Climate Service and Technology: a Key Tool of Climate Change Adaptation for the Energy Sector

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EBRD, London (UK), 2 Jun 2017

Outline

- The evolving relationship between Energy and Climate
- How Weather/Climate impacts Energy
- Copernicus Climate Service for Energy: European Climatic Energy Mixes

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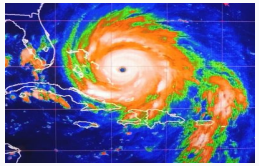
Energy and meteorology go hand in hand

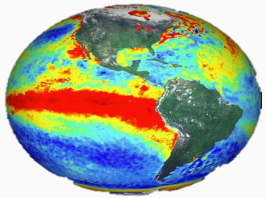
Passing clouds

Drop in solar power



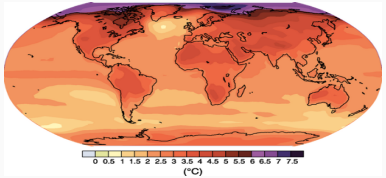
Hurricanes

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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Our primary goal is to enable improved

Sustainable energy

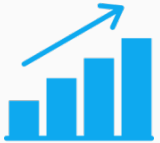
For a low carbon economy

Resilience

Of energy infrastructures

Efficiency

Of energy systems



Under ever changing weather and climate

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WEMC activities are

1. The dissemination of information on products, practices, and experiences in Energy & Meteorology including the promotion of the work of our members
2. The organisation and coordination of Special Interest Groups (SIGs) leading to the production of reports, analyses and syntheses on key topics in Energy & Meteorology
3. The development and maintenance of demonstration tools to assist with the uptake of weather, climate and water services by the energy industry and the education of the general public
4. The organisation of events such as the International Conference Energy & Meteorology (ICEM), including the development and delivery of professional workshops, seminars and webinars

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http://www.wemcouncil.org/

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.

Energy industry is multi-faceted









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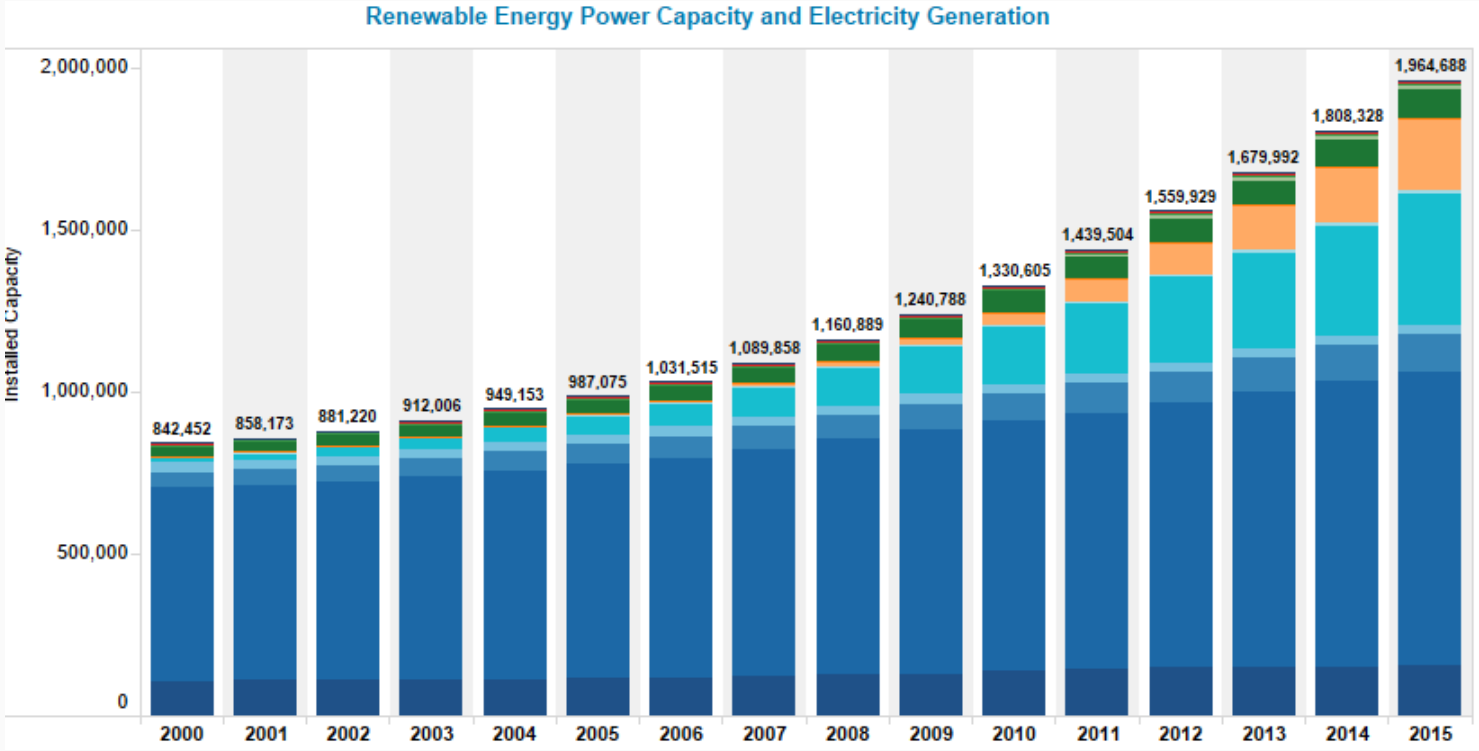
Strong growth in renewables



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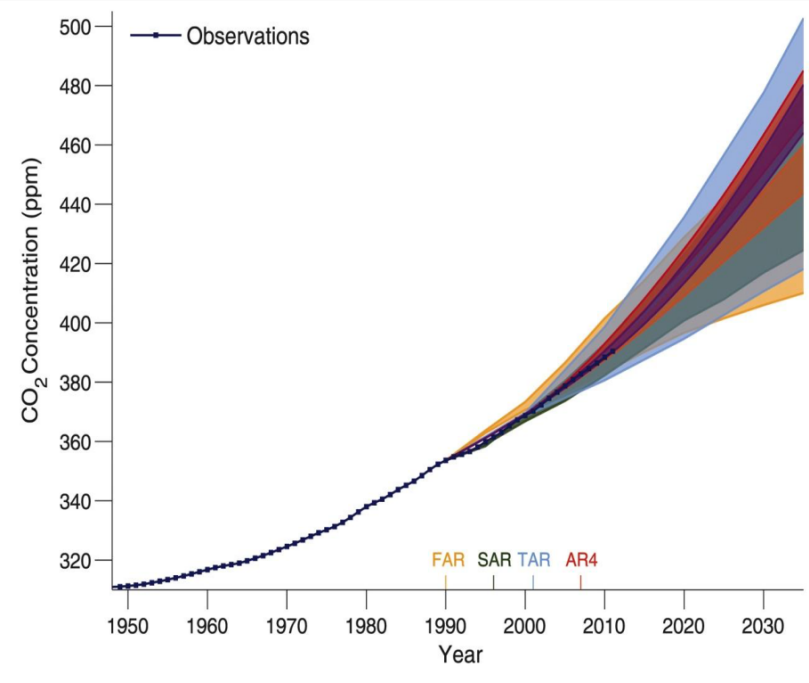
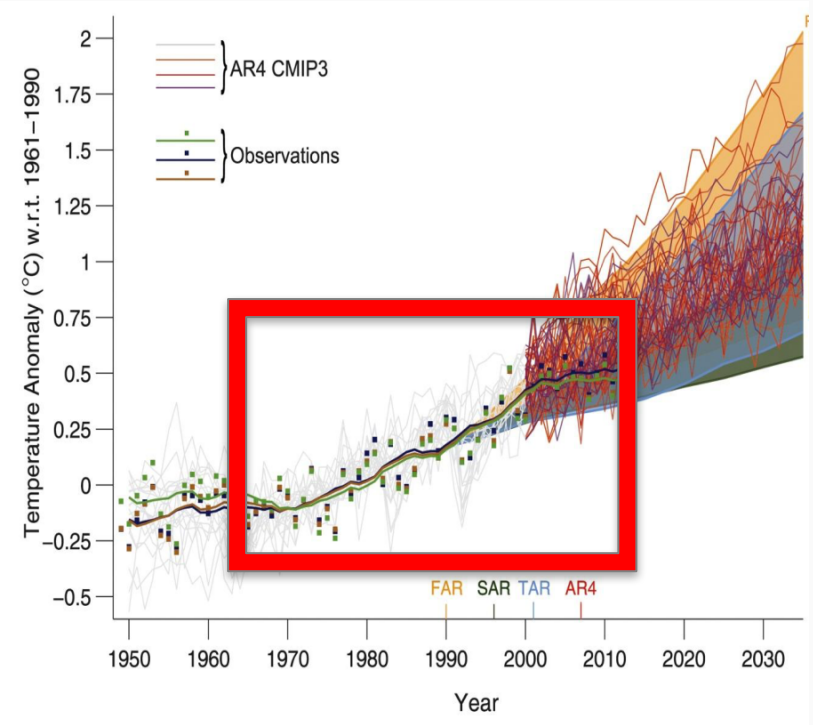
IRENA (2016)

C02 emissions and temperature





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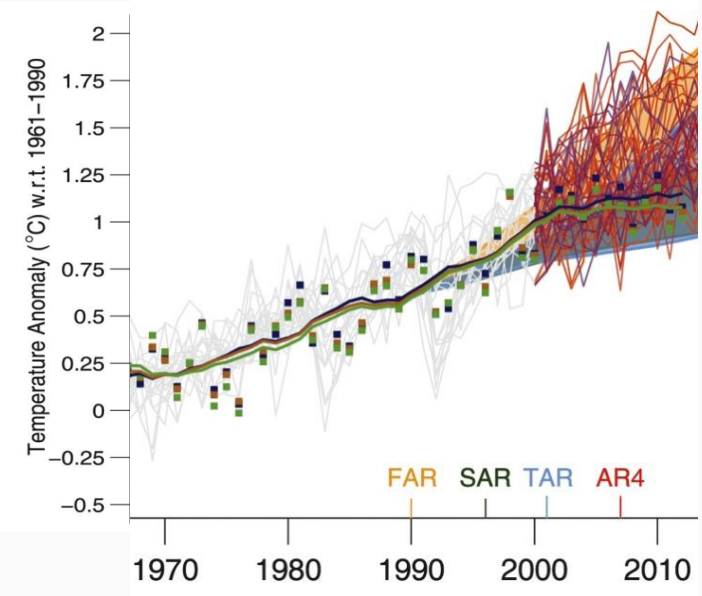
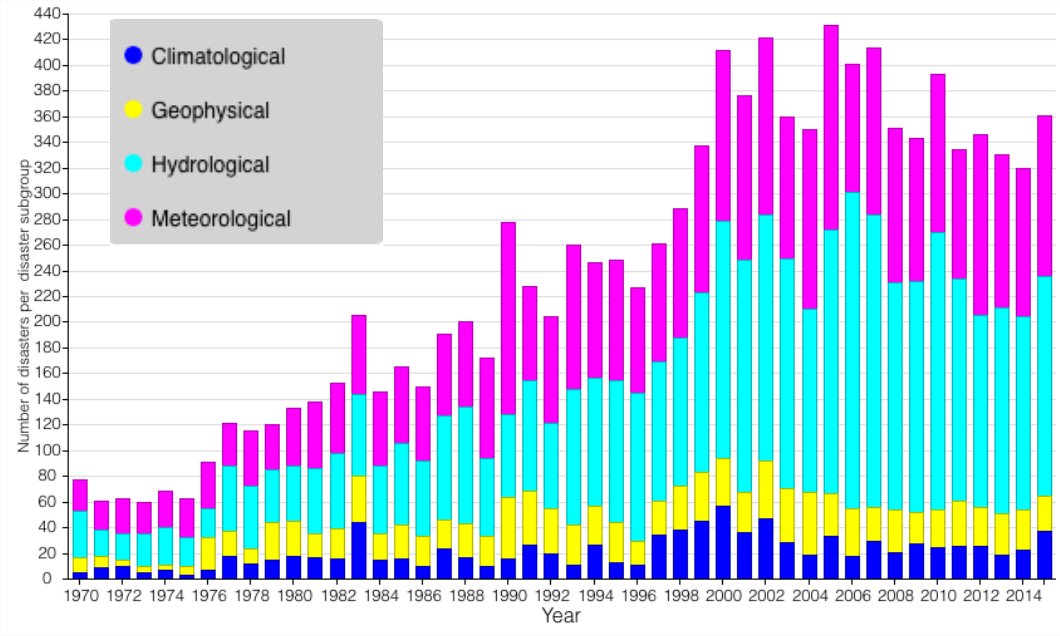
IPCC AR5 (2013)

Disasters due to natural events





EM-DAT (2016)

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Simplified Energy & Climate feedback

Emissions

Energy

Meteorology
Weather, Climate & Water

Impacts

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Climate impact on coal mines

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Love et al. (2014)

Climate impacts on hydro-power

Masinga Dam Water levels in different Years

From Christopher Oludhe (2015)

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Climate impact on nuclear power

The 2003 heatwave in France had serious consequences on the cooling of nuclear reactors. The overall cost of the heat wave for EDF was around €330 million

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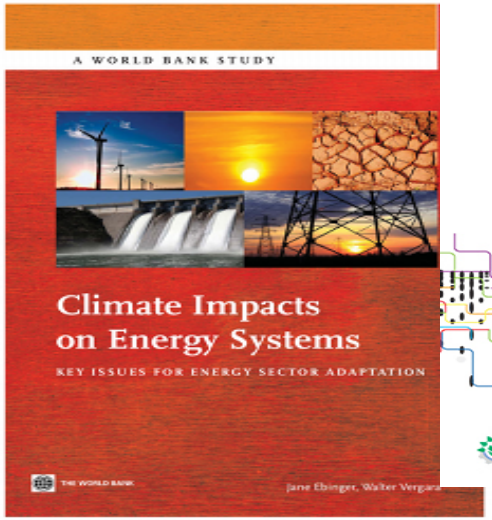
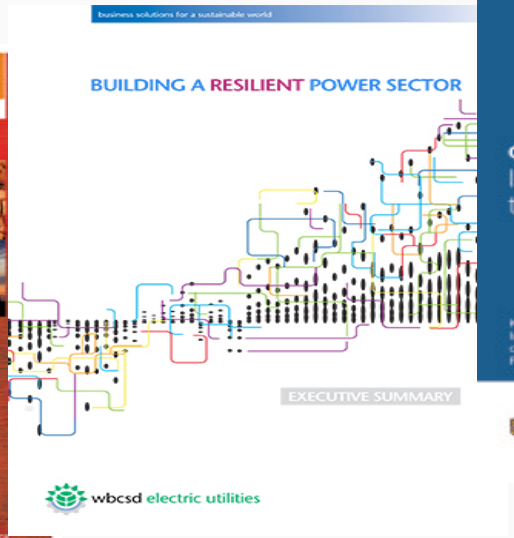
Dubus (2009)

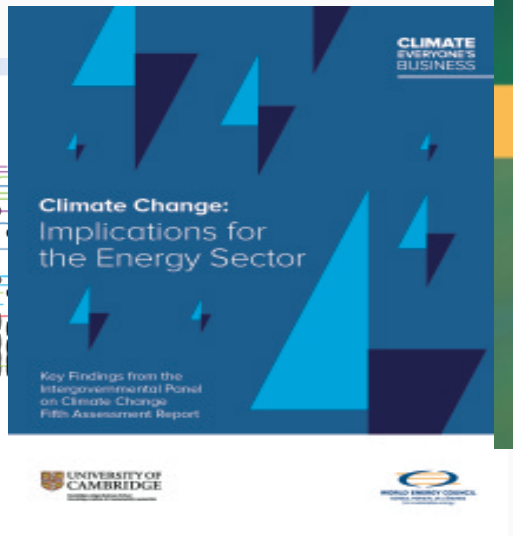
A selection of publications



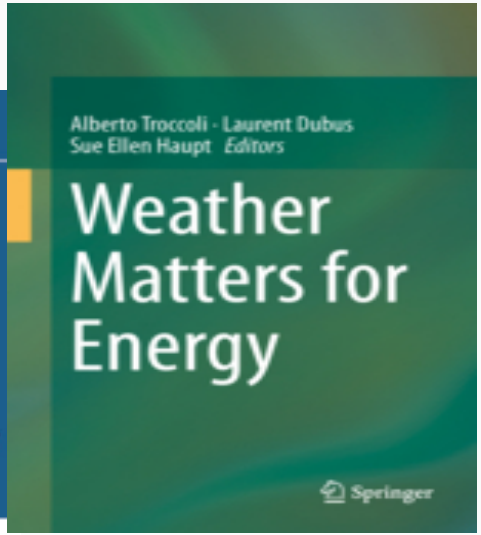
World Bank (2010)



WBCSD (2014)



WEC (2014)



ICEM (2014)

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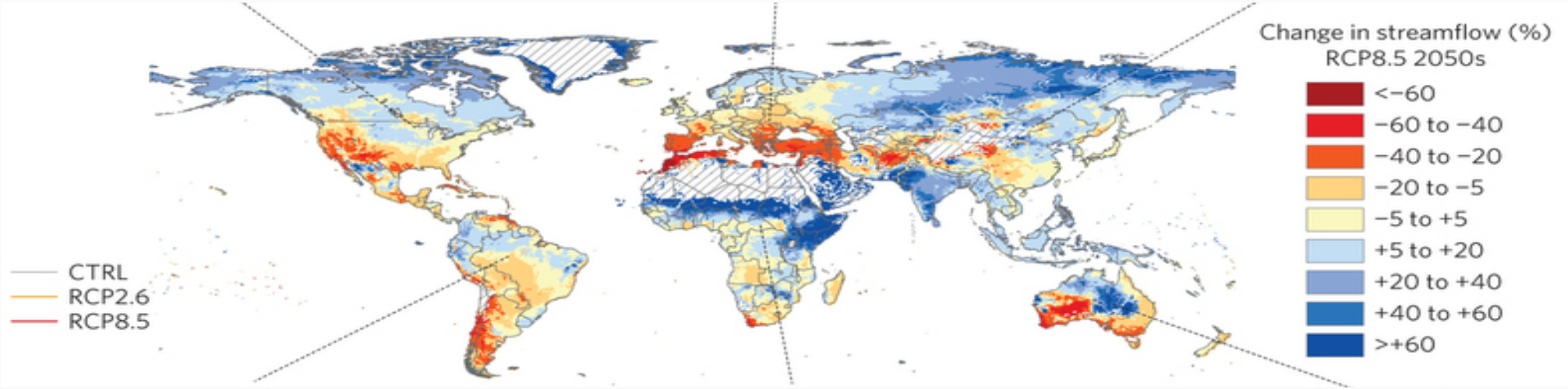
Global changes in streamflow projections



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

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

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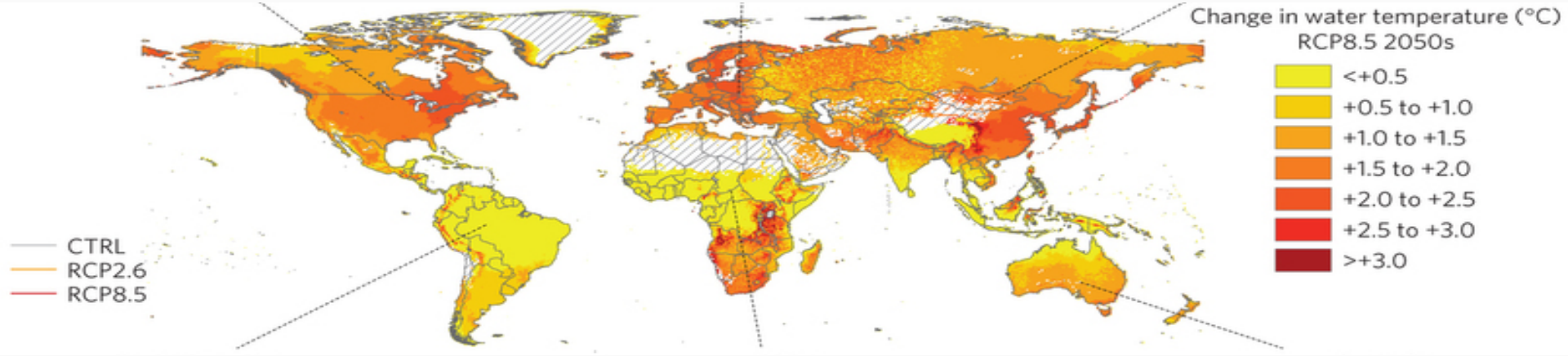
van Vliet et al. (2016)

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

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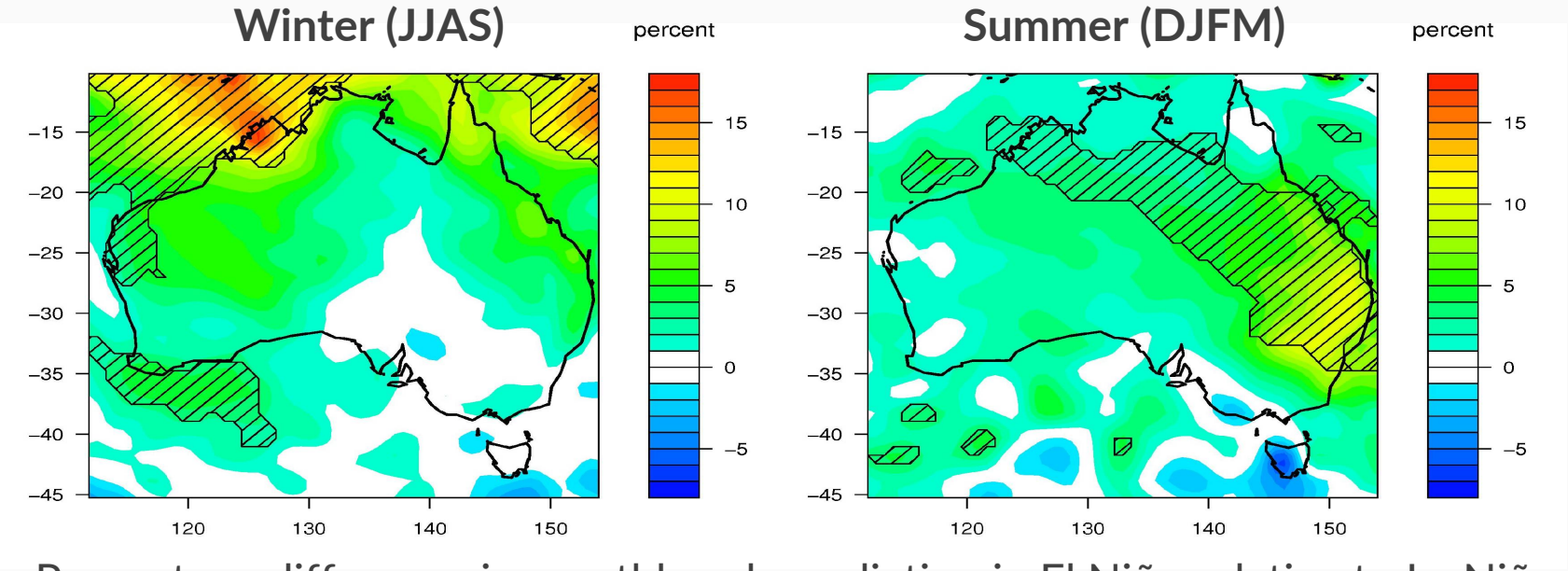
van Vliet et al. (2016)

Solar Radiation Inter-annual Variability



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

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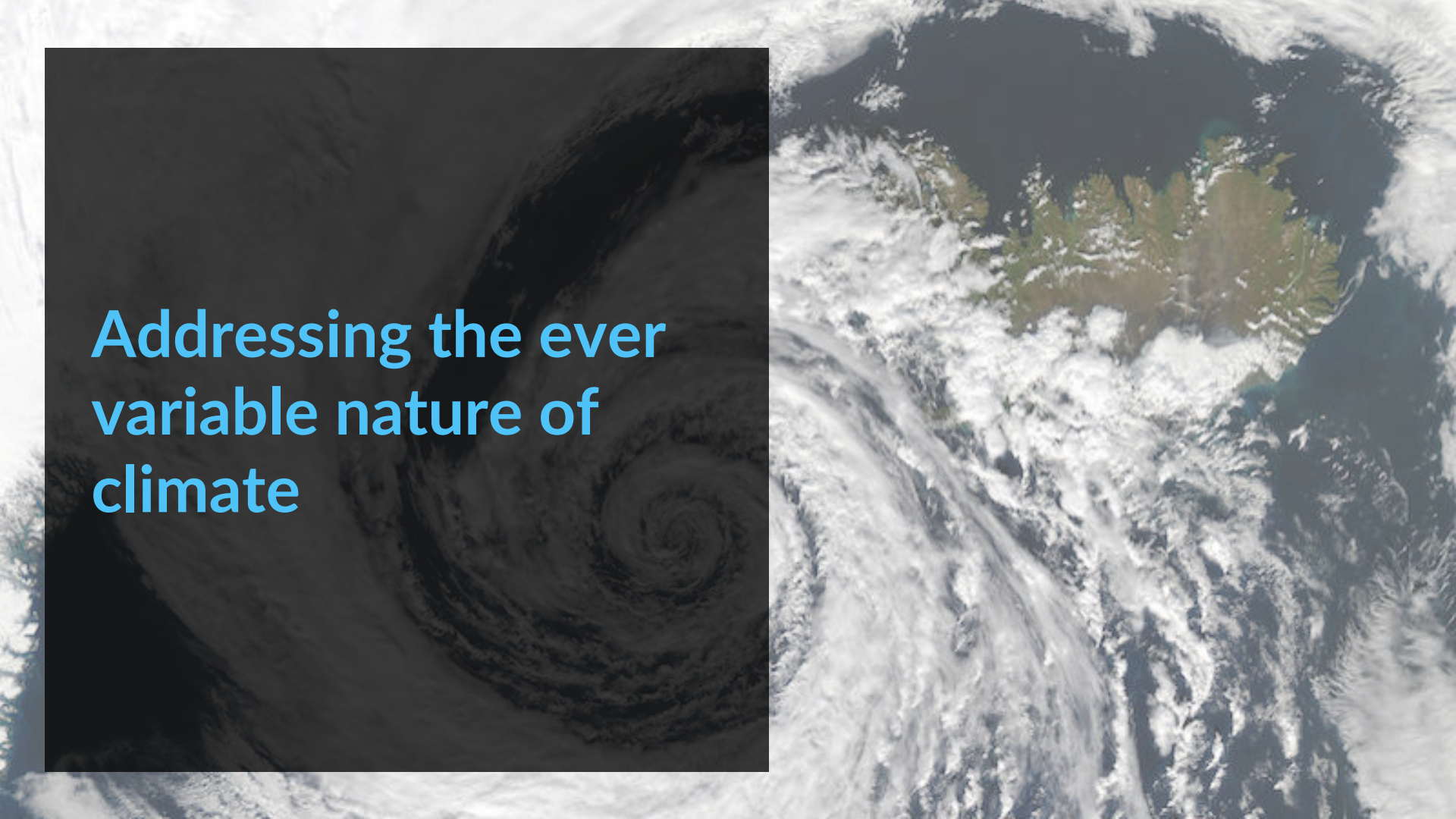
Davy and Troccoli (2012)

Addressing the ever variable nature of climate



Weather Services

- Very mature: 30+ years of experience
  - Also financial products since late 1990's
- Products well understood by many users
  - Relatively easy to identify needs
  - Users wish to be updated about latest developments in weather products but otherwise develop their own services
  - Regular (e.g. annual) users meetings and/or specific training normally offered by weather service providers

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Climate Services

- Relatively recent: ca. 10 years
  - First products from International Research Institute (IRI)
- Services still under developments
  - Large uncertainties in climate forecast/projections makes it more difficult for users to ascertain real value of climate information
  - Need to provide concrete examples of how to use climate information in practice

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But…

What is a Climate Service?

A set of actions/tools aimed at helping ‘people’ make the best use of climate information so as to improve their ‘business’

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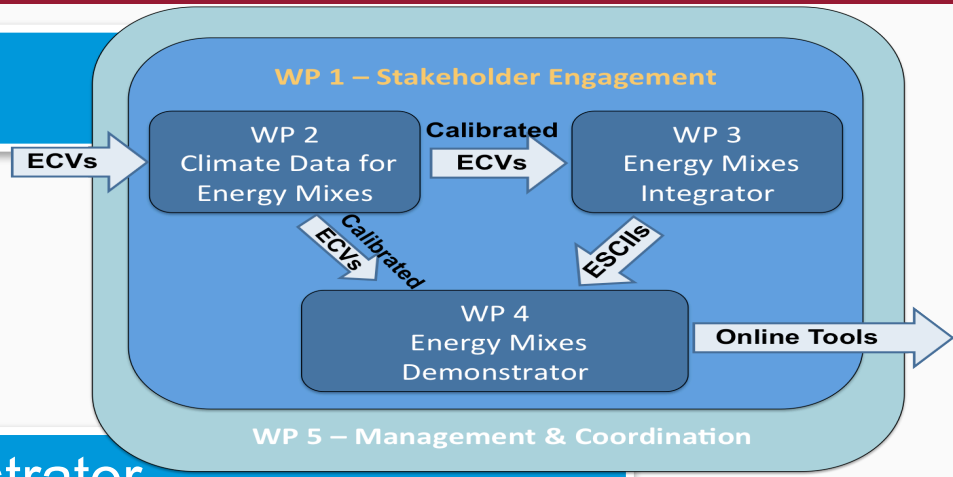
European Climatic Energy Mixes (ECEM)

Copernicus Europe's eyes on Earth

Climate Change Service
climate.copernicus.eu

C3S ECEM in brief

- Budget: €1.6 m
- Length: 27 mth (from Nov 2015)
- Six partners: UEA (lead) EDF, U Reading, Met Office, ARMINES and ENEA



Target: proof-of-concept or demonstrator

Stakeholder engagement central to ECEM

- Five stakeholder workshops, one every 6 months
- A tailored engagement plan

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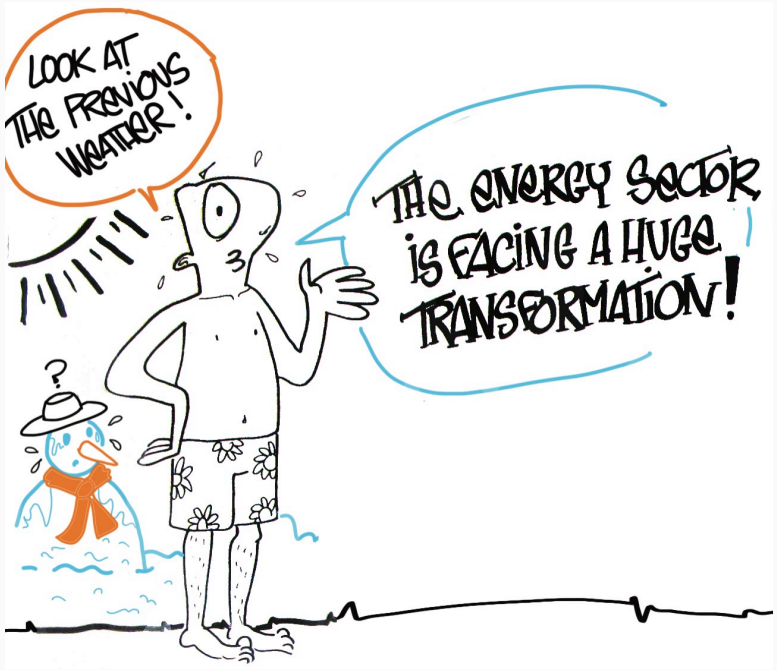
ECMWF · European Commission

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)

Integration of energy & climate information for energy mixes assessment

- ★ Is climate important for energy operations and planning?
- ★ What can climate R&D learn from interaction with energy sector and make output more easily adopted by the industry/policy makers?

European Climatic Energy Mixes (ECEM) is developing 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.

European Climatic Energy Mixes (ECEM)

Climate Change Service
climate.copernicus.eu

- **Energy Mix assessment for:**
  - **Present day**
  - **Seasonal Forecasts**
  - **Climate Projections**

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European Climatic Energy Mixes (ECEM)

Copernicus
Europe's eyes on Earth

Climate Change Service
climate.copernicus.eu

Calibrated Climate Variables

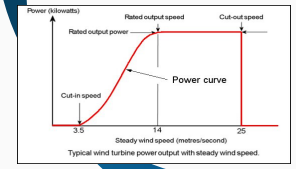
- Temperature
- Rainfall
- River Discharge
- Wind Speed
- Cloud Cover
- Solar Radiation
- Others ?

+Ancillary

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

+ Extreme Events Case Studies

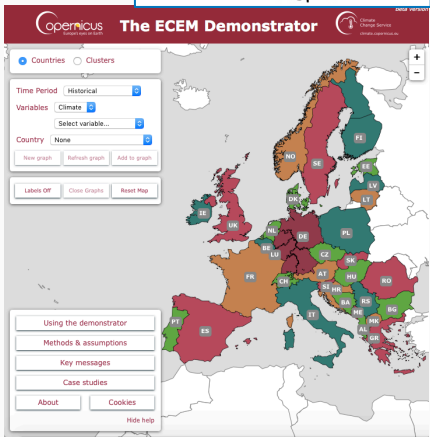
Define models & transfer functions
Select / Gather relevant datasets



Energy Variables

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

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



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Multi-faceted Stakeholder Engagement

- ★ Workshops
- ★ Advisory Committee
- ★ Survey
- ★ Presentation at events
- ★ Webinars
- ★ Web site
- ★ Twitter

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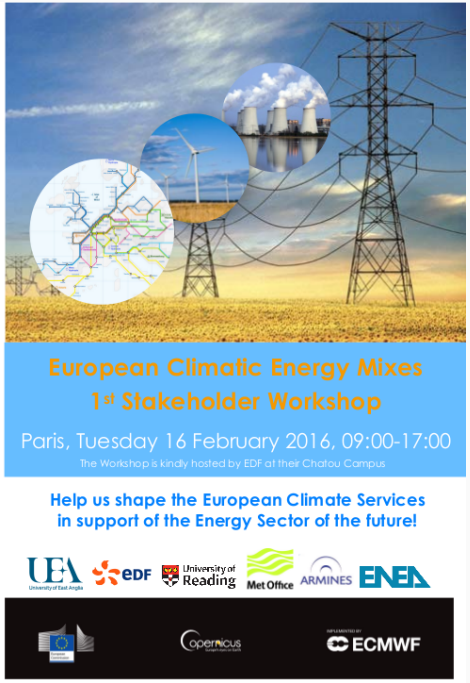
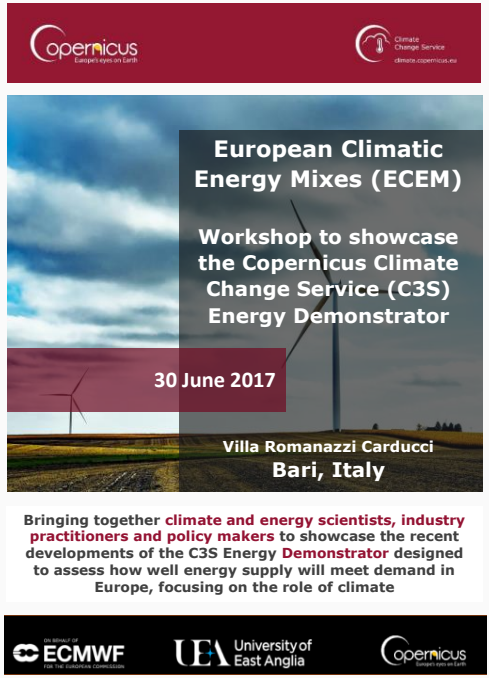
Stakeholder Engagement: Workshops





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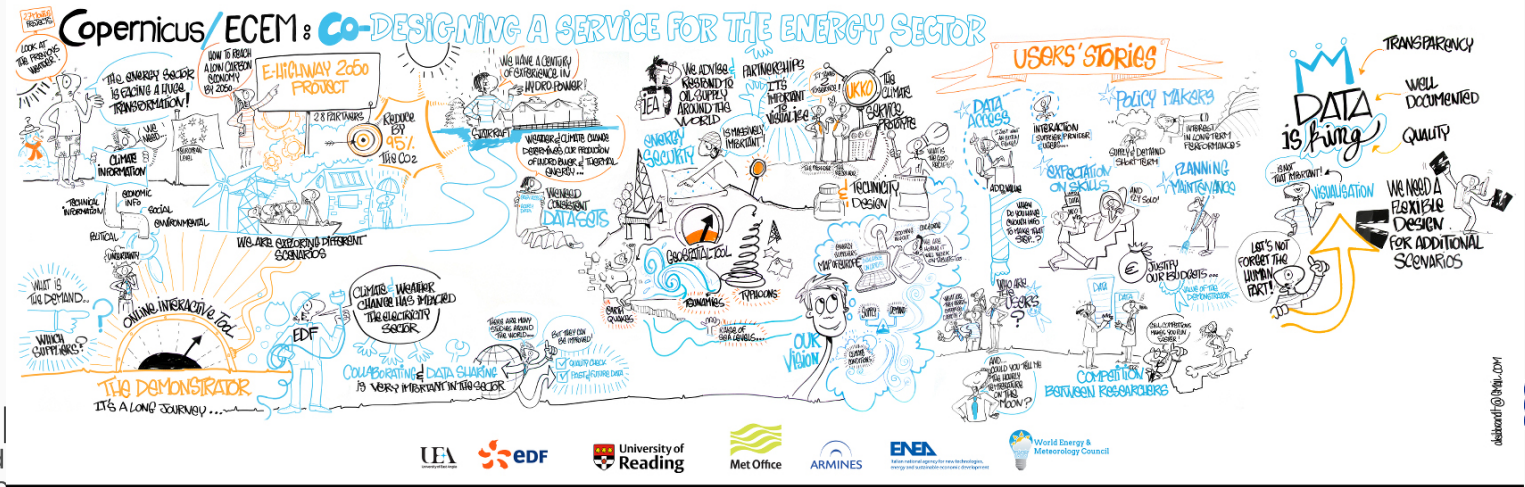
Stakeholder Engagement: Workshops



Stakeholder Engagement: Links & Committee

- Close links with international activities such as the Global Framework for Climate Services, a UN-led initiative

- Advisory Committee
  - A good mix of energy companies, energy industry association, climate/energy service providers and academia

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Climate variables

- ★ Assessing ERA-Interim quality by comparison to gridded observed data (over land areas) for various variables
- ★ Emphasis here on Climate Variables of greatest relevance to Renewable Energy (radiation/sunshine and wind), but others (e.g. temperature, RH influence Demand, precipitation influences HEP) are also relevant
- ★ ERA-Interim despite possibly being the best Reanalysis is not perfect. We can assess how good it is (when and where) by comparisons with gridded observational datasets. Improving on it is termed bias adjustment

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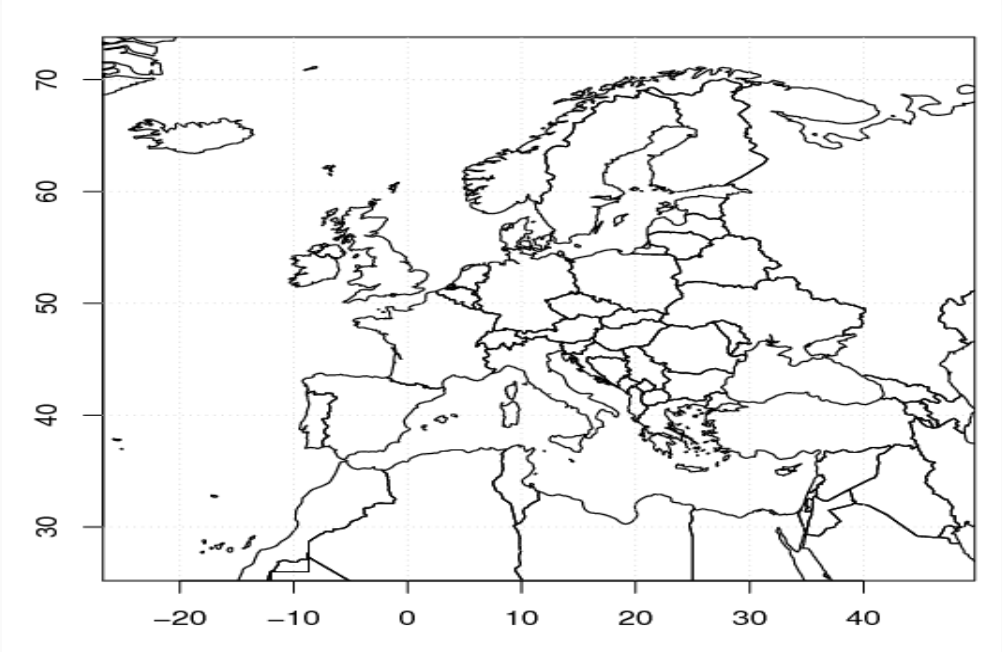
ECEM Domain and ERA Interim



ECEM will also average variables across 33 countries and 96 clusters within Europe from the E-Highway 2050 project

- ERA-Interim regridded from its ~0.7° by 0.7° grid to a latitude/longitude grid at 0.5° by 0.5° spacing
- ERA-Interim available every 6-hours. Some variables are from the analysis, some from the forecasts
- Many gridded climate datasets available for assessment on the 0.5° by 0.5° grid
- Gridded climate datasets produced by interpolation of station observations accounting for elevation

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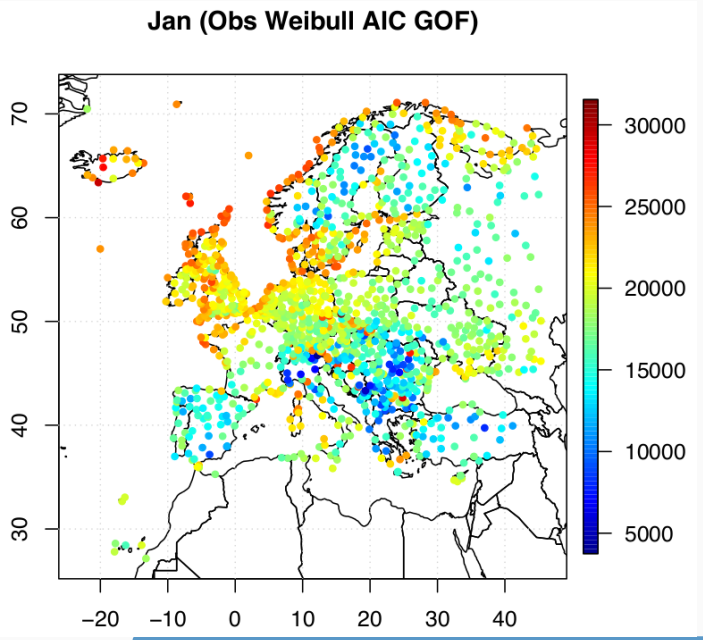
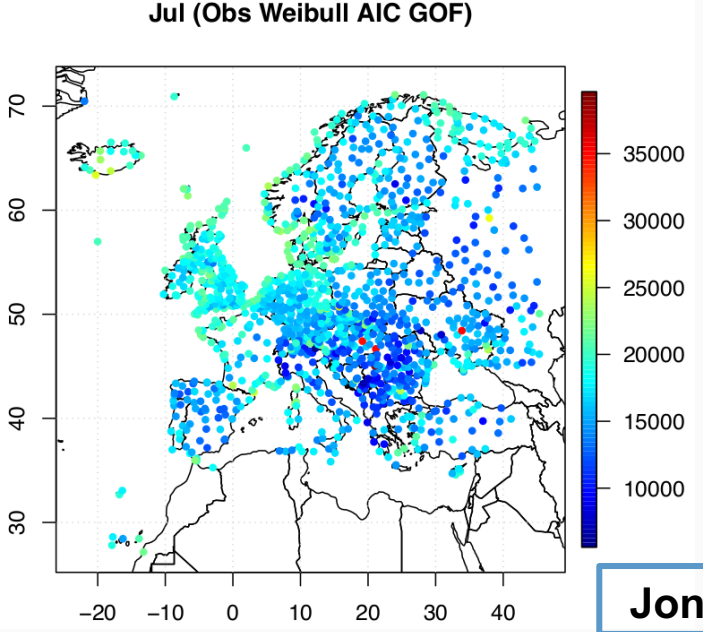
Ensuring Climate variables are fit-for-purpose

Fit of 10 m observations to Weibull distribution





Jones et al (2017)

Low number (blue) good fit; high number (red) poor fit

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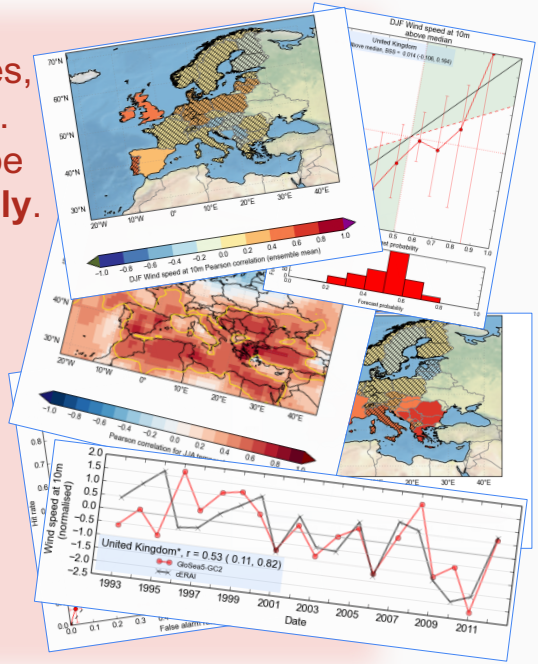
Seasonal forecast information will be part of the ECEM Demonstrator

What seasonal statistics can be provided to the energy sector, to help with energy system balancing?

Main points:

1. How skilful are current models in predicting relevant climate variables in European countries?
2. Where there *is* skill, can it be translated into skilful forecasts of energy indicators (supply/demand)
3. Demonstrate the use of seasonal forecast information through Case Studies and in the Demonstrator.

Skill is **varies** across countries, variables, seasons or models.
→ Seasonal forecasts must be used **carefully** and **selectively**.



How skillful do seasonal forecasts need to be, to help in decision-making?

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Ensuring we use the most accurate Energy data

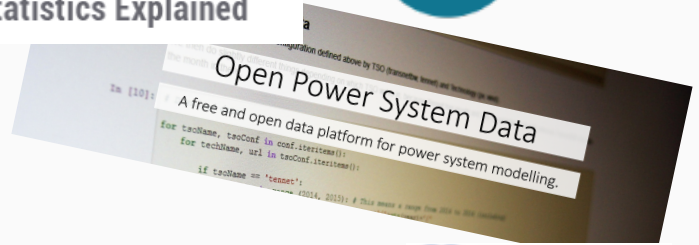
The Energy data challenge:

- ★ There is no single reference database for energy
- ★ Many data sources, inconsistencies between them, incompleteness, access rights (minimal open/free access data) …

- ➔ Need strong support to collect & organise the huge amount of energy data required for a useful service
- ➔ **ECEM is demonstrating that good data allows a good service!**

Rte open data

Enerdata intelligence + consulting



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Energy data: what's available?

Net Generation Capacity:

★ **Present:**

- country level (all countries, all energies)
- plant level (all countries, wind energy)
- plant level (France, ~all energies – Nuclear, Thermal, Wind, Solar, Hydro)

★ **2050:**

- country & cluster levels, from eHighWay2050 (all countries, all energies)

Generation and demand data:

★ Monthly values, most countries, different record lengths

★ Sub-daily (to 30min) demand data for some countries (e.g. France, from 1996)

★ Daily generation for some countries (e.g. France, 2013…)

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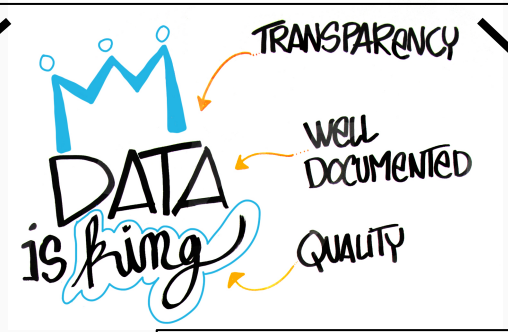
Computation of power supply and demand

From Climate (T, Wind, Precip…) to Energy (Demand, Generation), 2 options



OPTION 1

Energy = **TF** (Climate, Ancillary)

➔ if **Transfer Function TF** is known

OPTION 2

Energy = $\hat{F}$ (climate, ancillary)

➔ $\hat{F}$ being calibrated empirically based on climate & demand / power generation data

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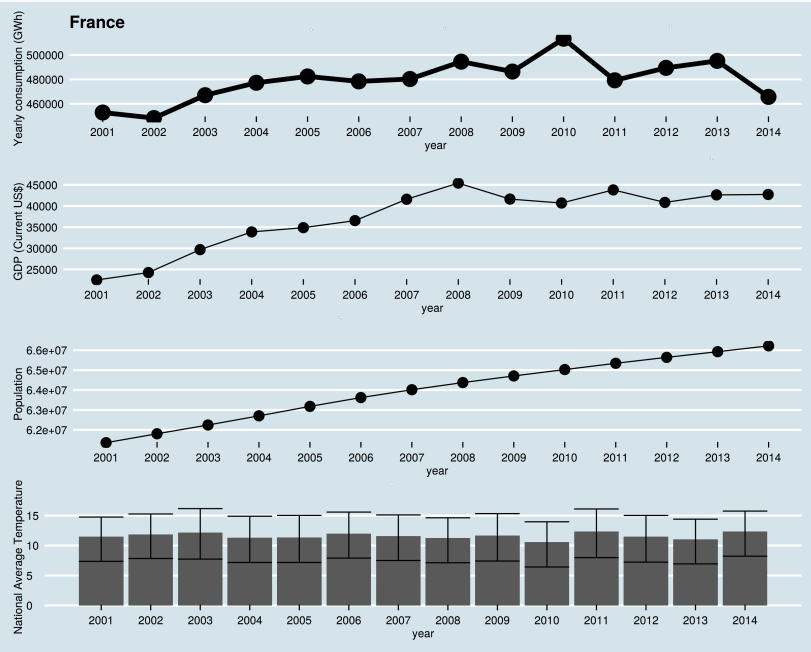
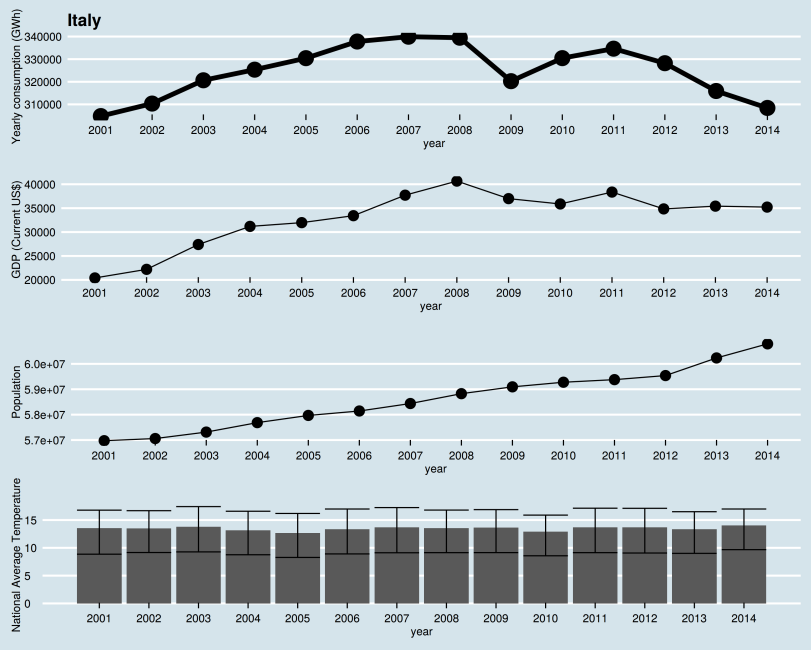
Demand modelling

Challenge: identify role of climatic factors





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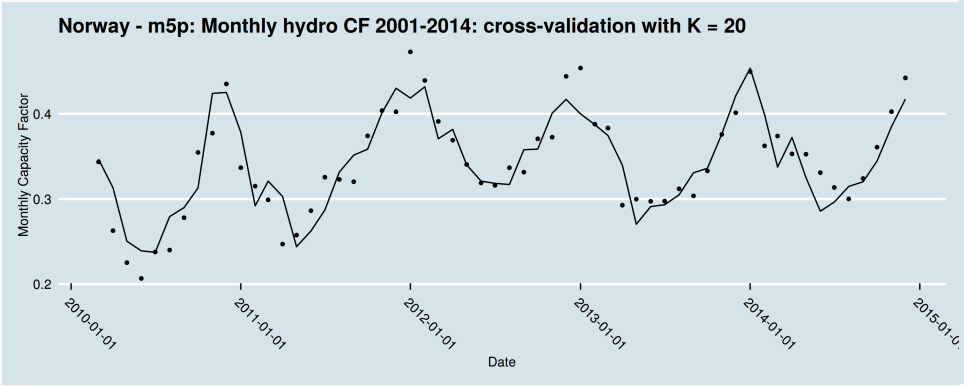
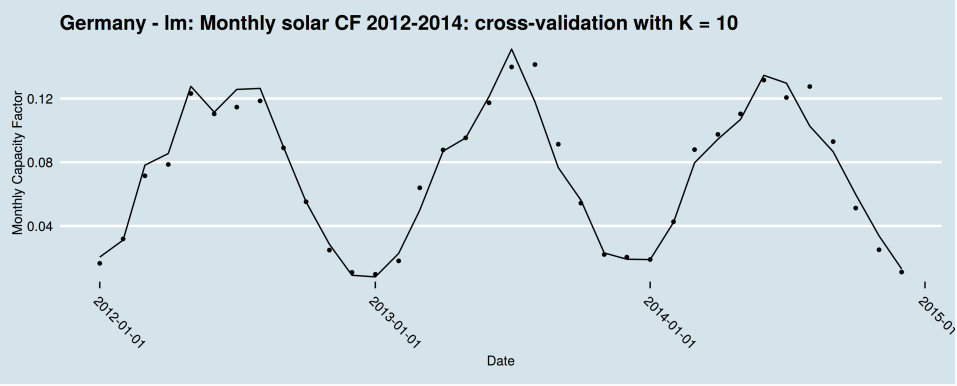
Historical monthly generation

Monthly hydropower production in Norway



Monthly solar generation in Germany



- ★ Statistical models: no big differences between different models (MLR, SVR, GAM, CARTs …) ➔ ideal for monthly time scales @ country level
- ★ Where no data is available for testing, need to use physical models

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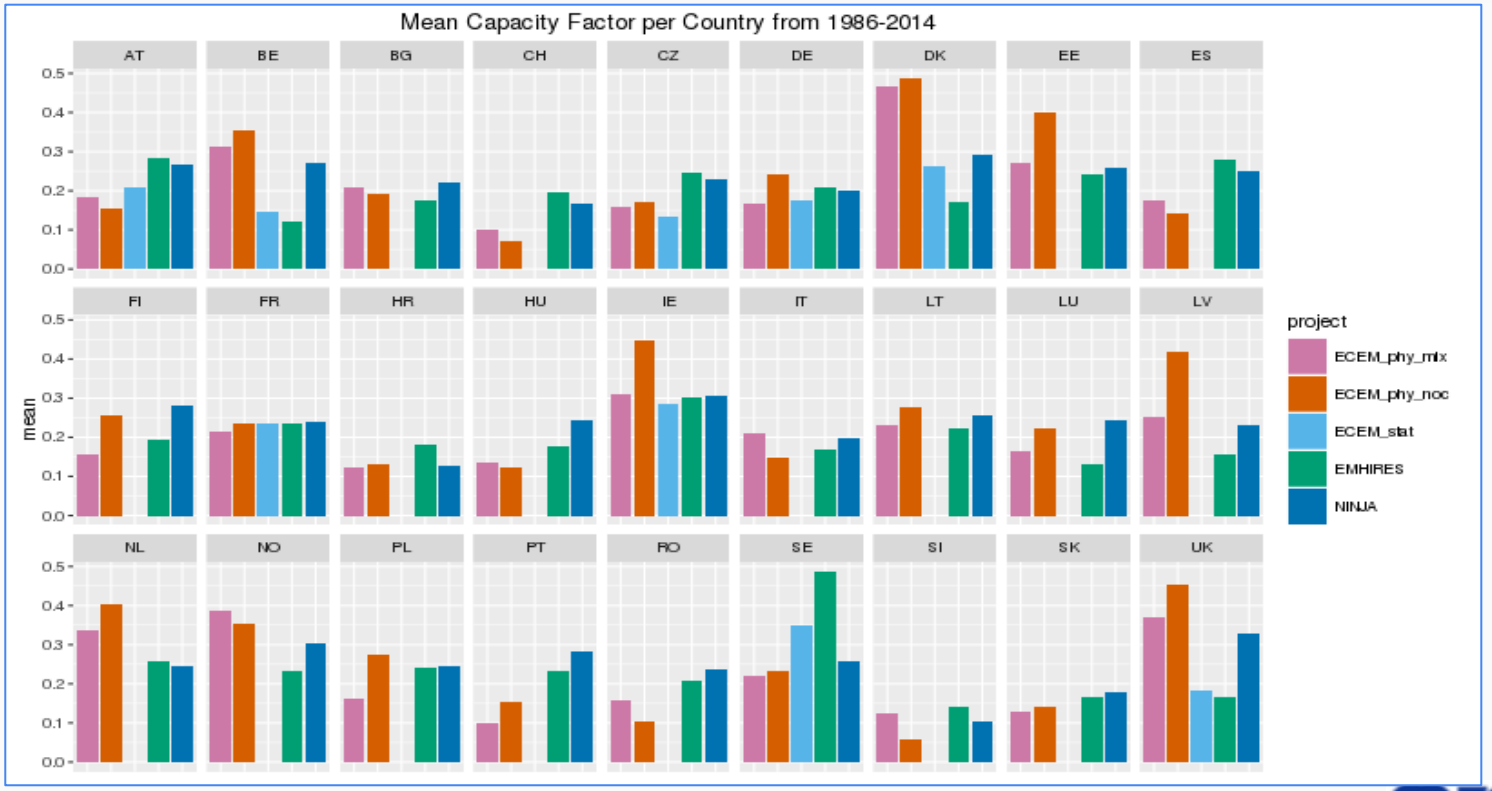
Wind Power Capacity Factor – 1986 -2014



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ARMINES

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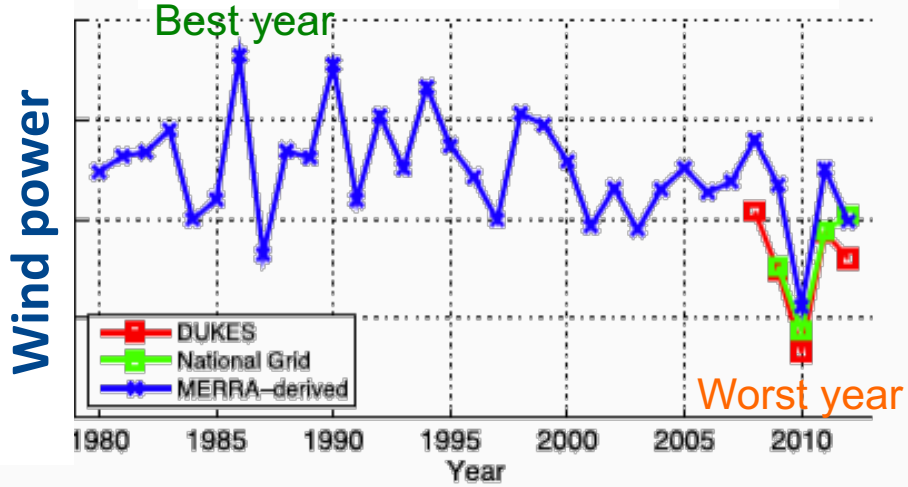
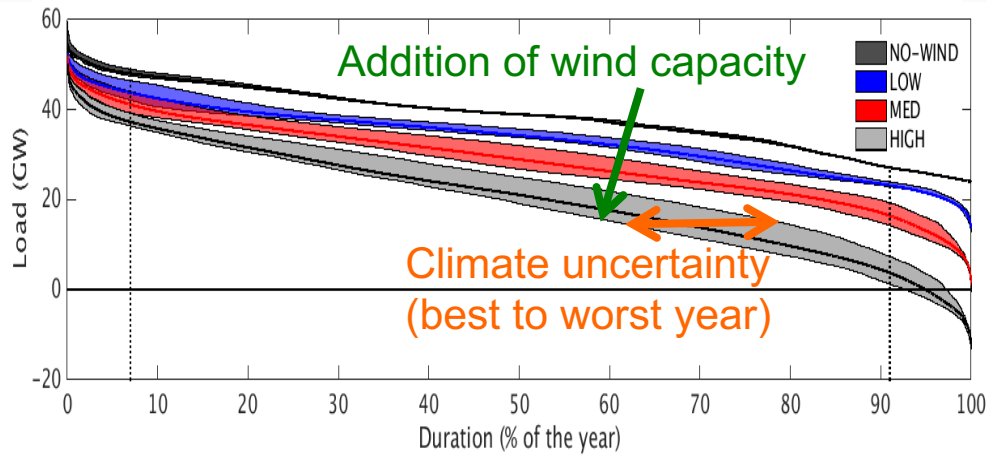
Risk climatologies - examples

★ Investor/owner/planner: Volumetric generation risk

Annual-total wind production



Load-duration



★ Ideas: p5-p95 of production volume for RE, p5-p95 of annual hours at a specified load level for conventional plant ,"best" and "worst" case years, Curtailment, Spatial correlations maps for neighbouring zones

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Cannon et al (2015, RE)
Bloomfield et al (2016)

ECEM Demonstrator

The purpose of the ECEM demonstrator is to enable the energy industry and policymakers to assess how well different energy supply mixes in Europe will meet demand, over different time horizons (from seasonal to long-term decadal planning), focusing on the role climate has on the mixes.

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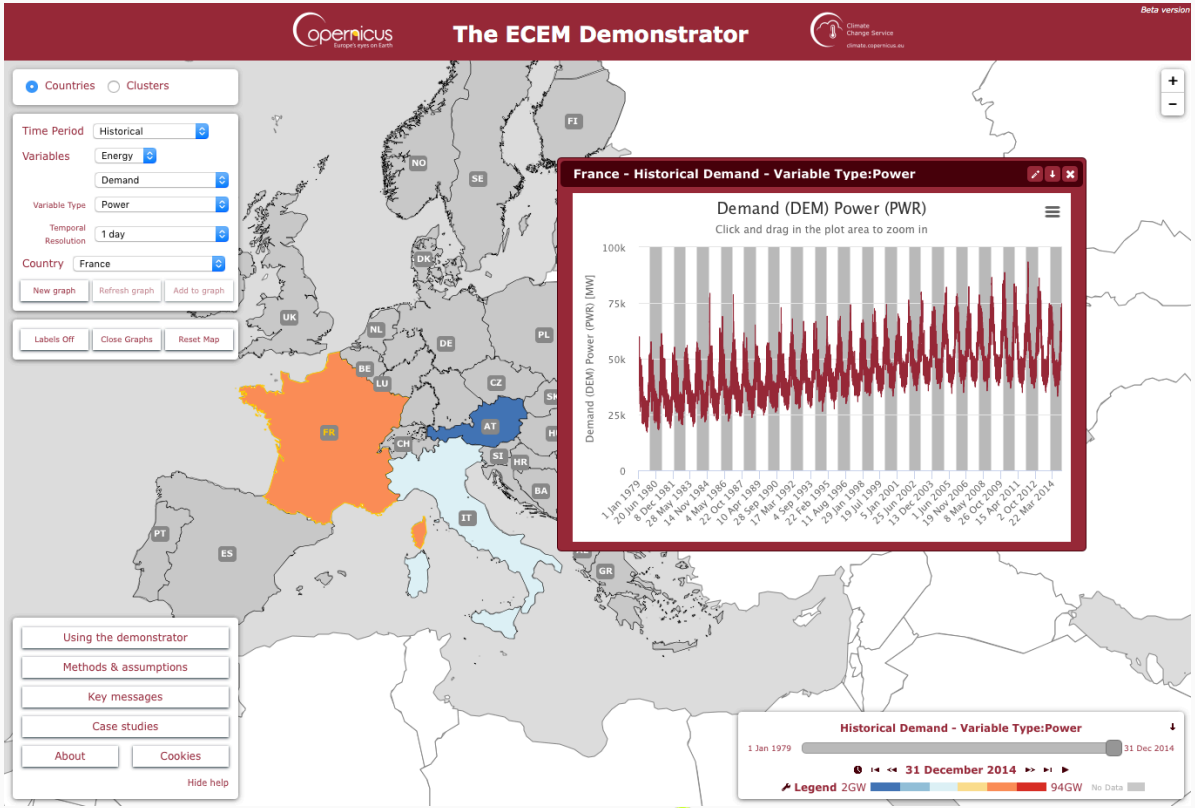
An online interactive tool to test energy mixes



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ECEM Summary

Integration of energy & climate information for energy mixes assessment

- ★ Is climate important for energy planning?
- ★ What can climate R&D learn from interaction with energy sector and make output more easily adopted by the industry/policy makers?

More info at: http://ecem.climate.copernicus.eu/

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Summary

- Energy and Meteorology are closely connected
- Energy systems are already experiencing sizeable impacts, which are likely to become more severe
- Climate services are emerging as robust useful tools for Energy planning, and operations/maintenance
- 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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