WEMC
World Energy & Meteorology Council

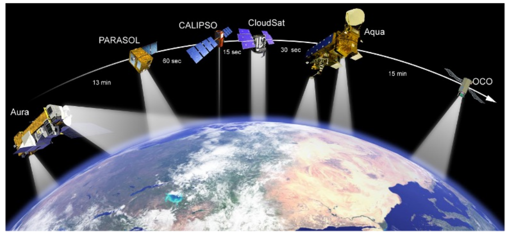
IEA Task 51 Seasonal Workshop
ECMWF, Reading, 18 May 2023

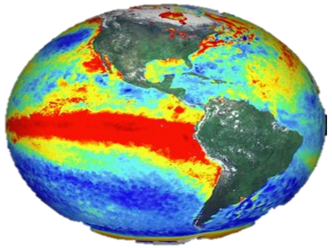
Co-production of seasonal forecasts for energy applications

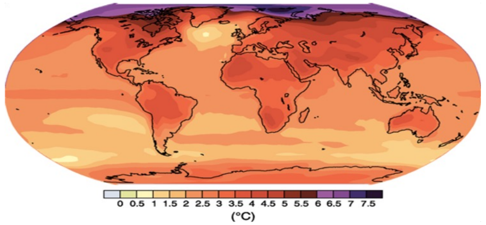
Alberto Troccoli
WEMC/ICS (UK/Italy/Australia)

ICS
Inside Climate Service

Energy & Meteorology are Inseparable







Observations/ Historical Climate → **Severe events assessment**

Passing clouds/ Thunderstorms → **Drop in solar power**

Hurricanes → **Disruptions to oil rig operations**

El-Niño → **Changes in Demand Patterns**

Long term changes → **Renewable Resource Assessment**

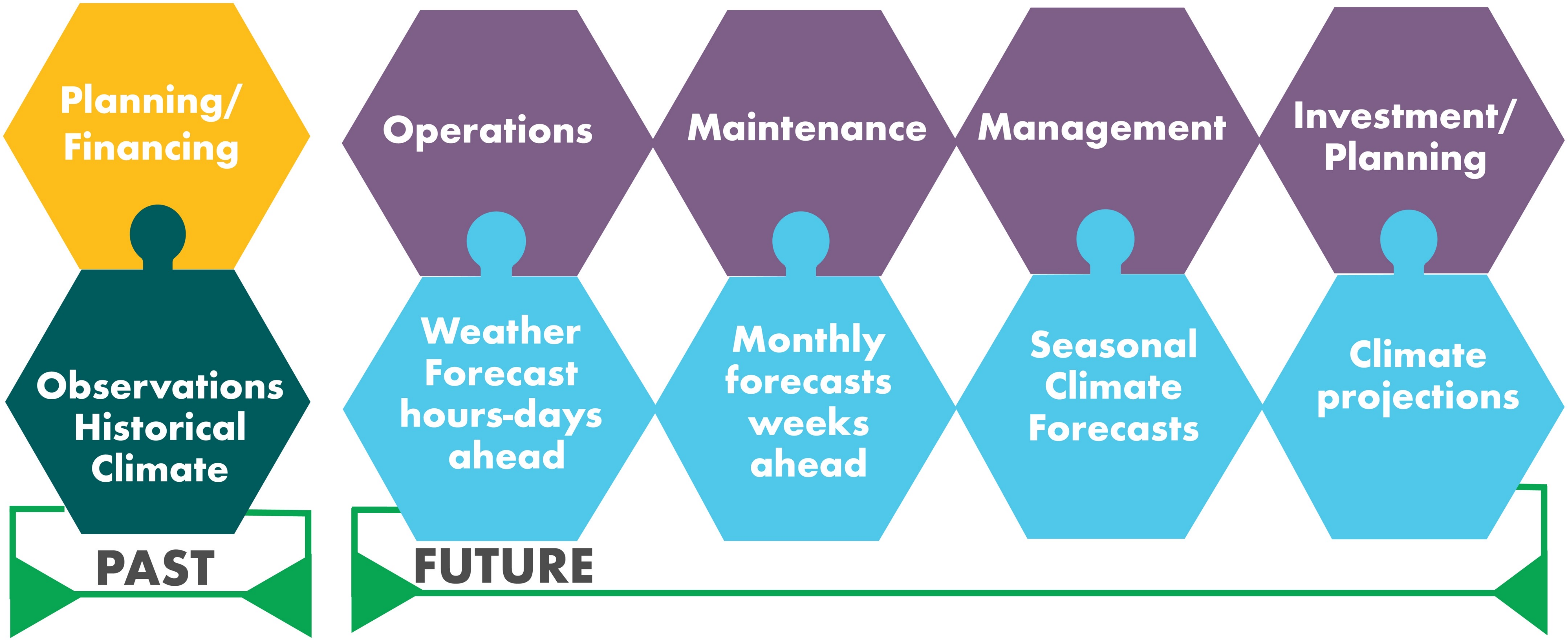
Historical | Seconds | Minutes | Days | Months | Seasons | Years | Decades

Past

Future

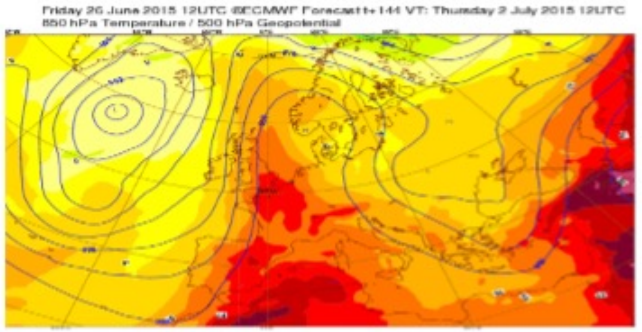
Warning: axis not to scale

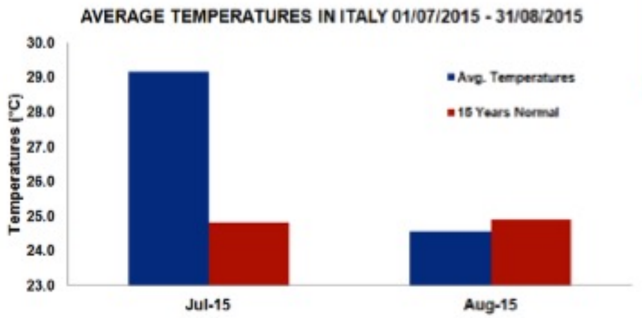
Energy & Meteorology are Inseparable



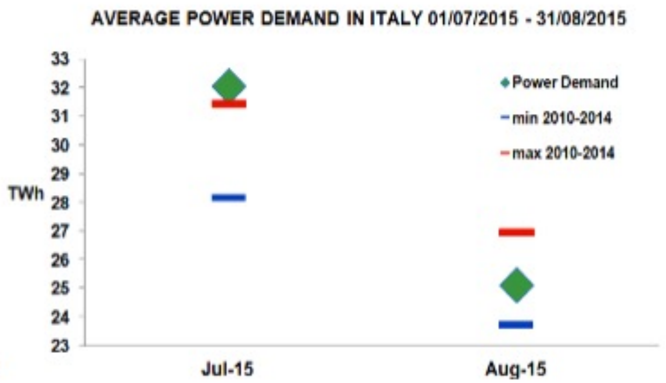
Courtesy Elena Bertocco (WEMC)

The incipit of SECLI-FIRM





Omega configuration in July => Extreme heat wave in southern Europe July 2015



Increase in power prices associated with spike in summer

an exceptional warm period on july with an extremely high power demand and prices (Case Study 1)

Strong hydro production forced also by the TSO

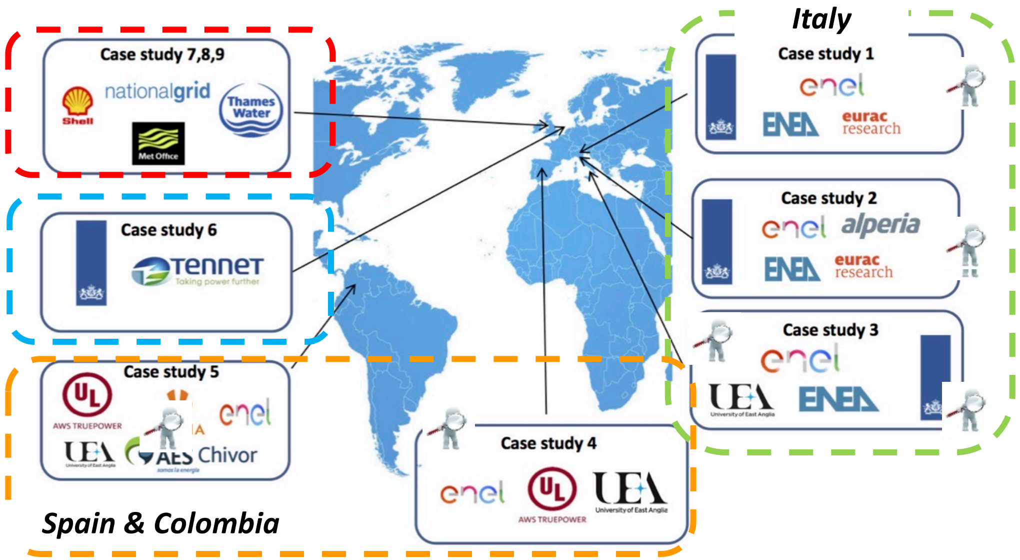
Consumption of water reservoir

Courtesy Marco Fromenton (ENEL)

SECLI FIRM

Case Studies

Case Study	Climate events	Geography	Sectoral impact	Co-designers
Italy				
CS1	Heat Wave 2015, and other similar extremes	Southern Europe	Energy –Thermal electricity plant cooling, demand model uncertainty	**ENEL**, ENEA, EURAC, KNMI
CS2	Dry Winter 2015-16 and other similar extremes	Northern Italy	Energy –Hydroelectric power production	**ENEL**, KNMI, ENEA, EURAC, Alperia
CS3	Strong Winds March 2016 and other similar extreme	Southern Italy	Energy – Wind power production	**ENEL**, ENEA, KNMI, UEA
Spain & Colombia				
CS4	Extreme Winds 2014-15 and other similar extremes	Spain	Energy – Wind power production and balancing	**AWS**, MO, ENEL
CS5	Strong El Niños	South America	Energy – Hydroelectric power production and other RE	**AWS**, UEA, AES Chivor, Celsia, ENEL
CS6	Low Winds	North Sea	Energy – Offshore operations and maintenance planning	**TenneT**, KNMI



Case Study	Climate events	Geography	Sectoral impact	Co-designers
CS7	Severe climate events in 'shoulder' months	North Sea	Energy – Offshore operations and maintenance planning	**Shell**, MO
CS8	Anomalous winter conditions	UK	Energy – Winter electricity demand	**National Grid**, MO
CS9	Dry Spring and Summers	UK	Water – Water use restrictions	**Thames Water**, MO

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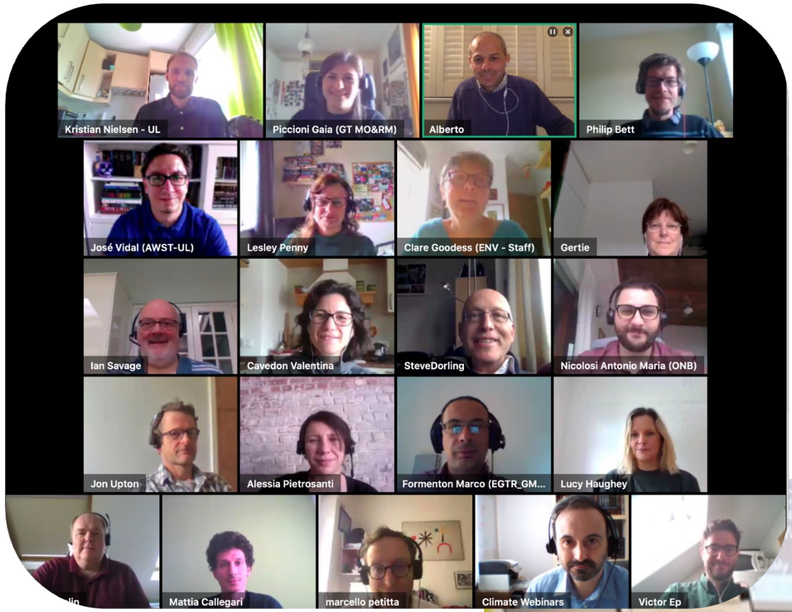
Climate Services: Co-Production

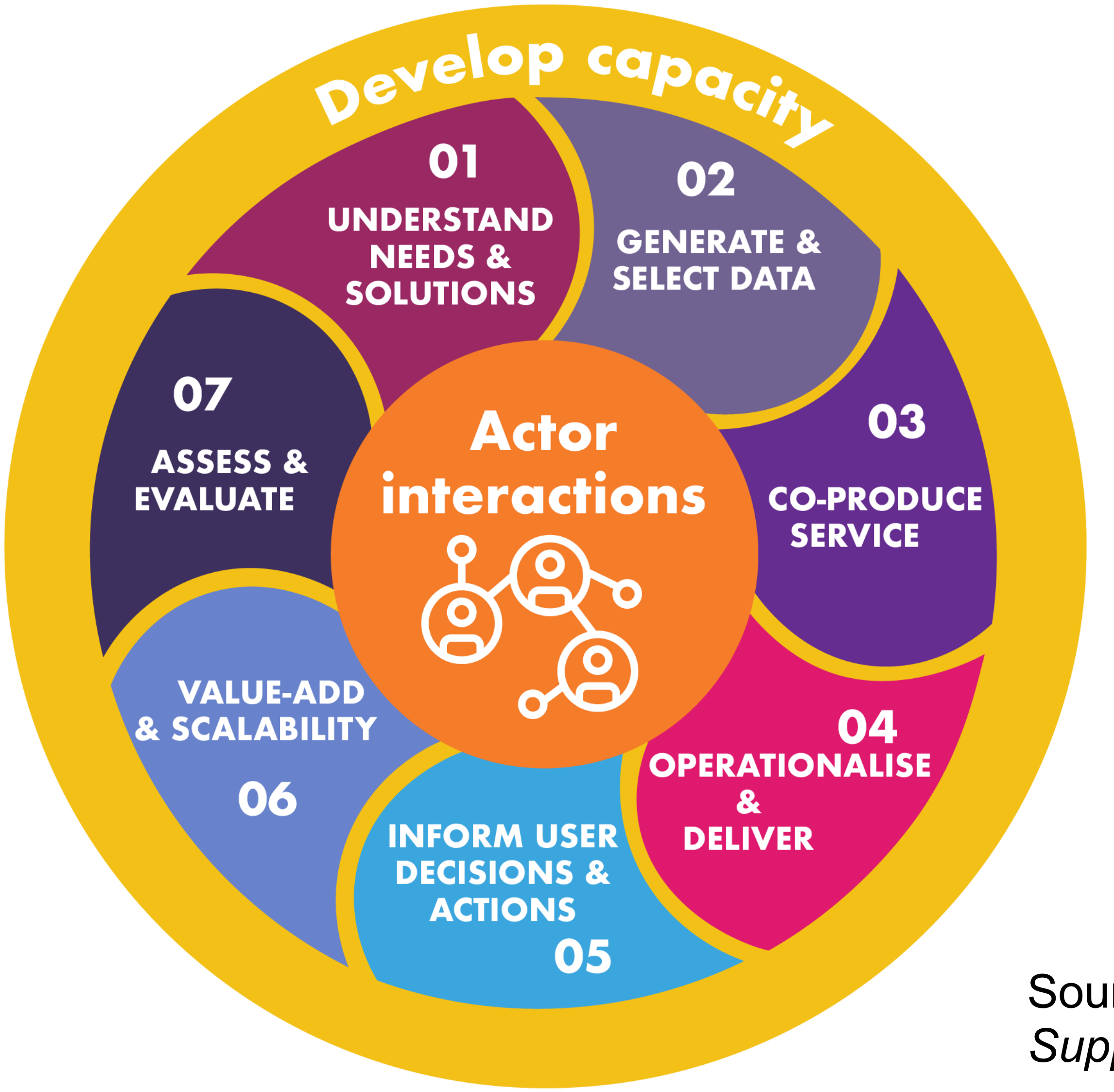


Close engagement with stakeholders is critical in transferring knowledge and instilling confidence in climate services

It follows the CO-CO-CO (Co-design, Co-development, Co-evaluation), or simply **Co-Production**

It goes beyond the traditional provider/client talk, though it boils down to **effective communication**!

Climate Services: The critical role of User Engagement



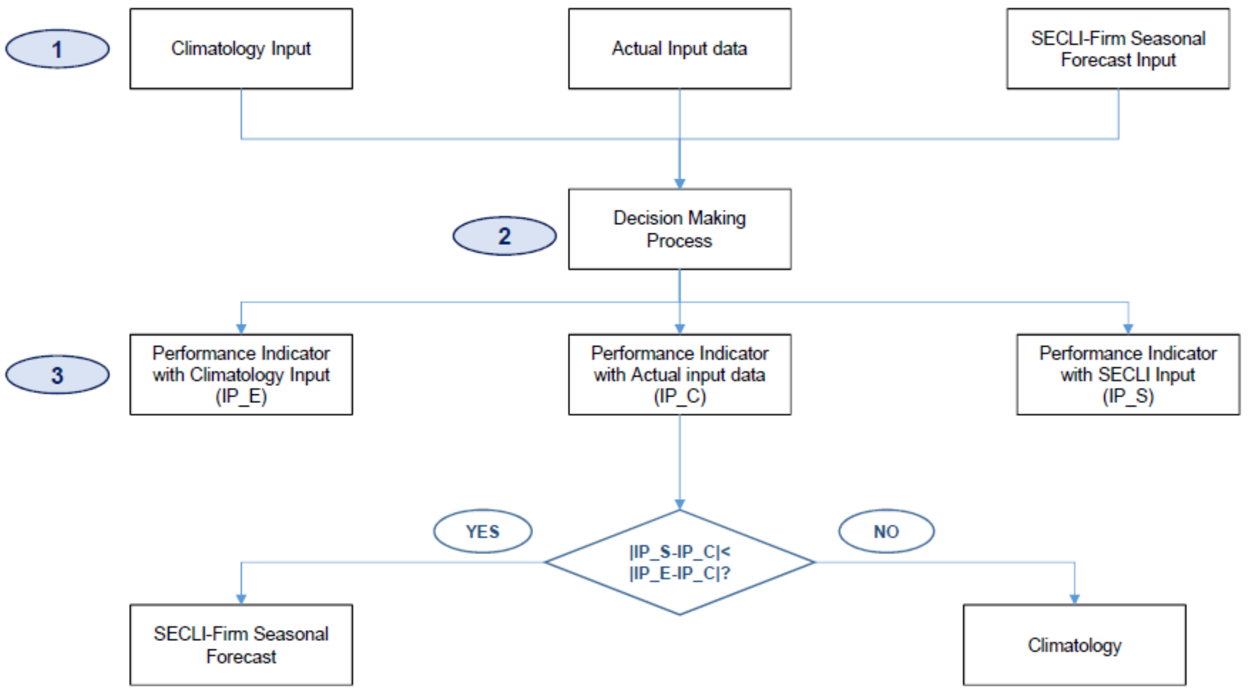
Science is key!

Models need to be improved …

… but service development should (normally) be done in **Collaboration with Users**

Source: *Integrated Weather and Climate Services in Support of Net Zero Energy Transition.* WMO (2022)

Assessing the value of seasonal climate forecasts



MENU OF ECONOMIC ASSESSMENT METHODS

- *DECISION THEORY MODELS*
- *AVOIDED COSTS*
- **ECONOMETRIC MODELS**
- *CONTINGENT VALUATION APPROACHES*
- PARTIAL AND GENERAL EQUILIBRIUM MODELS
- ALTERNATIVE METHODS

How to measure independence among seasonal prediction systems?

Newly developed Independency metric

The Brier Skill Score covariance (BSScov)

Starting from the definition of the Brier score a new metric has been developed, the Brier Score covariance (BScov), which estimates the relative independence of prediction systems 1 and 2:

$$\mathrm{BS} = \frac{1}{n}\sum_{i=1}^{n}(y_i - o_i)^2$$

$$\mathrm{BS}_{\mathrm{cov}} = \frac{1}{n}\sum_{i=1}^{n}(y_i^1 - o_i)(y_i^2 - o_i)$$

With the same scaling of to the Brier Skill Score a positively oriented metric is computed as follows

$$BSS = 1 - \frac{BS}{BS_{ref=clim}} \qquad BSS_{cov} = 1 - \frac{BS_{cov}}{BS_{ref=clim}}$$

Alessandri et al. 2022 (in preparation)
Catalano et al. 2022 (in preparation)

Grand MME in SECLI-FIRM

Homogenization at common 1º x 1º grid, common hindcast period 1993-2016; May, November [Feb, August] start dates, 10 members for each SPS. SPSs combined using equal weights.

Prediction Centre	Latest System	Atmos. model	Ocean model	Initialization Atmos.	Initialization Ocean
ECMWF, EU	SEAS5	IFS Cycle 43r1	NEMO v3.4	ERA-Interim	ORAS5
UKMO, UK	GloSea5-GC2-LI	Unified Model (UM)	NEMO v3.4	ERA-Interim	GS-OSIA
MF, France	System 6	ARPEGE v6.2	NEMO v3.4	ERA-interim	GLORYS2V2
DWD, Germany	GCFS 2.1	ECHAM 6.3.05	MPIOM 1.6.3	ERA5	ORAS5
CMCC, Italy	CMCC-SPS3.5	CAM 5.3	CanOM4	ERA5	C-GLORS 3D-VAR
MSC, Canada	GEM-NEMO	GEM 4.8-LTS.13	NEMO 3.6 ORCA	ERA-interim	ORAS5
MSC, Canada	CanCM4I	CanAM4	CanOM4	CMC	ORAS5
NCAR/Miami University, USA	COLA-RSMAS-CCSM4	CAM4	POP2	NCEP CFSR	NCEP CFSR
NCEP, USA	CFSv2	GFS	GFDL MOM4	NCEP CFSR	NCEP CFSR
GFDL, USA	SPEAR	AM 4.0	MOMv6	NCEP CFSR	GFDL ODA
JMA, Japan	JMA/MRI-CPS2	JMA-GSM	MRI.COM v3	JRA-55	MOVE/MRI.COM-G2

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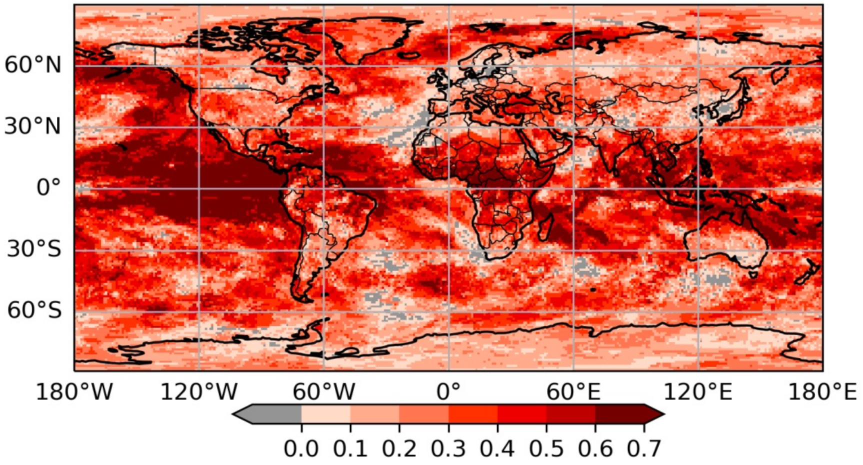
Optimisation of the skill using Grand-MME
T2m JJA (lead 1) BSS (> upper tercile)

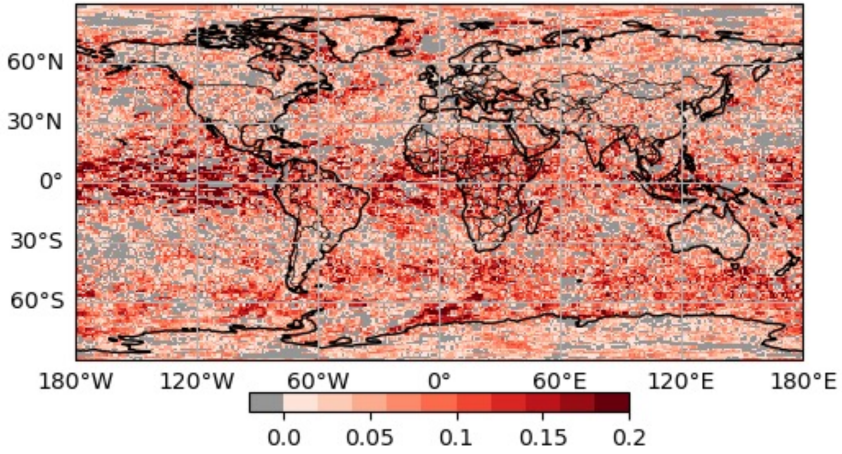
$$\mathrm{BS} = \frac{1}{n}\sum_{i=1}^{n}(y_i - o_i)^2 \qquad BSS = 1 - \frac{BS}{BS_{ref}}$$

BSS [**ref** = climatology]

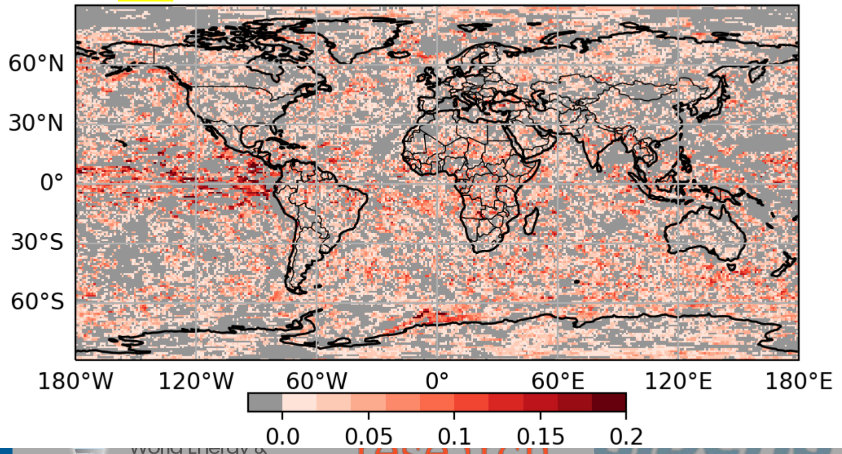


At each grid point all possible *[2047]* SPS combinations are evaluated (with equal weights) and then the one that maximizes probabilistic forecasts performance is selected.

BSS [**ref** = Best Single Prediction System]



BSS [**ref** = Max (EU MME; Extra-EU MME)]



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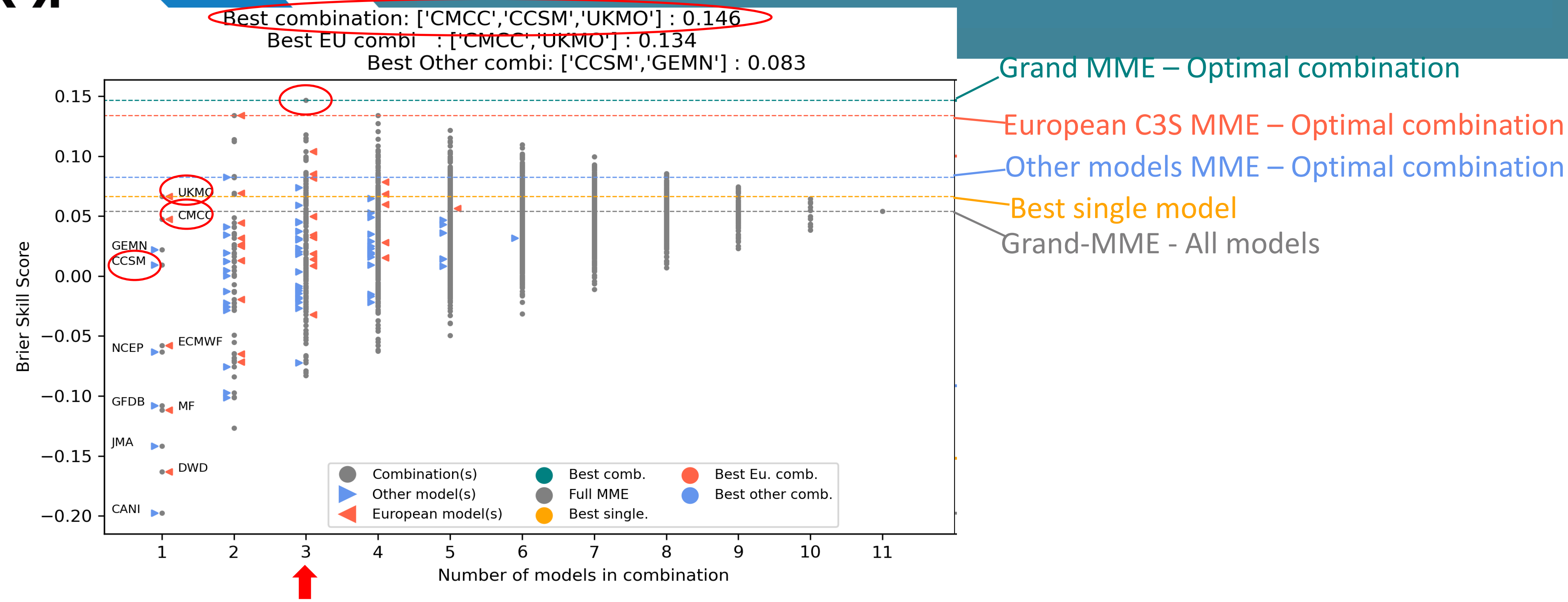
Case Study over Italy
T2m JJA (lead 1) BSS (> upper tercile)

$$BSS = 1 - \frac{BS}{BS_{ref=clim}}$$



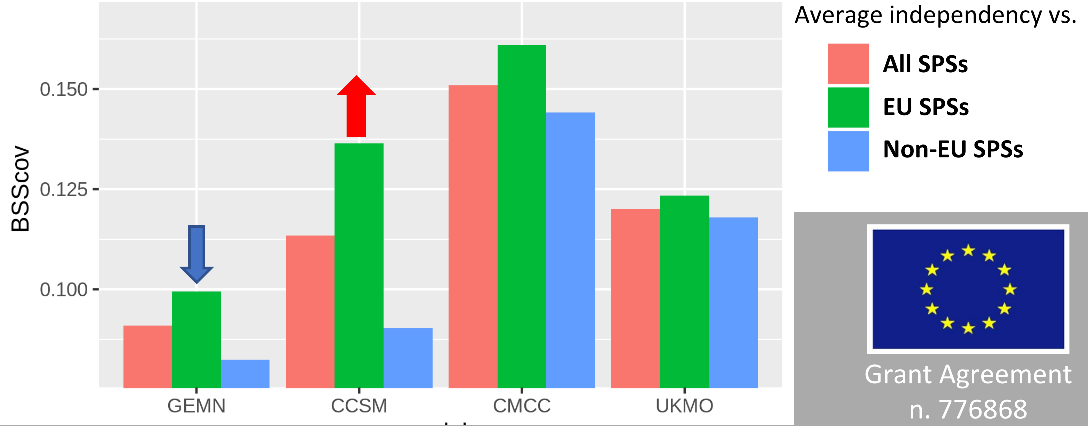
$$BSS_{cov} = 1 - \frac{BS_{cov}}{BS_{ref=clim}}$$

Independency Matrix

	GEMN	CM4I	CCSM	GFDL	JMA	NCEP	CMCC	UKMO	DWD	MF
CM4I	0.06									
CCSM	0.15	0.03								
GFDL	0.10	-0.04	0.10							
JMA	0.04	-0.04	0.08	-0.01						
NCEP	0.07	0.08	0.10	0.08	0.04					
CMCC	0.17	0.12	0.21	0.12	0.09	0.15				
UKMO	0.12	0.08	0.18	0.12	0.08	0.12	0.22			
DWD	0.07	-0.07	0.08	0.00	-0.01	0.09	0.12	0.08		
MF	0.07	-0.00	0.10	0.05	0.03	0.07	0.13	0.10	0.02	
ECMWF	0.07	0.01	0.12	0.07	0.01	0.09	0.17	0.09	0.00	0.08

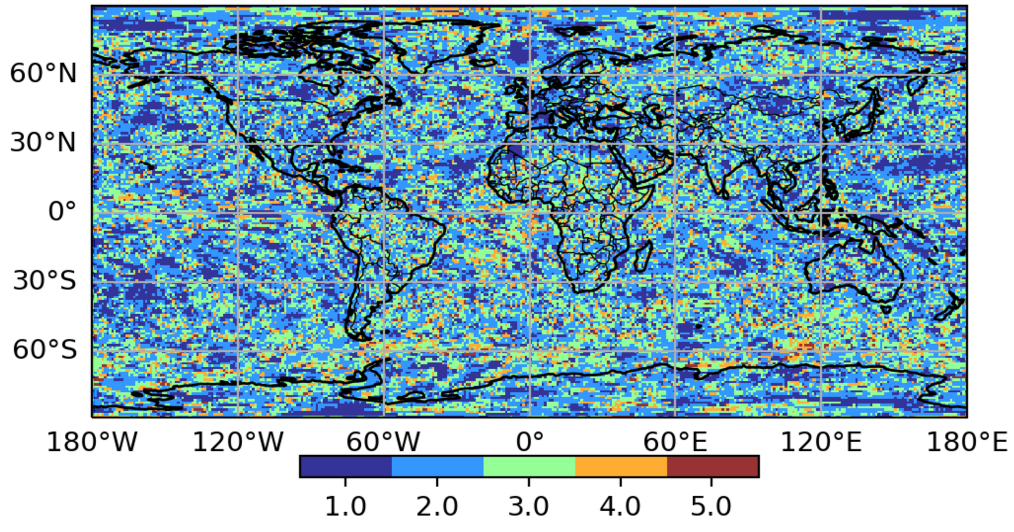
BSScov: 0.2200, 0.1475, 0.0750, 0.0025, -0.0700

Marginal Independency (mBSScov)



How many/which SPS
T2m JJA (lead 1) BSS (> upper tercile)

Number of SPSs in best combination



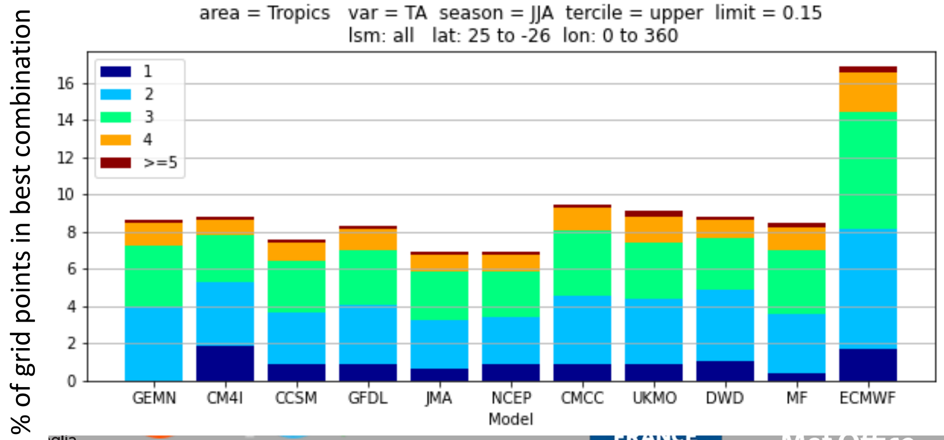
range 1-5 (1.73% ≥ 5)

mean = 2.52

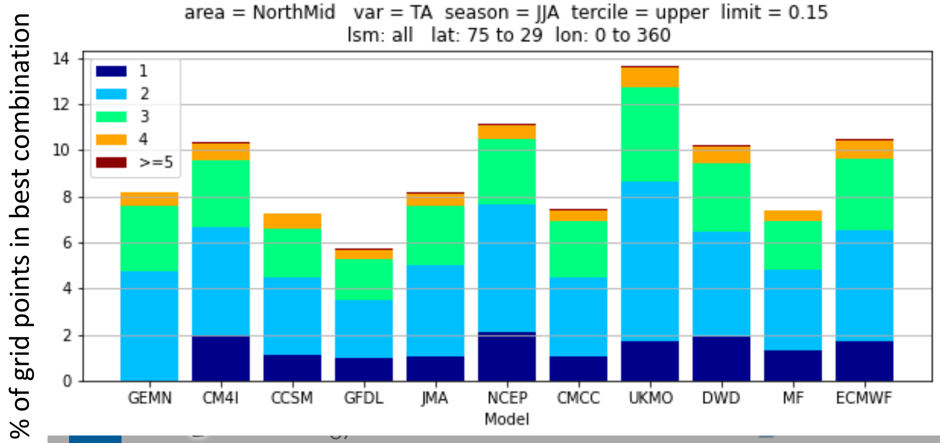
median = 2.0

Optimal combination is never the full (11 SPS) Grand MME

Tropics



North Mid-latitudes



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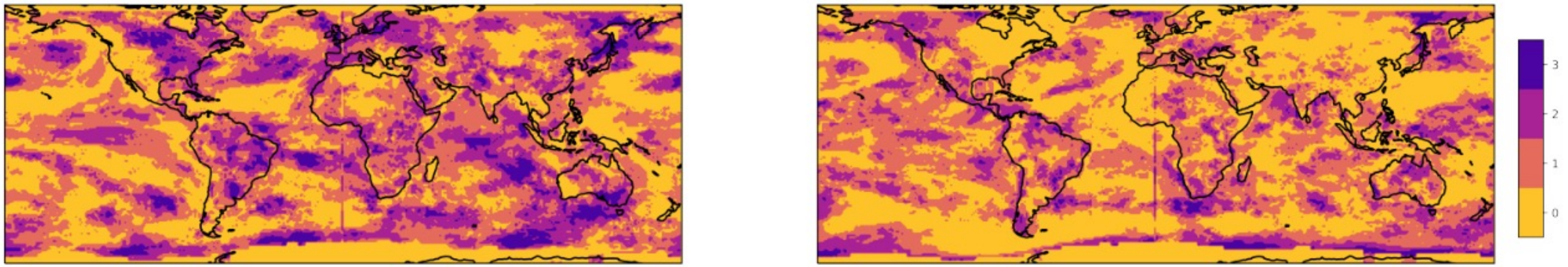
Do statistical models add value to dynamical models?

Test: From a suite of 12 dynamical and 3 statistical (linear and non-linear) models create every possible 5-model combination (~2000 combinations per gridpoint). Then select the model combination with the lowest RMSE (based on the 5-multi-model average) and count how many statistical model are in this ‘best model combination’.



The colors indicate the nr. of statistical models present in the best possible 5-model combination per gridpoint.

Note: the results are very sensitive to the observational products used as reference, hence we used the average of multiple reanalysis and observational products as observational estimate.

Conclusion: There are a lot of regions where one or more statistical model are present in the best possible 5-model combination. Hence, in a multi-model seasonal forecasting framework there is added value for statistical models

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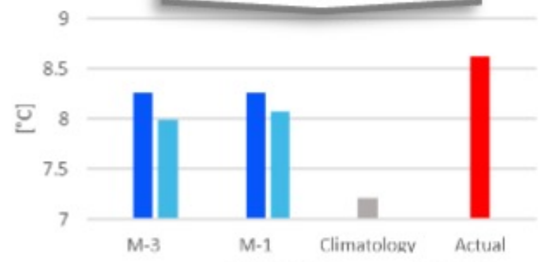
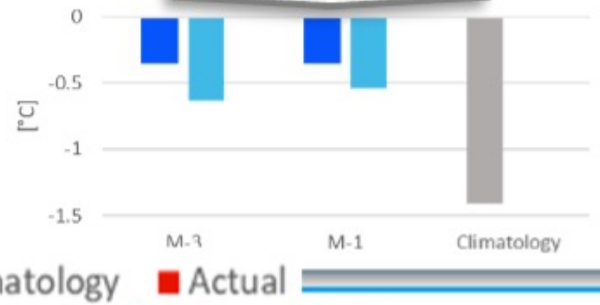
Some results (from Case Study 1)

Values | **Errors** | **Results**

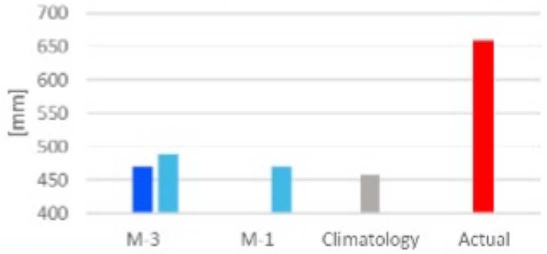
Temperature

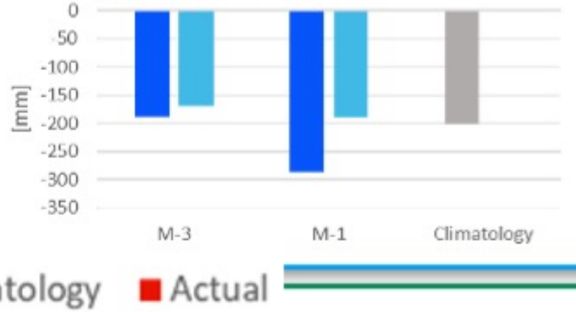




Significantly better performances of Single and Multi-Model temperature forecasts than climatology **This result also affects the power demand**

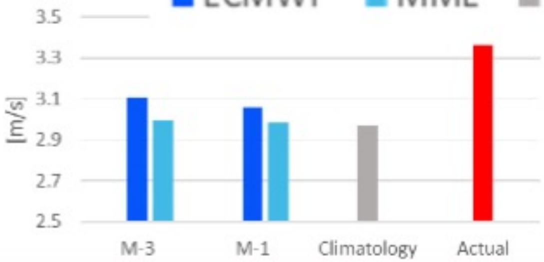
Total Precipitation

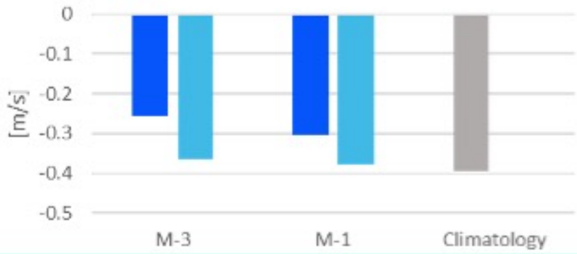




Total precipitation forecasts foresee a slightly increasing (except M-1 ECMWF) but **not catch the magnitude** of the event

Wind Speed





Forecasts are slightly above the climatology

Courtesy Marco Fromenton (ENEL)

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Case Study Flyers

http://www.secli-firm.eu/case-studies/

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Met Office

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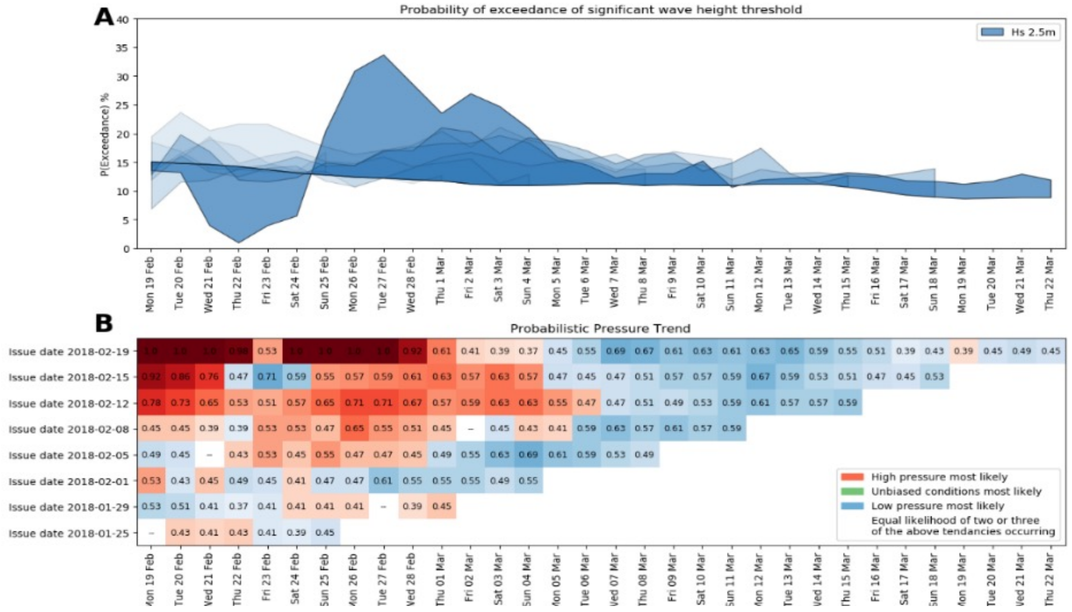
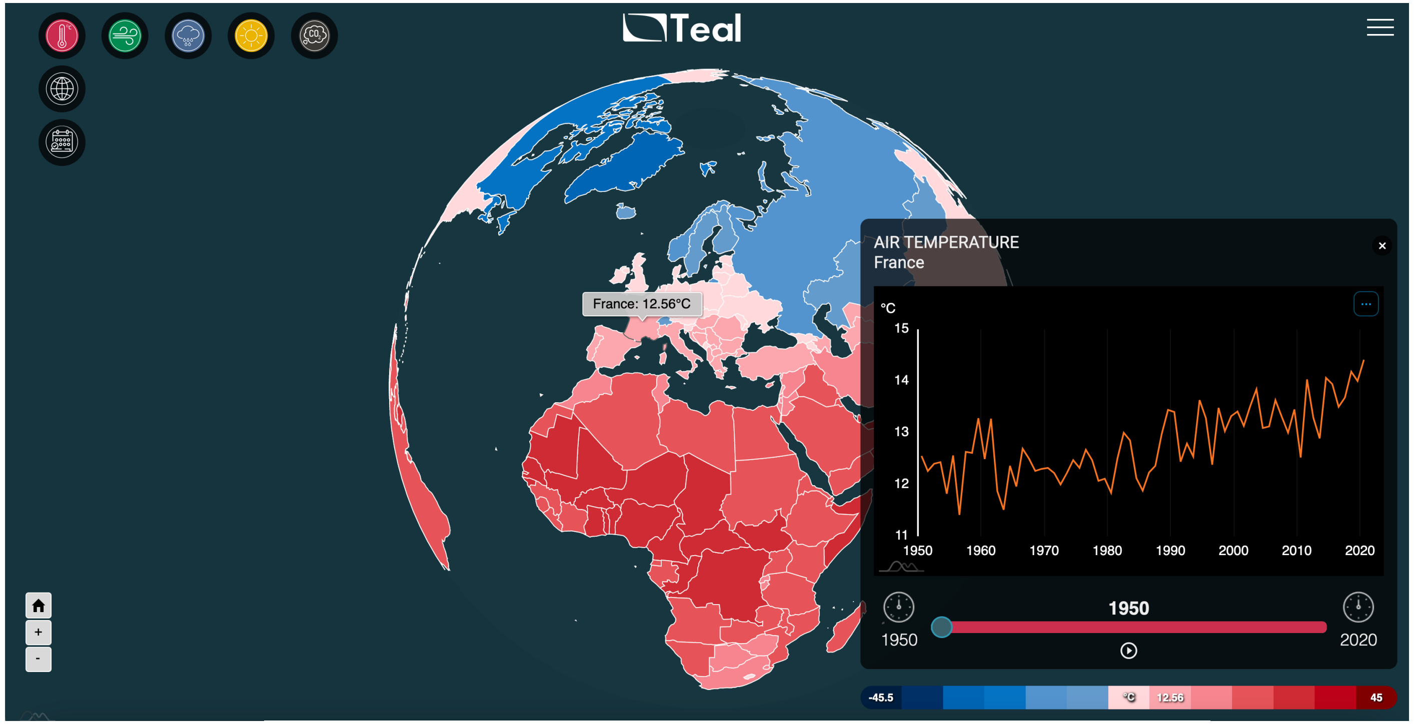
Climate Services Delivery

The exact way climate services are delivered is not critical. However, it seems users appreciate an easy to use and pleasing to the eye climate service





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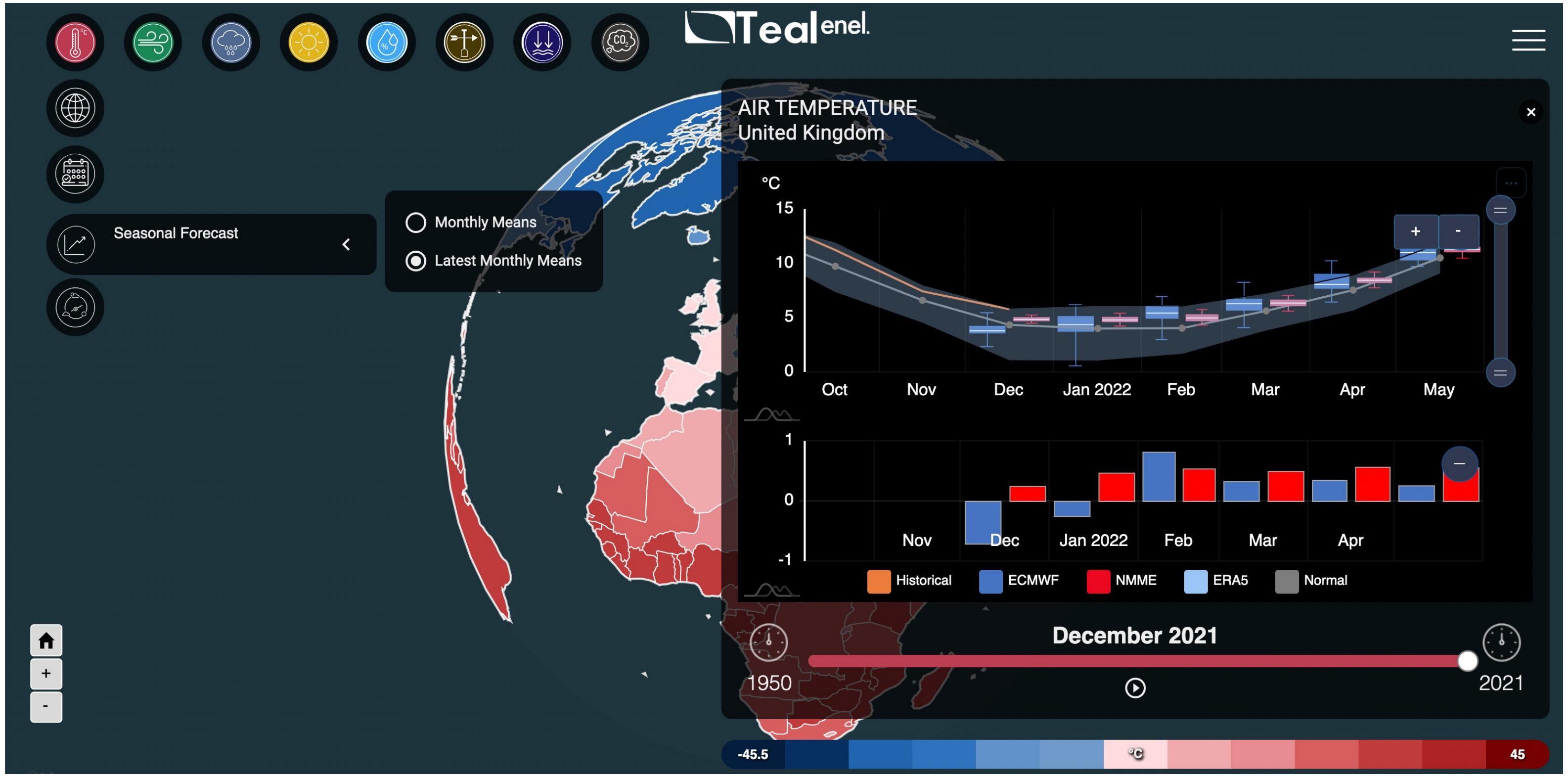
https://tealtool.earth

The Teal Climate Service



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Co-developed by

WEMC World Energy & Meteorology Council

enel

Delivered by

ICS Inside Climate Service

https://www.inclimateservice.com

Based on award winning ***C3S Edu Demo***

http://c3s-edu.wemcouncil.org/

European Commission | Copernicus Europe's eyes on Earth | ECMWF

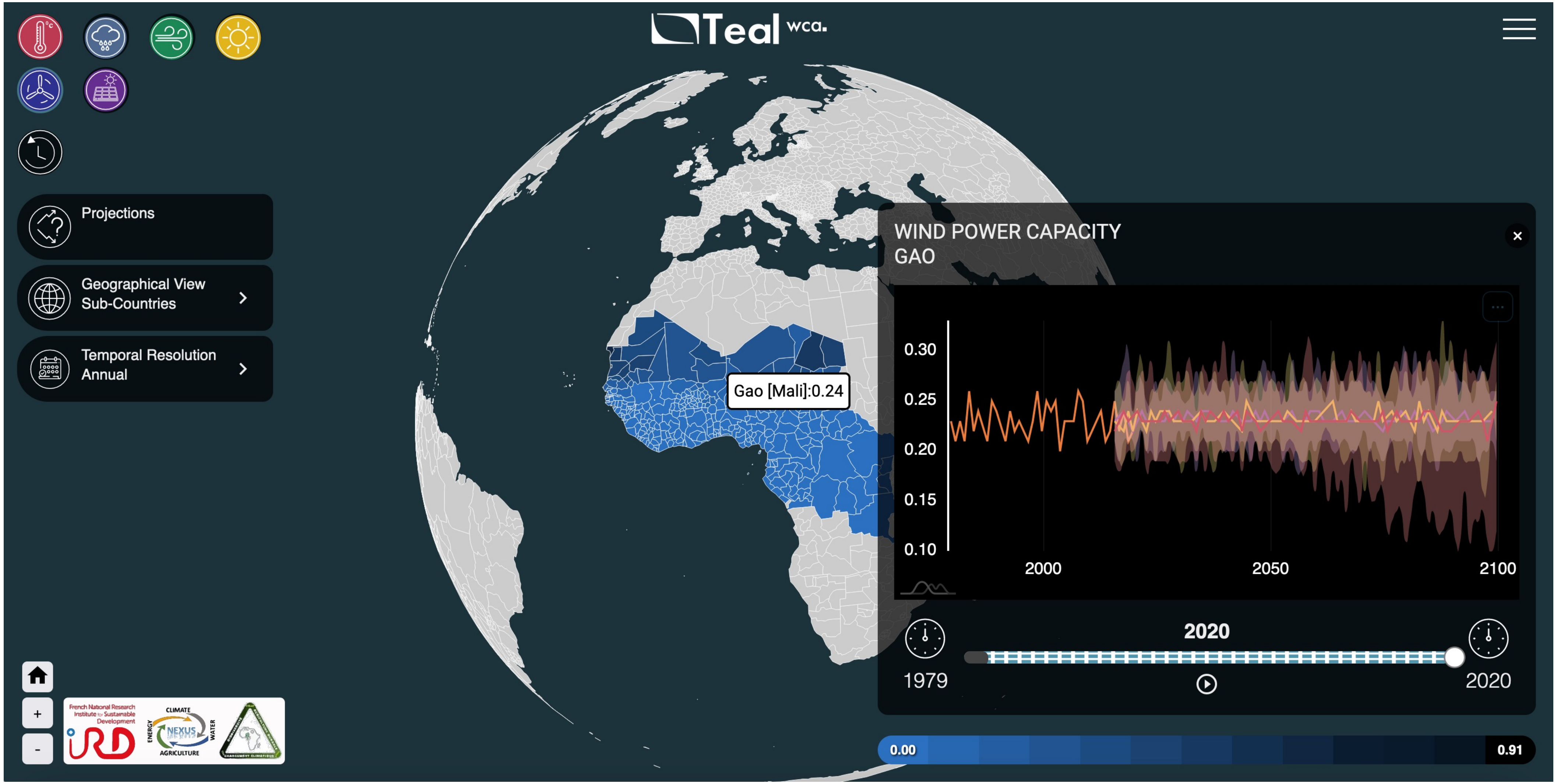
Powered by

Climate Change Service

NOAA — National Oceanic and Atmospheric Administration, U.S. Department of Commerce

North American Multi-Model

Teal West-Central Africa (WCA)



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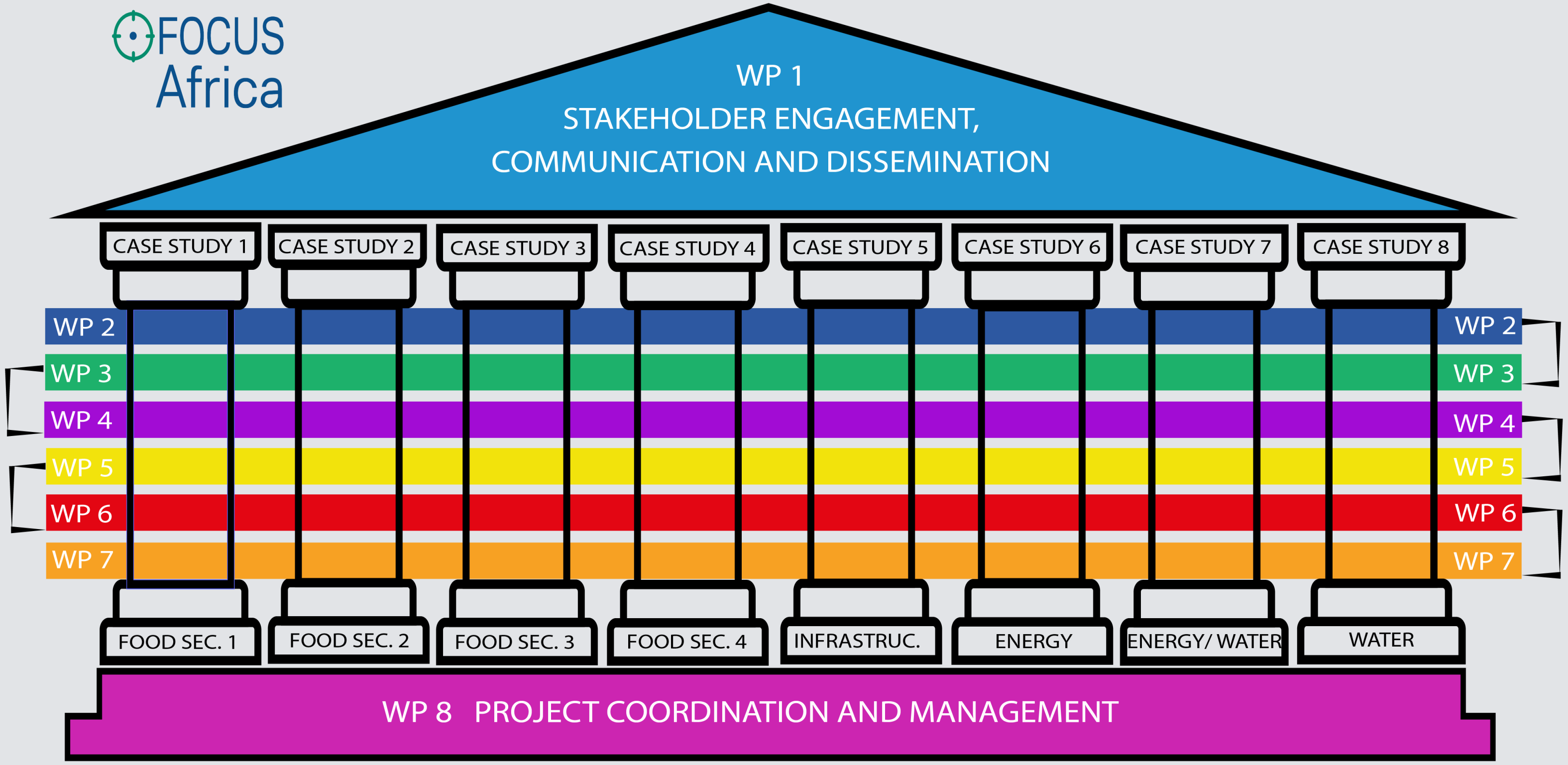
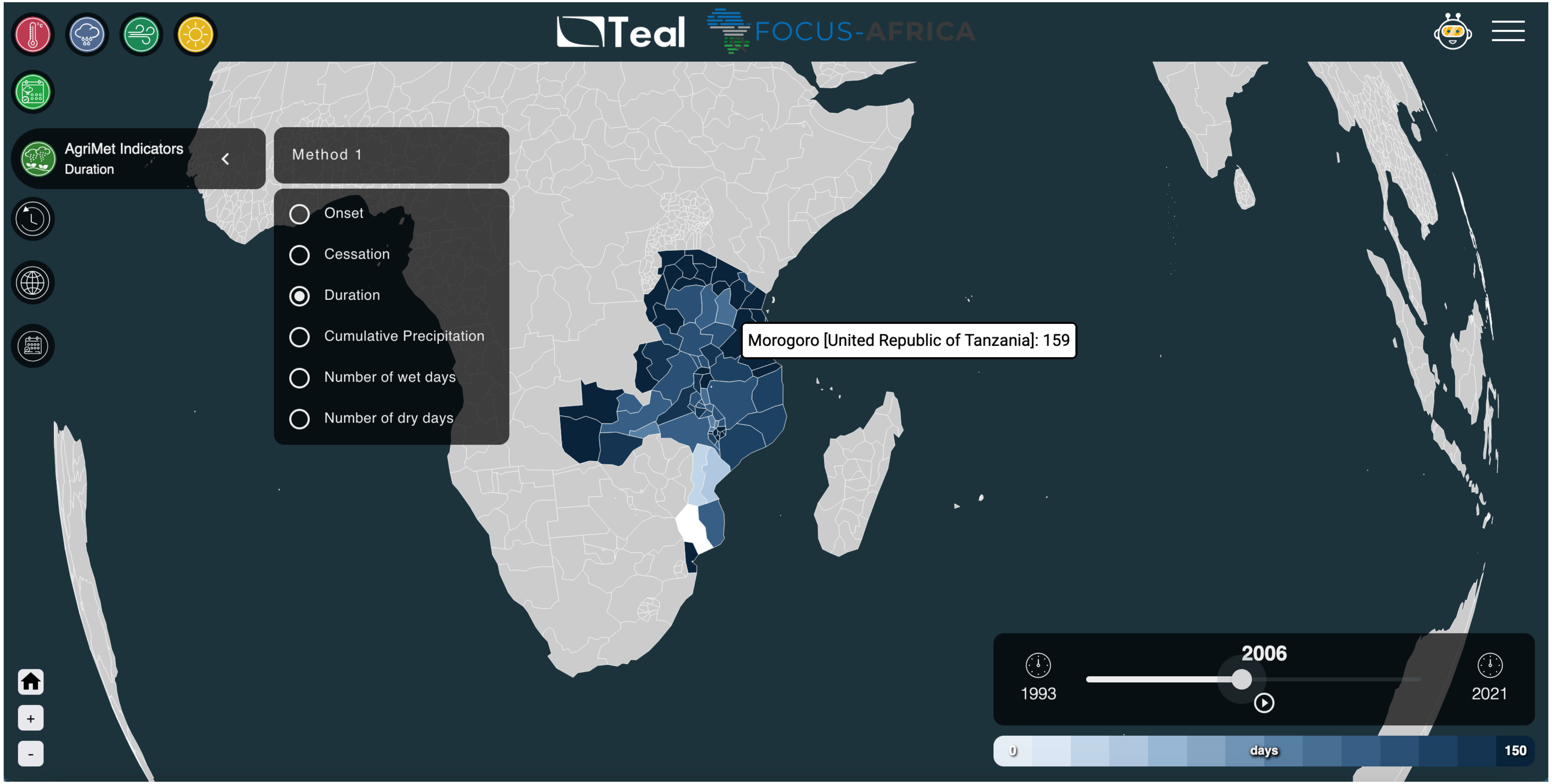
EU H2020 FOCUS-Africa (2020-2024)

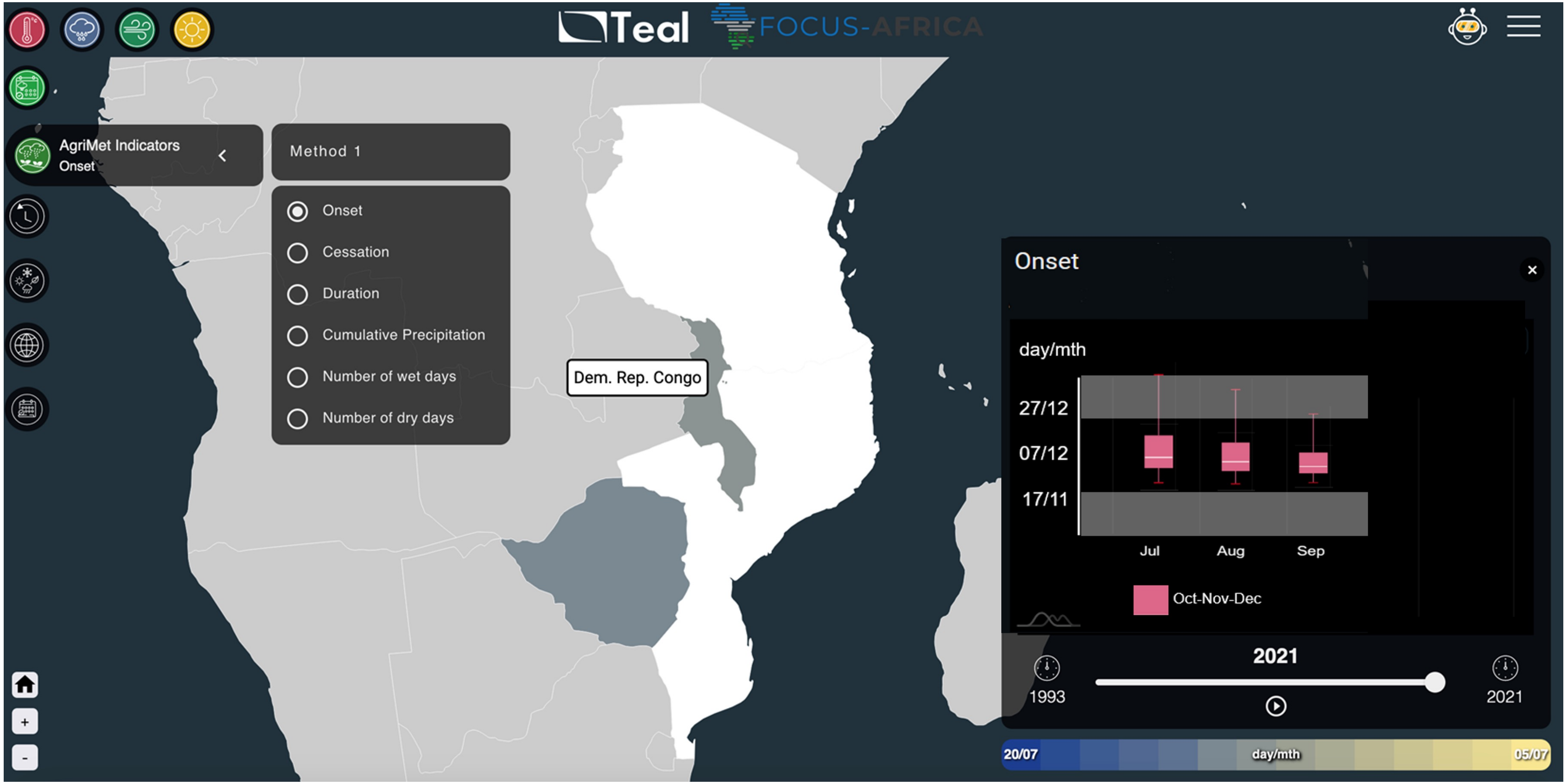
FOCUS-AFRICA
Full-value chain Optimised Climate User-centric Services for Southern Africa



Teal FA Demo – Historical indicators

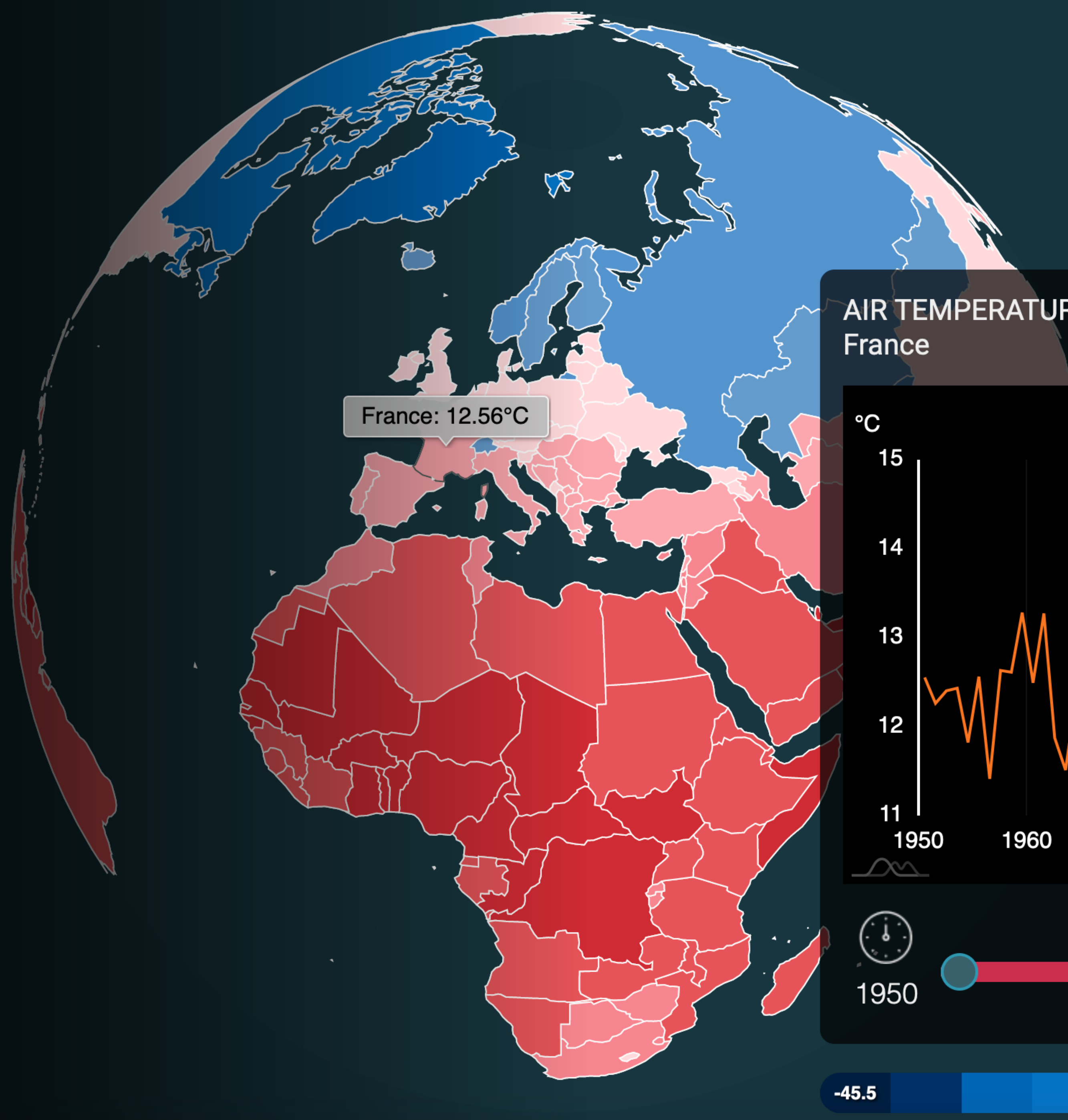


Teal FA Demo – Seasonal Forecast Mock up



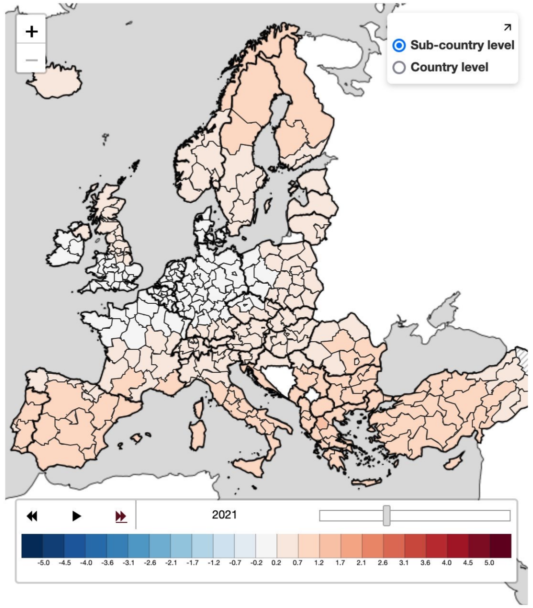
The Teal:
https://tealtool.earth
(Free version)

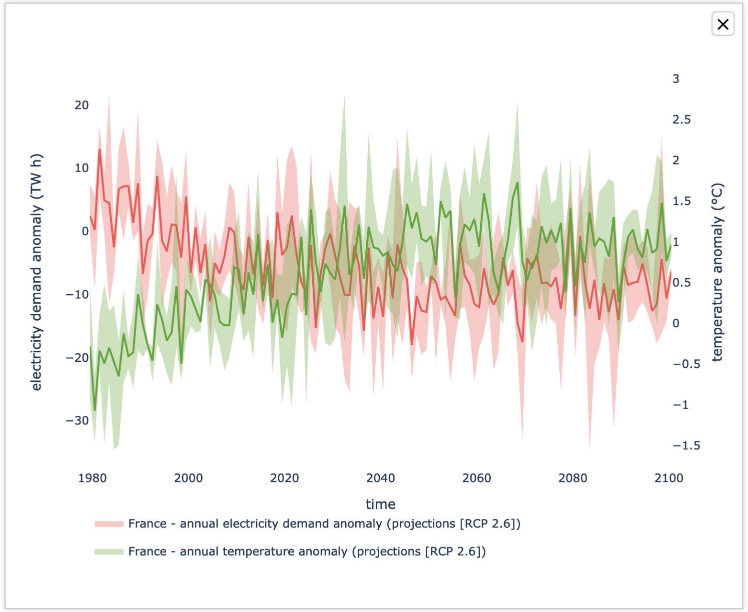
More info at:
https://www.wemcouncil.org/wp/teal



C3S Operational Energy Service

Climate Change

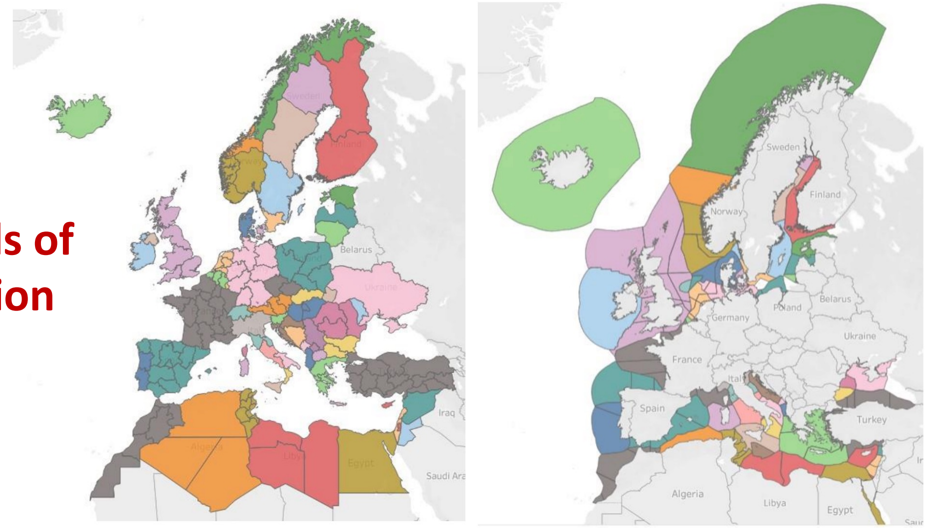




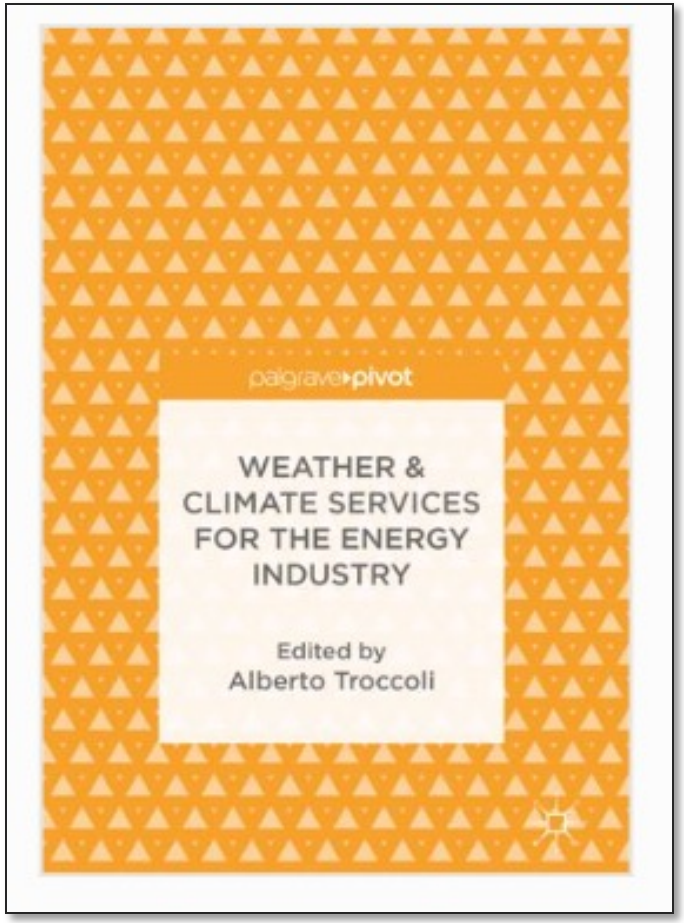
A multi-variable, multi-timescale view of the climate and energy systems

Supporting C3S Core Users: European Network of Transmission System Operators ENTSO-E to build the Pan European Database (PECD) v4

Different levels of data aggregation for the PECD



Learn more about E & M



palgrave macmillan

Springer Link

Download it (it's free!)

wemcouncil.org/wp/resources

7th International Energy & Meteorology Conference

https://www.wemcouncil.org/wp/icem-2023

Enjoy the meeting!