Climate Change

Seasonal Forecasting for the European energy sector

C3S European Climatic Energy Mixes (ECEM)

Webinar 18th Oct 2017

Philip Bett, Met Office Hadley Centre

Copernicus Europe's eyes on Earth

European Commission

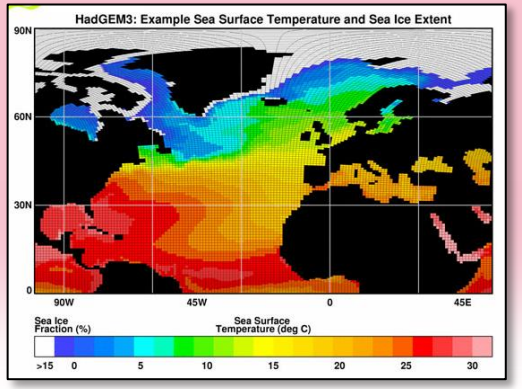
Climate Change

Seasonal Climate Prediction

- Forecasting for **several months** (e.g. a **3-month season**) with a lead time of **several weeks** (e.g. **1 month**) → e.g. forecasting for DJF in Oct/Nov

- Traditional weather forecasts lose predictability after around 10 days, due to the naturally chaotic nature of the atmosphere…

- But some parts of the climate system change slower than the atmosphere, e.g.
  - Oceans
  - Sea ice
  - Soil moisture
- For example – the ocean is still predictable even when the atmosphere is not!
  → we can predict how the atmosphere might respond to the oceans.



Copernicus Europe's eyes on Earth

European Commission

Climate Change

Seasonal Climate Prediction

- Forecasting for **several months** (e.g. a **3-month season**)
  with a lead time of **several weeks** (e.g. **1 month**) → e.g. forecasting for DJF in Oct/Nov

- So we use a coupled climate model (**atmosphere** + **land** + **ocean** + **sea ice**),
  initialised with current observations,
  and try to forecast the climate for the coming season….

- Climate drivers are large-scale phenomena,
  so forecasts are only skillful over large areas (e.g. Spain-sized!), and are probabilistic.

- Seasonal climate predictions are ***not*** "extended weather forecasts"!
  - We **can't** predict the **weather on 25th January** from 1st Nov forecast!
  - We **can** estimate how likely the **Dec-Jan-Feb** period is to be **colder**/**warmer than normal** (if skillful).

→ Seasonal forecasts are useful for **different types of decisions** (long-term risk-based planning)

- Use as **part** of a decision-making chain, along with monthly, weekly & daily forecasts.

Copernicus Europe's eyes on Earth

European Commission

Climate Change

Seasonal Forecasting in ECEM

- Demonstrate the use of seasonal forecast data from C3S for the energy sector, linking with data sets produced elsewhere in the project.

- Before forecasts can be provided, the **skill** of the forecasting systems must be assessed.
- Skill depends on the variable in question, the particular model used, and the region and season being investigated.

1. Assess the skill of **climate variables** relevant to the energy sector
   → Data now on Demonstrator, full results in report → final update Nov 2017

2. Assess the skill of methods of forecasting **energy variables** themselves (demand, wind power, etc.), for select countries.
   → Due: December 2017

Additional work: **Case studies** (Emma Suckling, U. Reading) → See previous webinar

Copernicus Europe's eyes on Earth | European Commission

Climate Change

Seasonal Forecast Skill

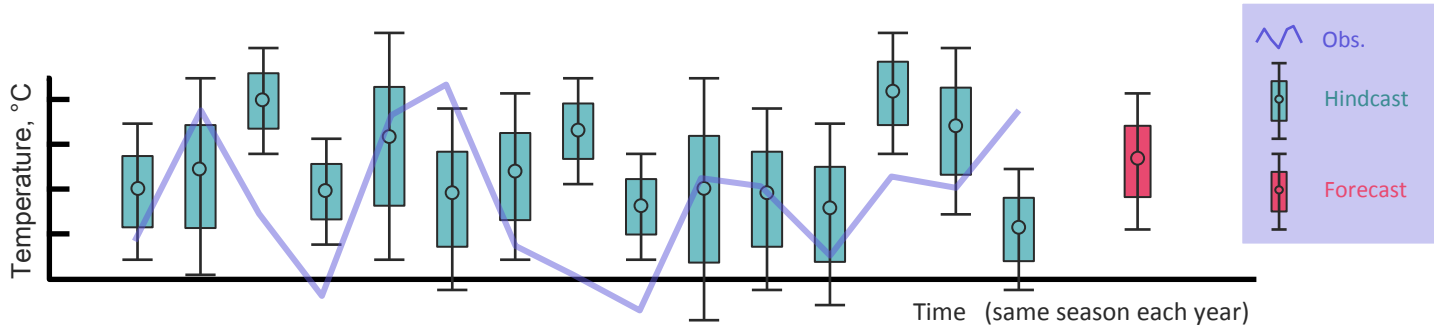
Uncertainty in a **single forecast**

Skill of a **forecast system**

and reliability,
and resolution,
and sharpness,
and bias,
and …

These can be related, but they are not the same!

There are many ways of measuring skill and related quantities - different *skill scores*…



The skill of the forecast system is estimated from a series of re-forecasts over a historical period (hindcasts), compared to observations over that period.

Hindcast data sets are limited (number of years, number of realizations each year), and the observations can be uncertain – so skill estimates are also uncertain!

Real forecasts are often produced using a slightly different system to the hindcast (e.g. more realizations), so can be more accurate than the skill assessment suggests.

Copernicus Europe's eyes on Earth
European Commission

Climate Change

Models and Parameters

Seasonal forecasting systems:

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

Variables:

- Seasonal mean 10m wind speed (m/s)
- Seasonal mean 2m air temperature (°C)
- Seasonal mean 2m relative humidity (%)
- Seasonal total precipitation amount (mm)
- Seasonal mean downwelling shortwave irradiance (W/m²)
- Seasonal mean air pressure at sea level (hPa)

Skill statistics:

Gridded maps:

- Correlations

Country-average:

- Timeseries & correlations
- Reliability diagrams & Brier skill scores
- ROC diagrams & ROC skill scores

Seasons:

- Winter (DJF)
- Summer (JJA)

Observational data:

- ERA-Interim
- ECEM bias-adjusted reanalysis

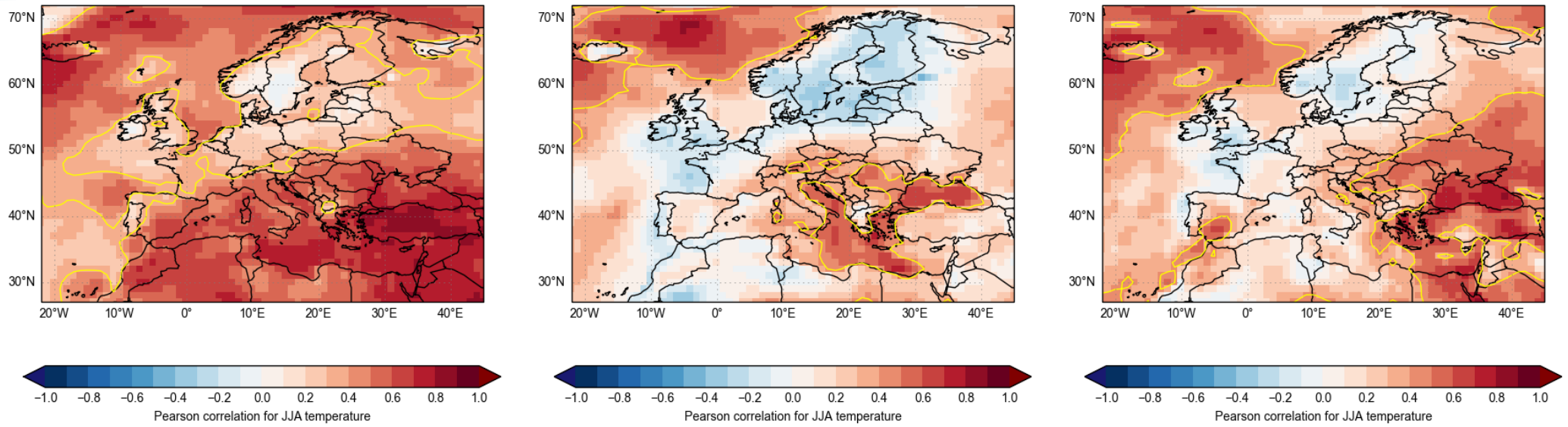
Copernicus Europe's eyes on Earth

European Commission

Climate Change

Example: Summer temperatures

Maps of correlation skill, against ERA-Interim:



ECMWF | Météo-France | Met Office

Skill is not universal,
but in this case there are some common signals across the models.

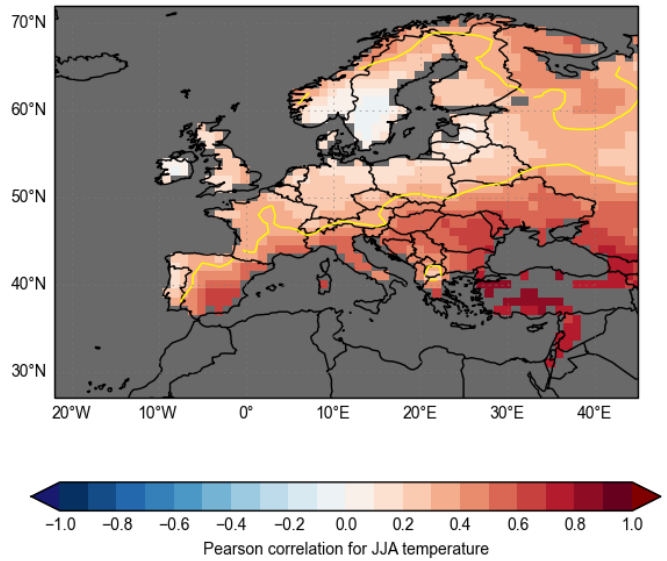
Note: *We're only assessing direct model skill here.*
In some cases, better results can be obtained using larger-scale drivers (e.g. NAO) as the predictor of temperature etc.

Copernicus Europe's eyes on Earth | European Commission

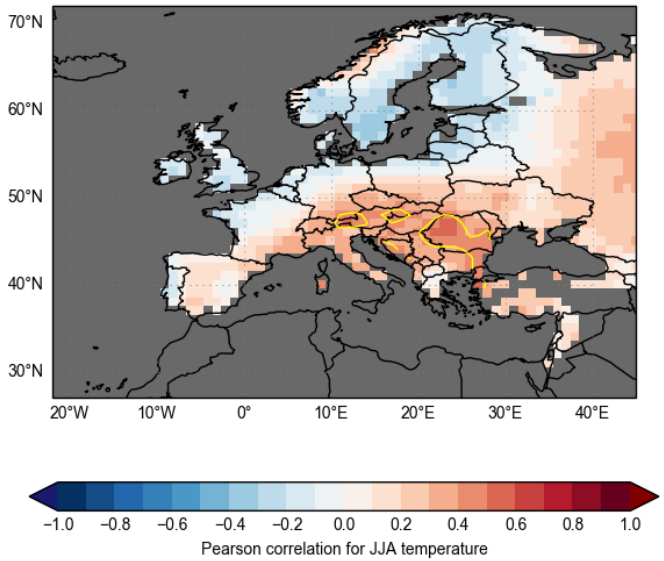
Climate Change

Example: Summer temperatures

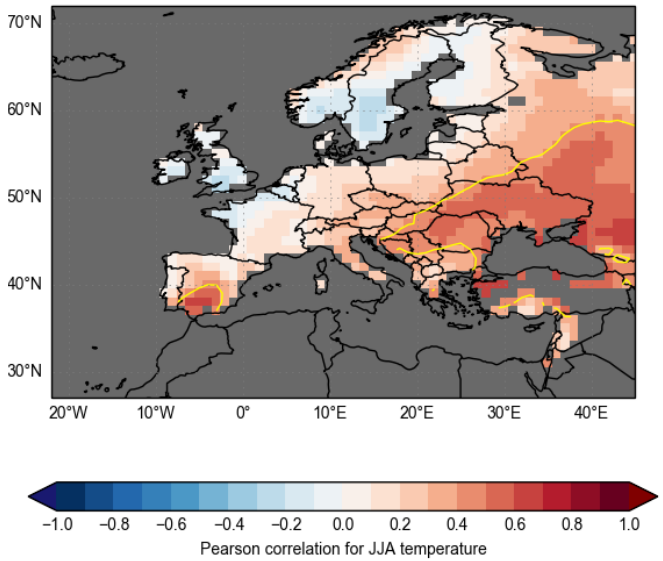
Maps of correlation skill, against ECEM bias-adjusted reanalysis:



ECMWF



Météo-France



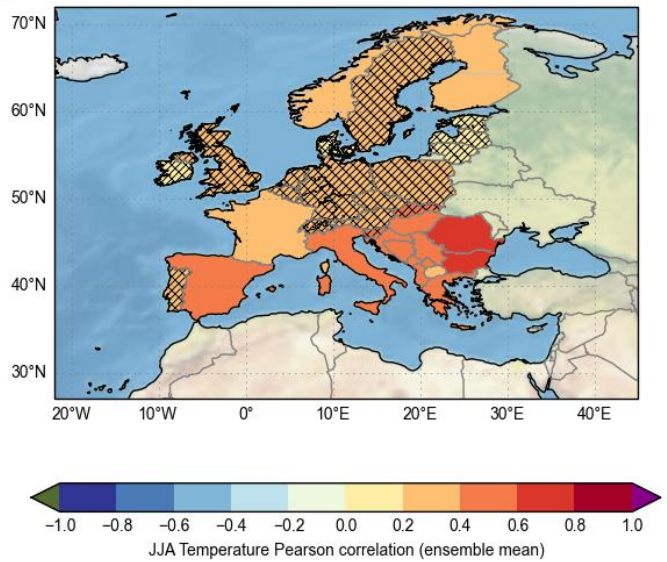
Met Office

At the seasonal time scale, there is very little change in the correlation skill when moving to the ECEM bias-adjusted reanalysis

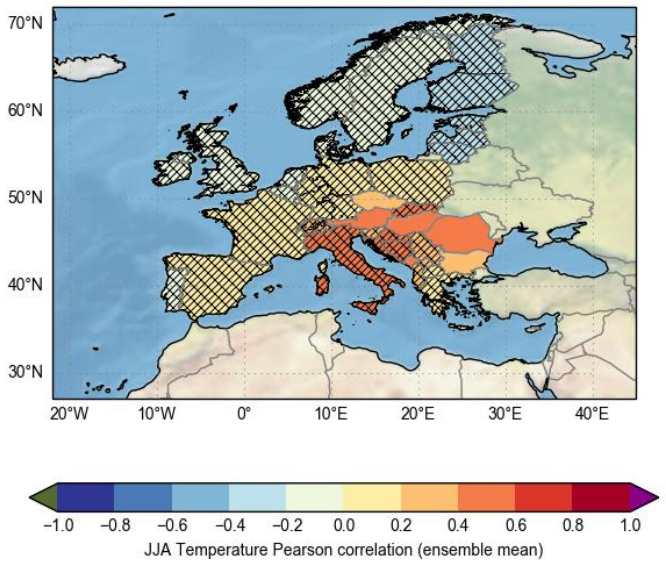
Climate Change

Example: Summer temperatures

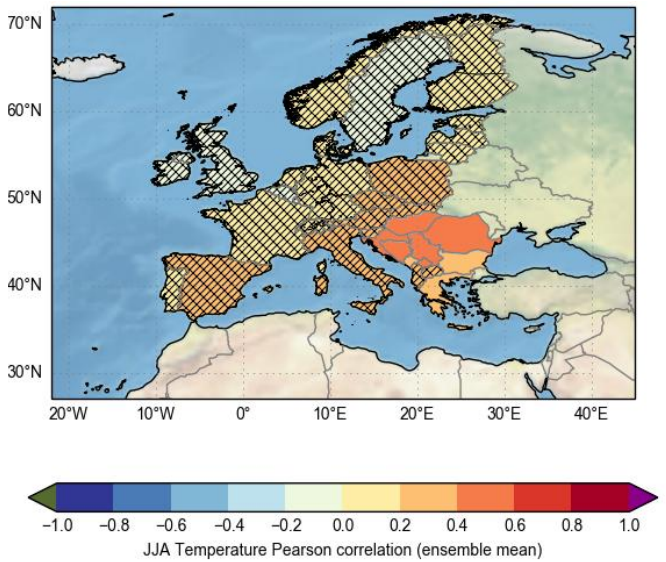
Correlation skill in countries:



ECMWF



Météo-France



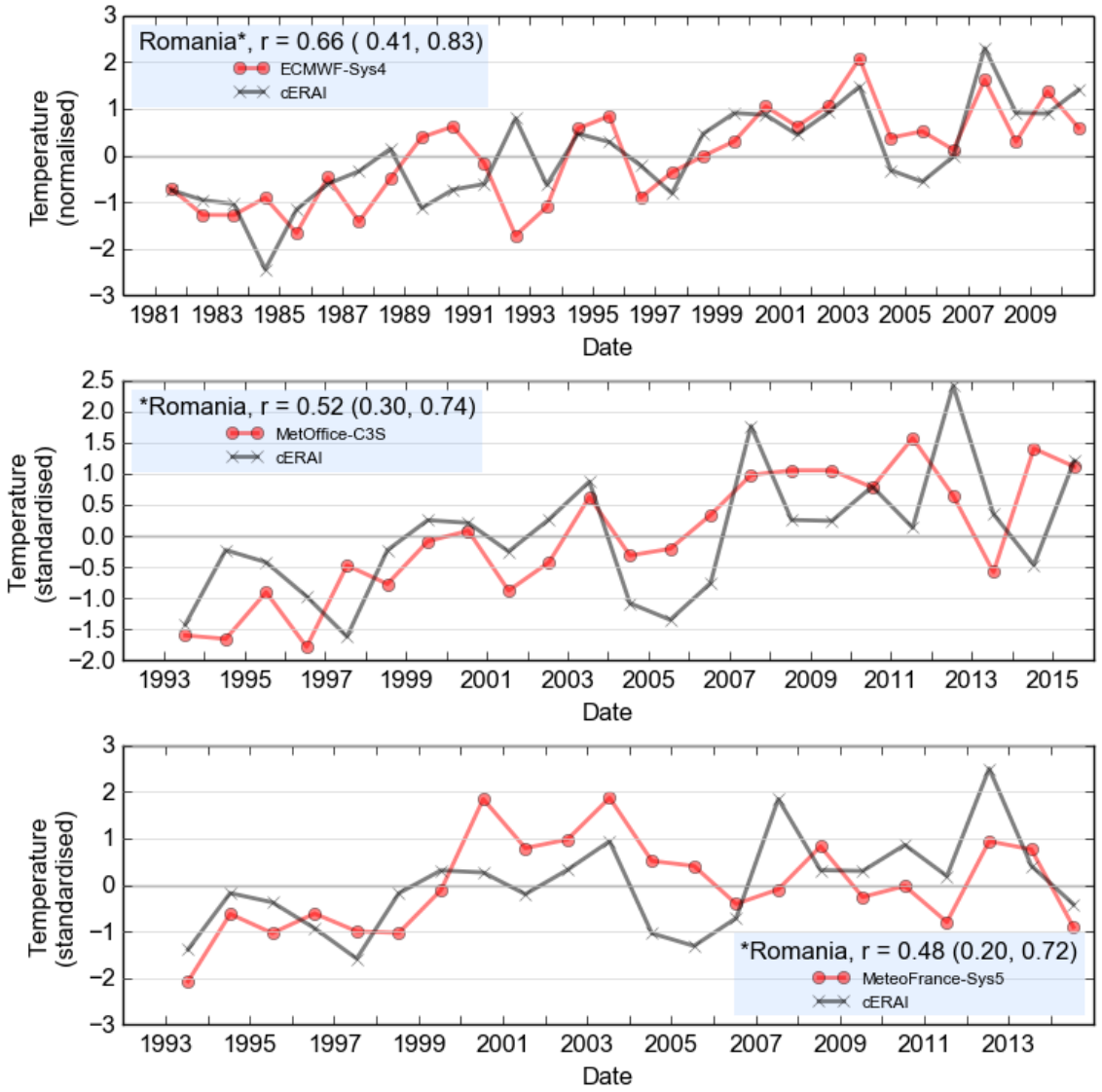
Met Office

Getting results for individual countries is essential, but care needs to be taken with these results.

We're taking a very simple approach to country-averaging, and comparing against the gridded data can be helpful.

Climate Change

Example: Summer temperatures



Romania shows significant skill across models for JJA temperatures.

There is a trend in the observations, and the ability of the forecast systems to reproduce the trend contributes to the positive skill.

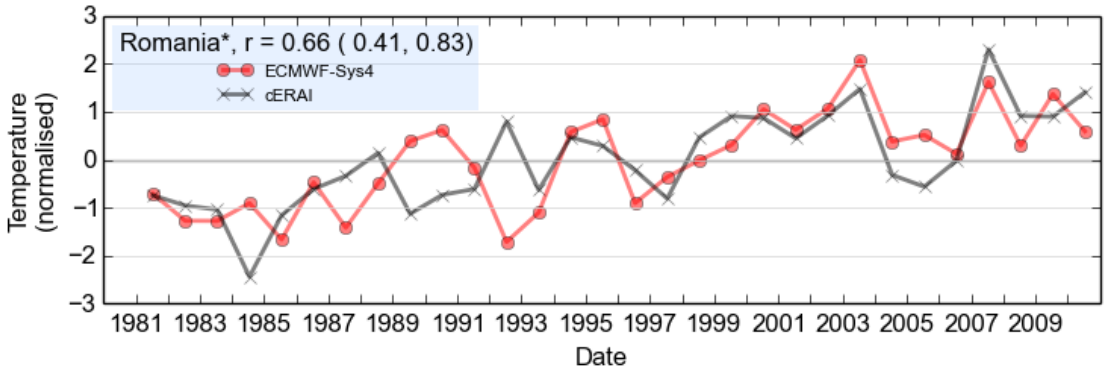
("Standardised" or "normalised": Plotting $(T - \mu_T) / \sigma_T$ instead of just T here, i.e. removing the mean and scaling by the variability, to match the calculation of the correlation)

Copernicus Europe's eyes on Earth

European Commission

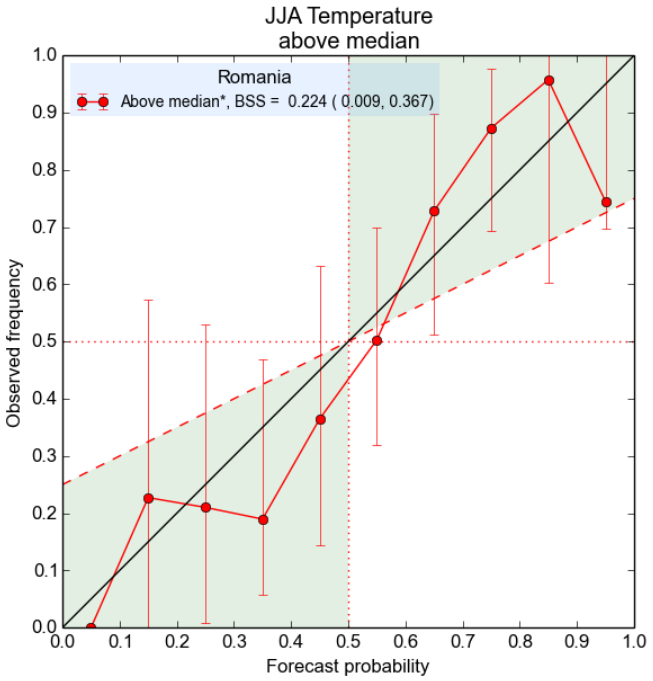
Climate Change

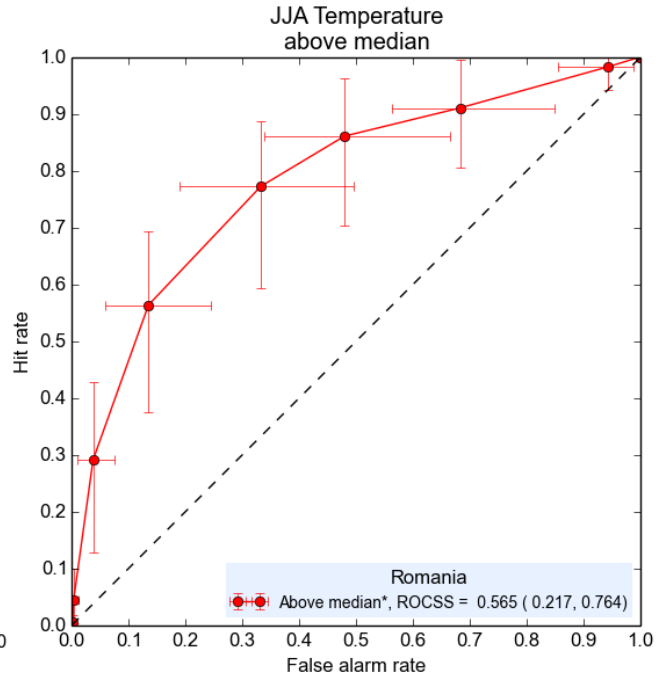
Example: Summer temperatures



The reliability and ROC diagrams for forecasts of above-average temperatures also show significant skill.

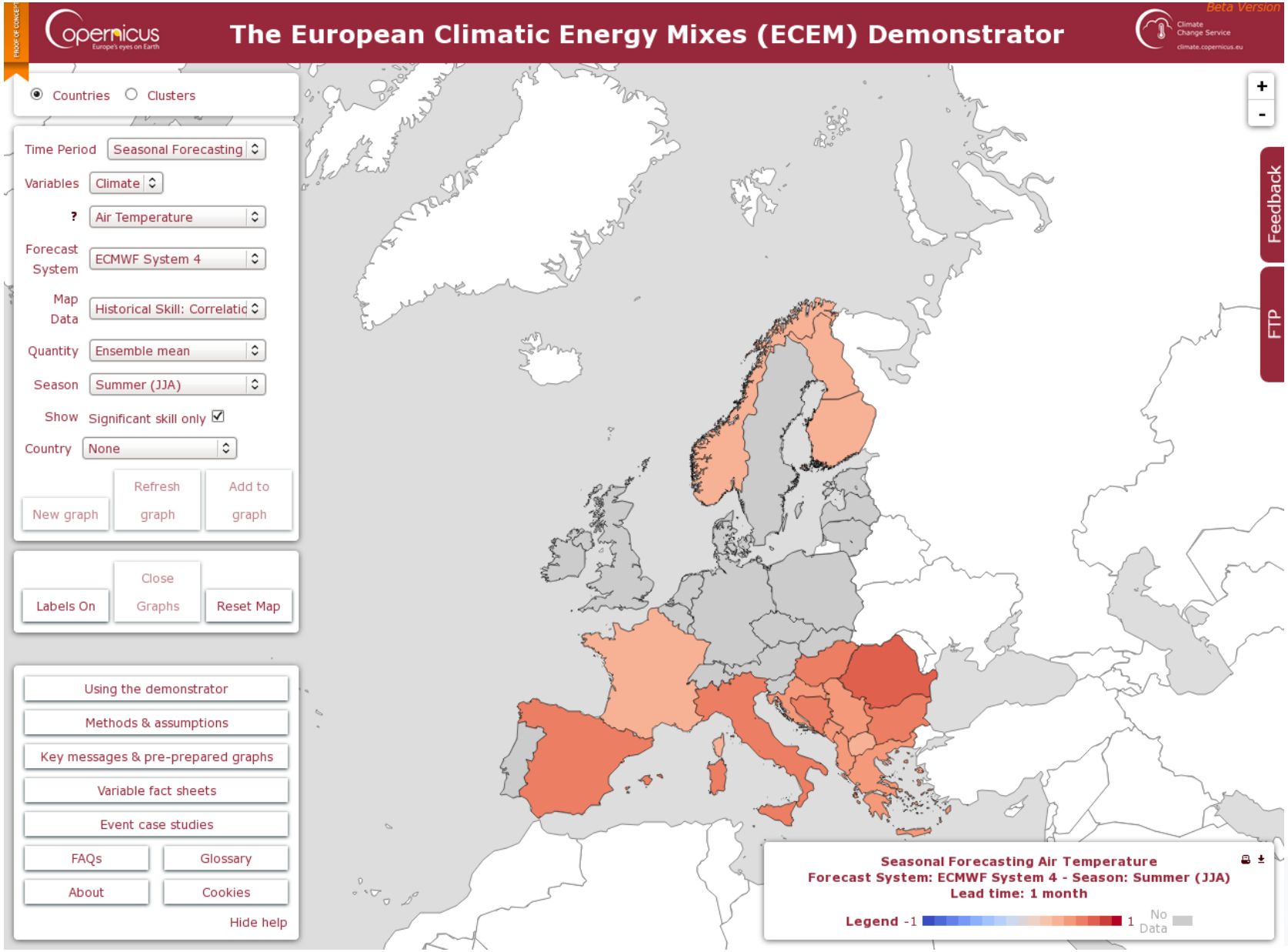
(Showing ECMWF only here)





Climate Change

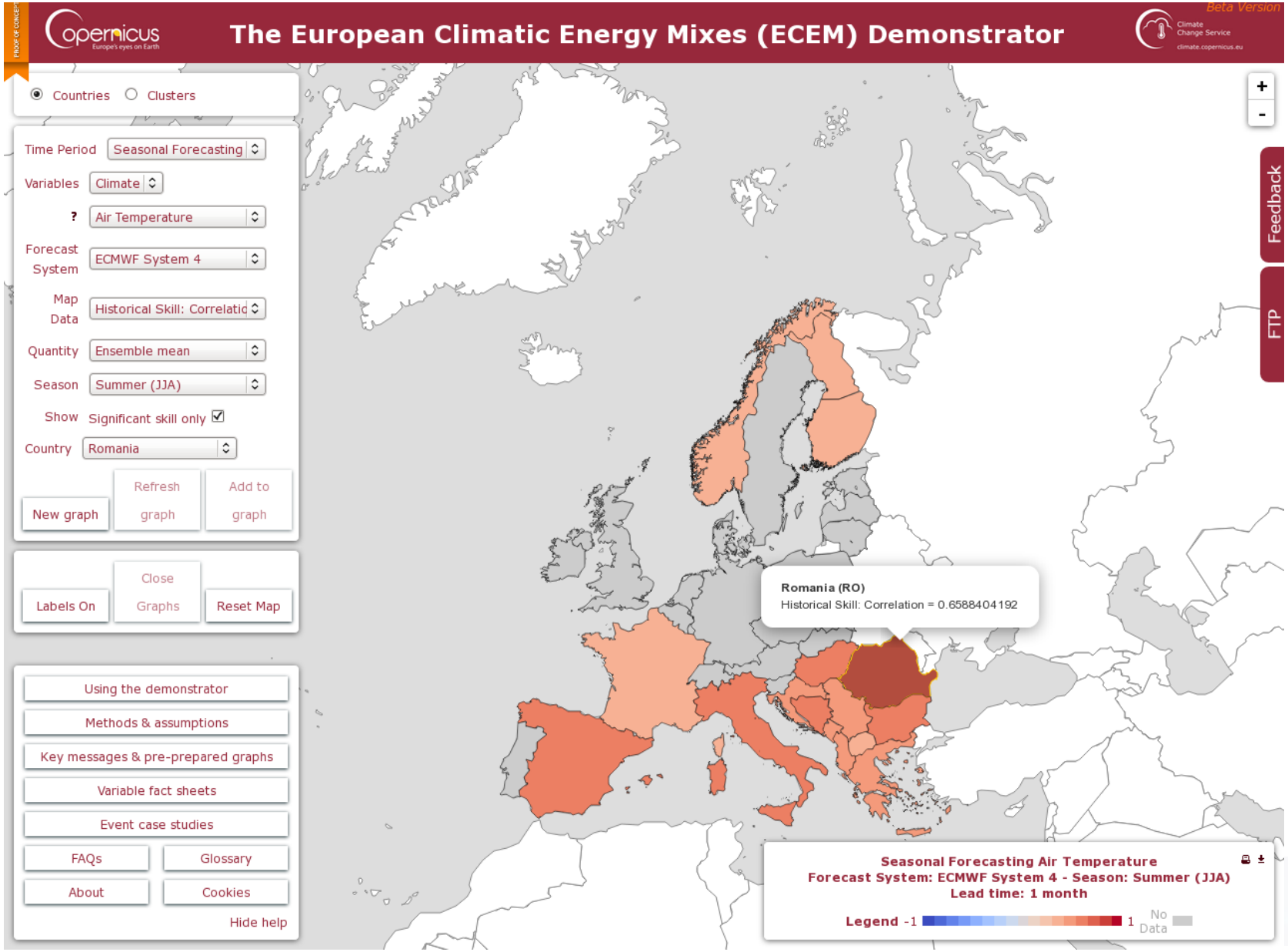
Example: Summer temperatures



European Commission

Climate Change

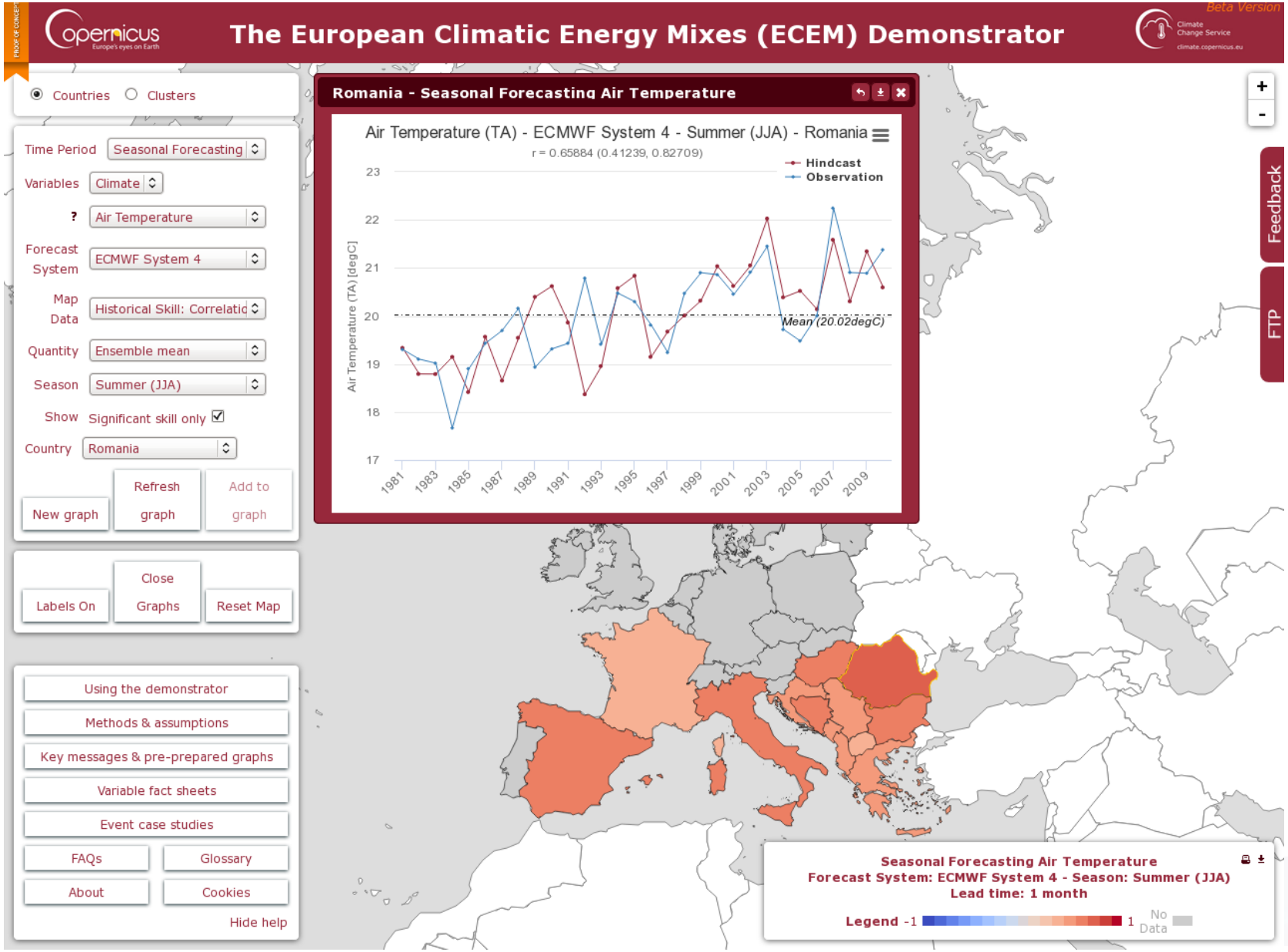
Example: Summer temperatures



European Commission

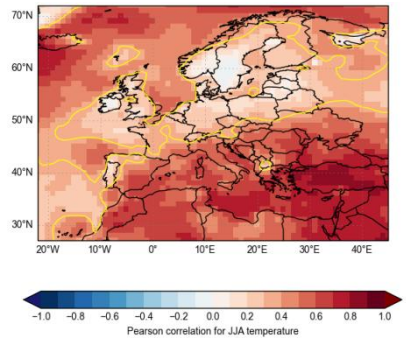
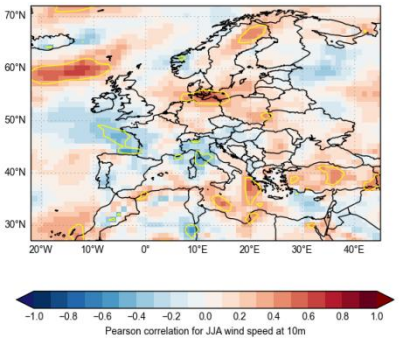
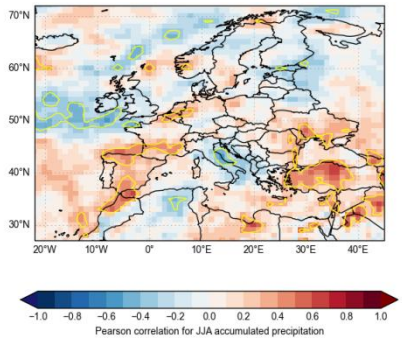
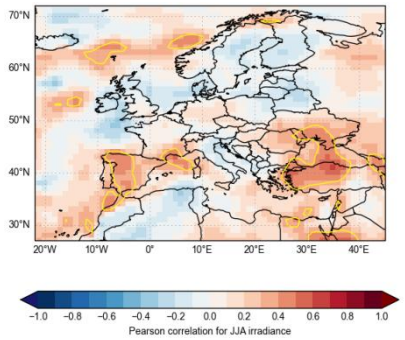
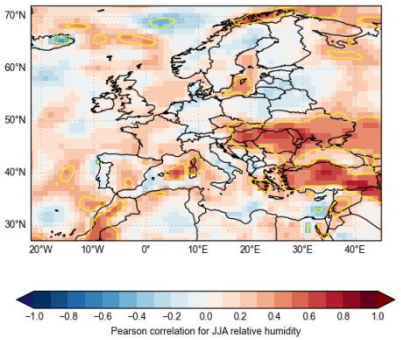
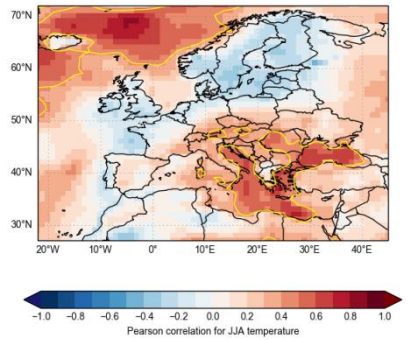
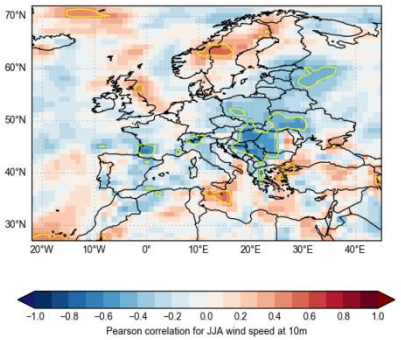
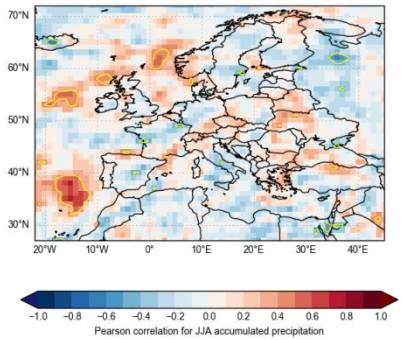
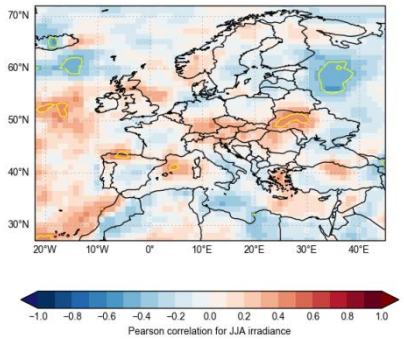
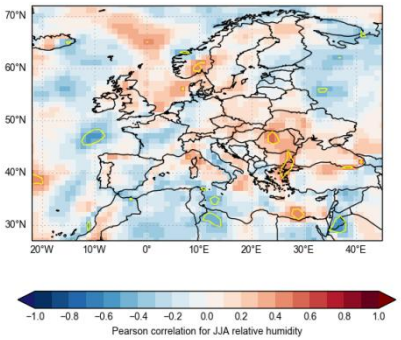
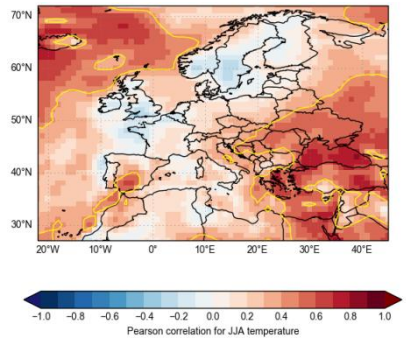
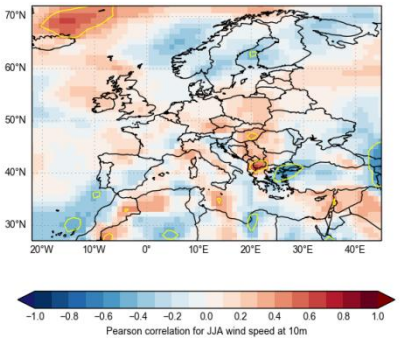
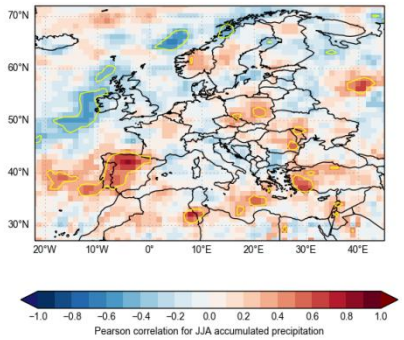
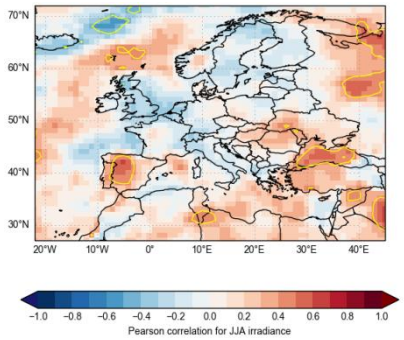
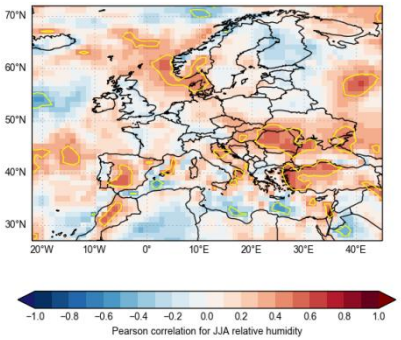
Climate Change

Example: Summer temperatures



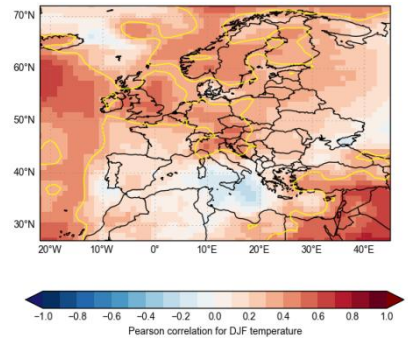
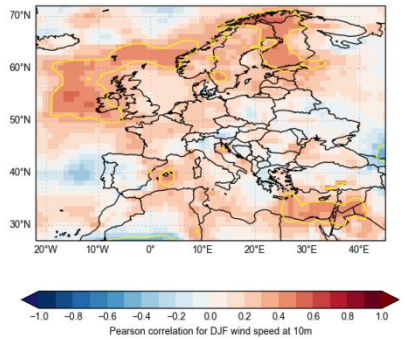
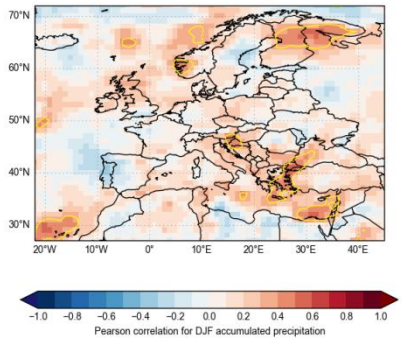
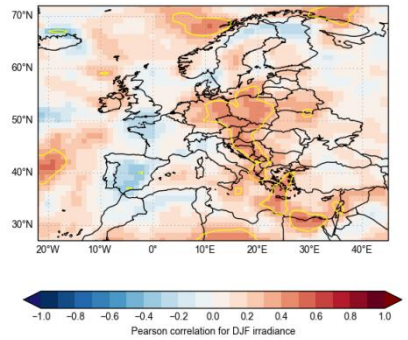
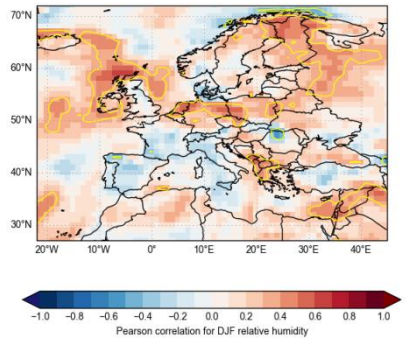
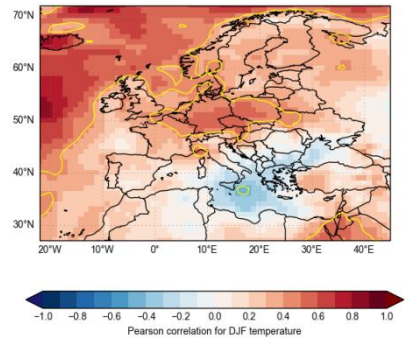
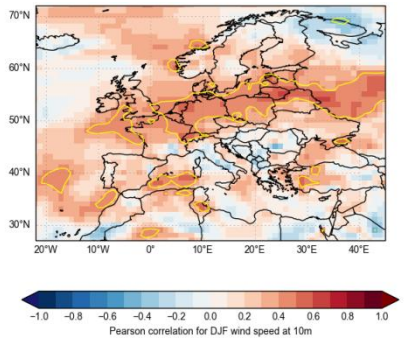
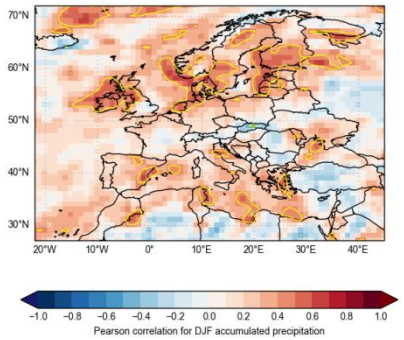
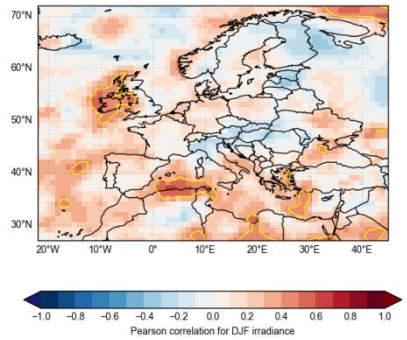
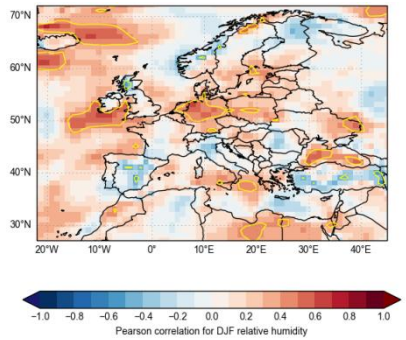
Climate Change

Summary: JJA Correlations

	Temperature	Wind speed	Precipitation	Irradiance	Relative humidity
ECMWF Sys 4					
Météo-France Sys 5					
Met Office GloSea5					

Climate Change

Summary: DJF Correlations

	Temperature	Wind speed	Precipitation	Irradiance	Relative humidity
ECMWF Sys 4					
Météo-France Sys 5					
Met Office GloSea5	*Available Nov 2017*				

Copernicus Europe's eyes on Earth

European Commission

Climate Change

The diversity of skill

Country		Met Office					ECMWF					Météo-France				
Code	Name	WS	T2M	RH	TP	SSRD	WS	T2M	RH	TP	SSRD	WS	T2M	RH	TP	SSRD
AL	Albania	C- -	---	---	---	---	---	C- -	---	---	---	---	---	---	---	---
AT	Austria	---	---	---	---	---	---	---	---	---	---	---	C-R	---	---	---
BE	Belgium	---	---	---	---	---	---	---	---	C- -	---	---	---	---	---	---
BA	Bosnia-Herzegovina	---	C- -	---	---	---	---	C- -	---	---	---	---	---	---	---	---
BG	Bulgaria	---	C- -	---	---	---	---	C-R	C- -	---	---	---	C-R	---	---	---
HR	Croatia	---	C- -	C- -	---	---	---	C-R	---	---	---	---	---	---	---	---
CZ	Czech Republic	---	---	---	- -R	---	---	---	---	---	---	---	C- -	---	---	---
DK	Denmark	---	---	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- -	---	---	---	---	---	C- -	---	---	---	---	---	---	---	---
ME	Montenegro	---	C- -	---	---	---	---	C- -	---	---	---	---	C- -	---	---	---
NL	Netherlands	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
NO	Norway	---	---	---	---	---	---	C-R	---	---	---	---	---	---	---	---
PL	Poland	---	---	---	---	---	- -R	---	---	---	---	---	---	---	---	---
PT	Portugal	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
RO	Romania	---	CBR	C- -	---	---	---	CBR	C-R	---	---	---	C-R	---	---	---
RS	Serbia	---	C- -	---	---	---	---	C- -	---	---	---	---	---	---	---	---
SK	Slovakia	---	---	---	---	---	---	- -R	CBR	---	---	---	---	---	---	---
SI	Slovenia	---	---	---	---	---	---	C- -	---	---	---	---	---	---	---	---
ES	Spain	---	---	---	---	---	---	CBR	C- -	---	---	---	---	---	---	---
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.

Copernicus Europe's eyes on Earth

European Commission

The diversity of skill

Climate Change

Country		Met Office					ECMWF					Météo-France				
Code	Name	WS	T2M	RH	TP	SSRD	WS	T2M	RH	TP	SSRD	WS	T2M	RH	TP	SSRD
AL	Albania								C- -		C- -					
AT	Austria							C- -					C- -			
BE	Belgium							C- -	C- -			C- -	C- -			
BA	Bosnia-Herzegovina										C- -					
BG	Bulgaria															
HR	Croatia							- -R		C- -	C- -					
CZ	Czech Republic							C- -	C- -		C- -		C- -			
DK	Denmark														C- -	
EE	Estonia						C- -	C- -								
FI	Finland						C-R	C- -							C- -	
FR	France												C- -			
DE	Germany							C- -	C-R			C- -	C- -	C-R		
GR	Greece								C- -	C- -	C- -					
HU	Hungary										C- -					
IE	Ireland							C- -	C- -						C-R	
IT	Italy															
LV	Latvia											C- -				
LT	Lithuania											C- -				
LU	Luxembourg							C- -	C- -				C- -			
MK	Macedonia								C- -		C- -					
ME	Montenegro								C- -		C- -					
NL	Netherlands							C- -	C-R			C- -	C- -		C- -	
NO	Norway						C-R	C-R	- -R	C- -						
PL	Poland								C- -		- -R	C- -	C- -			
PT	Portugal															
RO	Romania															
RS	Serbia										C- -					
SK	Slovakia										C- -		C- -			
SI	Slovenia							C- -					C- -			
ES	Spain															
SE	Sweden						C–	C-R							C- -	
CH	Switzerland											C- -	C- -			
UK	United Kingdom							C-R								

Available Nov 2017

DJF 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.

Copernicus Europe's eyes on Earth

European Commission

Climate Change

SUMMARY

- Seasonal forecasting uses global climate models to predict the climate of the coming 3-month season, with a lead time of about a month.
- Skill comes from slowly-varying components of the global climate system
- Uncertainty means we forecast probabilities of average seasonal conditions
  - e.g. "*a 60% probability of the Dec-Jan-Feb period on average being colder than normal*"

- We use hindcasts of the historical period to estimate the skill of the forecast systems. The limited size of the hindcasts makes these estimates uncertain.

- Skill in Europe is **very diverse** across different models, variables and seasons.
  - *How skillful do **you** need a seasonal forecast to be, before it is useful for your decisions?*
- Initial estimates of skill are provided in the **ECEM Demonstrator**, providing a starting point when considering if a seasonal forecast could be useful.

Copernicus Europe's eyes on Earth

European Commission

Climate Change

Thank you for listening!

Copernicus
Europe's eyes on Earth

European Commission