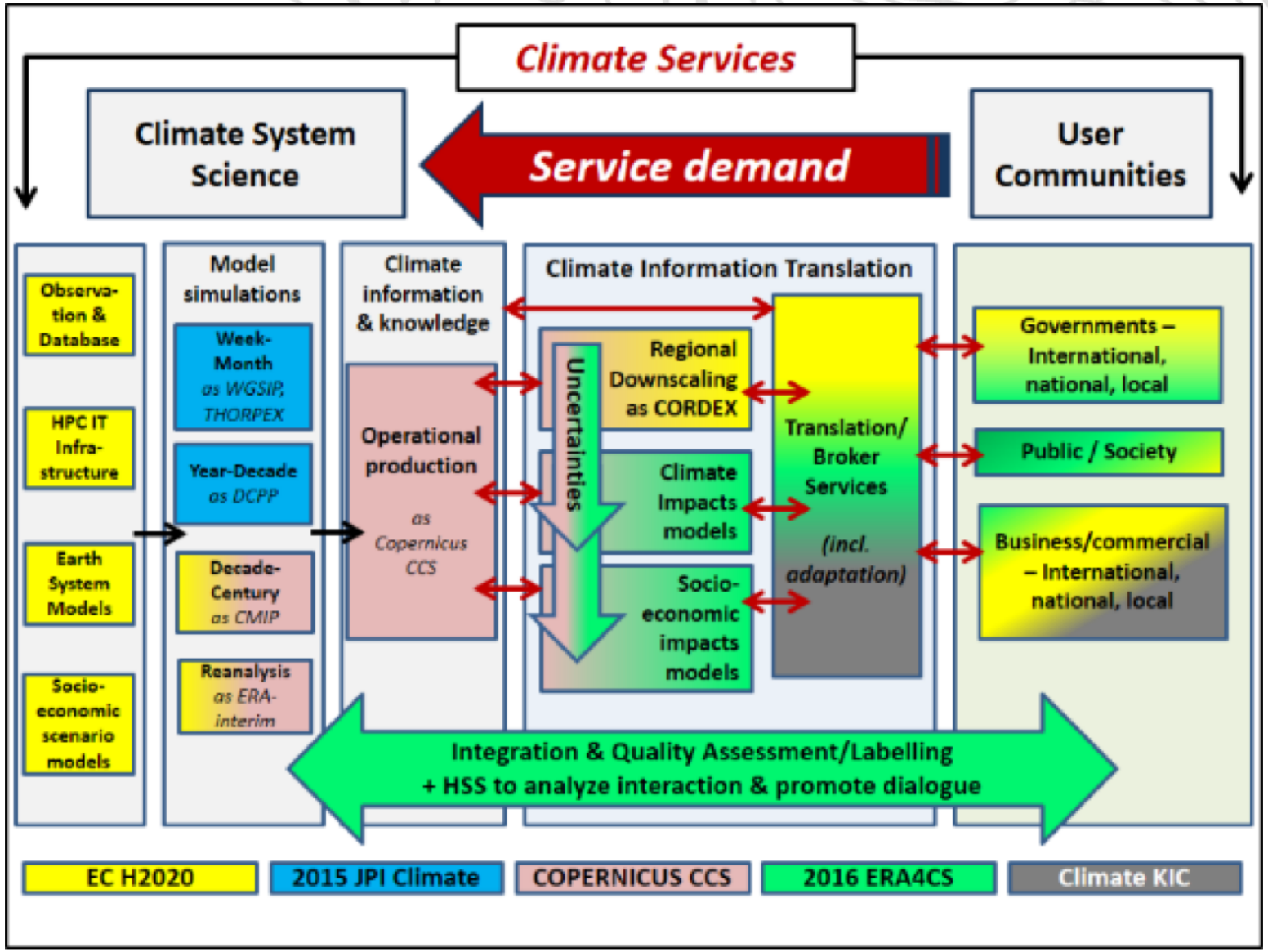
Climate Services Landscape in Europe

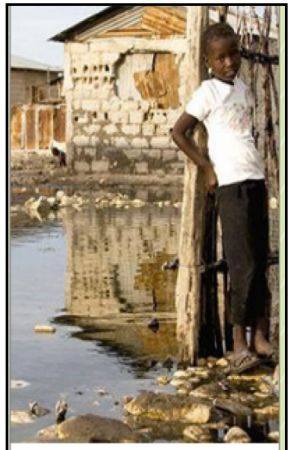


Global Framework for Climate Services

To enable **better management of the risks** of climate variability and change and **adaptation to climate change**, through the development and incorporation of science-based climate information and prediction into planning, policy and practice on the global, regional and national scale.

Priority Areas

Agriculture and food security



Disaster risk reduction

Water

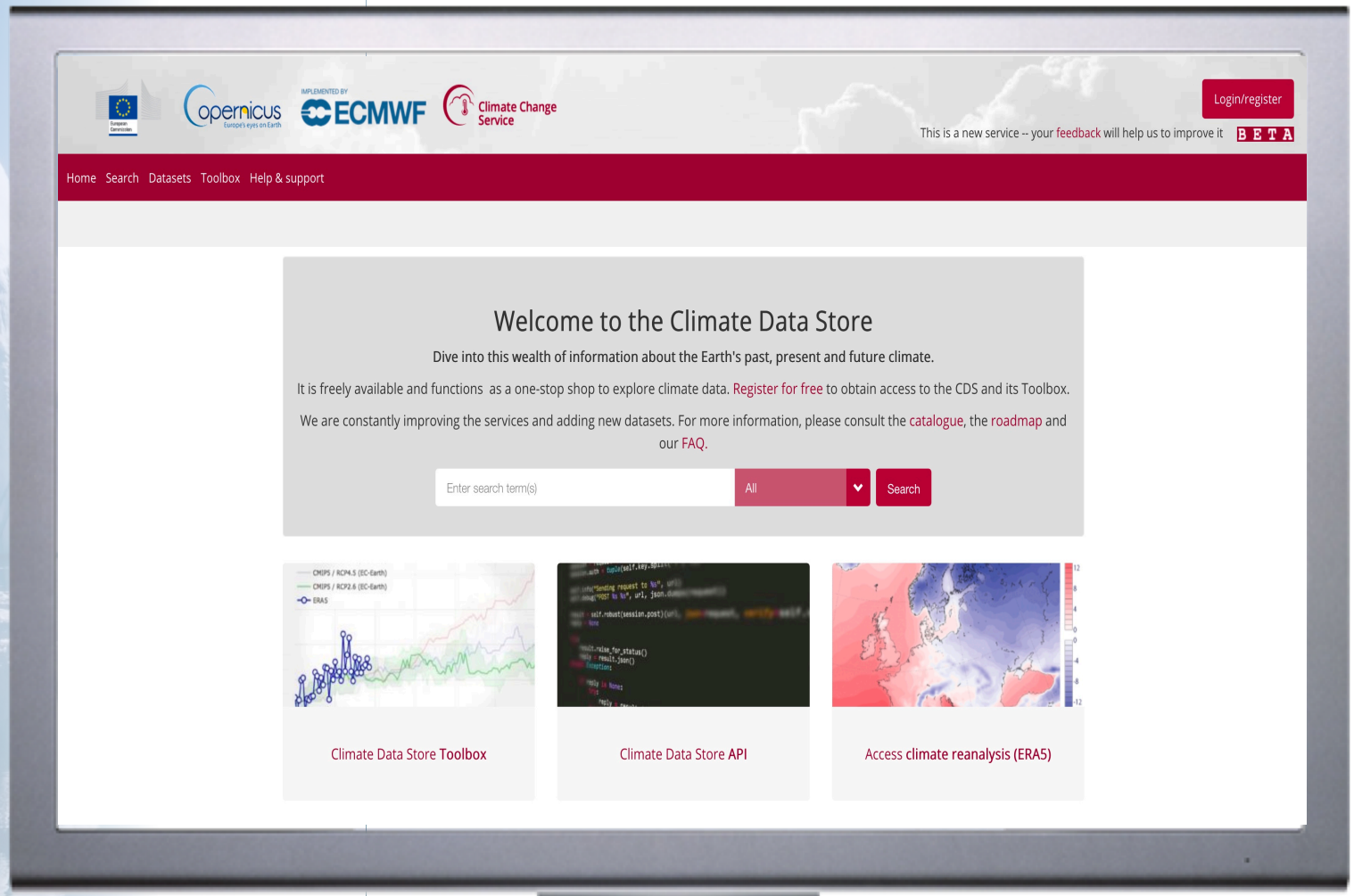
Health

Energy

https://library.wmo.int/doc_num.php?explnum_id=3581

C3S – Climate Data Store

Climate Change



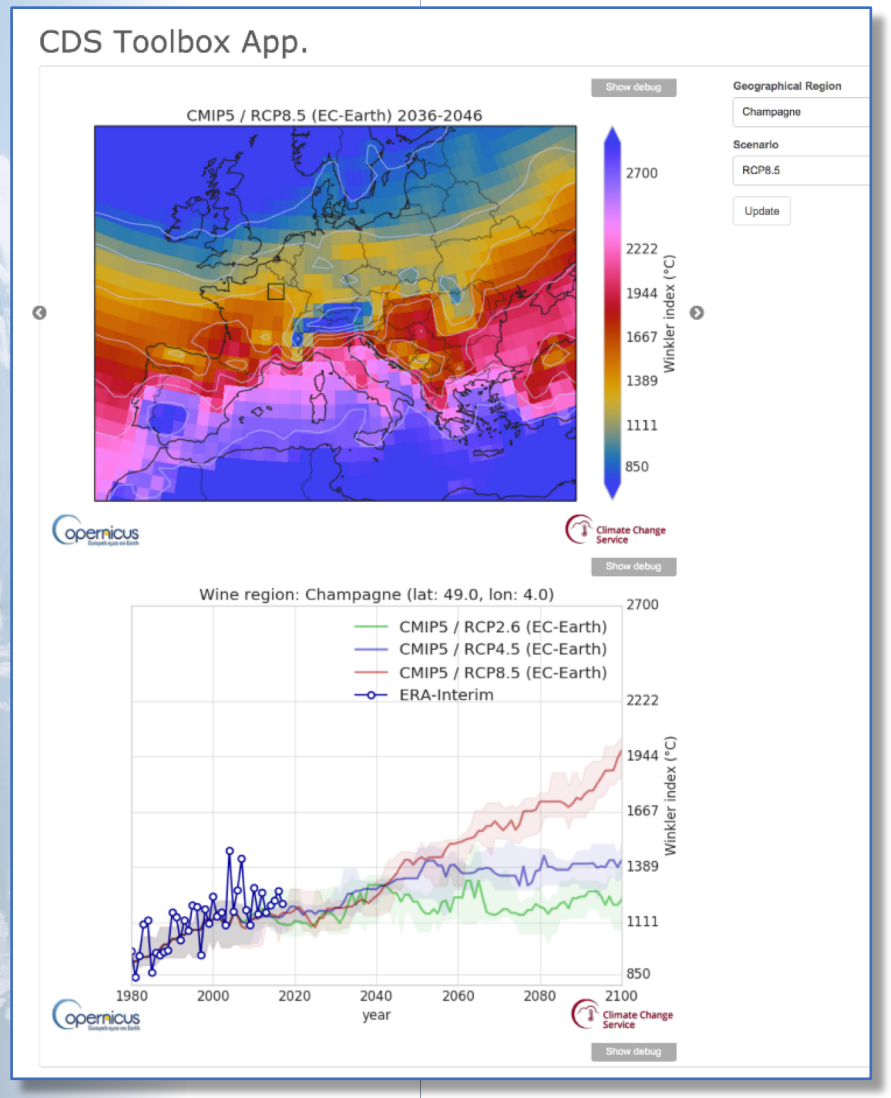
The CDS contains **observations**, global and regional **climate reanalyses**, global and regional **climate projections** and **seasonal forecasts**

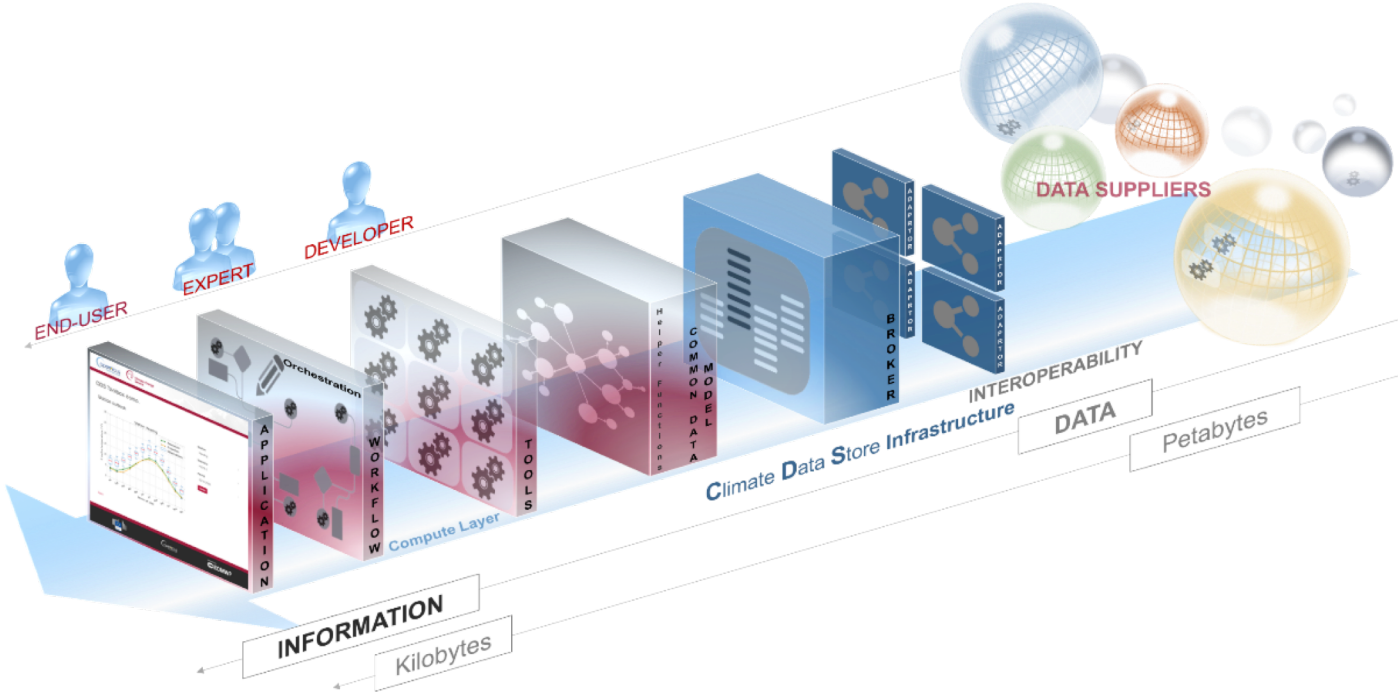
The CDS is designed as a **distributed system**, providing improved access to **existing datasets** through a **unified web interface**

https://cds.climate.copernicus.eu/

Climate Change

Access to tools, workflows and applications

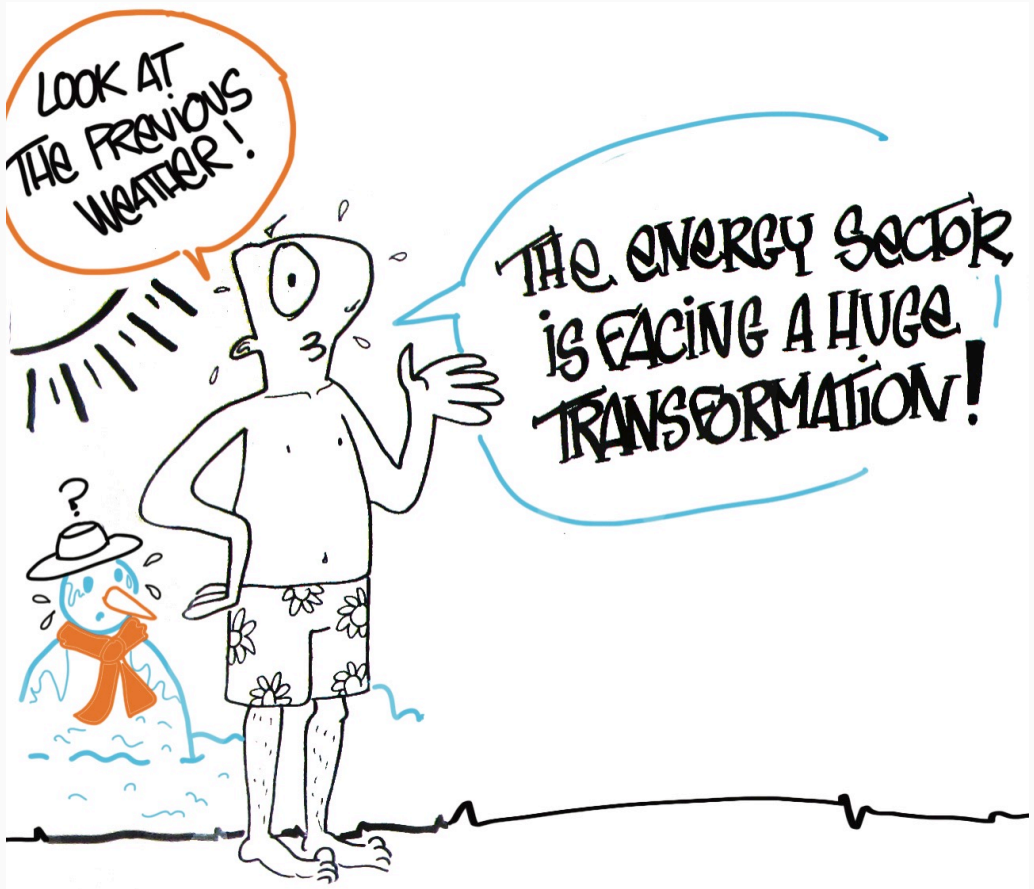




Copernicus Climate Change Service (C3S):

http://www.climate.copernicus.eu

European Climatic Energy Mixes (ECEM)



Increasing share of power supply from variable renewable energy (RE) sources. Demand variability is also increasing.

The transformation is taking place against a **variable and changing climate**.

European Climatic Energy Mixes (ECEM)

Copernicus
Europe's eyes on Earth

Climate Change Service
climate.copernicus.eu

The Copernicus Climate Change Services (C3S) European Climatic Energy Mixes (ECEM) developed a **demonstrator** to assess how well **different energy supply mixes** in Europe will meet demand, over different time horizons, focusing on the role climate has on the mixes.

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University of Reading

Met Office

ARMINES

ENEA

ECMWF

European Commission

European Climatic Energy Mixes (ECEM)

Copernicus
Europe's eyes on Earth

Climate Change Service
climate.copernicus.eu

Calibrated Climate Variables

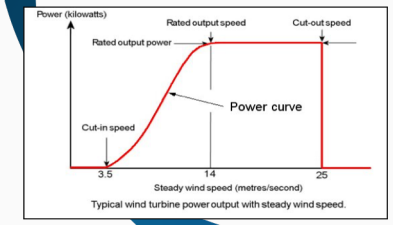
- Temperature
- Rainfall
- River Discharge
- Wind Speed
- Cloud Cover
- Solar Radiation
- Others ?

+Ancillary

- Skill & Reliability
- Assessment of Seasonal Forecasts of Energy Variables

+ Extreme Events Case Studies

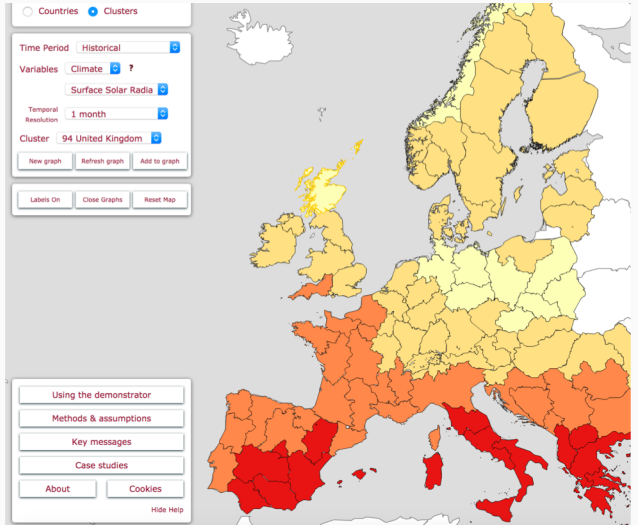
Define models & transfer functions
Select / Gather relevant datasets



Energy Variables

- Demand
- Hydro Power
- Wind Power
- Solar Power
- Thermal Power

- Sub-Country Scale
- Historical Period
- Seas. Fcst
- Clim. Proj.



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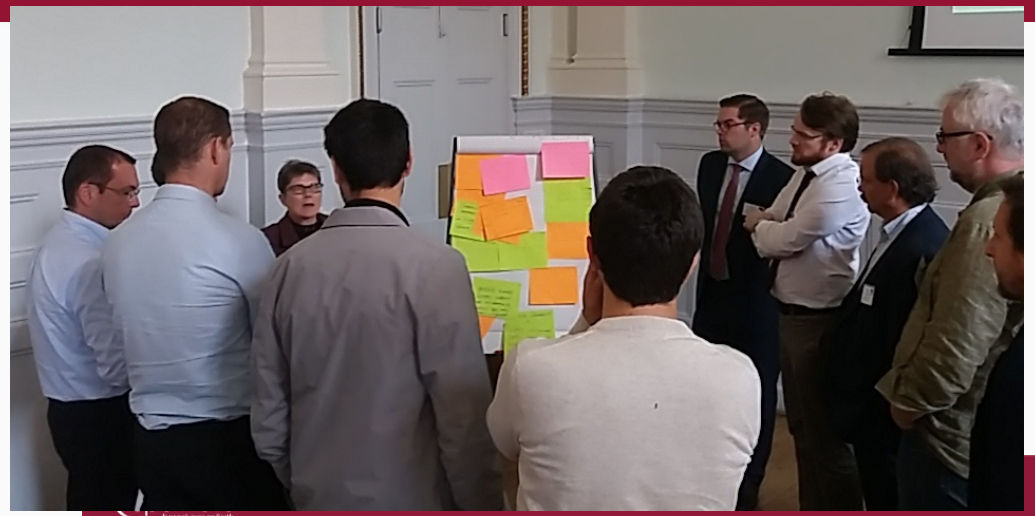
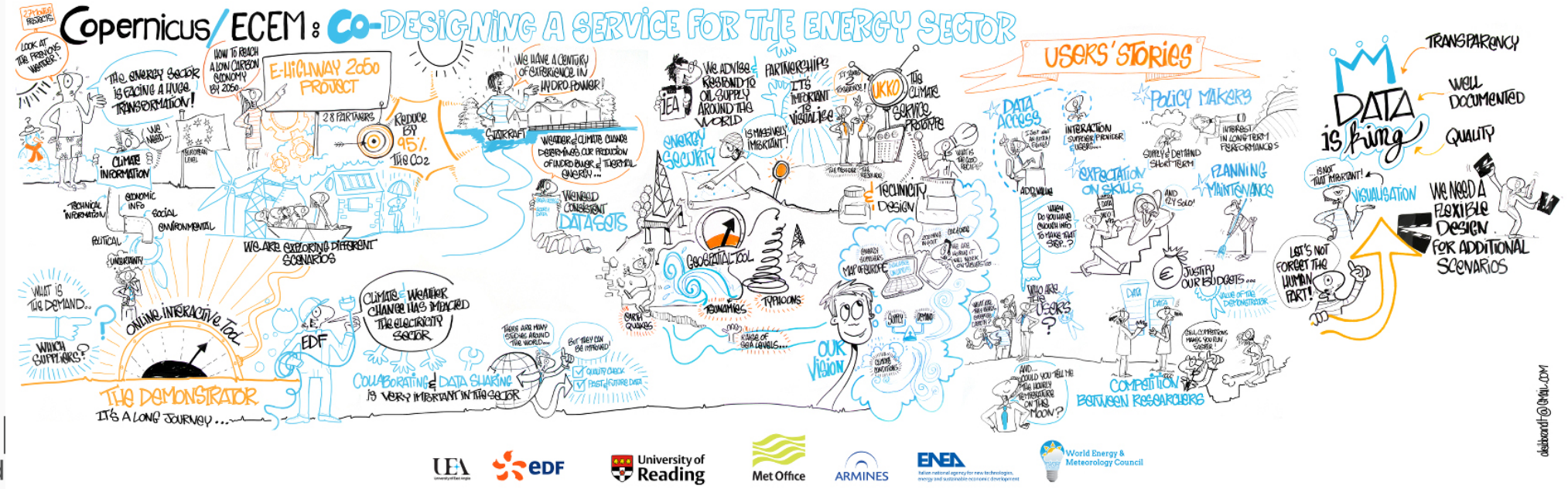
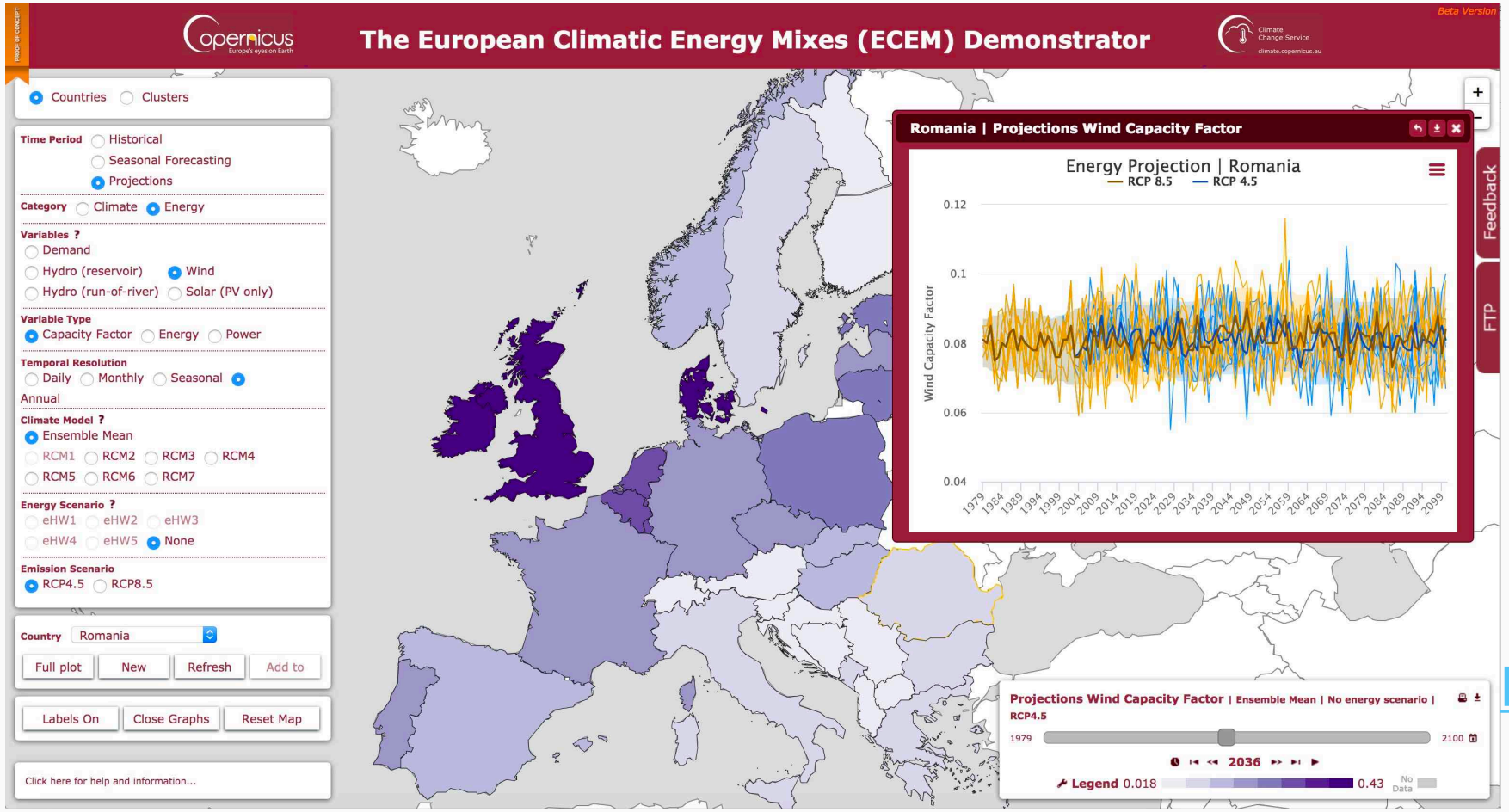
Stakeholder Engagement: Workshops





An online interactive tool to test energy mixes



https://www.youtube.com/watch?v=U-w5_sTHqG4

http://ecem.wemcouncil.org

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EDF

University of Reading

Met Office

ARMINES

ENEA

ECMWF

European Commission

The C3S ECEM Demonstrator

https://www.youtube.com/watch?v=U-w5_sTHqG4

Seasonal Forecasting systems used in C3S ECEM

Originator	Forecast System	Model	Spatial resolution	Hindcast period	Hindcast ensemble size	Forecast ensemble size
ECMWF	System 4	IFS Cyc36r4	T255 L91 (~ 80 km)	1981–2010 (30 years)	51	51
Météo-France	System 5	Arpege-IFS Cyc37	T255 L91 (~ 80 km)	1993–2014 (22 years)	15	51
Met Office	GloSea5-GC2	HadGEM3-GC2	N216 L85 (~ 60 km)	1993–2015 (23 years)	28	42

Bett et al (2017)

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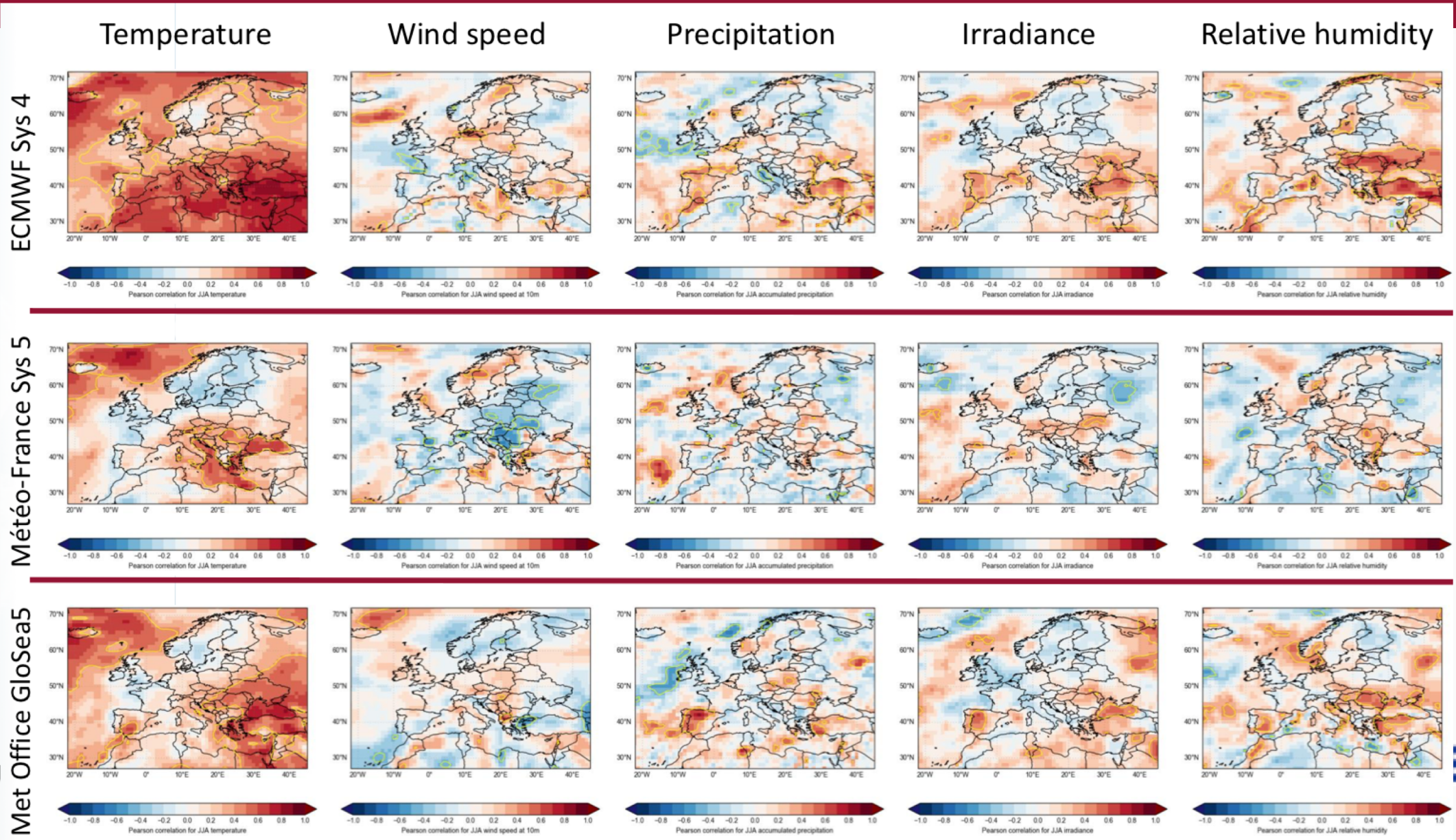
UEA University of East Anglia · EDF · University of Reading · Met Office · ARMINES · ENEA

ECMWF · European Commission

Seasonal forecasting skill: correlations for summer



Bett et al (2017)

Seasonal forecast: summary table skill for Summer

Country		Met Office					ECMWF					Météo-France				
Code	Name	WS	TA	RH	TP	GHI	WS	TA	RH	TP	GHI	WS	TA	RH	TP	GHI
AL	Albania	- - -	- - -	- - -	- - -	- - -	- - -	C- -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
AT	Austria	- - -	- - -	- - -	- - -	- - -	- - -	- -R	- - -	- - -	- - -	- - -	C- -	- - -	- - -	- - -
BE	Belgium	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	C- -	- - -	- - -	- - -	- - -	- - -	- - -
BA	Bosnia-Herzegovina	- - -	C- -	- - -	- - -	- - -	- - -	C- -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
BG	Bulgaria	- - -	C- -	- - -	- - -	- - -	- - -	C-R	C-R	- - -	- - -	- - -	C-R	- - -	- - -	- - -
HR	Croatia	- - -	C- -	C- -	- - -	- - -	- - -	C-R	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
CZ	Czechia	- - -	- - -	- - -	- -R	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
DK	Denmark	C-R	- - -	C-R	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
EE	Estonia	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
FI	Finland	- - -	- - -	- - -	- - -	- - -	- - -	C- -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
FR	France	- - -	- - -	- - -	- - -	- - -	- - -	C-R	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
DE	Germany	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
GR	Greece	- - -	C- -	- - -	- - -	- - -	- - -	C-R	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
HU	Hungary	- - -	C- -	C- -	- - -	- - -	- - -	C-R	CBR	- - -	- - -	- - -	C- -	- - -	- - -	- - -
IE	Ireland	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
IT	Italy	- - -	- - -	- - -	- - -	- - -	- - -	C-R	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
LV	Latvia	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
LT	Lithuania	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
LU	Luxembourg	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
MK	Macedonia	- - -	- - -	- - -	- - -	- - -	- - -	C- -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
ME	Montenegro	- - -	C- -	- - -	- - -	- - -	- - -	C- -	- - -	- - -	- - -	- - -	C- -	- - -	- - -	- - -
NL	Netherlands	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
NO	Norway	- - -	- - -	- - -	- - -	- - -	- - -	- -R	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
PL	Poland	- - -	- - -	- - -	- - -	- - -	- -R	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
PT	Portugal	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
RO	Romania	- - -	CBR	C- -	- - -	- - -	- - -	CBR	C-R	- - -	- - -	- - -	C-R	- - -	- - -	- - -
RS	Serbia	- - -	C- -	- - -	- - -	- - -	- - -	C- -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
SK	Slovakia	- - -	C- -	- - -	- - -	- - -	- - -	- -R	C-R	- - -	- - -	- - -	C- -	- - -	- - -	- - -
SI	Slovenia	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
ES	Spain	- - -	- - -	- - -	C- -	- - -	- - -	CBR	C-R	- - -	- - -	- - -	- - -	- - -	- - -	- - -
SE	Sweden	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
CH	Switzerland	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
UK	United Kingdom	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -

JJA skill:

Where a skill score is significantly greater than zero, it is marked with a **C** (correlation), **B** (Brier skill score) or **R** (ROC skill score).

Colours: 1 score, 2 scores, 3 scores

Skill is diverse across models, variables and seasons.

Having more significant skill scores can add confidence, but the behaviour of the models should be examined in detail for each use case.

Bett et al (2017)

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Seasonal Forecast of PV CF

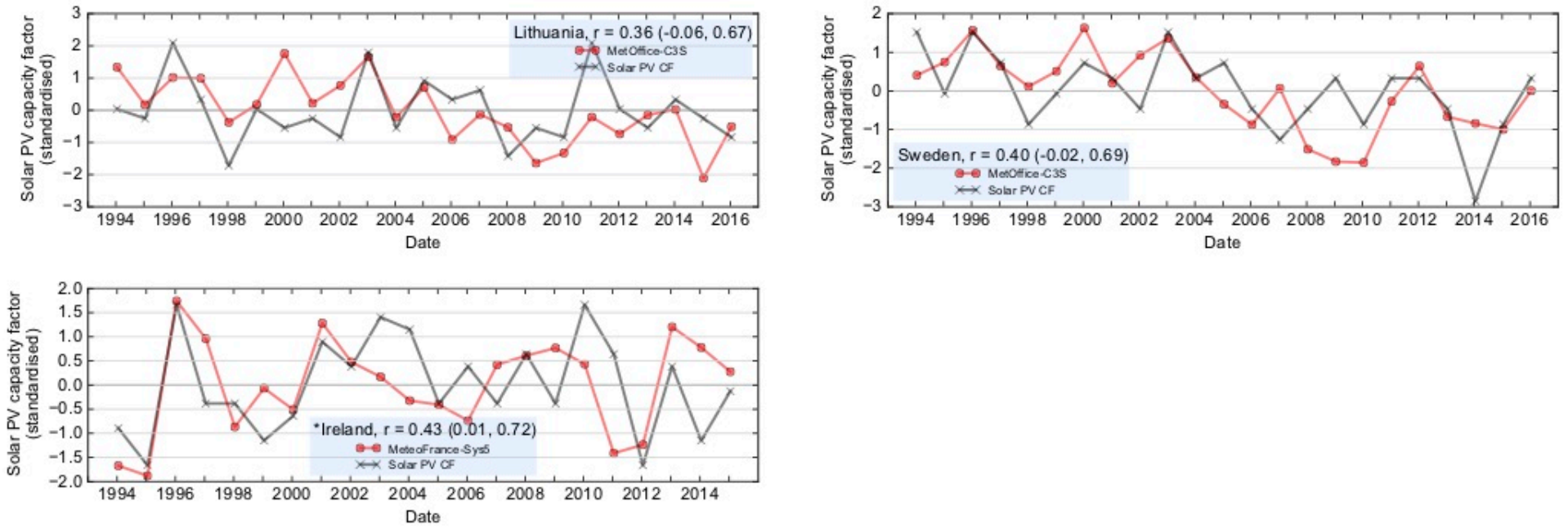

Figure 5: Standardised time series of forecasts of DJF solar PV capacity factor, using irradiance as the predictor. Top: results from the Met Office system, for Lithuania (left) and Sweden (right). Bottom: Similar forecasts for Ireland, using the Météo-France system. In each panel, the hindcast is shown in red, and the ECEM historical energy data is shown in black, in standardised units (see equation 2). The correlation skill r is shown in the legend with 95% confidence intervals; an asterisk * indicates significance based on these intervals.

Bett et al (2017)

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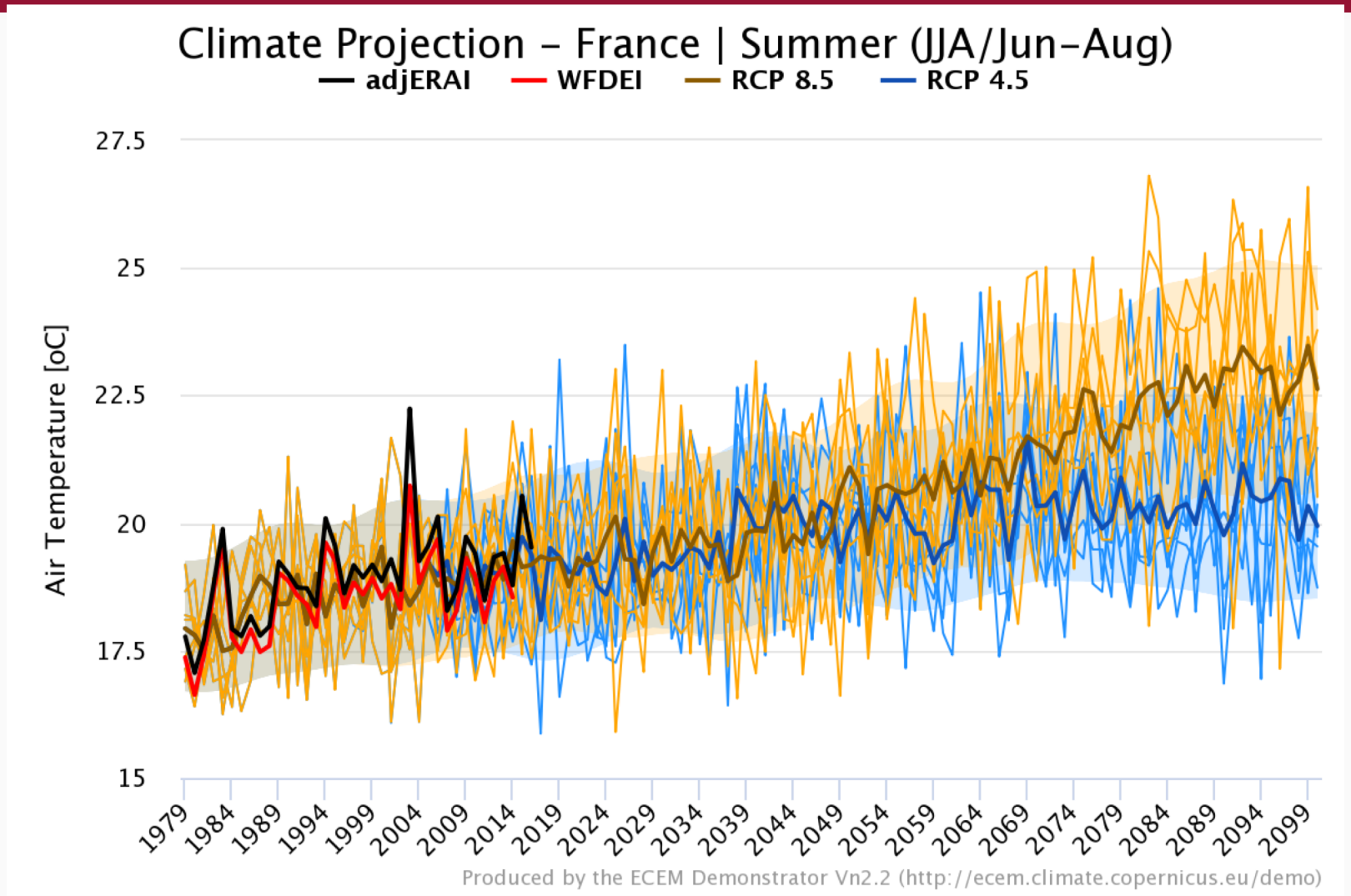
Climate Projection time series – Temperature



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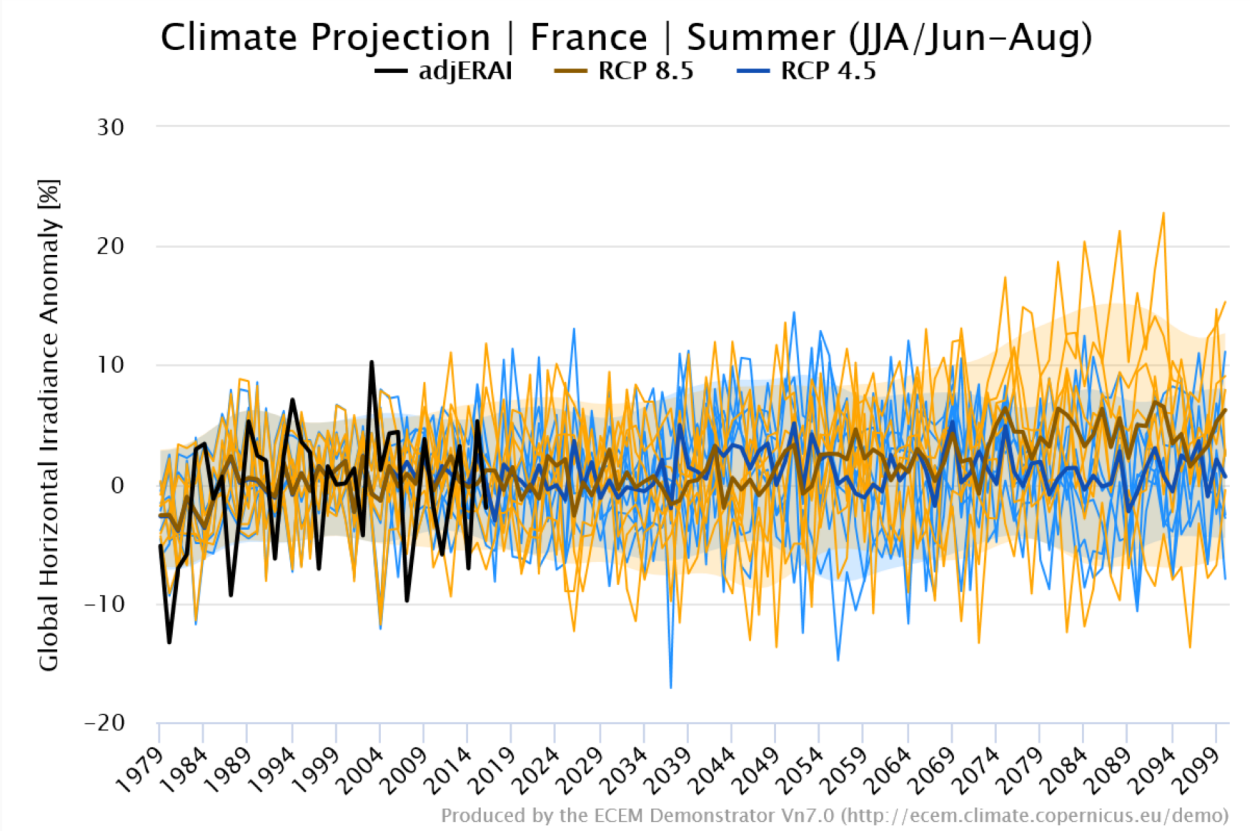
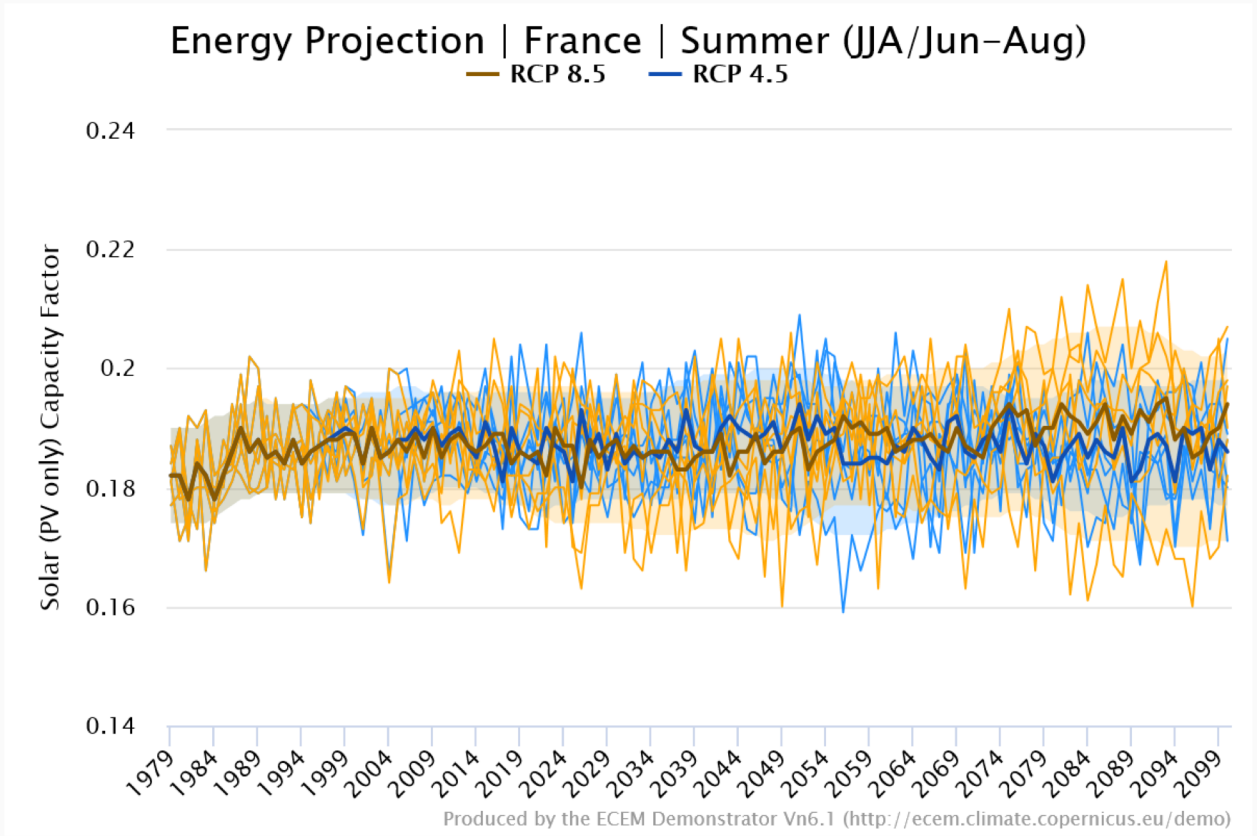
Climate Projection time series – Solar Rad & Power





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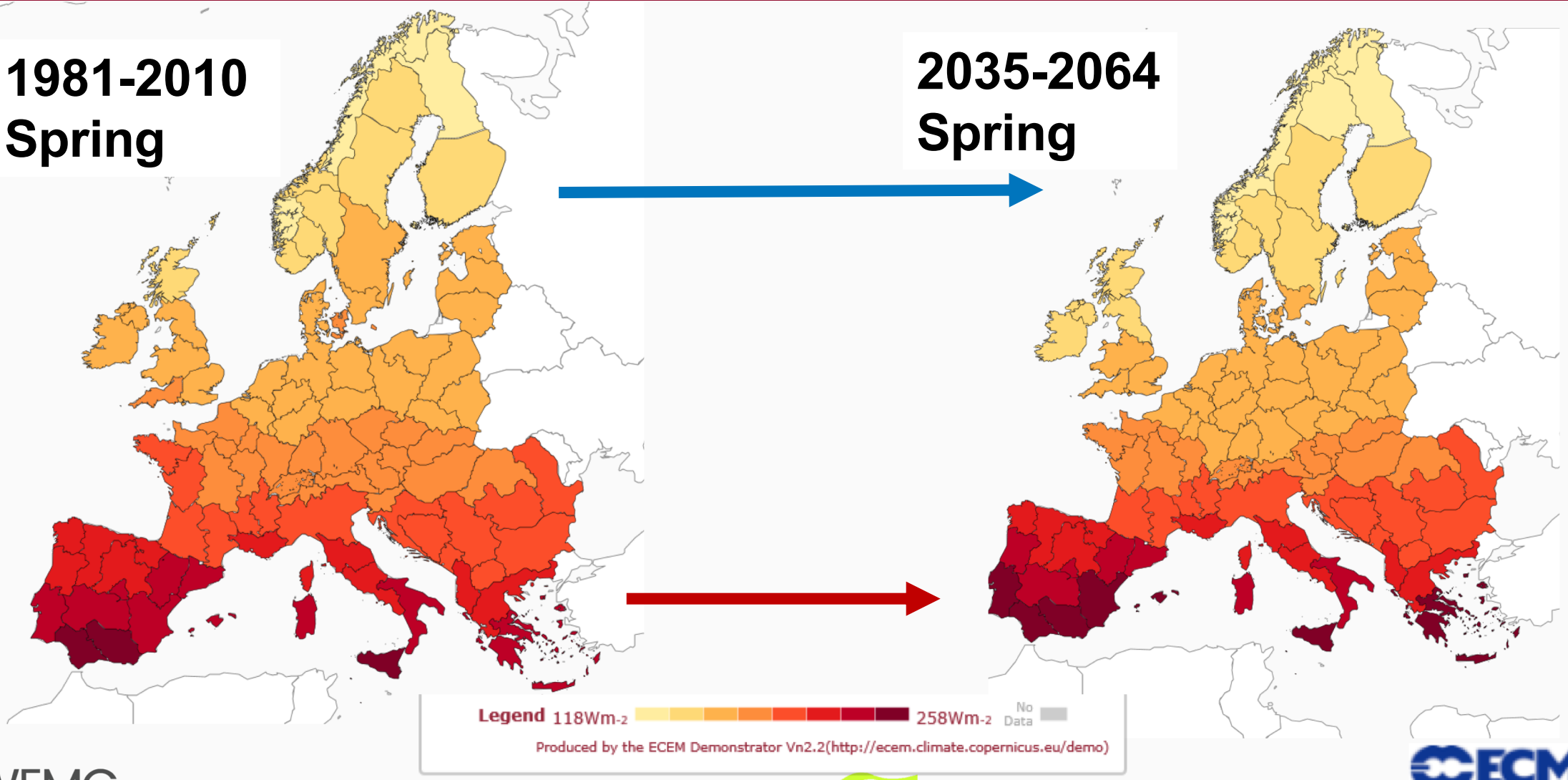
Climate Projection (RCP 8.5) Radiation



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Projected changes in Solar Rad. Global vs Regional models

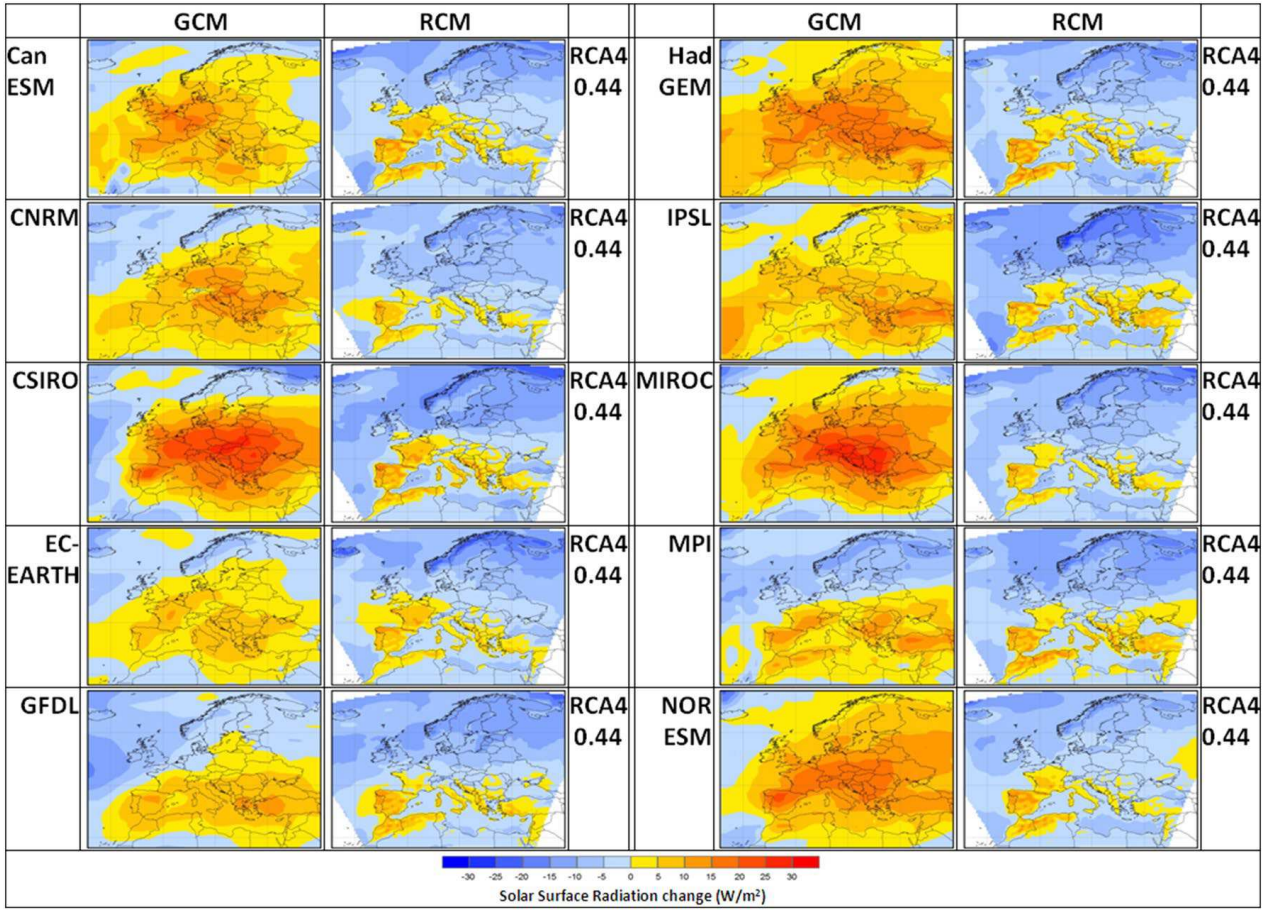

Fig. 2 Annual projected changes in SSR in the RCA4 regional model and in different driving GCMs. The changes are defined as the difference between the future projections for RCP8.5 (2071–2100) and the historical simulation (1971–2005)

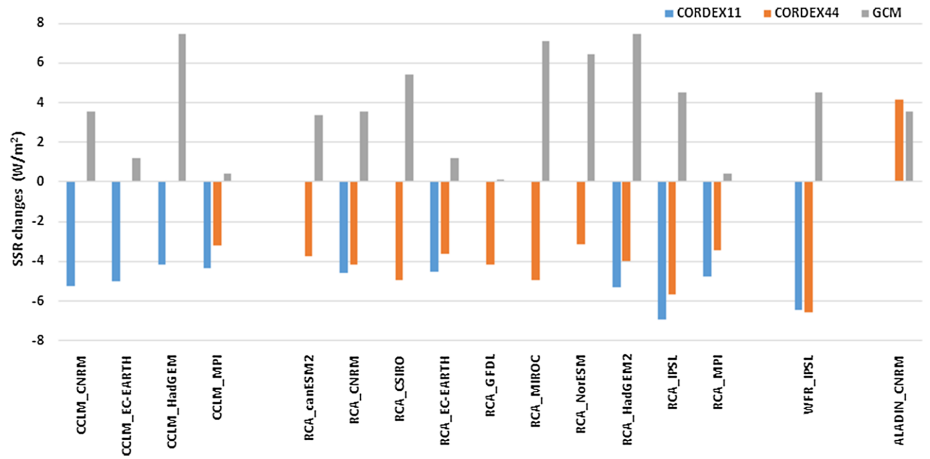

Fig. 3 Annual changes in SSR in individual RCMs (first name on x axes) and in GCM applied as boundary conditions (second name on x axes) over the European domain. *Blue columns* depict changes for RCMs with 0.11° resolution, *orange columns* depict changes for RCMs with 0.44° resolution, and *grey columns* depict changes in GCMs. The changes are defined as the difference between the future projections of RCP8.5 (2071–2100) and historical simulation (1971–2005)

Bartok et al (2016)

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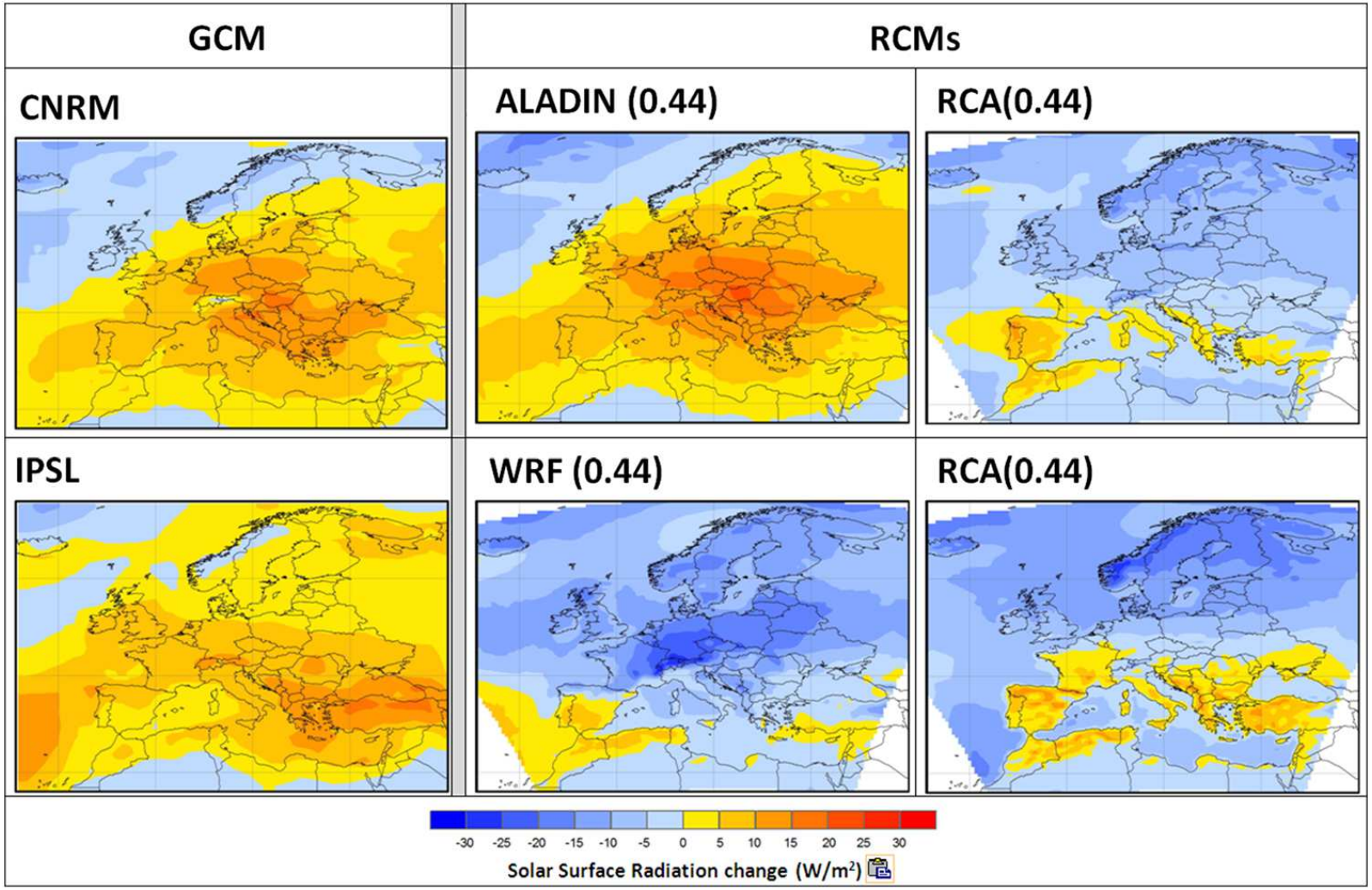
Projected changes in Solar Rad. Global vs Regional models



Bartok et al (2016)

Want to learn more about C3S ECEM?

For more information about C3S ECEM please visit:

http://ecem.climate.copernicus.eu

and the demonstrator can be accessed at:

http://ecem.wemcouncil.org

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SECLI FIRM

The Added Value of Seasonal Climate Forecasting for Integrated Risk Management

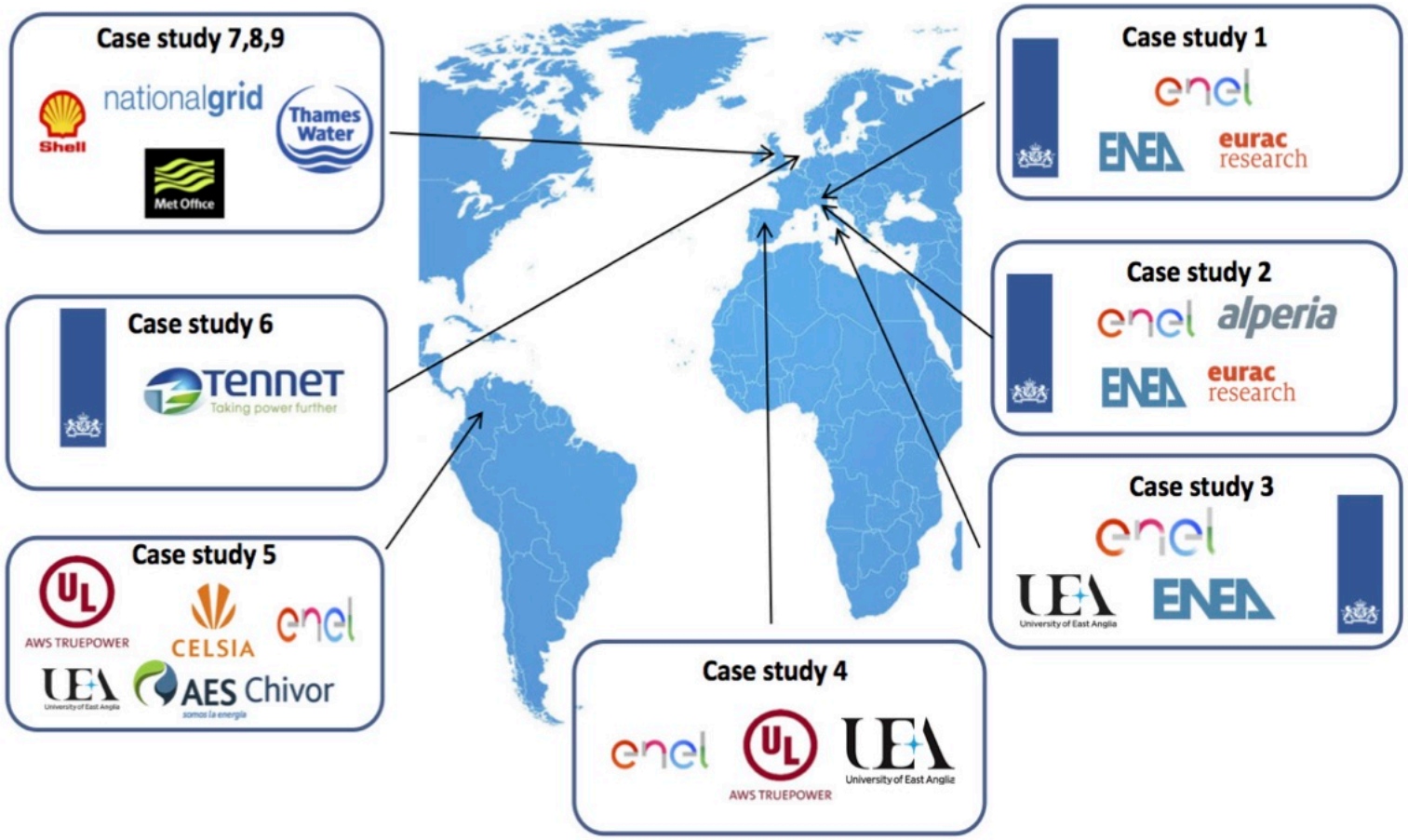
How can seasonal climate forecasts help your business?

University of East Anglia
enel
ENEA Italian national agency for new technologies, energy and sustainable economic development
Met Office
AWS TRUEPOWER
WEMC World Energy & Meteorology Council
eurac research
alperia

Grant Agreement n. 776868

The How – Experiments

Nine cases for Europe and S. America will be investigated. These represent recent seasons with anomalous climate conditions leading to problematic and quantifiable impacts for the energy and/or water industry. They will be co-designed by industrial and research partners



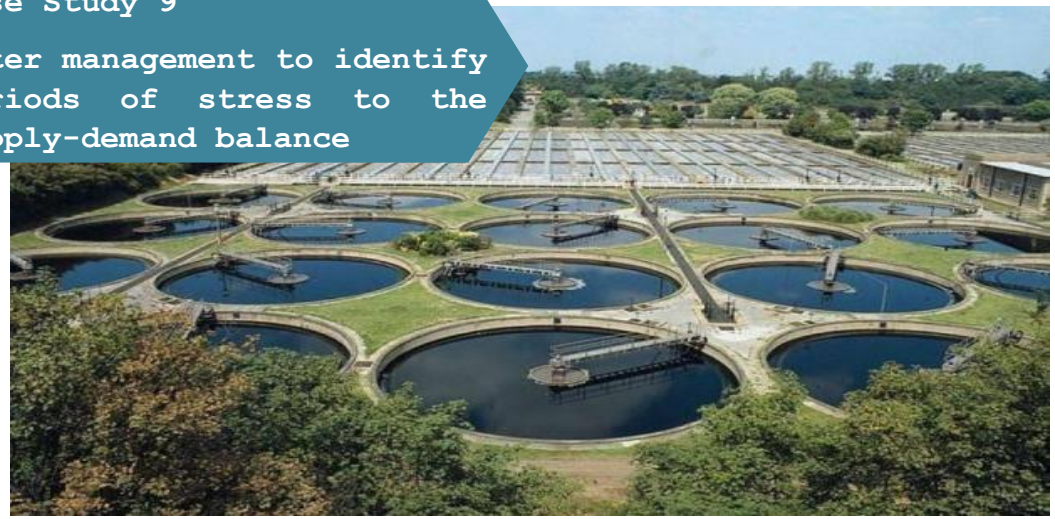
Grant Agreement n. 776868

Case Study – Water

Use of seasonal forecasts for water management to identify periods of stress to the supply-demand balance

Case Study 9

Water management to identify periods of stress to the supply-demand balance



By targeting periods of stress to the UK supply-demand balance, we will assess the role of seasonal forecasts in the operational management of the water system and in the experience of the consumer through supply restrictions

DRAFT DOCUMENT – v0

Case Study 9

Water management to identify periods of stress to the supply-demand balance

Executive Summary: Use of seasonal forecasts for water management to identify periods of stress to the supply-demand balance.

Boosting Decision Making

The water industry case studies will explore the application of seasonal forecasting to identify periods of stress to the UK supply-demand balance. These seasonal signatures may highlight chronic or acute periods of stress many weeks out, which will affect the operational management of the water system and experience of the consumer through supply restrictions.

The seasonal forecasting context

The ability to identify periods of chronic stress (prolonged excessively high demand) including conditions indicative of a drought or extreme prolonged peaks in demand due to long periods of below average temperatures or dry and hot summers will be explored. If such conditions were predictable at seasonal resolution, it would help flag high demand and support preparedness in terms of capacity and demand management. The ability to identify acute stress (highly variable demand) including heat waves or extremely cold winter conditions will also be explored. If such conditions were predictable at seasonal resolution, it would help flag high variability in demand and support preparedness in terms of resilience.

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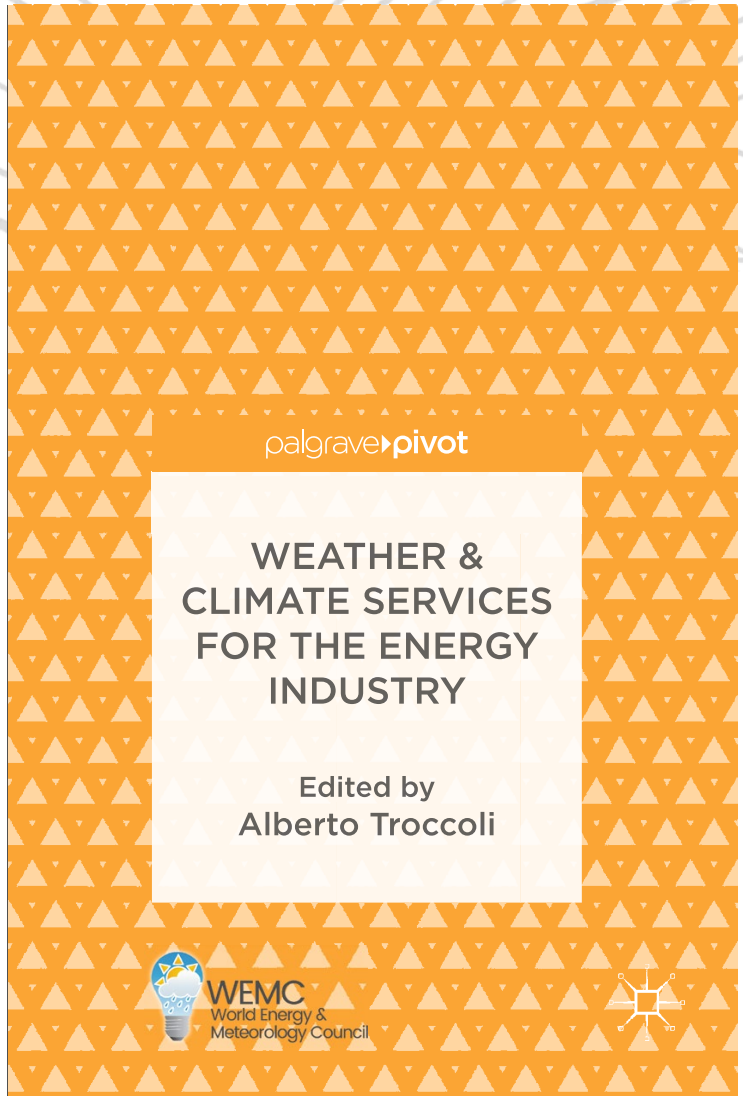
Grant Agreement n. 776868



To download it (it's free!), please visit:
https://link.springer.com/book/10.1007%2F978-3-319-68418-5 or
http://www.wemcouncil.org/wp/resources/

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Save the date – 24-27 June 2019
Lyngby, Copenhagen, Denmark

http://www.wemcouncil.org/wp/icem2019/

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Summary

- Meteorology and Energy, as well as other sectors, are closely connected
- Energy systems, and society more generally, are already experiencing sizeable climate impacts, which are likely to become more severe
- Climate services (with seasonal climate forecast, climate projections, but also reconstructions of the past) are emerging as useful tools for Energy planning, and operations/maintenance
- Despite emerging use of climate in energy (and other) sectors, there is a strong need:
  - to improve knowledge of meteorological data and processes
  - to improve access to meteorological and energy data for improved products

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Thank You

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