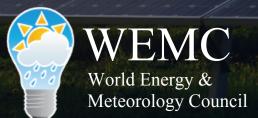
## Climate Service and Technology: a Key Tool of Climate Change Adaptation for the Energy Sector

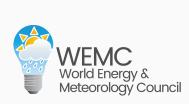
Alberto Troccoli
World Energy & Meteorology Council (UK)
University of East Anglia (UK)



JRC, Ispra (Italy), 10 Nov 2016

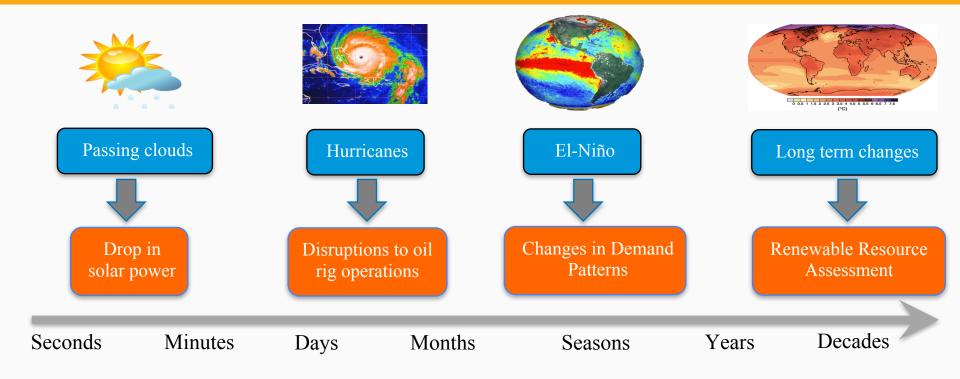
### **Outline**

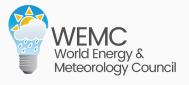
- The evolving relationship between Energy and Climate
- How Weather/Climate impacts
   Energy
- Copernicus Climate Service for Energy: European Climatic Energy Mixes





## Energy and meteorology go hand in hand





## WEMC: 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



#### WEMC work focuses on







Enhancing productivity and policy formulation for the energy industry

Achieving improved adoption of weather, climate and other environmental information by the energy industry

Maximizing the exchange of relevant information between developed and developing countries



Icons designed by Smartline and Gregor Cresnar on flaticon.com

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

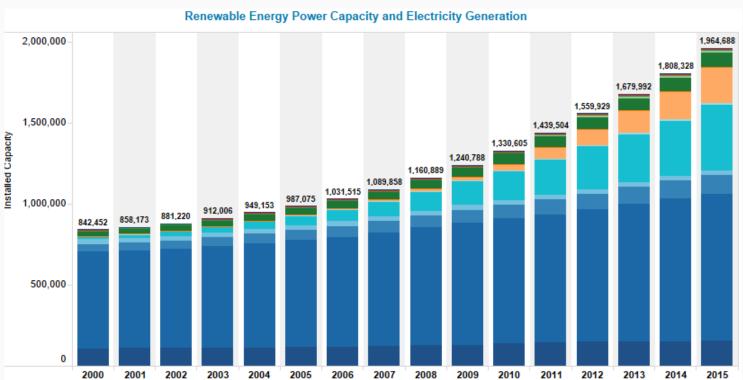
The landscape, in both climate and energy spaces, is changing rapidly.

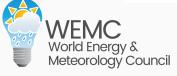


## Energy industry is multi-faceted

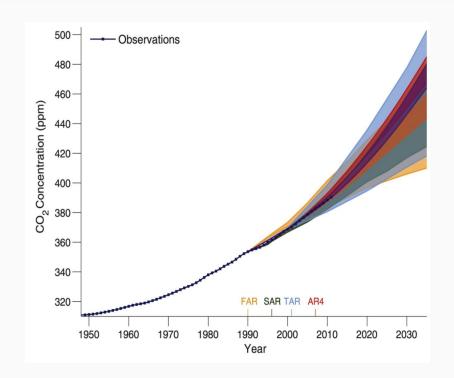


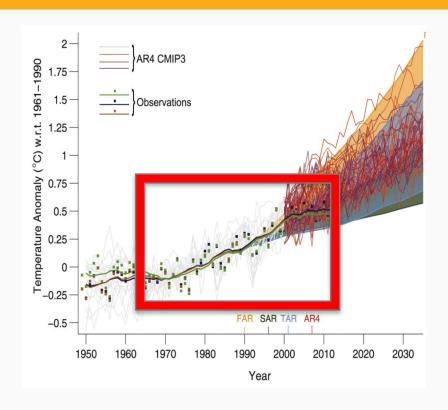
## Strong growth in renewables





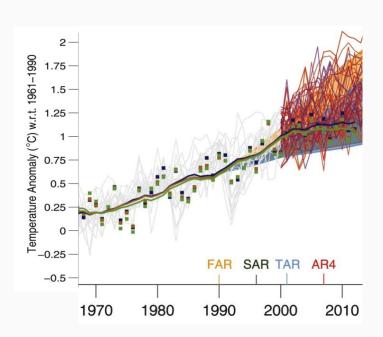
## C02 emissions and temperature

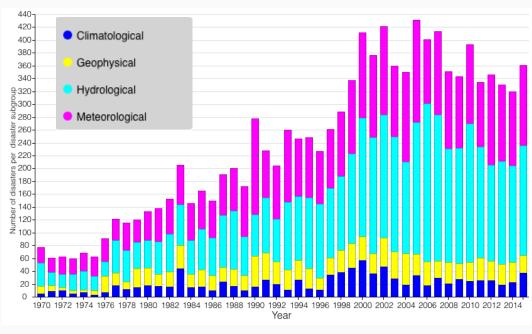


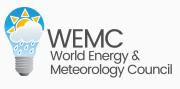




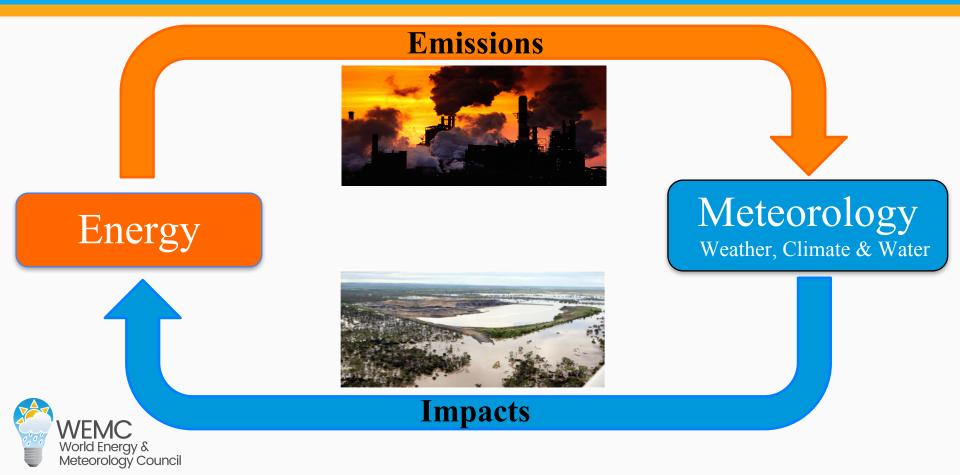
### Disasters due to natural events







## Simplified Energy & Climate feedback



## Climate impact on coal mines





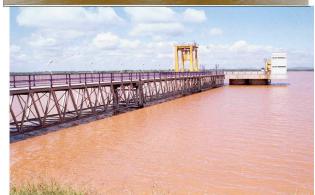
## Climate impacts on hydro-power

#### **Masinga Dam Water levels in different Years**







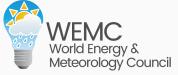


From Christopher Oludhe (2015)

## 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



## A selection of publications

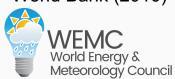


Alberto Troccoli - Laurent Dubus
Sue Ellen Haupt Editors

Weather
Matters for
Energy

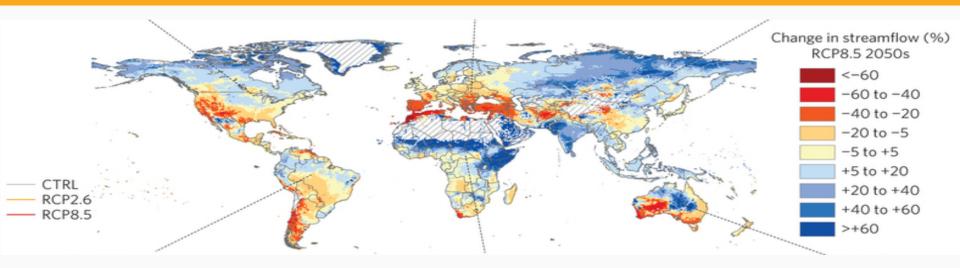
ICEM (2014)

World Bank (2010)



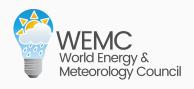
WBCSD (2014)

## Global changes in streamflow projections

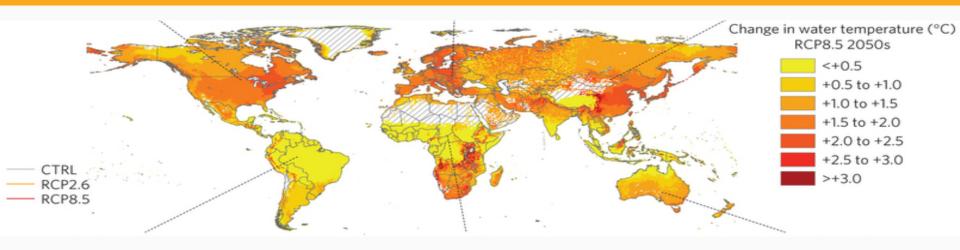


Change in streamflow for RCP8.5, 2040–2069 (2050s) vs1971–2000

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

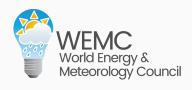


## Global changes in water temperature projections

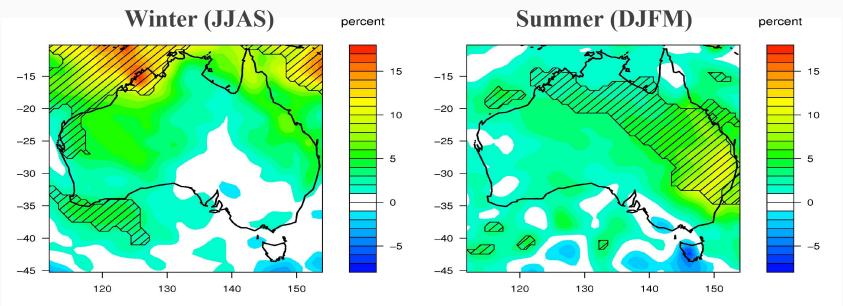


Change in water temperature for RCP8.5, 2040–2069 (2050s) vs 1971–2000

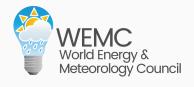
Reductions in usable capacity for 81–86% of the thermoelectric power plants



## Solar Radiation Inter-annual Variability



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





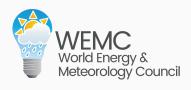
#### Weather Services

- 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



### 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



#### 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'





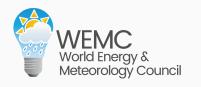
## A major EU programme

Copernicus is harnessing world leading science and technology to equip society to understand and adapt to our changing environment.

Six Information Services: Land, Marine, Atmosphere, Climate, Security and Emergency

Make use of satellite, reanalysis and forecast data via data stores

**Funding: €4.3 billions for 2014-2020** 



Data is full, free and open to all



here

Meteorology Council



- ★ Seven services: 2x Energy, 2x Water, 1x Agriculture, 1x Cities, 1x Insurance
- **★** Aim: to achieve operational climate services codesigned and co-developed with final users

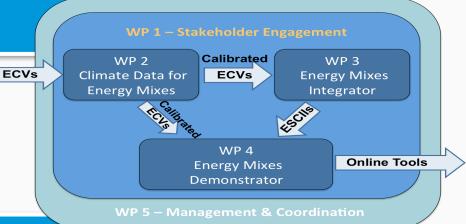






### C3S ECEM in brief

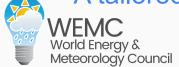
- Budget: €1.6 m
- Length: 27 mth (from Nov 2015)
- Six partners: UEA (lead) EDF, U Reading, Met Office, ARMINES and ENEA



### Target: proof-of-concept or demonstrator

#### Stakeholder engagement central to ECEM

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





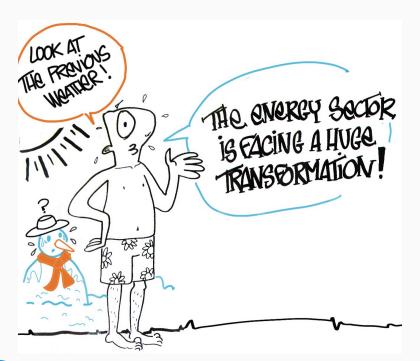






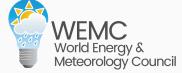






Increasing share of power supply from variable renewable energy (RE) sources. Demand variability is also increasing.

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











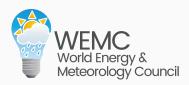




## Integration of energy & climate information for energy mixes assessment

- ★ 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?

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.













**★** Energy Mix assessment for:

- **★** Present day
- **★** Seasonal Forecasts
- **★ Climate Projections**











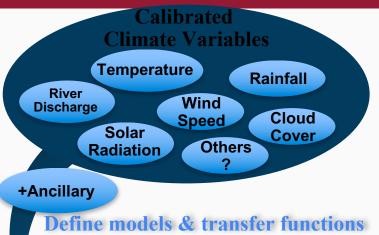








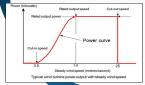


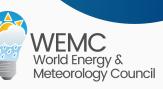


- Skill & Reliability
- Assessment of Seasonal Forecasts of Energy Variables
- + Extreme Events Case Studies

Impacts of Climate Variability & Change on Energy Variables









Sub-Country Scale

Historical

Period

Seas. Fcst

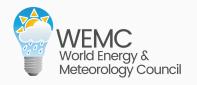
Clim. Proj



### Multi-faceted Stakeholder Engagement

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





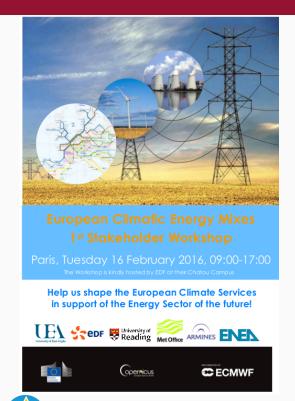


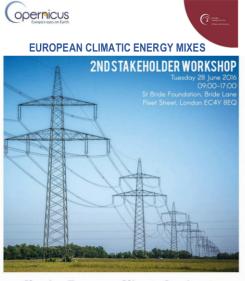






## Stakeholder Engagement: Workshops





Shaping European Climate Services to support the Energy Sector of the future!







#### Copernicus Symposium on Climate Services for the Energy Sector



#### 22-23 February 2017 Barcelona (Spain) – Venue to be confirmed

The European <u>Copernicus Climate Change Service</u> (C3S) programme, funded by the European Commission and operated by the European Centre for Medium-range Weather Forecasts, aims to deliver cutting-edge climate and sectoral information for the society facing climate change adaptation and mitigation. As part of the C3S programme, several <u>demonstration products</u> are being developed and trialled for the energy sector.

This symposium brings together leading climate and energy scientists, industry practitioners and policy makers, to present and explore newly emerging tools and opportunities for managing climate information for the energy sector.

Attendees will also be given hands-on access to the latest developments from the C3S energy-climate services prototypes - and invited to shape the ongoing development of forthcoming publically-available C3S products.



For more info, please contact: Robert.Vautard@cea.fr & A.Troccoli@uea.ac.uk

















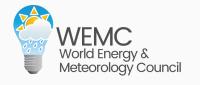




## Stakeholder Engagement: Workshops













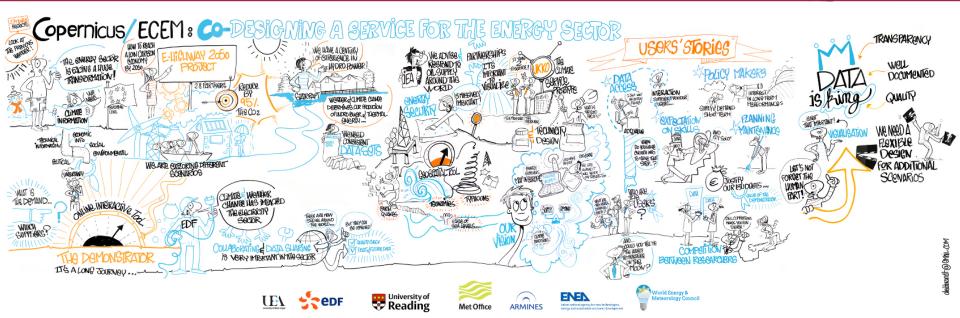




## Stakeholder Engagement: Workshops



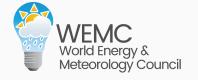




**ECMWF** 

University of East Anglia

















### 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



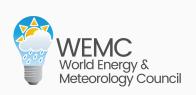






#### Climate variables

- ★ 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

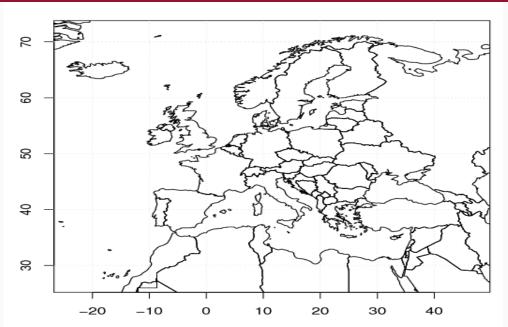








#### **ECEM Domain and ERA Interim**



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

World Energy & Meteorology Council

- ★ 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 6hours. 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



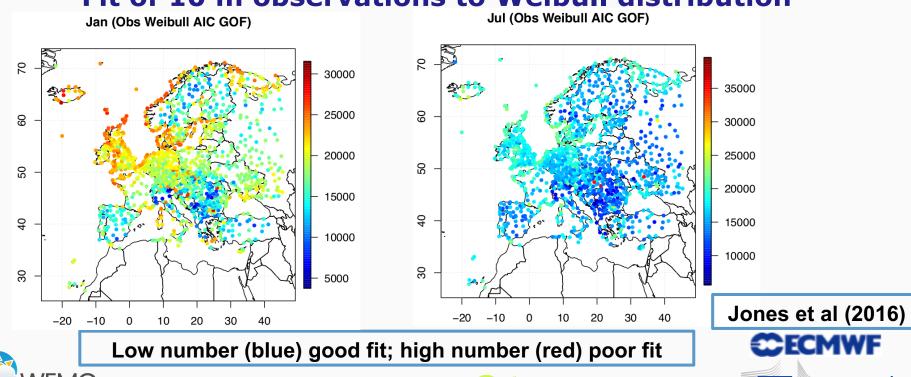






# **Ensuring Climate variables are fit-for-purpose**

#### Fit of 10 m observations to Weibull distribution















Commission

### Ensuring we use the most accurate Energy data

The DATA ISSUE: there is no single reference database for energy Many data sources, inconsistencies between them, incompleteness, access rights (few open data) ...

- Need high level support to make things evolve
- → ECEM will demonstrate that good data allows good service!



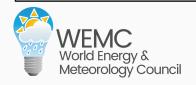
# Energy data: what's available?

### **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...)





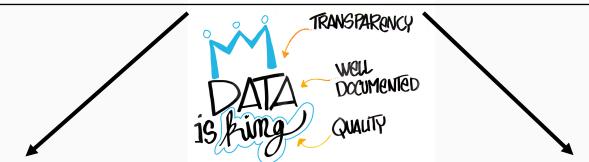






# Computation of power supply and demand

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



#### **OPTION 1**

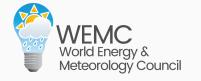
Energy = TF (Climate, Ancillary)

→ if **Transfer Function TF** is known

#### **OPTION 2**

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

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



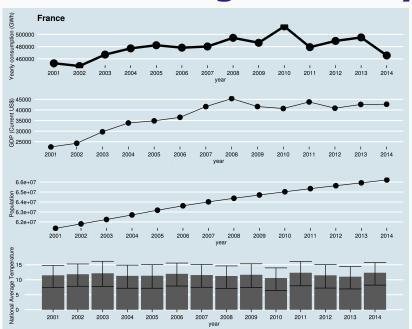


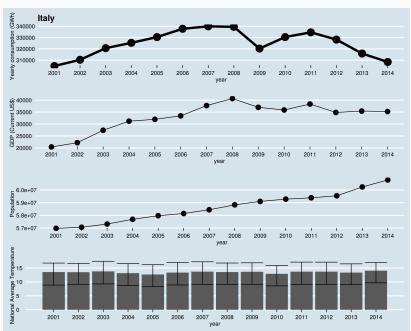




## **Demand modelling**

### Challenge: identify role of climatic factors











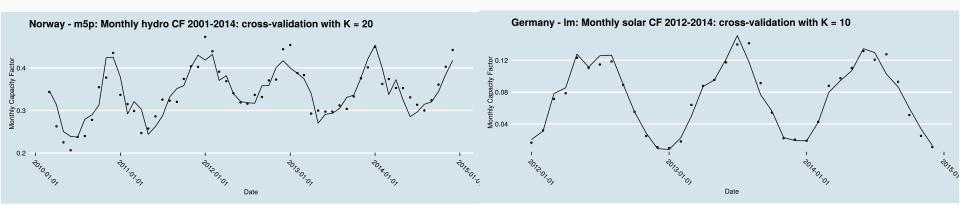




# Historical monthly generation

### 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











# Some expectations from C3S

- Improved wind speed (60, 80, 100, 120, 140 m) ERA5 ?
- Improved solar radiation
- Hydropower generation: physical models (e.g. like van Vliet et al, 2016) require local river flow
- Thermal & nuclear cooling system availability: require local river flow and water temperature
- Lack of energy data: ECEM will provide as detailed information as possible, and show the added value of having good input data
   time and space resolution- e.g. in France with RTE data



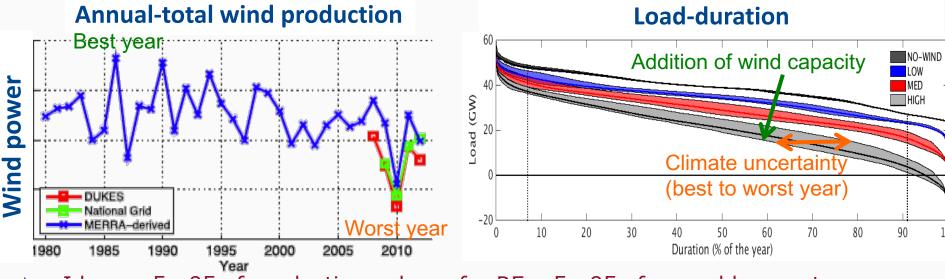






# Risk climatologies - examples

★ Investor/owner/planner: Volumetric generation risk



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









### **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.











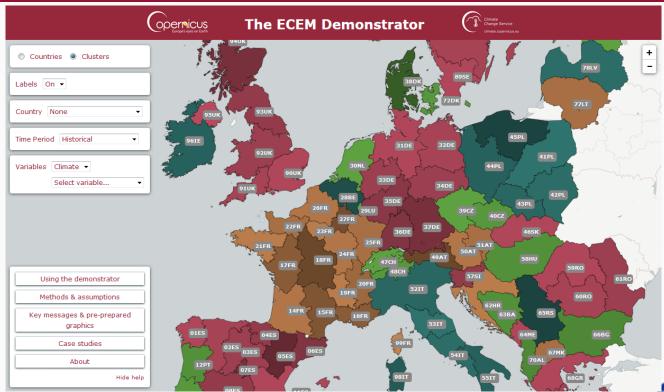


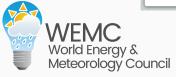






# An online interactive tool to test energy mixes





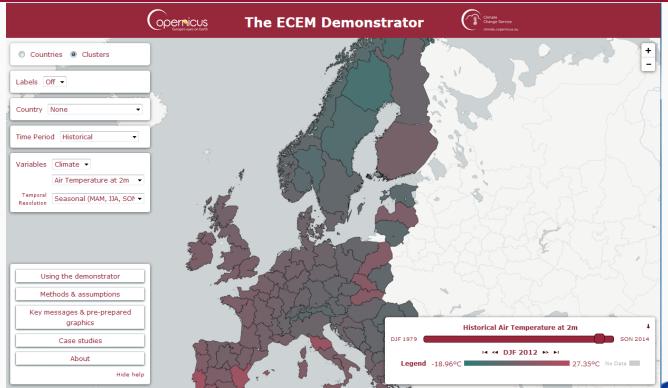


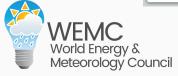






## An online interactive tool to test energy mixes





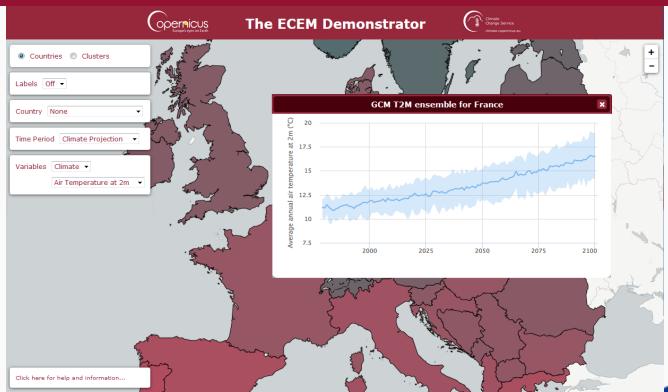


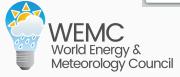






# An online interactive tool to test energy mixes













# **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: <a href="http://ecem.climate.copernicus.eu/">http://ecem.climate.copernicus.eu/</a>









# **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:

Meteorology Council

- to improve knowledge of meteorological data and processes
- to improve access to meteorological and energy data for improved products



# The Energy & Meteorology Conference Series





3RD INTERNATIONAL CONFERENCE

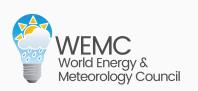
# **Energy & Meteorology**

WEATHER & CLIMATE FOR THE ENERGY INDUSTRY

22 - 26 June 2015 | Millennium Harvest House, Boulder, Colorado USA

















http://www.wemcouncil.org/



# Get in touch!

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