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Meteorology Council

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

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

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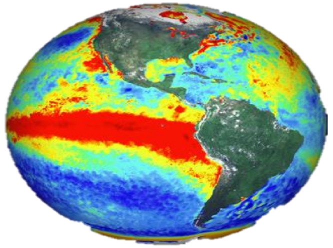

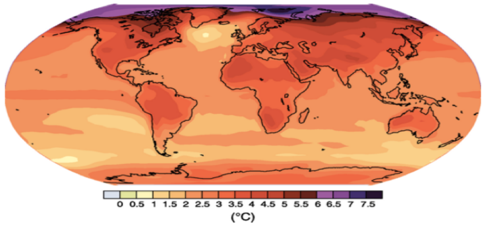

Passing clouds → **Drop in solar power**

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 → 'Weather' Forecast (hours-days ahead)

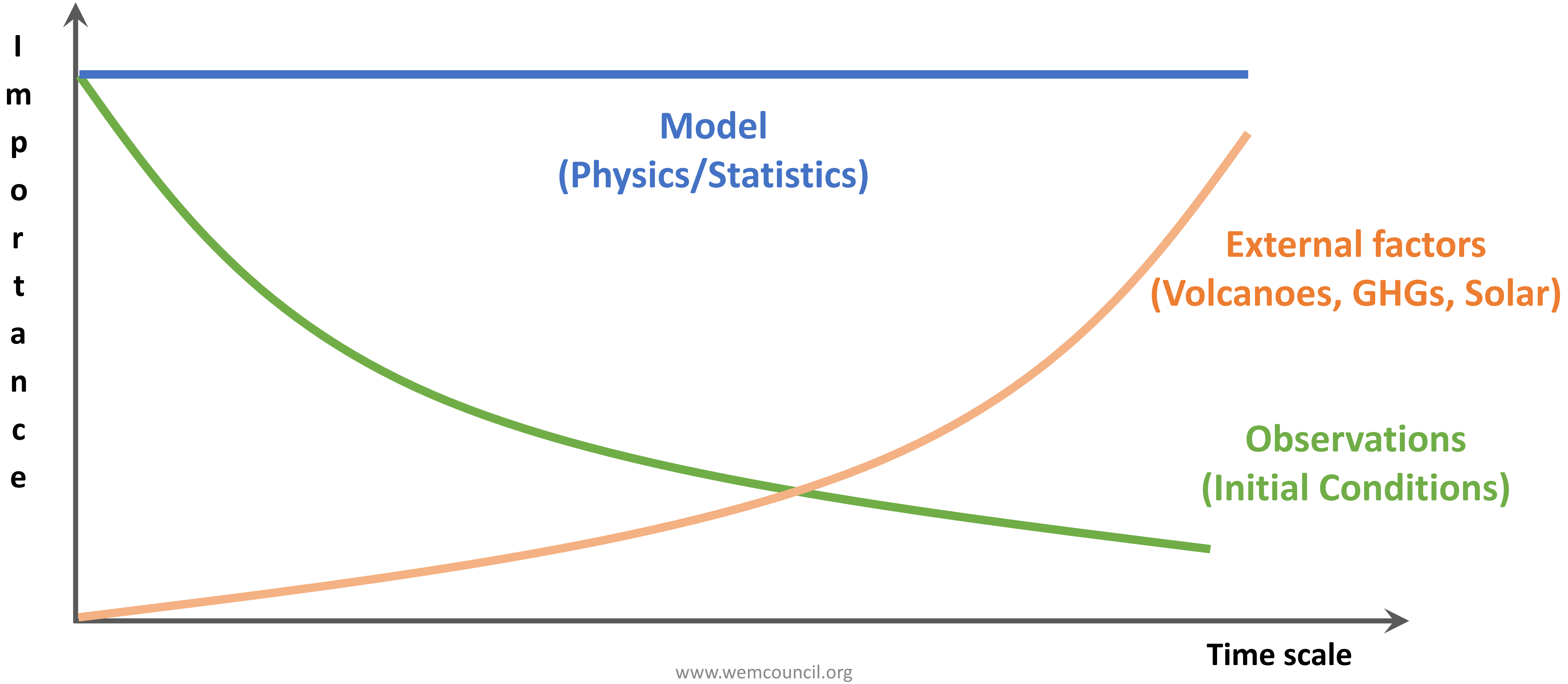
Maintenance → Monthly forecasts (weeks ahead)

Management → Seasonal Climate Forecasts

Investment/Planning → Climate projections

Seconds — Minutes — Days — Weeks — Months — Seasons — Years — Decades

Critical components of a prediction system



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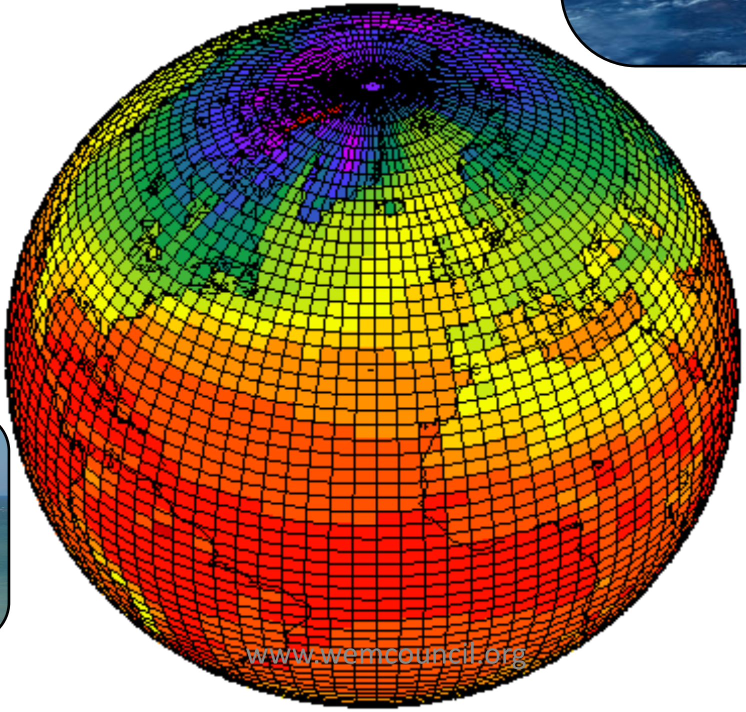
The complexity of the Earth System



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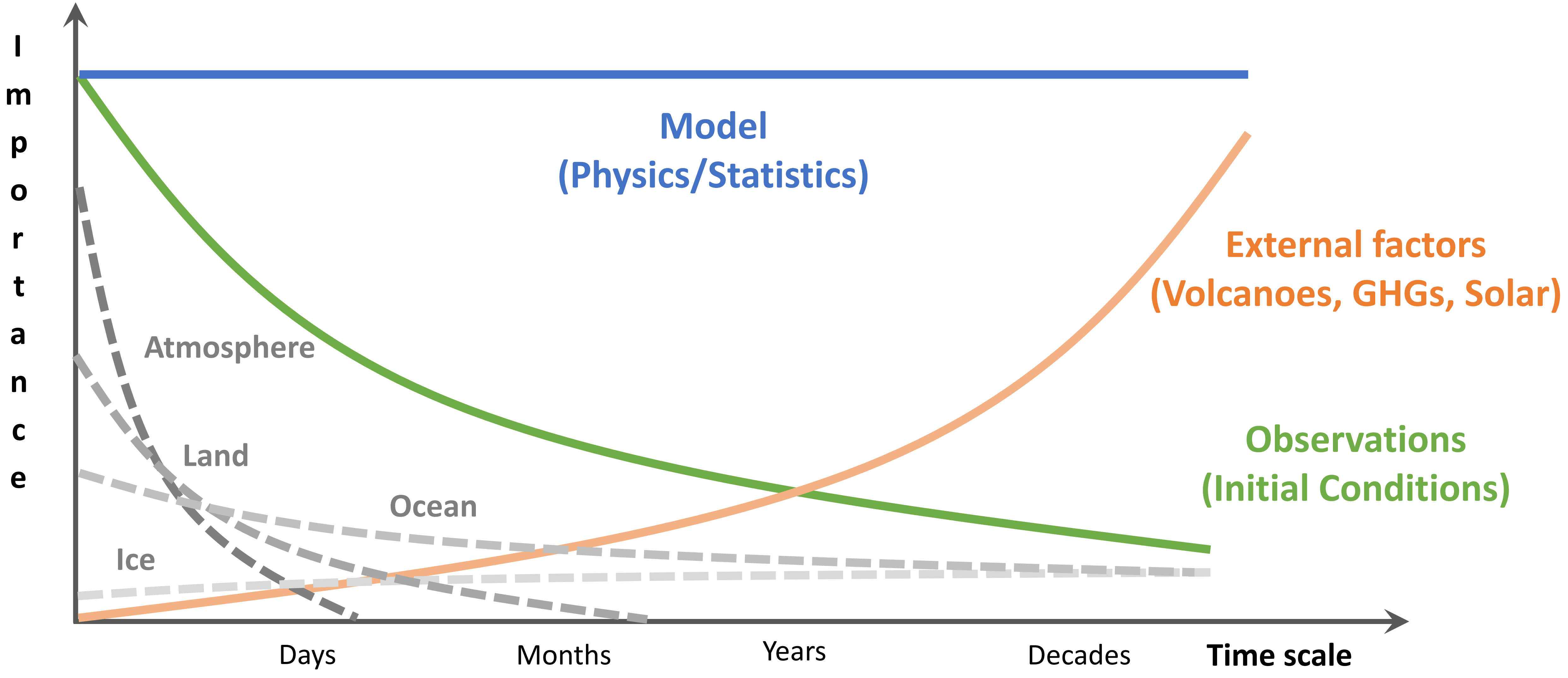
Critical components of a prediction system



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

Our Activities

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

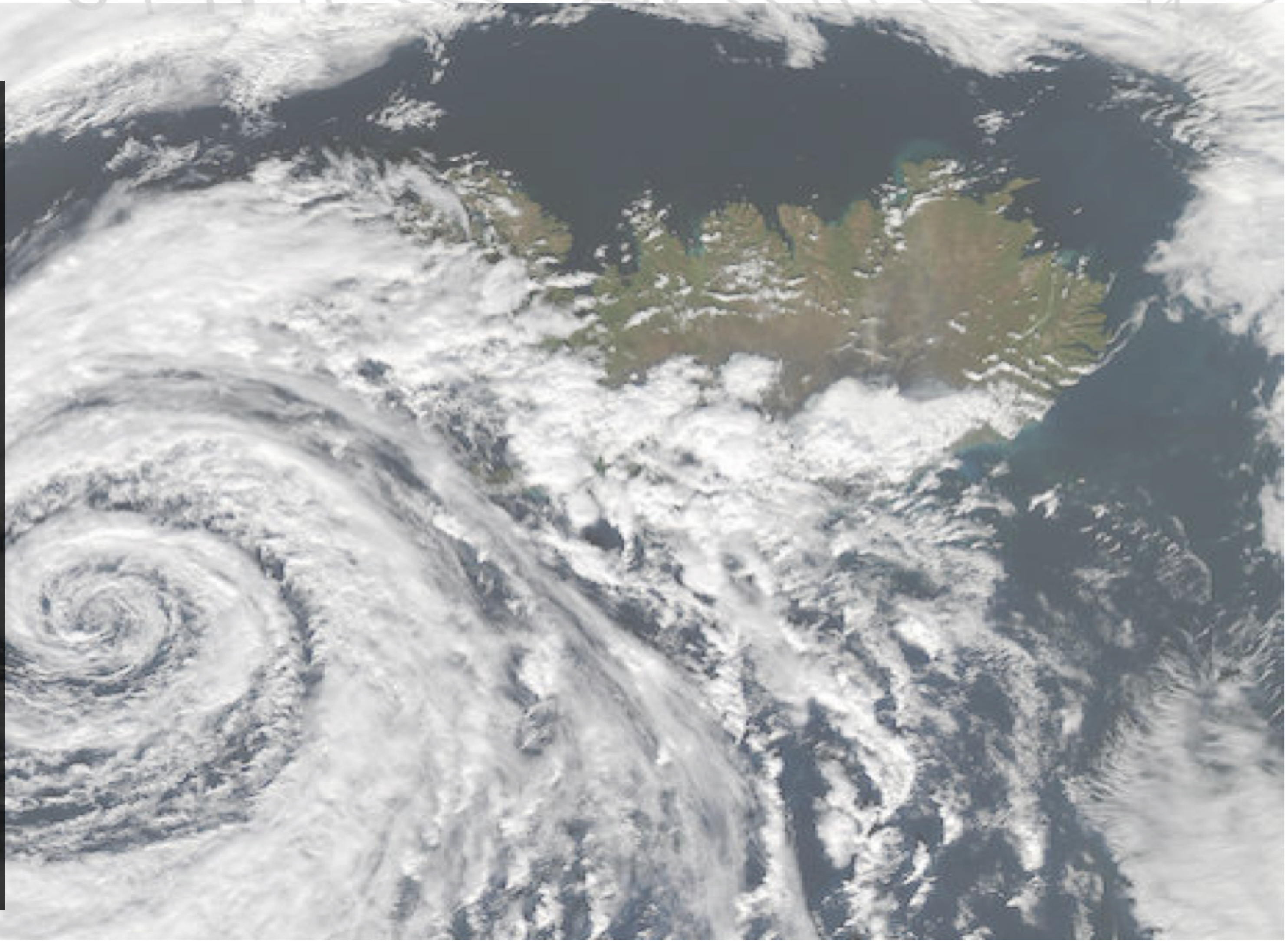
2. The **coordination of Special Interest Groups** leading to the production of reports, analyses and syntheses on key topics in Energy & Meteorology

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

The energy industry has a multi-decadal experience in dealing with meteorological variables. So, what's the big deal?

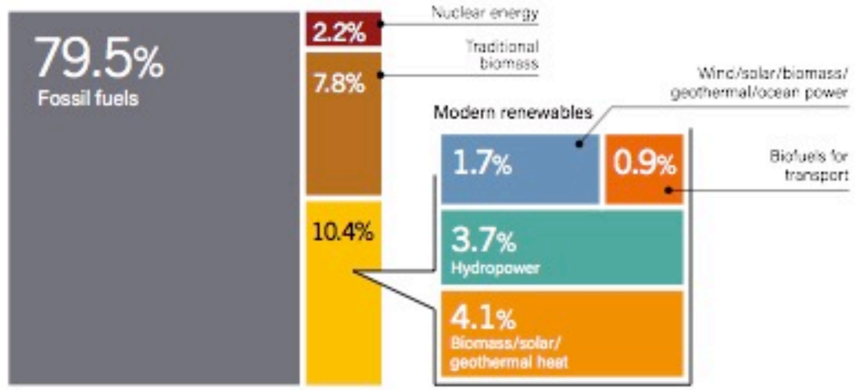
The landscape, in both climate and energy spaces, is changing rapidly.



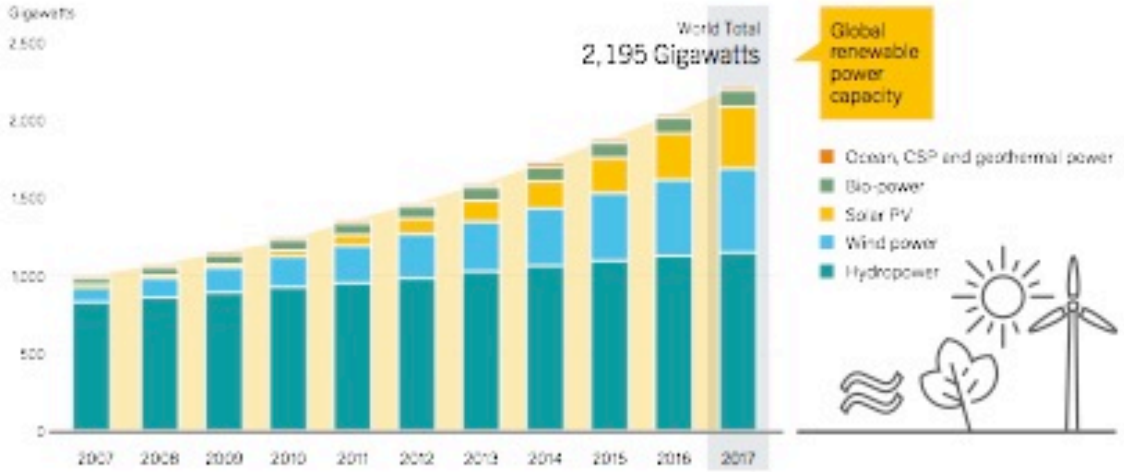
Strong growth in renewables

GSR 2018 KEY FIGURES

ESTIMATED RENEWABLE ENERGY SHARE OF TOTAL FINAL ENERGY CONSUMPTION, 2016

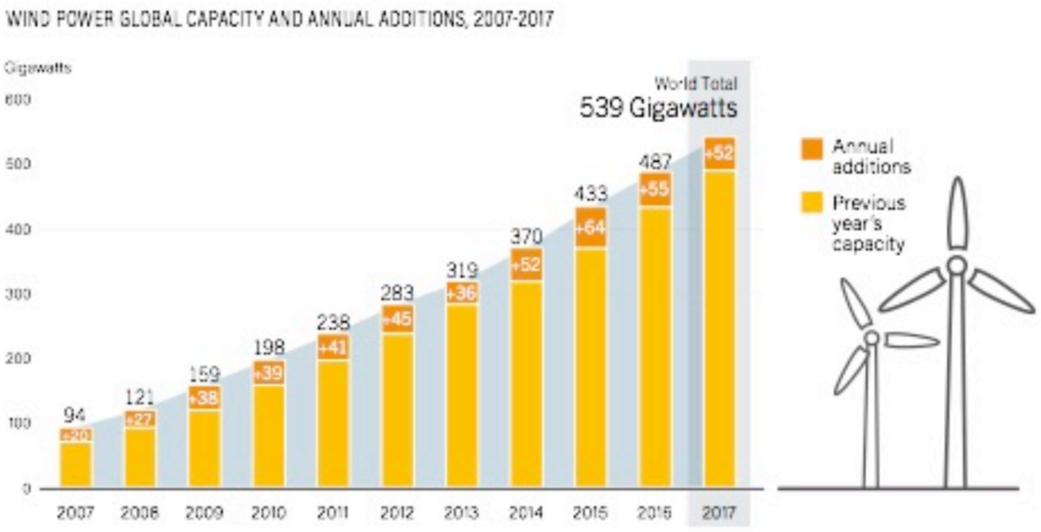


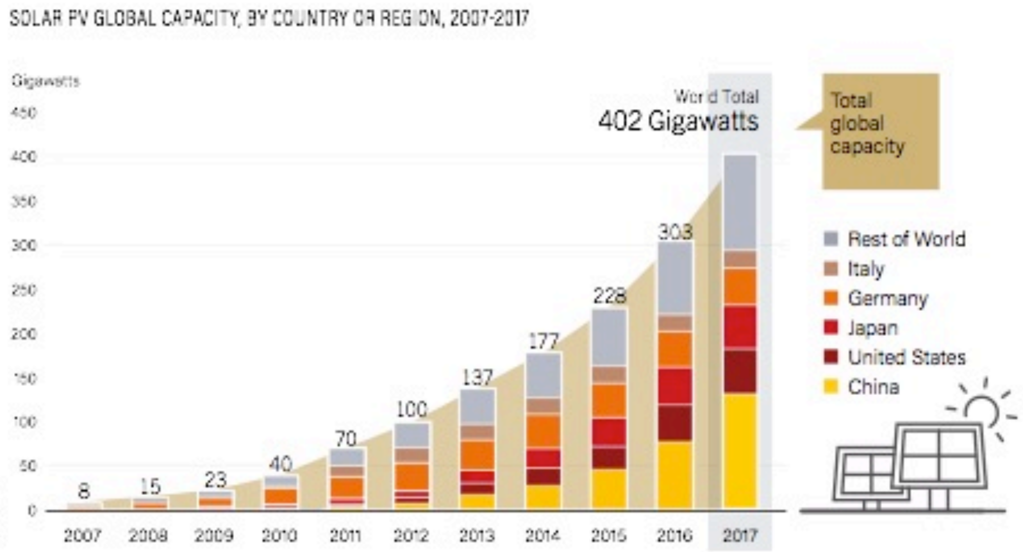
ESTIMATED RENEWABLE ENERGY SHARE OF TOTAL GLOBAL ELECTRICITY PRODUCTION, END-2017



REN21 (2018)

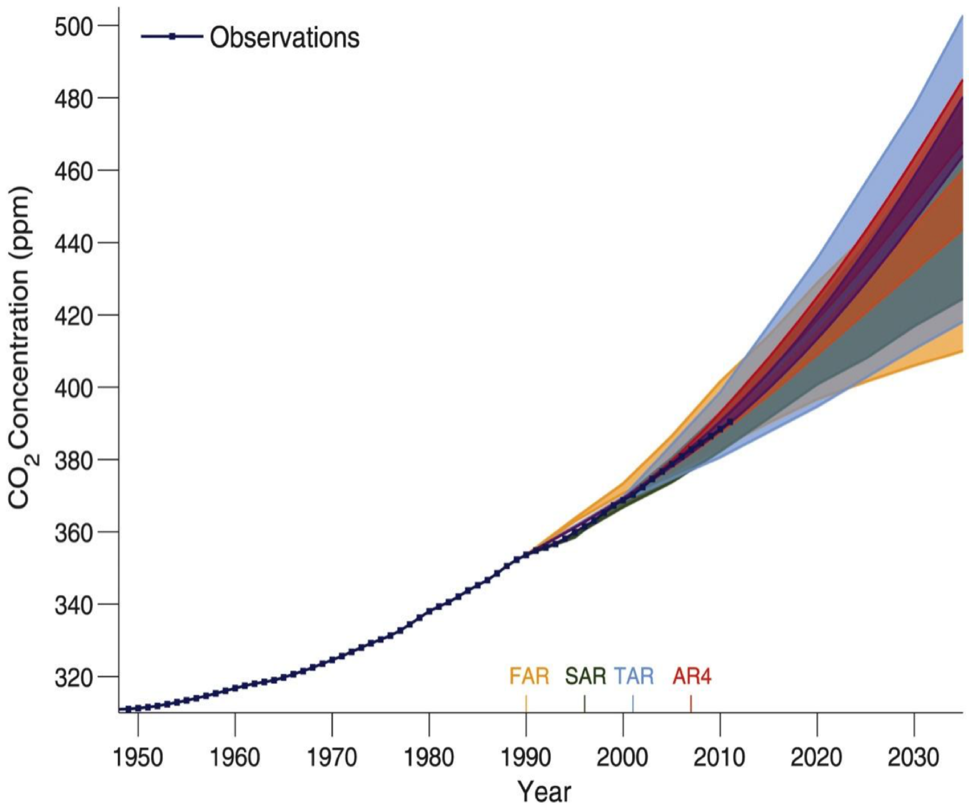
Impressive growth in Wind and Solar

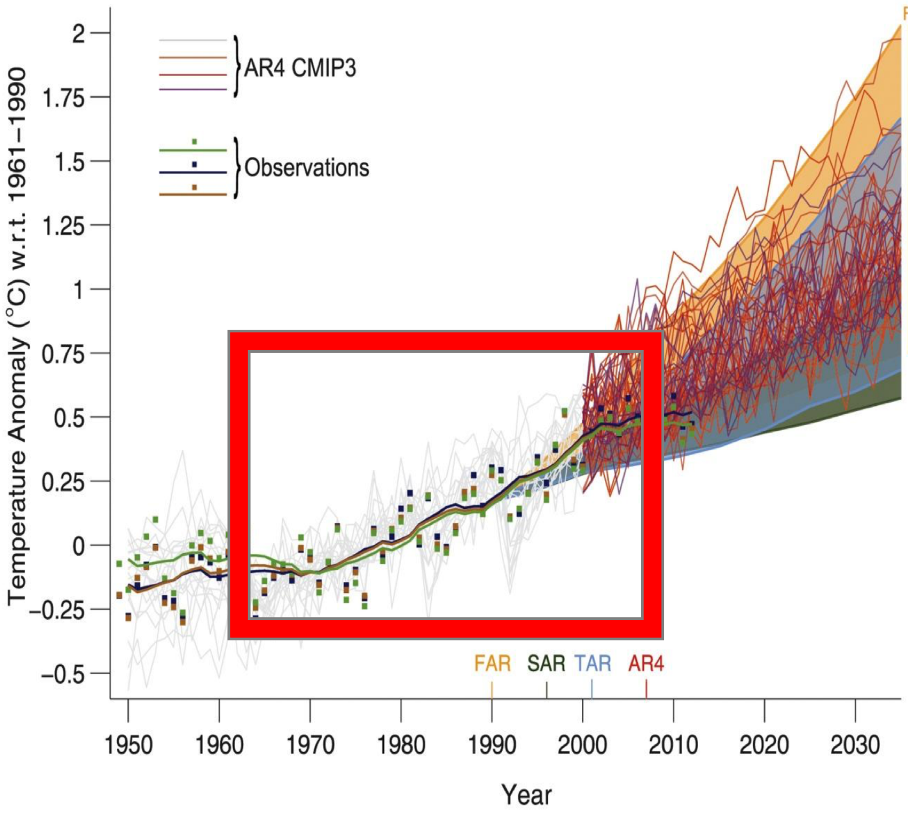




REN21 (2018)

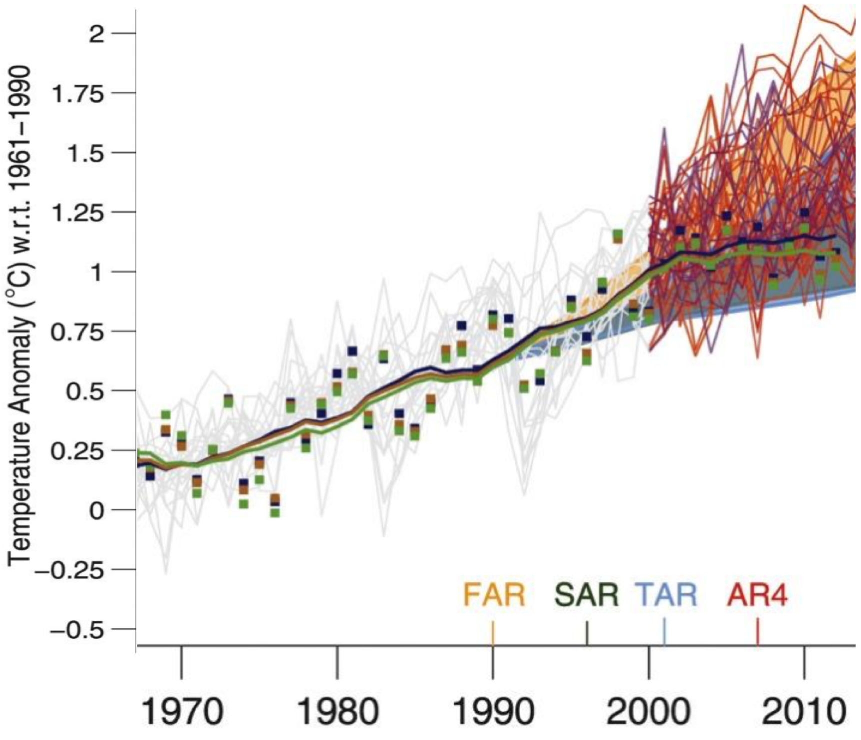
CO_2 emissions and temperature

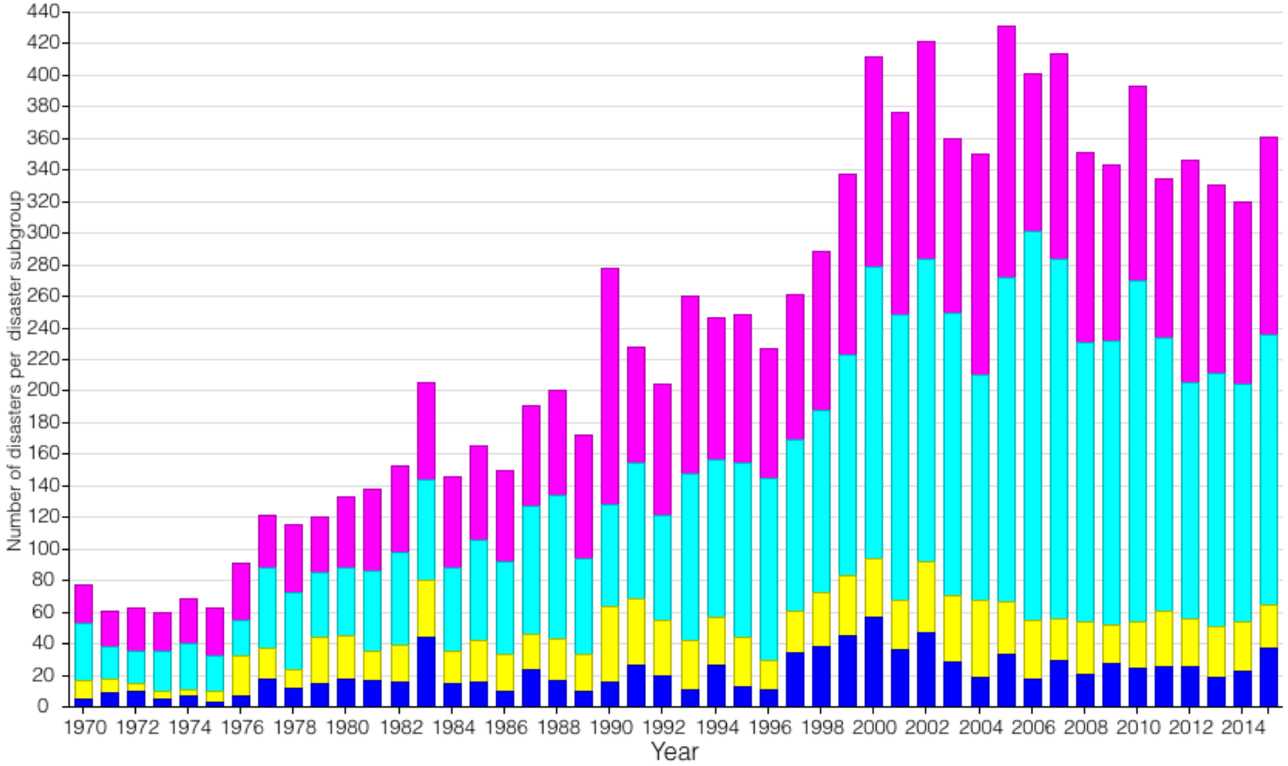




IPCC AR5 (2013)

Disasters due to natural events





EM-DAT (2016)

See also Diffenbaugh et el. (2017, PNAS)

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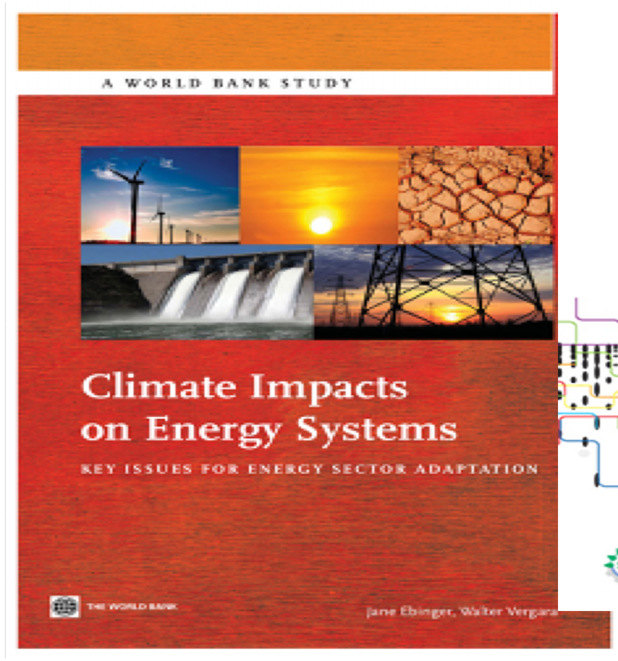
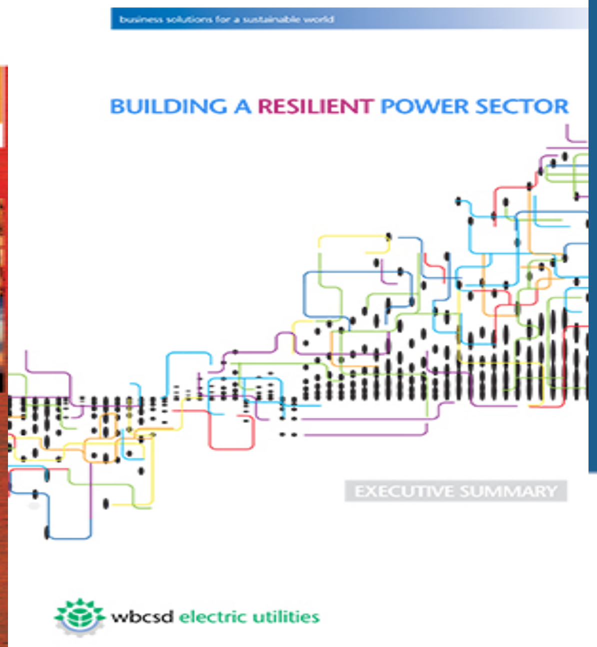
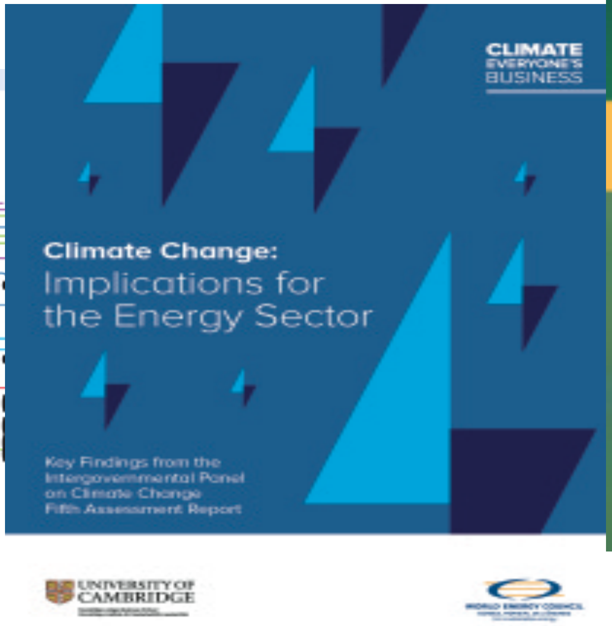
A selection of publications



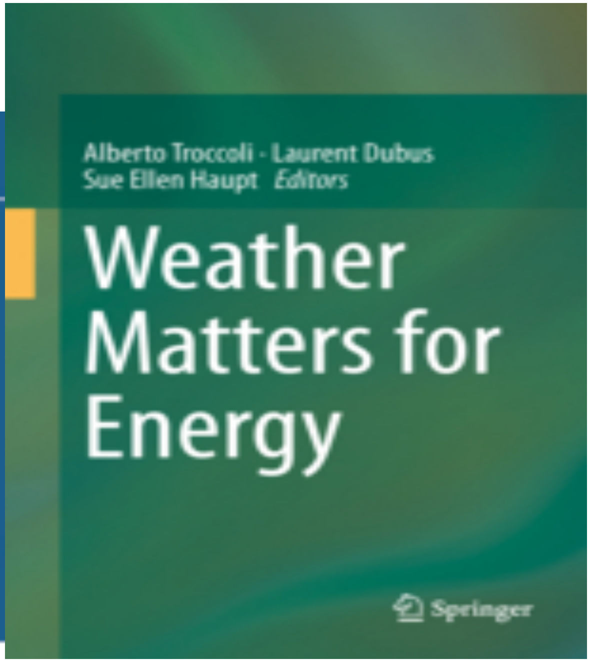
World Bank (2010)



WBCSD (2014)

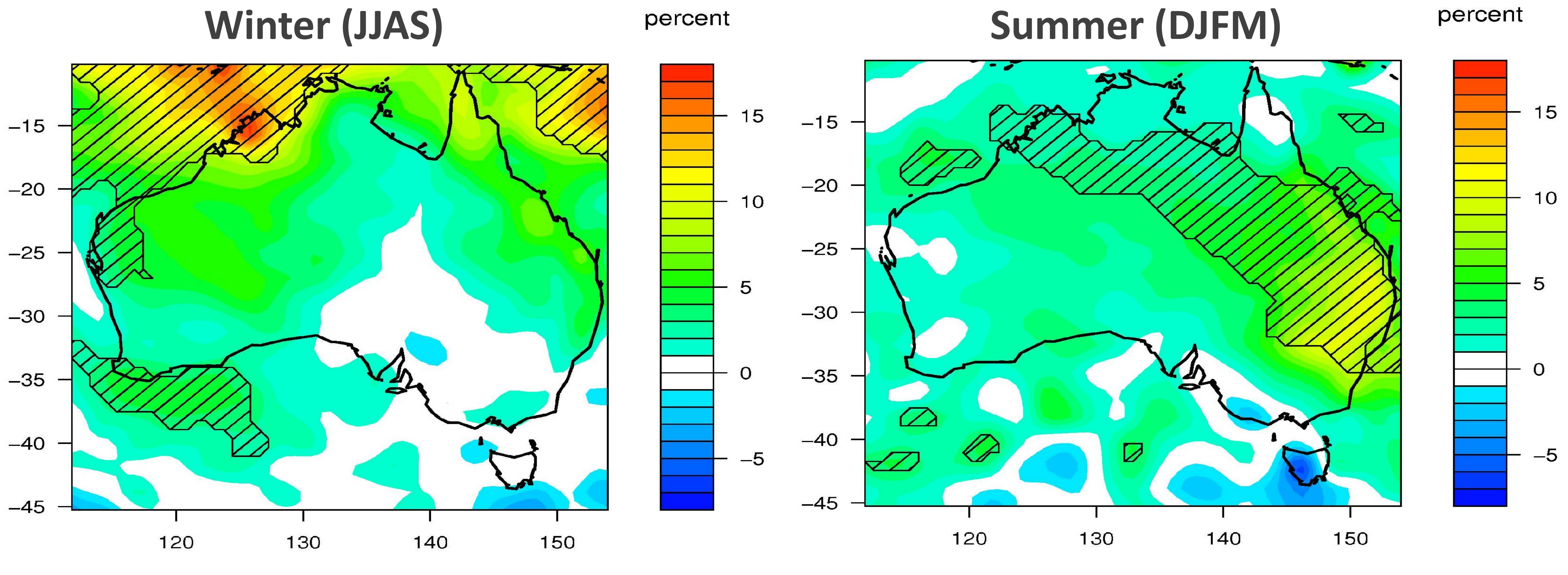


WEC (2014)



ICEM (2014)

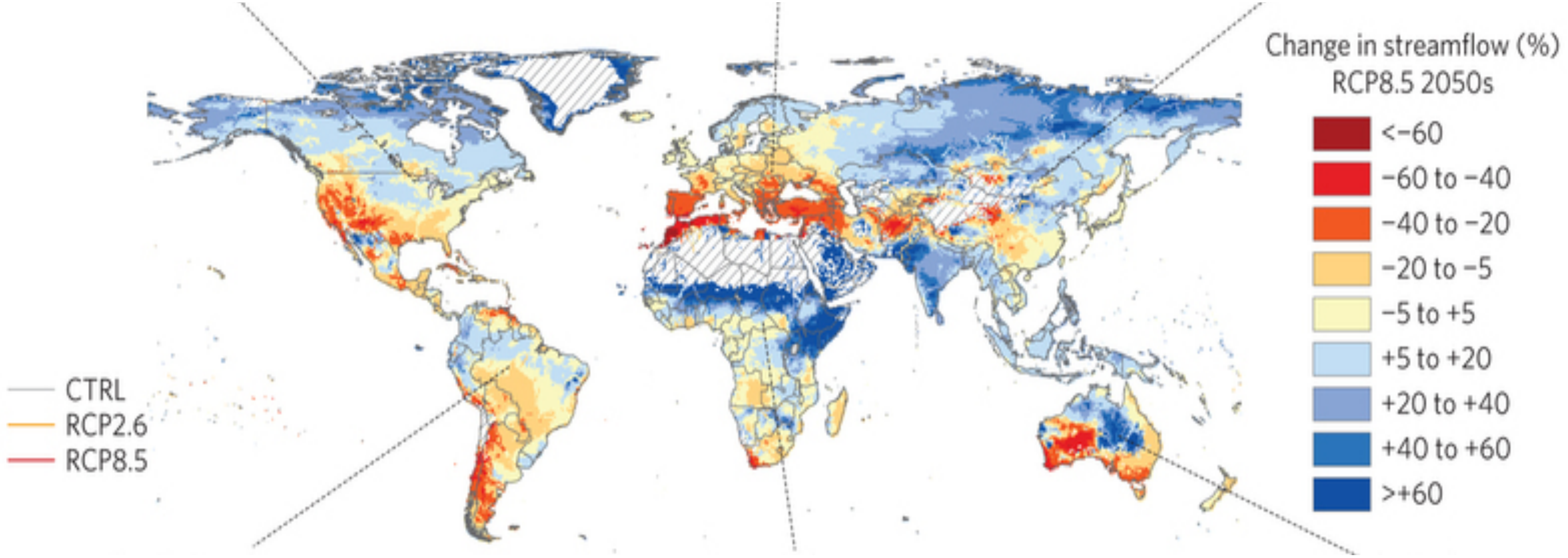
Solar Radiation Inter-annual Variability



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

Davy and Troccoli (2012)

Global changes in streamflow projections

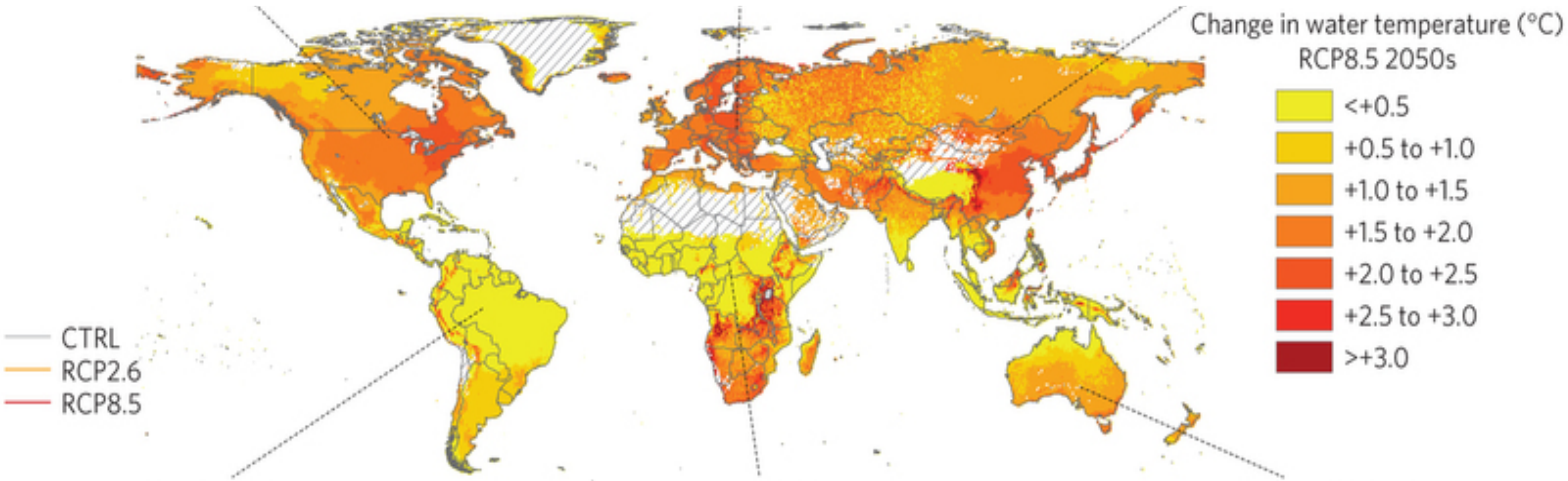


Change in streamflow for RCP8.5, 2040–2069 (2050s) vs1971–2000

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

van Vliet et al. (2016)

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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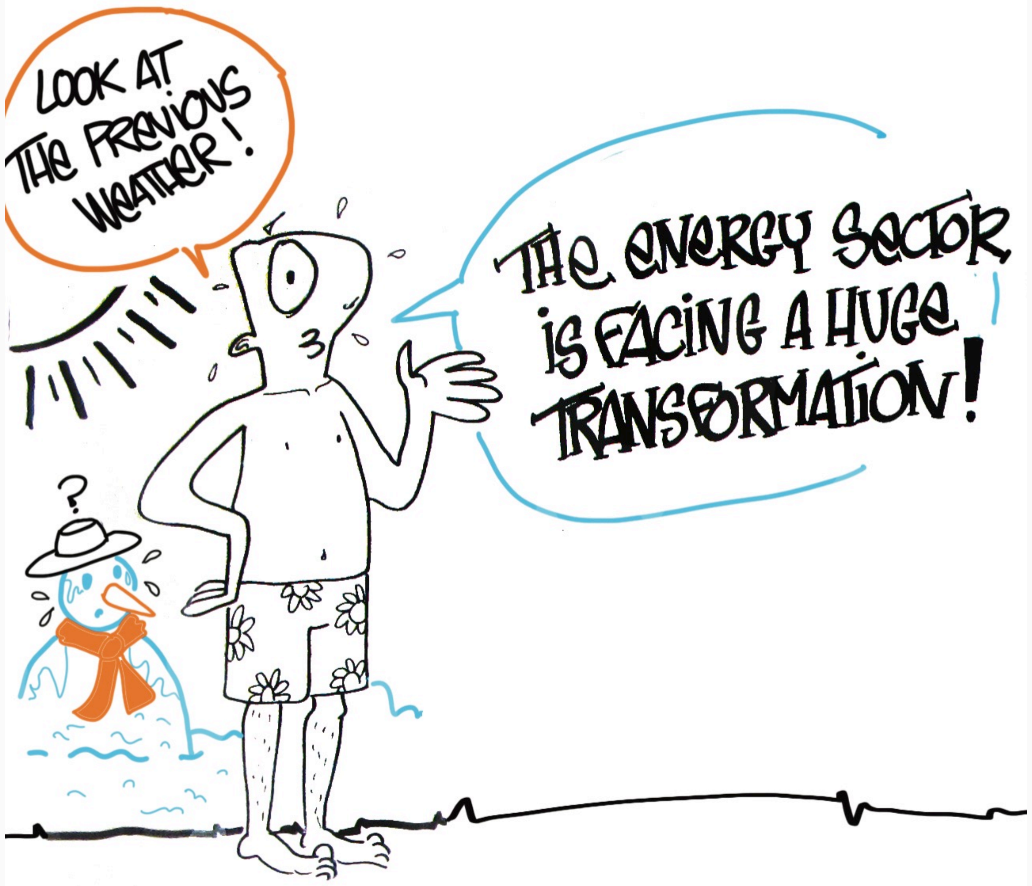
Addressing the ever variable nature of climate

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**.

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.

Copernicus
Europe's eyes on Earth

European Climatic Energy Mixes (ECEM)

Climate Change Service
climate.copernicus.eu

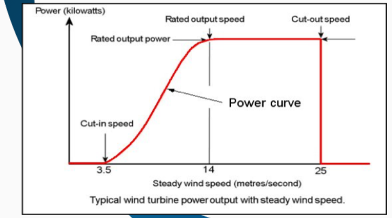
Calibrated Climate Variables

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

+Ancillary

Define models & transfer functions

Select / Gather relevant datasets



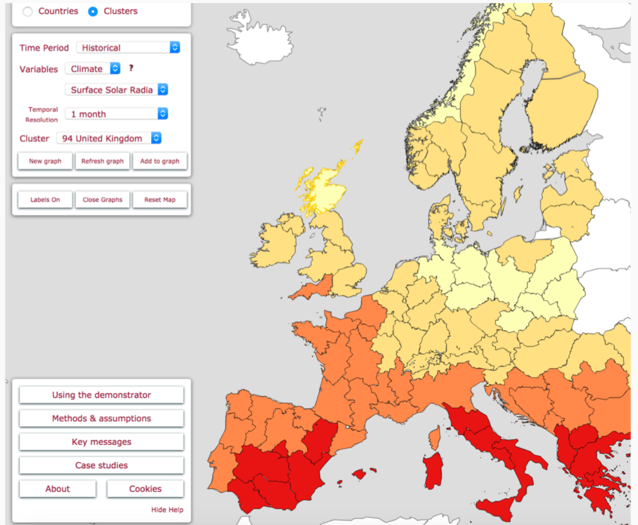
- Skill & Reliability
- Assessment of Seasonal Forecasts of Energy Variables

+ Extreme Events Case Studies

Energy Variables

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

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



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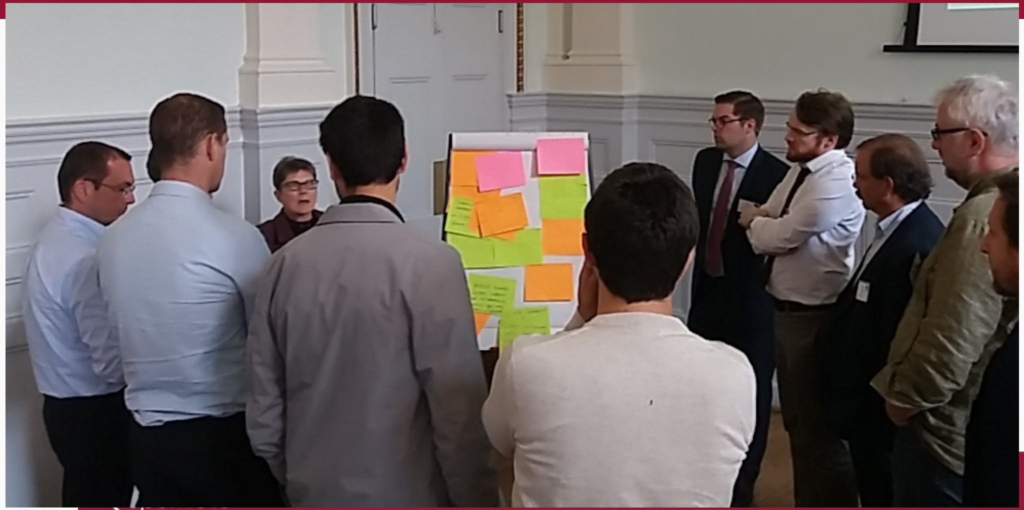
Stakeholder Engagement: Workshops



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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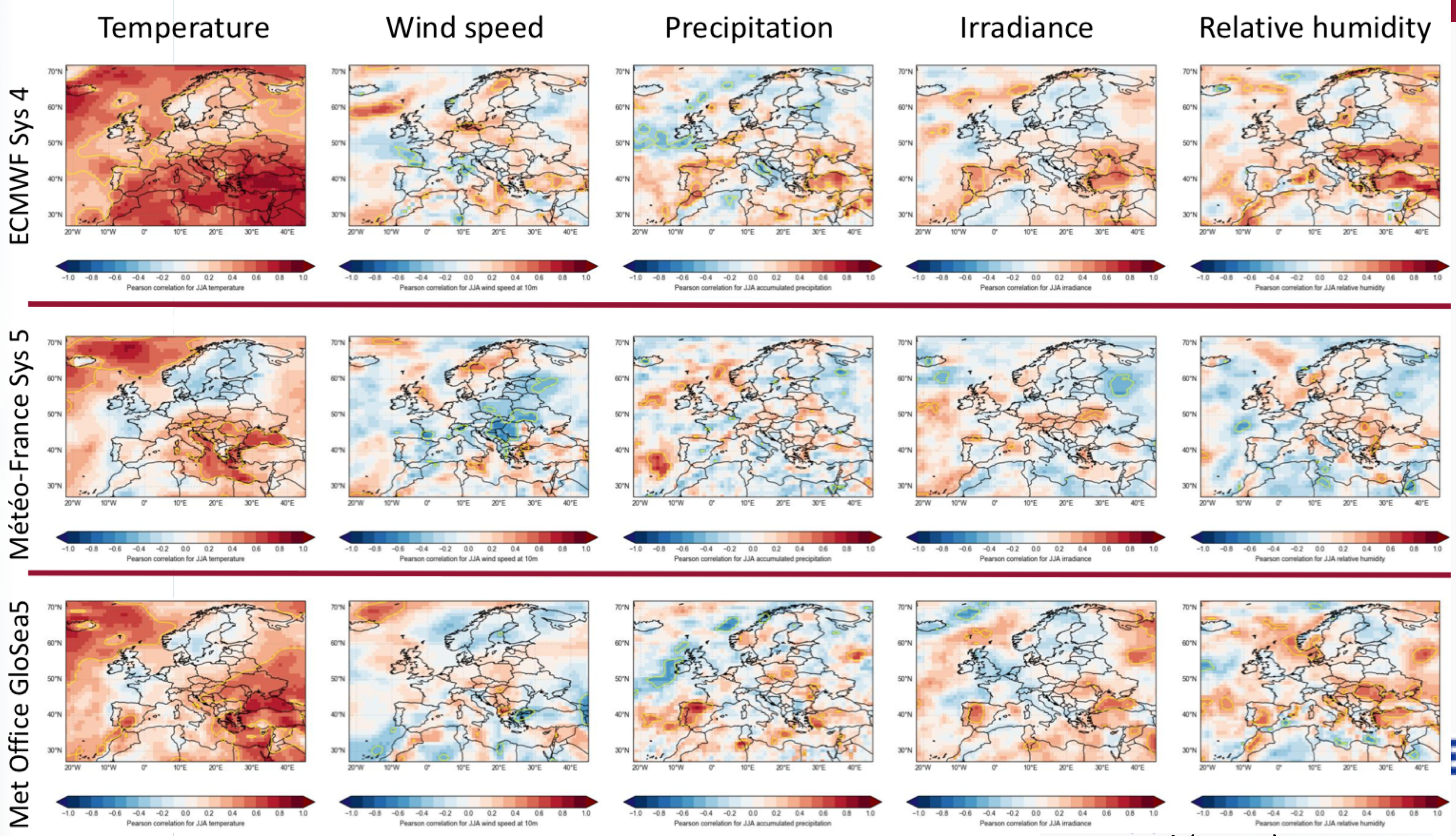
Seasonal forecasting skill: correlations for summer



Bett et al (2017)

ECMWF

European Commission

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)

Correlation predicted solar radiation vs PV CF

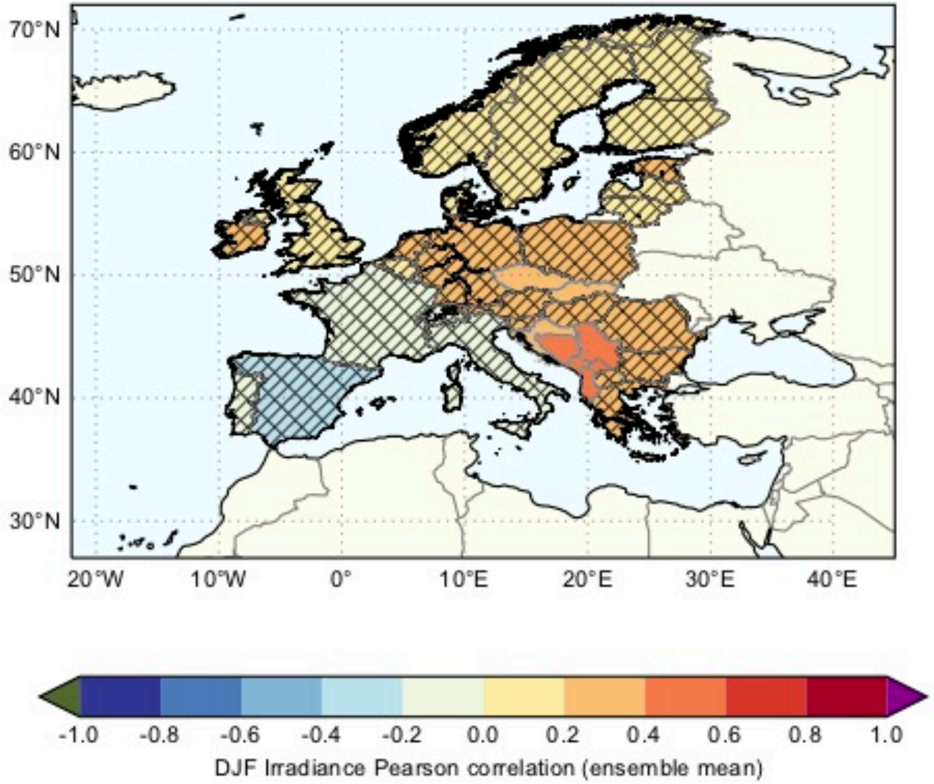


Figure 7: Map of the correlation skill between DJF solar PV generation and irradiance from the ECMWF system. Countries where the skill is indistinguishable from zero at the 95% confidence level are obscured by cross-hatching.

Bett et al (2017)

Seasonal Forecast of PV CF

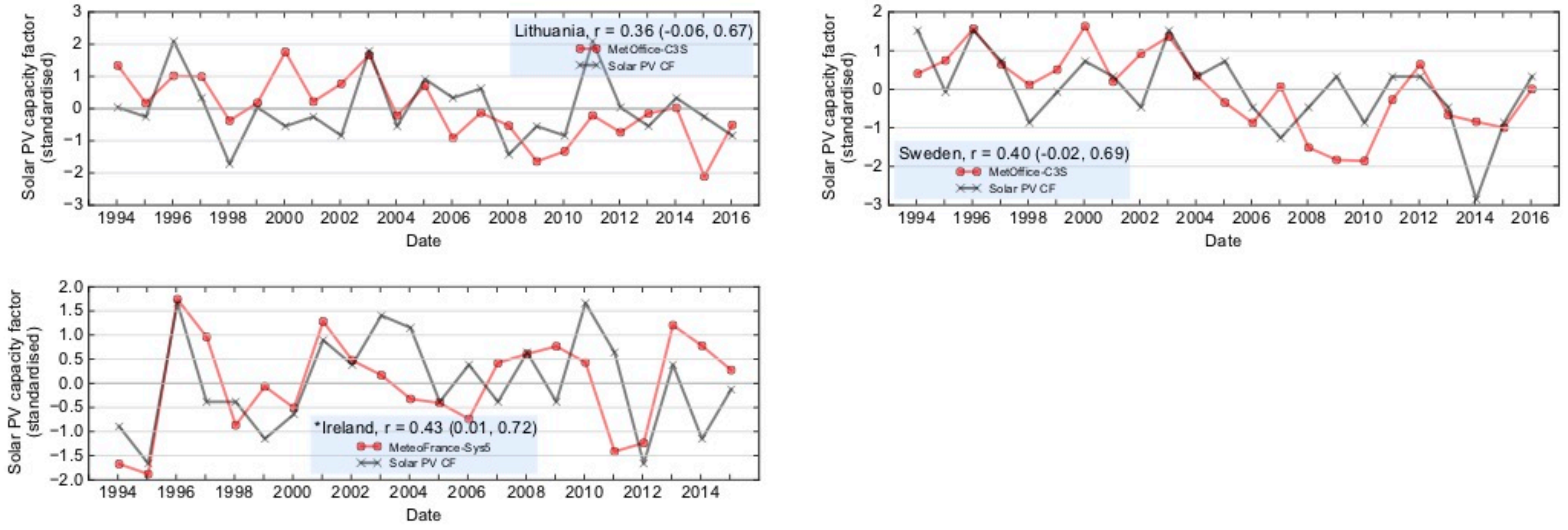


Figure 5: Standardised time series of forecasts of DJF solar PV capacity factor, using irradiance as the predictor. Top: results from the Met Office system, for Lithuania (left) and Sweden (right). Bottom: Similar forecasts for Ireland, using the Météo-France system. In each panel, the hindcast is shown 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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University of Reading
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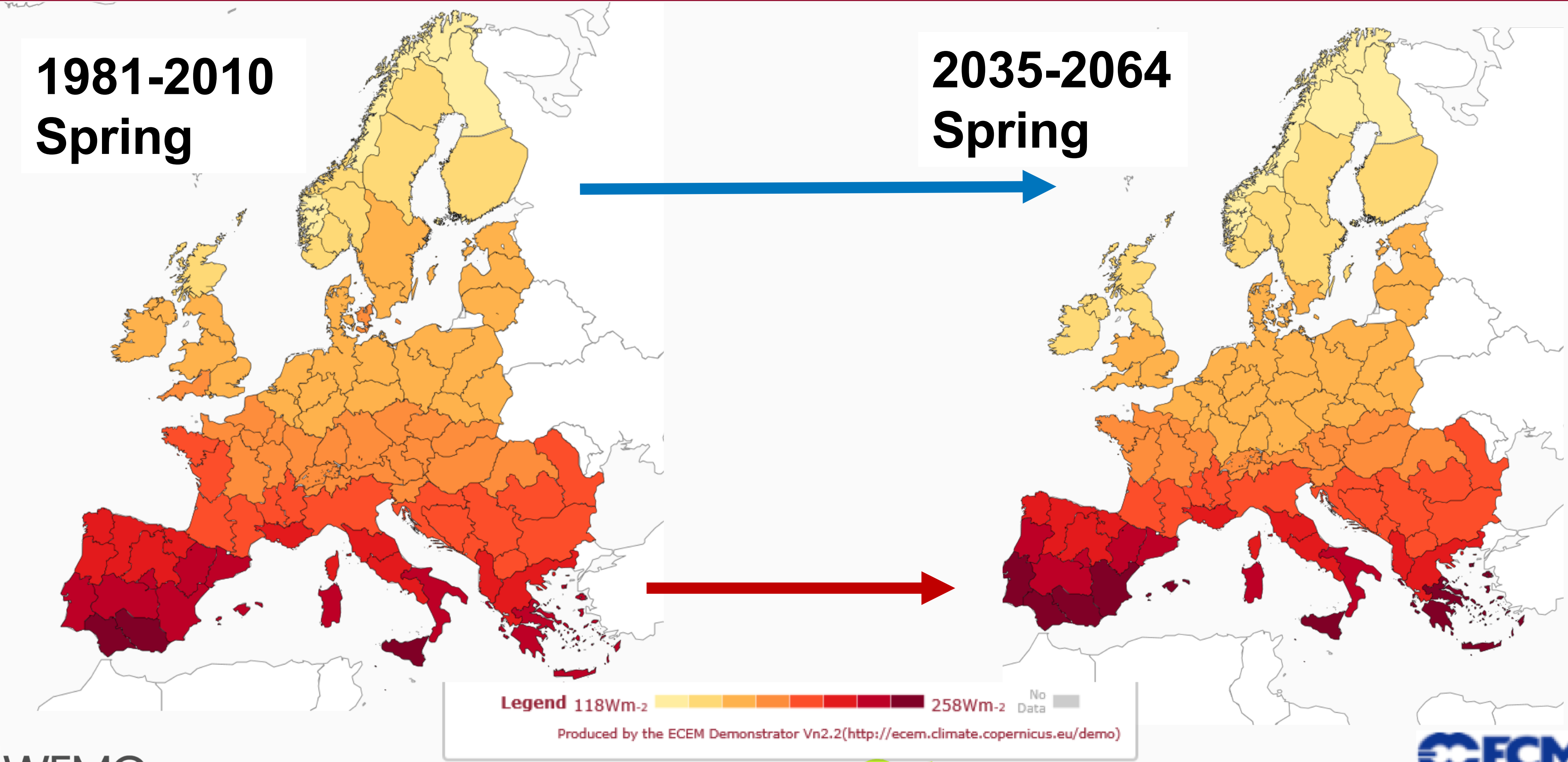
ARMINES
ENEA
ECMWF
European Commission

Climate Projection (RCP 8.5) Radiation



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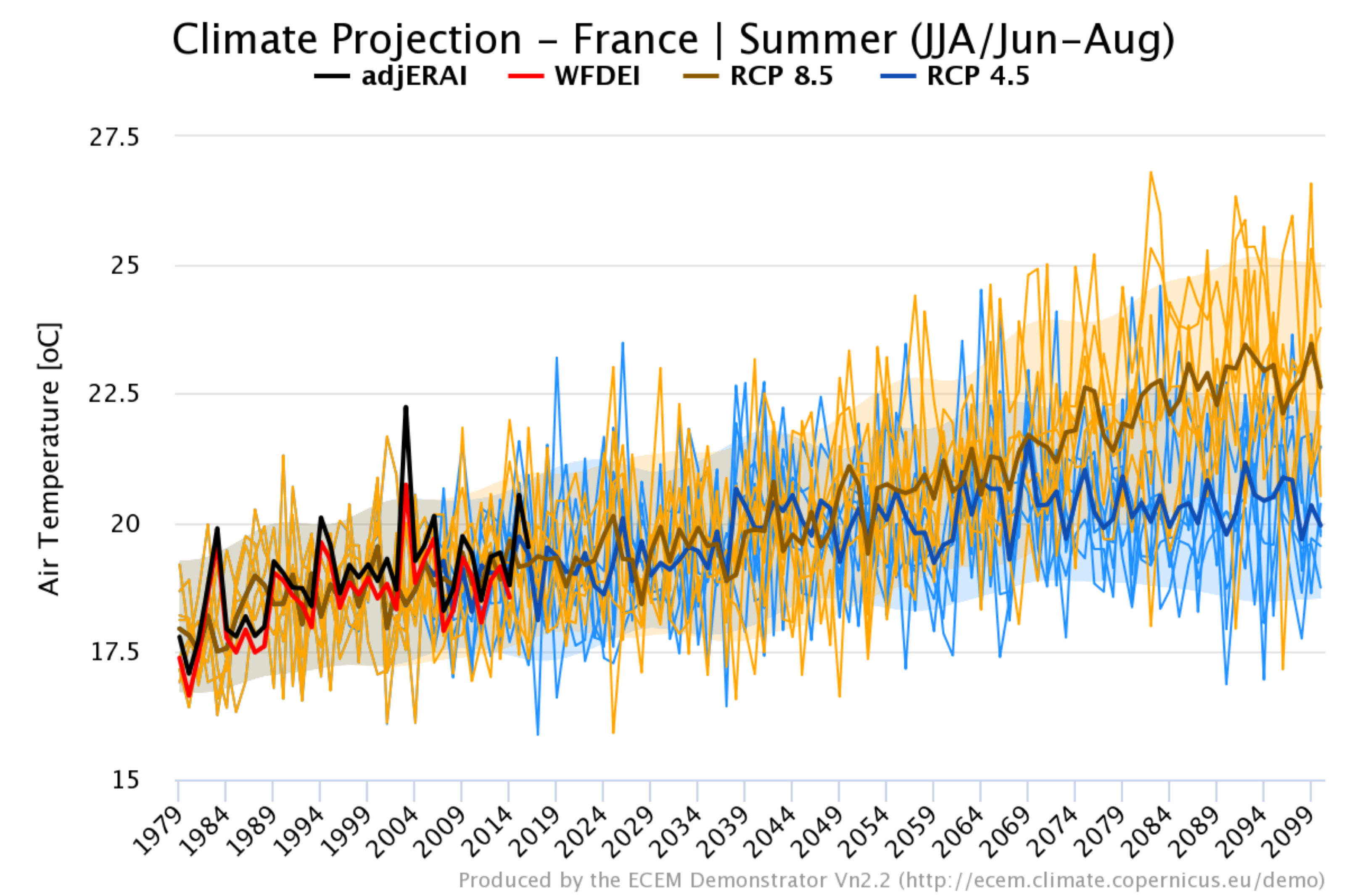
Climate Projection time series – Temperature



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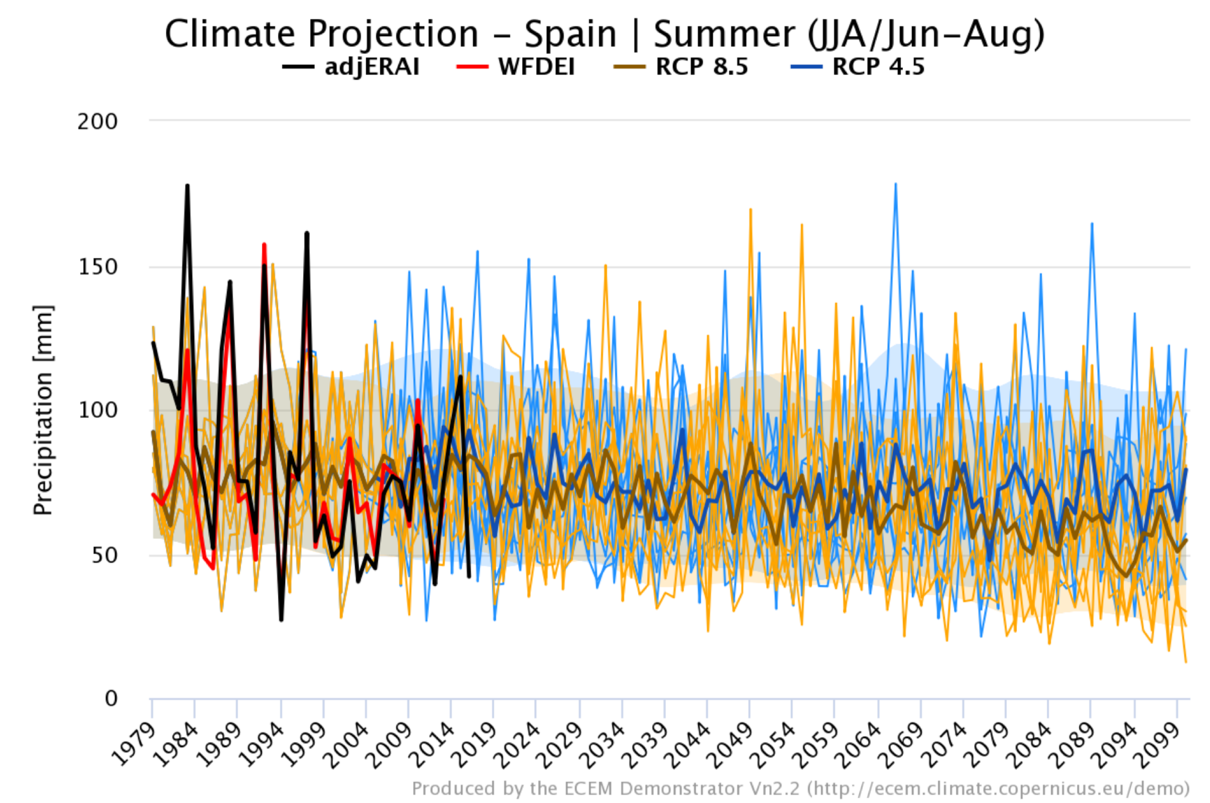
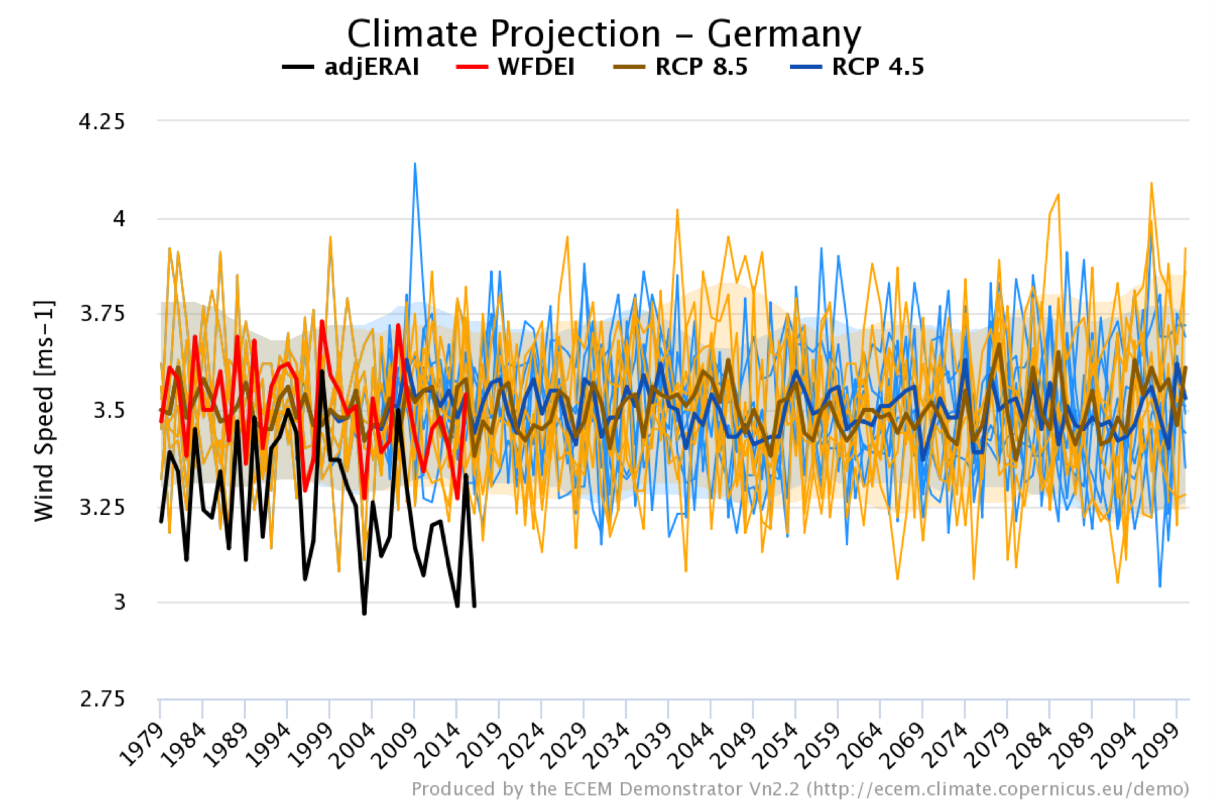
European Commission

Climate Projection time series – Precip and Wind





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ENEA

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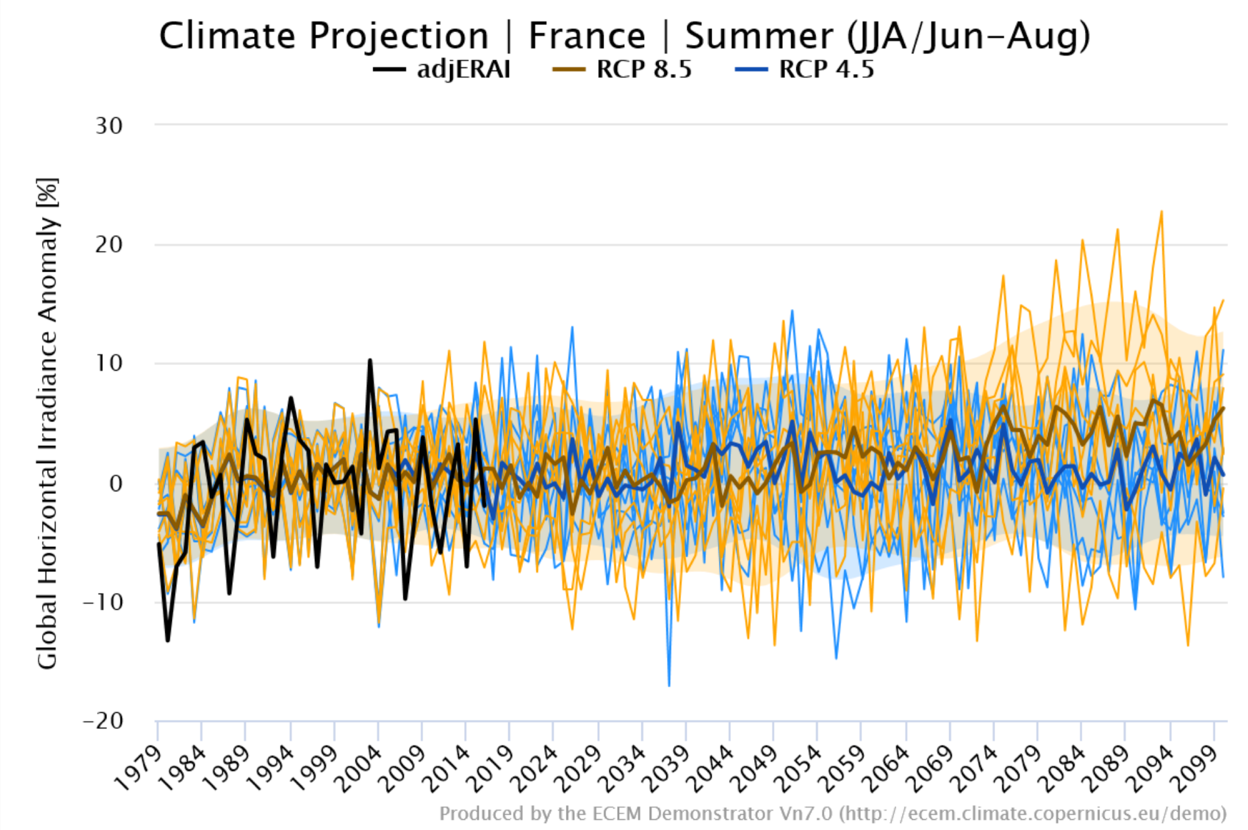
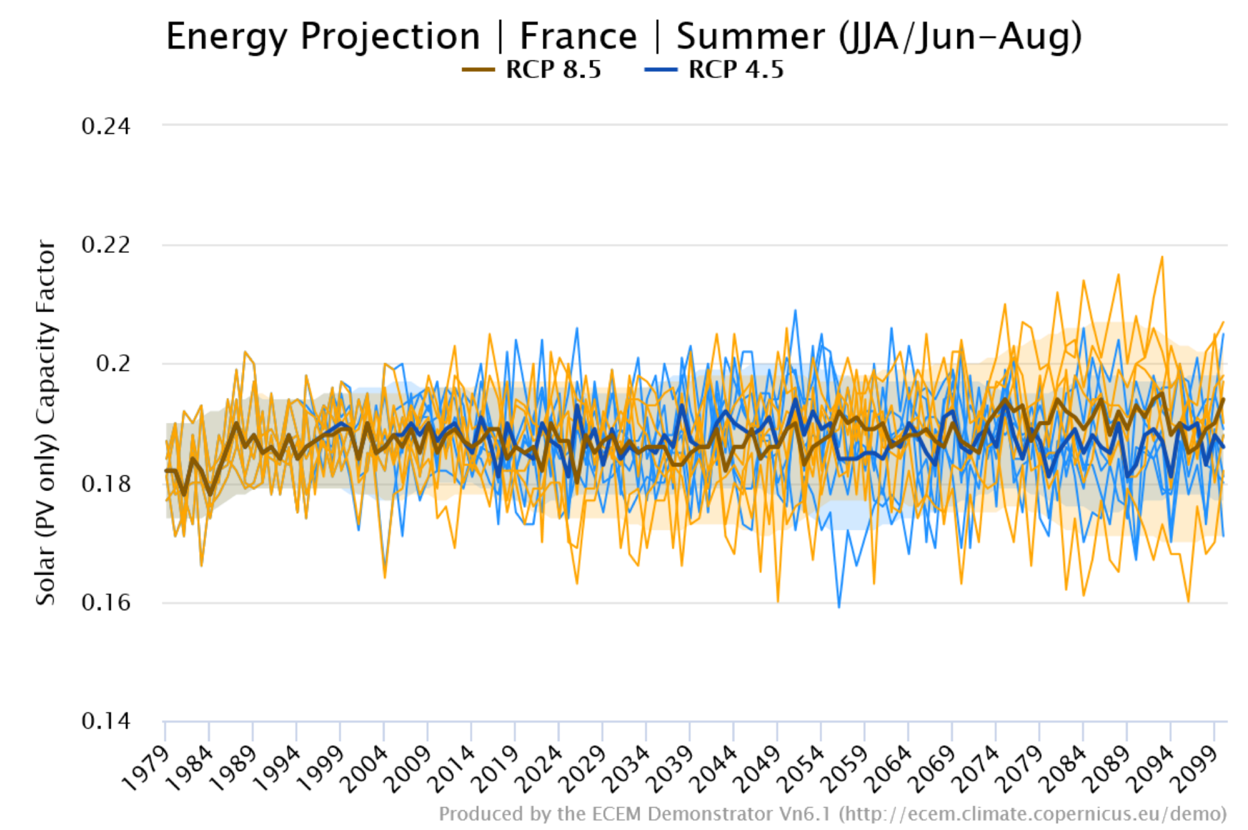
Climate Projection time series – Solar Rad & Power





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Projected changes in Solar Rad. Global vs Regional models

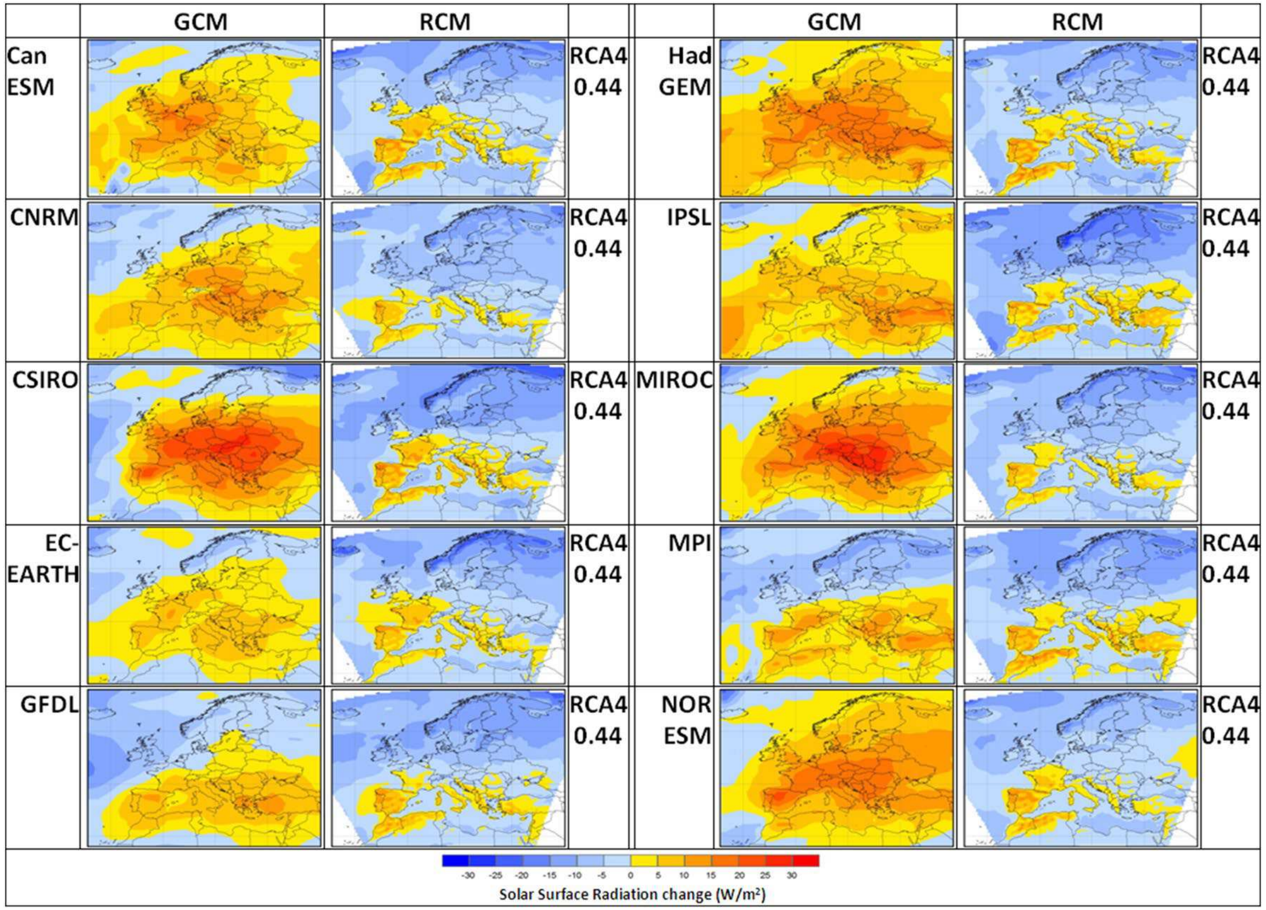


Fig. 2 Annual projected changes in SSR in the RCA4 regional model and in different driving GCMs. The changes are defined as the difference between the future projections for RCP8.5 (2071–2100) and the historical simulation (1971–2005)

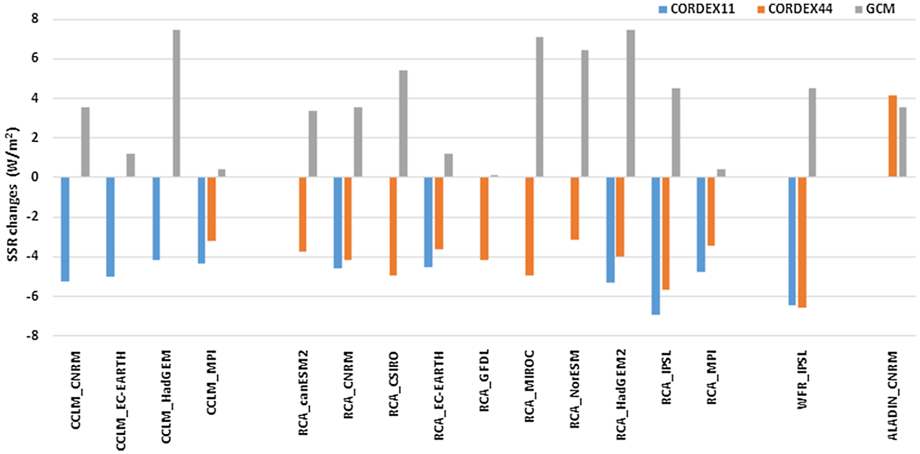
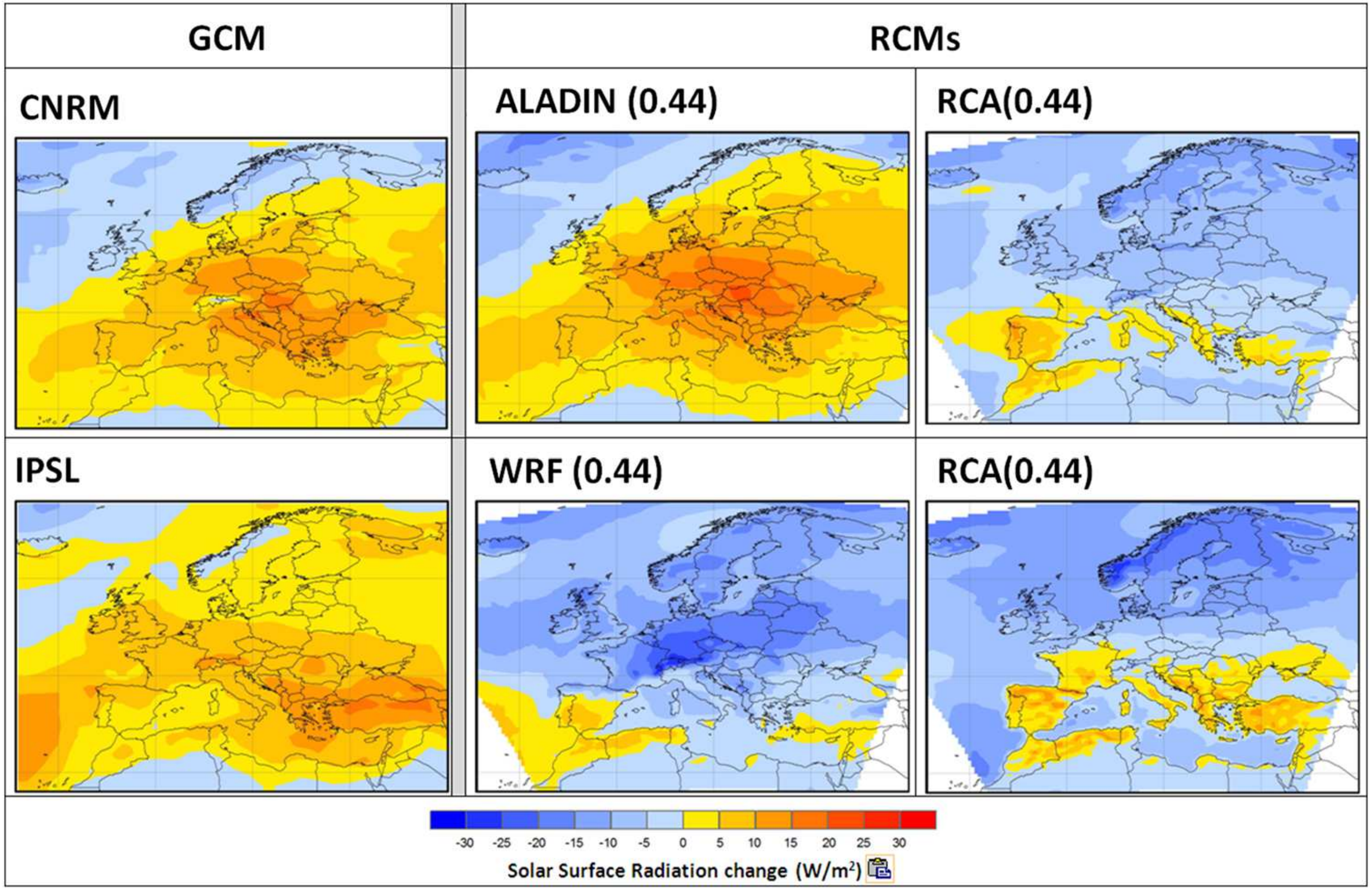


Fig. 3 Annual changes in SSR in individual RCMs (first name on x axes) and in GCM applied as boundary conditions (second name on x axes) over the European domain. *Blue columns* depict changes for RCMs with 0.11° resolution, *orange columns* depict changes for RCMs with 0.44° resolution, and *grey columns* 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)

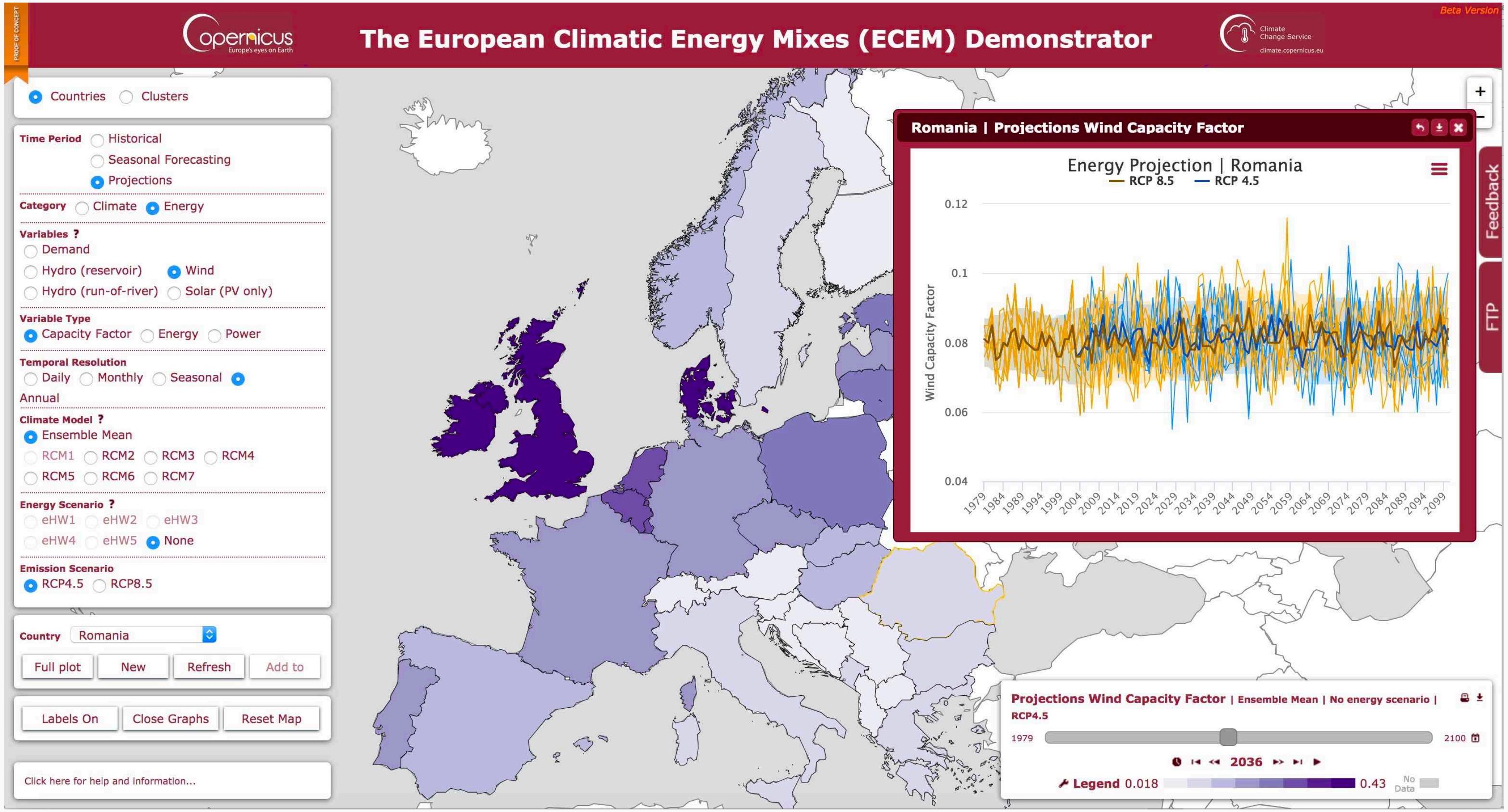
Bartok et al (2016)

Projected changes in Solar Rad. Global vs Regional models



Bartok et al (2016)

An online interactive tool to test energy mixes



http://ecem.wemcouncil.org

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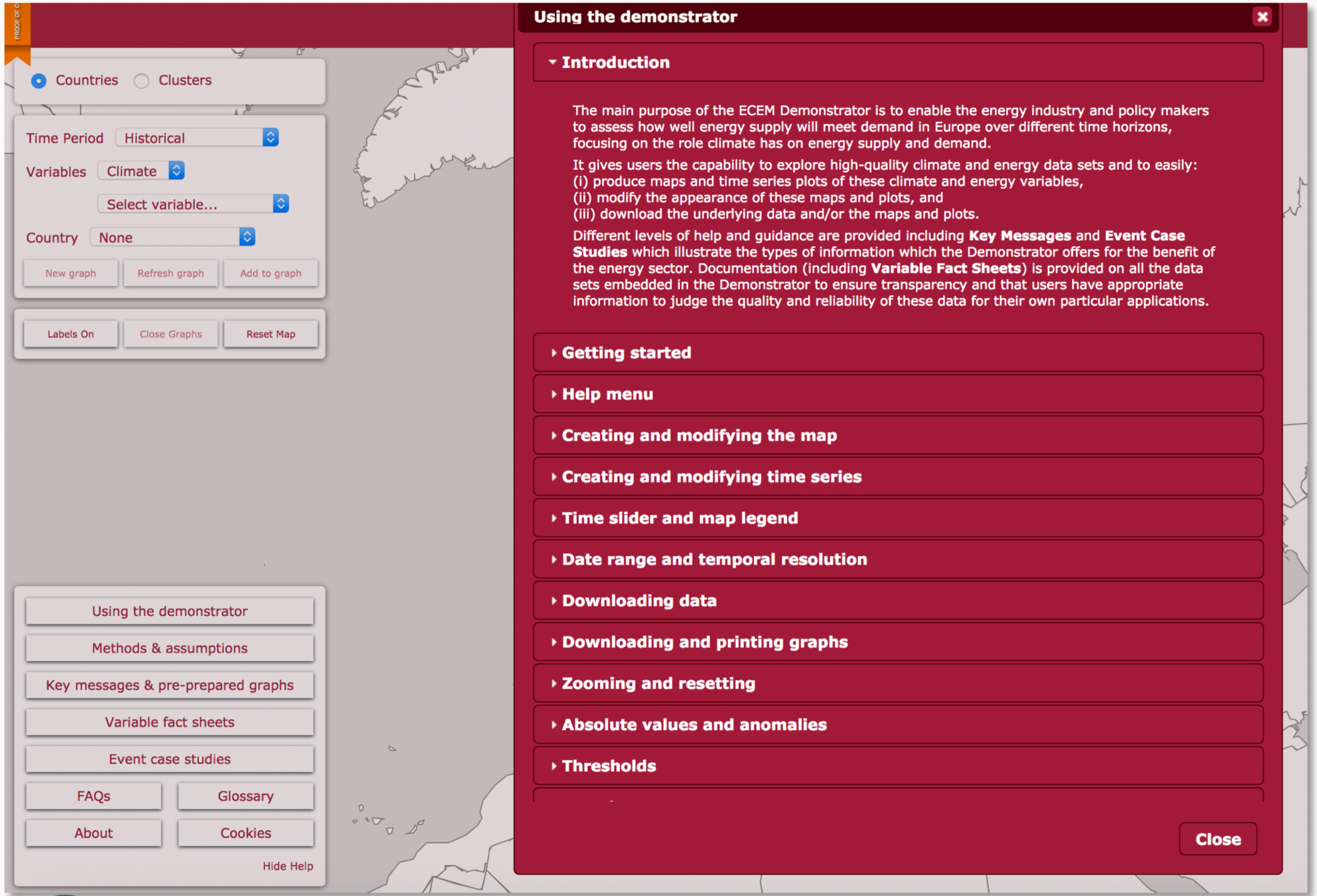
General Documentation and Key Messages

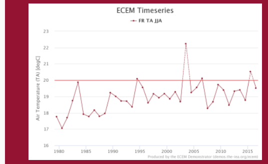


EUROPEAN CLIMATIC ENERGY MIXES (ECEM)

KEY MESSAGES

ECEM KM 01

A warming Europe



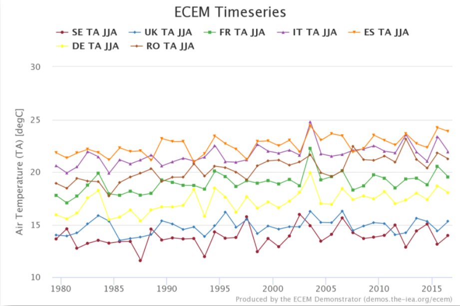
A series of Key Messages for the European energy sector based on the analysis of data in the ECEM Demonstrator.

Key messages: A warming Europe

- Temperatures have risen consistently across Europe over the last ~40 years
- In countries such as Germany the warming has been strongest in winter whereas in Spain, for example, it is strongest in summer
- At the same time, variability from year-to-year and day-to-day persists, and cold events have continued to occur in recent years
- Temperature is a major driver of the ECEM models for energy demand and of solar and hydro supply thus these trends and patterns of variability will impact estimates of these energy variables

How do we know Europe is warming?

Warming trends are evident in time-series plots of historic air temperature data (°C) for 1979-2016 including those for the seven countries shown here (Sweden, UK, France, Italy, Spain, Germany and Romania). The plot below shows the trends for summer (June, July and August).



For more information visit www.ecem.climate.copernicus.eu or contact the ECEM team at support@ecem.climate.copernicus.eu

Date of publication: 25 June 2017

WEMC World Energy & Meteorology Council
University of East Anglia
University of Reading
Met Office
ARMINES
ENEA
ECMWF
European Commission

Variables and Event Case Studies Fact Sheets

EUROPEAN CLIMATIC ENERGY MIXES (ECEM)

VARIABLE FACT SHEET
ECEM VFS E01

Energy demand

A series of fact sheets which provide metadata for the climate and energy variables produced by ECEM

1 General

1.1 Description
1.2 Units
1.3 Links
1.4 Data format
1.5 Keywords
1.6 Contact

2 Dataset coverage

2.1 Geographic area
2.2 Temporal resolution
2.3 Time period
2.4 Spatial resolution

3 Usage

3.1 License conditions
3.2 Citation(s)

4 Lineage statement

4.1 Original data source
4.2 Tools used in production of indicators

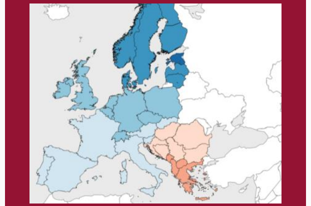
5 Data quality

For more information visit
http://ecem.climate.copernicus.eu
Date of publication: 12 June 2017

EUROPEAN CLIMATIC ENERGY MIXES (ECEM)

EVENT CASE STUDY
ECEM CS 001

High demand in winter 2009/10



A series of case studies based on extreme events which illustrate how the ECEM demonstrator can be used by the energy sector to enhance understanding and support decision making.

Boosting Decision Making

1 Winter 2009/10 saw high power demand due to extremely cold temperatures across much of northern Europe, as seen in the ECEM demonstrator

2 The impact of another winter similar to 2009/10 is likely to be greater today because of the increase of weather-sensitive renewables such as wind in the energy mix. For the UK, the ECEM historical dataset shows a significant drop in wind power if 2009/10 conditions occurred today

Scientific/Technical Advances

1 ECEM has brought together credible data from the climate and energy communities, processed in a consistent way over a range of time scales

2 The demonstrator tool provides valuable insight into the winter 2009/10 event and can be used to study the impact of other extreme weather events on European power systems

3 Analysis of the ECEM datasets has revealed dependencies and risks across European countries and between energy and climate variables

Key Lessons

1 The ECEM historical dataset allows:
- Investigation of an event in the context of recent history
- 'What if' questions to be assessed based on today's energy mix and the climate drivers

2 The demonstrator can help anticipate future risks through:
- Seasonal forecasts
- Climate projections

For more information visit
www.ecem.climate.copernicus.eu
or contact the ECEM team at
support@ecem.climate.copernicus.eu

Version 4, Date of publication: 4 December 2017

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University of East Anglia
EDF
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ENEA
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European Commission

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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University of East Anglia

University of Reading

Met Office

ARMINES

ENEA

ECMWF

European Commission

SECLI FIRM

The Added Value of Seasonal Climate Forecasting for Integrated Risk Management

How can seasonal climate forecasts help your business?

UEA University of East Anglia

enel

ENEA Italian national agency for new technologies, energy and sustainable economic development

Met Office

UL AWS TRUEPOWER

WEMC World Energy & Meteorology Council

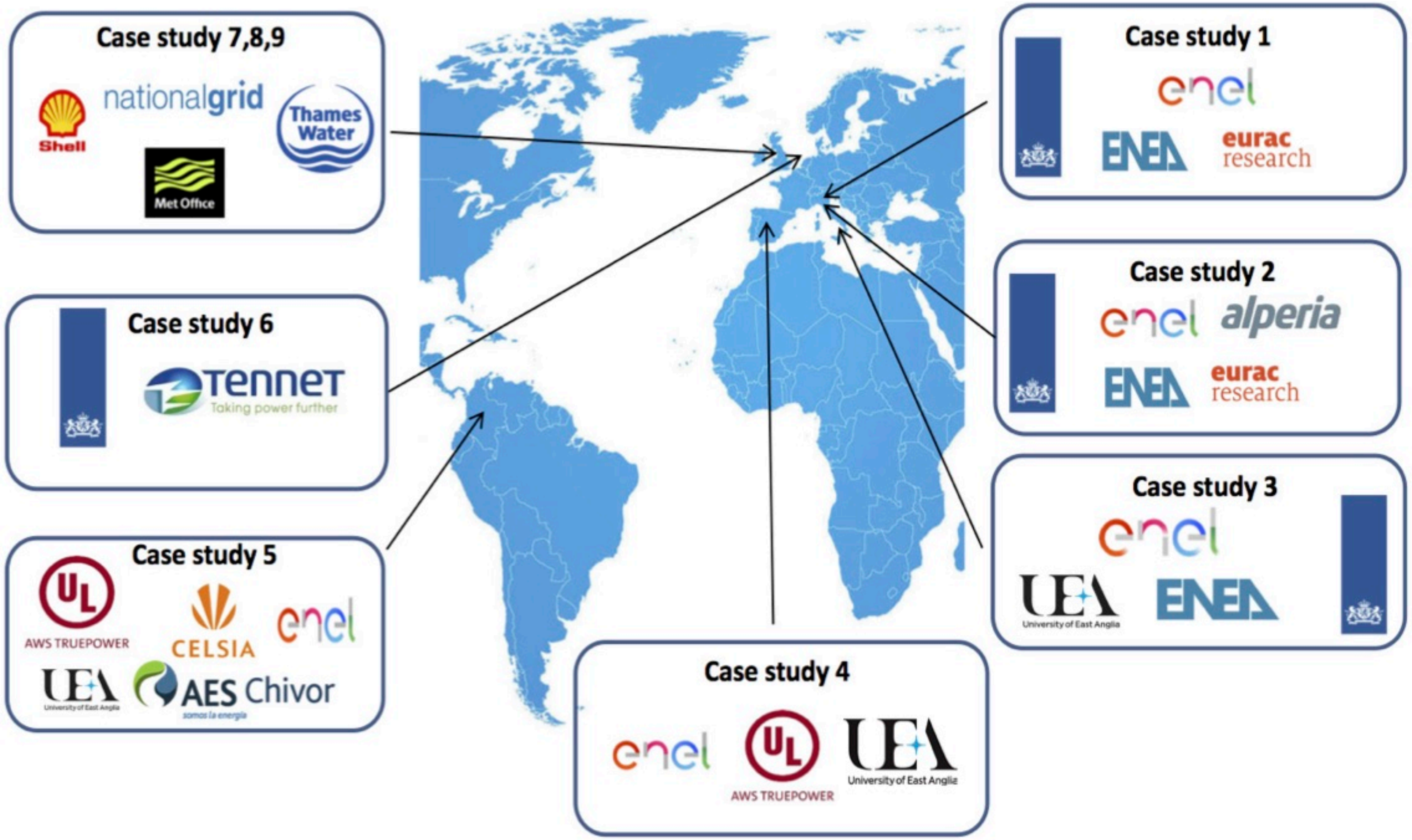
eurac research

alperia

Grant Agreement n. 776868

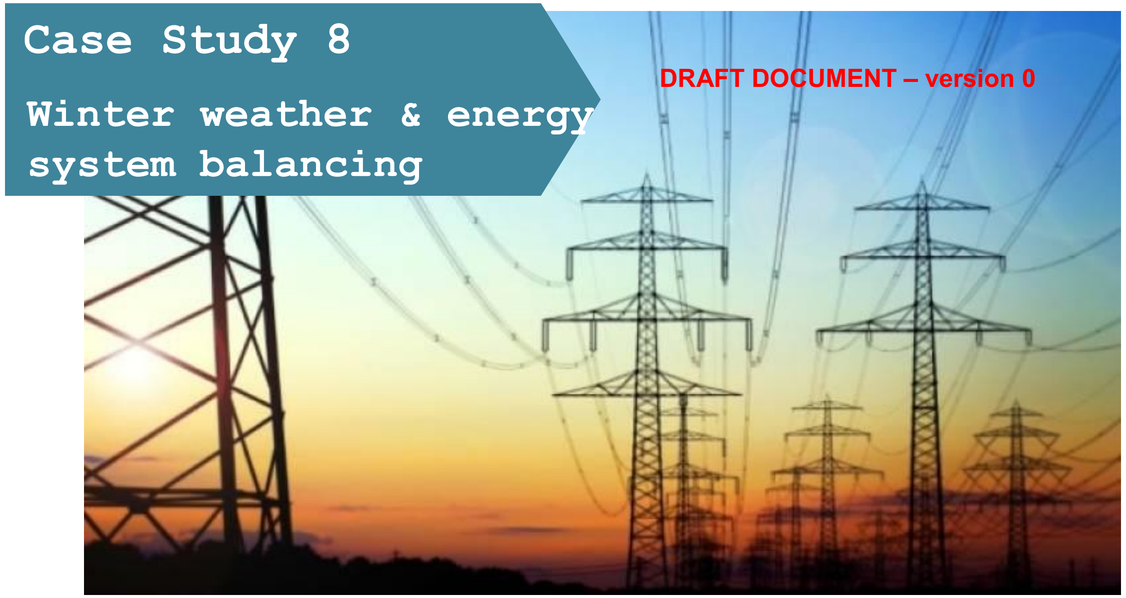
The How – Experiments

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

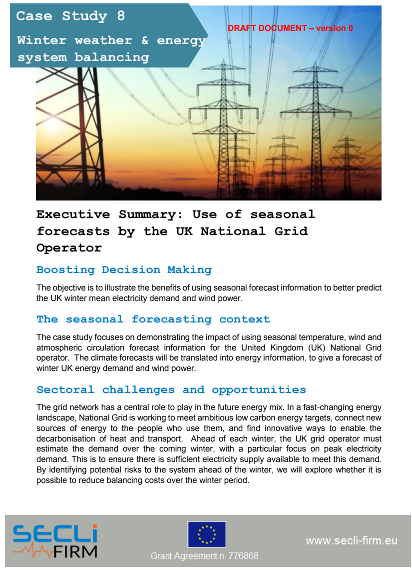


Case Study – Grid

Use of seasonal forecasts by the UK National Grid Operator



The objective is to illustrate the benefits of using seasonal forecast information to better predict the UK winter mean electricity demand and wind power


Case Study 8
Winter weather & energy system balancing
DRAFT DOCUMENT – version 0

Executive Summary: Use of seasonal forecasts by the UK National Grid Operator

Boosting Decision Making

The objective is to illustrate the benefits of using seasonal forecast information to better predict the UK winter mean electricity demand and wind power.

The seasonal forecasting context

The case study focuses on demonstrating the impact of using seasonal temperature, wind and atmospheric circulation forecast information for the United Kingdom (UK) National Grid operator. The climate forecasts will be translated into energy information, to give a forecast of winter UK energy demand and wind power.

Sectoral challenges and opportunities

The grid network has a central role to play in the future energy mix. In a fast-changing energy landscape, National Grid is working to meet ambitious low carbon energy targets, connect new sources of energy to the people who use them, and find innovative ways to enable the decarbonisation of heat and transport. Ahead of each winter, the UK grid operator must estimate the demand over the coming winter, with a particular focus on peak electricity demand. This is to ensure there is sufficient electricity supply available to meet this demand. By identifying potential risks to the system ahead of the winter, we will explore whether it is possible to reduce balancing costs over the winter period.

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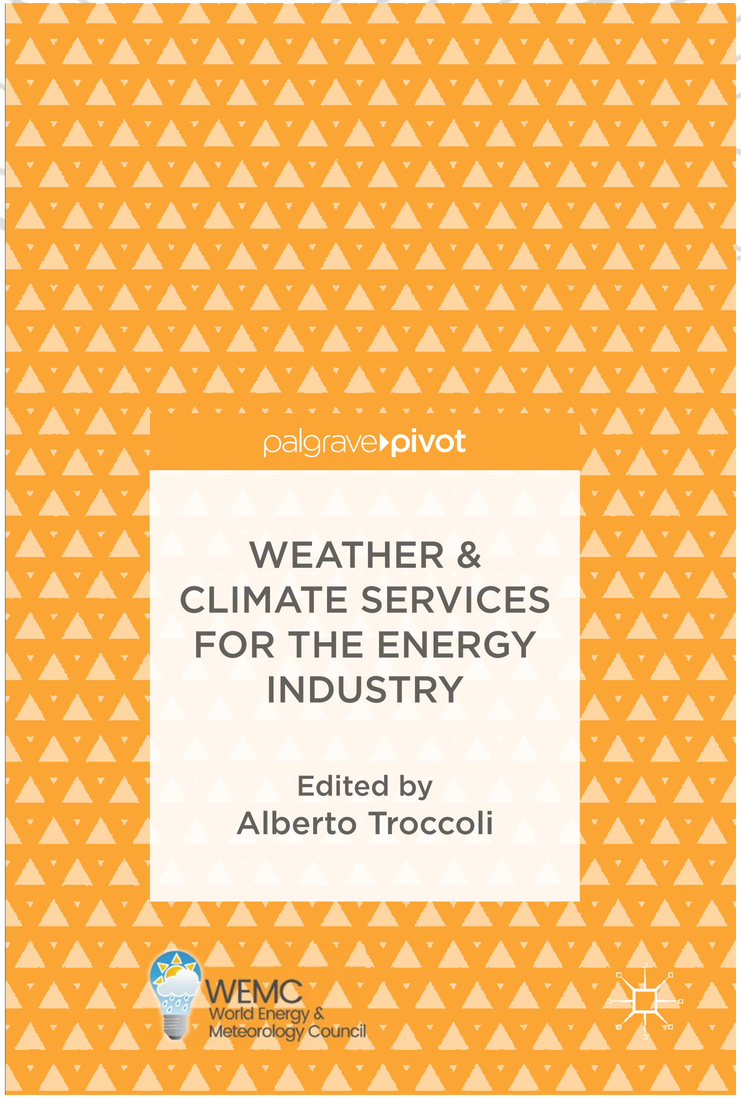

To download it (it’s free!), please visit:
https://link.springer.com/book/10.1007%2F978-3-319-68418-5 or
http://www.wemcouncil.org/wp/resources/

Summary

- Energy and Meteorology are closely connected
- Energy systems 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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