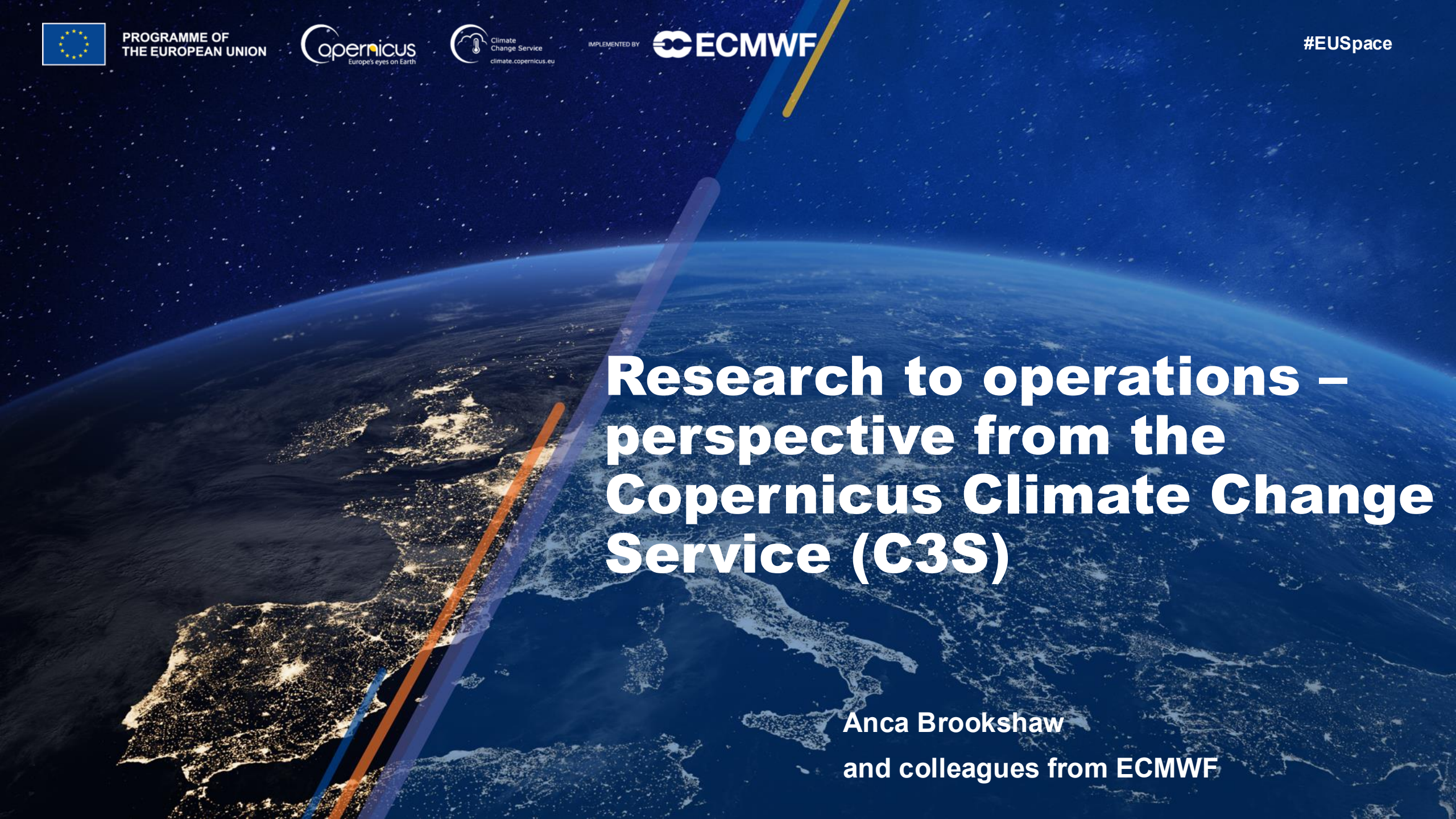
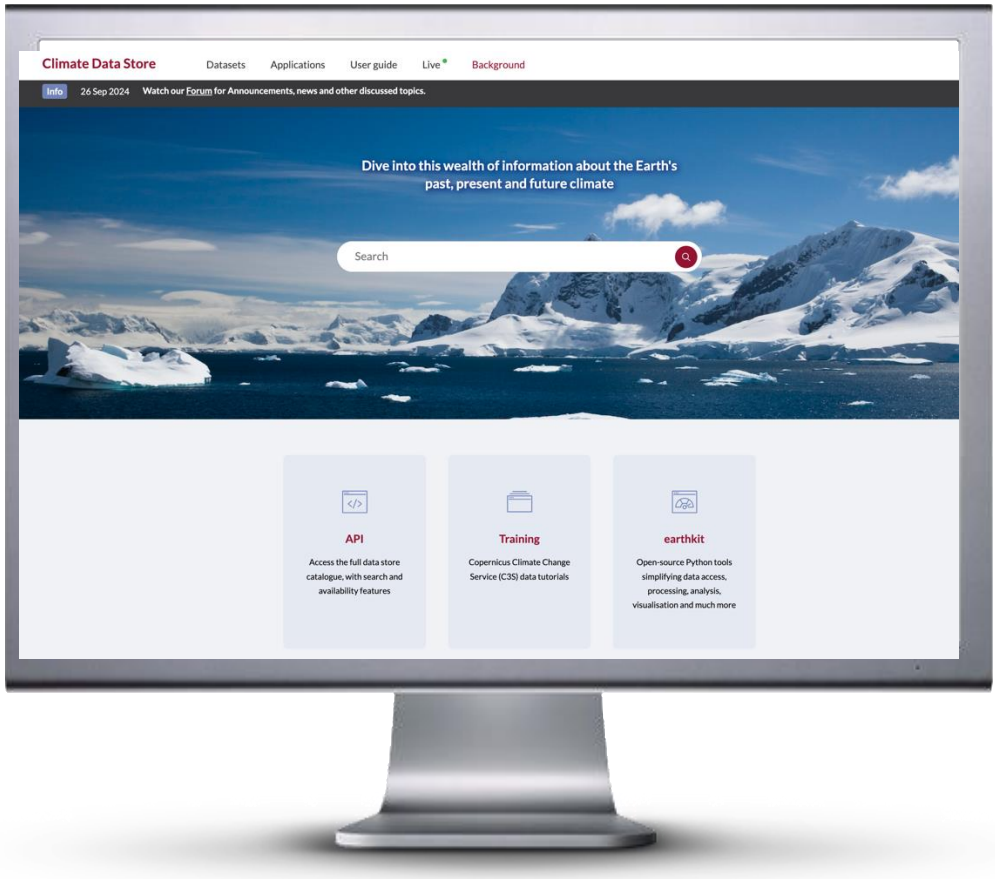

PROGRAMME OF
THE EUROPEAN UNION
Copernicus
Europe's eyes on Earth
Climate
Change Service
climate.copernicus.eu
IMPLEMENTED BY
ECMWF
#EUSpace
Research to operations – perspective from the Copernicus Climate Change Service (C3S)
Anca Brookshaw
and colleagues from ECMWF

Free, full and open access to data and services for any citizen or organization

C3S Climate Data Store



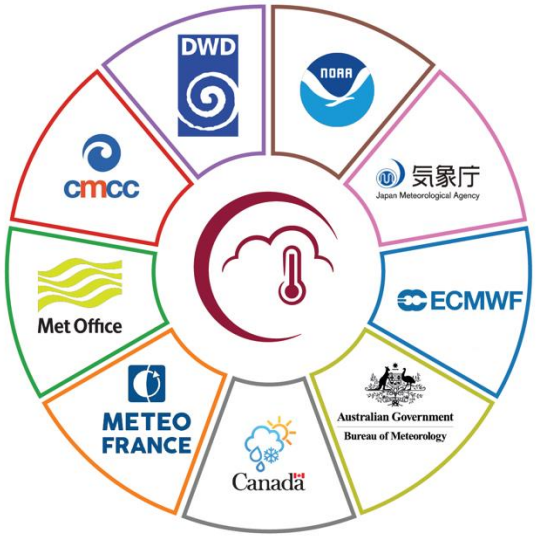
- Data catalogue
- API
- Tools (web applications)
- User support

https://cds.climate.copernicus.eu

C3S Seasonal Prediction Multi-System

Data products
cds.climate.copernicus.eu

- Datasets available in the Climate Data Store
  - Atmosphere
    - daily and subdaily data (6h, 12h, 24h)
    - monthly statistics (mean, max, min, standard deviation)
    - bias corrected data (monthly anomalies)
  - Ocean monthly means
- Multi-system retrospective forecasts and real-time forecasts, the latter published on 6th (ECMWF) and 10th day of month (the rest)



CDS API

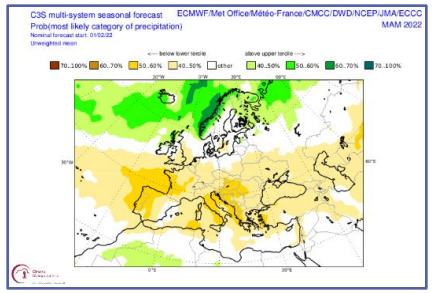
```
import cdsapi

c = cdsapi.Client()

c.retrieve(
    'seasonal-monthly-single-levels',
    {   'format':'grib',
        'originating_centre':'meteo_france',
        'variable':'total_precipitation',
        'product_type':[
            'ensemble_mean','hindcast_climate_mean'
        ],
        'year':'2018',
        'month':'09',
        'leadtime_month':['1','2','3','4','5','6'] },
    'cds_seasonal_output.grib')
```

Python workflows

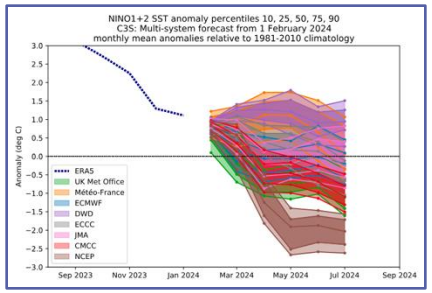
jupyter

Graphical products
climate.copernicus.eu/charts/packages/c3s_seasonal/

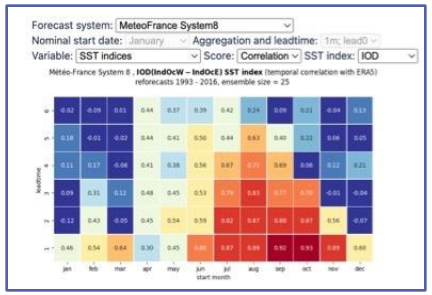
Products for individual contributing systems and multi-system combination



Total precipitation
Near-surface temperature and wind
Mean sea-level pressure
Sea surface temperature
Sea ice concentration
Geopotential height at 500 hPa
Temperature at 850 hPa



Sea surface temperature NINO regions
Sea surface temperature Indian Ocean
Zonal mean wind at 10hPa



Temporal correlation
Relative Operating Characteristic (ROC) score
Ranked Probability Score (RPS)

PROGRAMME OF THE EUROPEAN UNION

Copernicus Europe's eyes on Earth

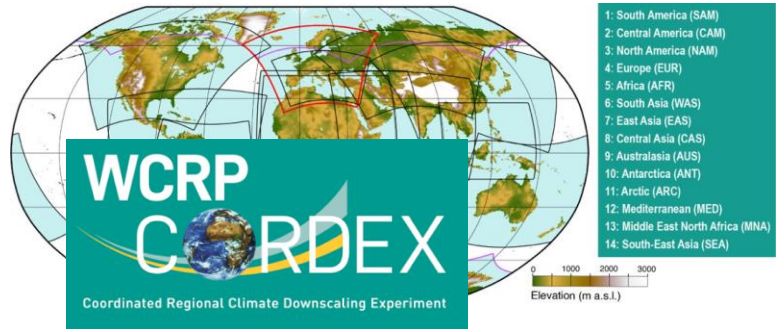
Climate Change Service climate.copernicus.eu

IMPLEMENTED BY ECMWF

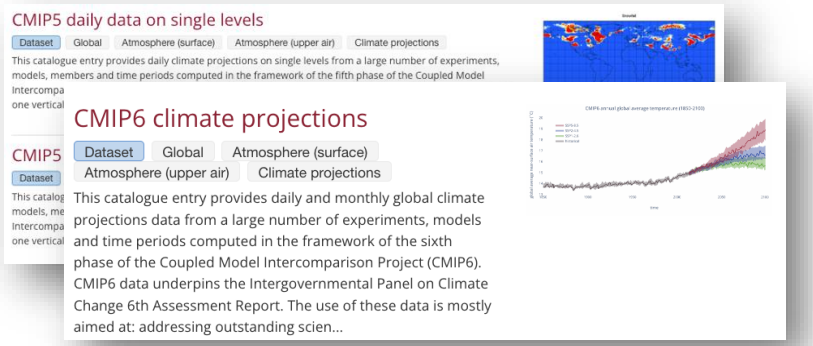
C3S Climate Prediction and Projection Data

WCRP CMIP5 World Climate Research Programme

WCRP CMIP6 World Climate Research Programme



Global climate projections



CMIP5 daily data on single levels

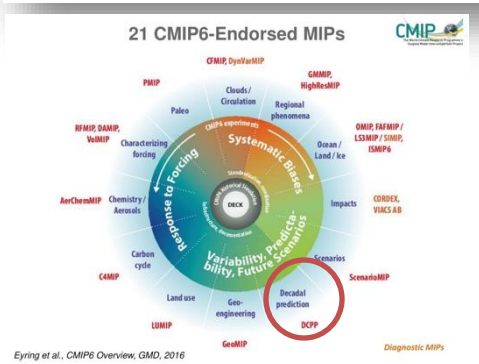
Dataset | Global | Atmosphere (surface) | Atmosphere (upper air) | Climate projections

This catalogue entry provides daily climate projections on single levels from a large number of experiments, models, members and time periods computed in the framework of the fifth phase of the Coupled Model Intercompa... one vertical...

CMIP6 climate projections

Dataset | Global | Atmosphere (surface) | Atmosphere (upper air) | Climate projections

This catalogue entry provides daily and monthly global climate projections data from a large number of experiments, models and time periods computed in the framework of the sixth phase of the Coupled Model Intercomparison Project (CMIP6). CMIP6 data underpins the Intergovernmental Panel on Climate Change 6th Assessment Report. The use of these data is mostly aimed at: addressing outstanding scien...



Climate Change Service climate.copernicus.eu

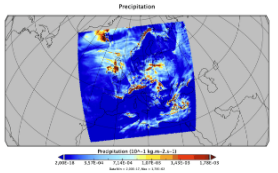
- operational data access
- quality control
- data tutorials

Regional climate projections

CORDEX regional climate model data on single levels

Dataset | Europe | Atmosphere (surface) | Atmosphere (upper air) | Climate projections

This catalogue entry provides Regional Climate Model (RCM) data on single levels from a number of experiments, models, domains, resolutions, ensemble members, time frequencies and periods computed over several regional domains all over the World in the framework of the Coordinated Regional Climate Downscaling Experiment (CORDEX). The term "single levels" is used to express that the variables are 2...

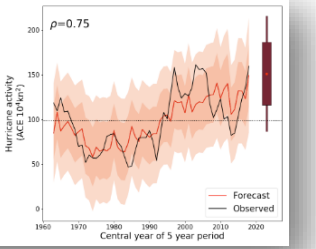


Decadal predictions

CMIP6 predictions underpinning the C3S decadal prediction prototypes

Dataset | Global | Atmosphere (surface) | Atmosphere (upper air) | Climate projections

This catalogue entry provides daily and monthly global climate model data from Decadal Climate Predictions Project (DCPP) experiments, part of the sixth phase of the Coupled Model Intercomparison Project (CMIP6). The decadal data in the Climate Data Store (CDS) are a quality-controlled subset of the full DCPP. CMIP6-DCPP data addresses the ability of the climate system to be predicted on annual, m...



An Operational Service

users	development/design	operations/services	users

	Predictions:
	- hindcasts and forecasts – consistency (method, time,..)
	- definition of products (extracting information from data)
	- evaluation of products
	- documentation
		Predictions:
		- automation
		  - appropriate software
		  - testing
		  - documentation
		  - data handling
		- standardisation; quality
		- timeliness
		  - arrival of inputs (e.g. forcings, initial conditions)
		  - publication of outputs
			Predictions:
			- ‘average’ skill
			- ‘value’
			- support

Climate predictions and projections

Climate predictions (seasonal, decadal, etc) – depend on **initial conditions**

- regular, relatively frequent updates, which **need to be published at predictable time**
- 'best method' required (e.g. updates to prediction systems) – **user interaction with the data is fundamentally different from that applicable to many other datasets**
- no terms of comparison – **evaluation and quality control is fundamentally different**
- need for inputs about climate-relevant 'events' in near-real time (e.g. volcanic eruptions for seasonal/decadal predictions) – **operational-standard generation procedures are needed for these inputs**

Climate projections

- currently available as collections of 'opportunity' (MIPs) – **not properly designed for the purpose of services** (e.g. incomplete sampling of uncertainties)
- conflicting priorities from different communities (issues of **traceability, versioning**; **practical constraints**)
- **co-existence of a variety of sources of data** (CMIP5- and CMIP6-generation model runs), without clear guidance on how to interpret and/or combine

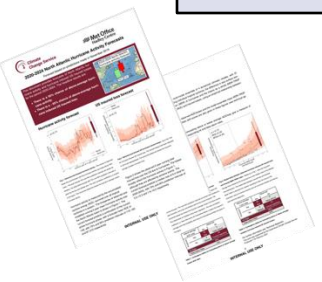
User support is indispensable!

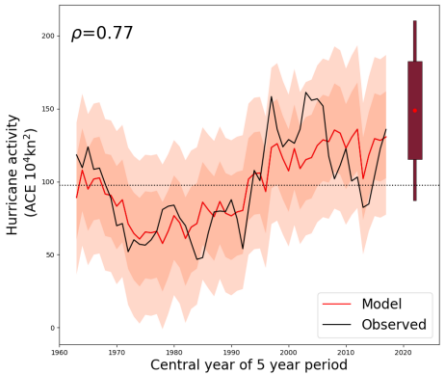
C3S Decadal Prediction Prototype (2021)

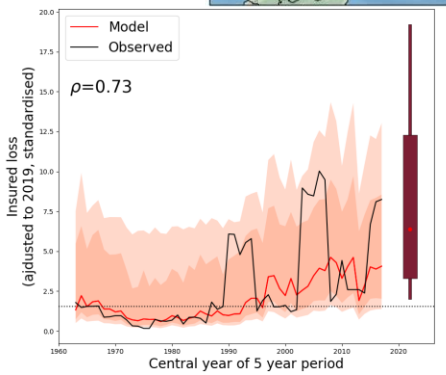
INSURANCE

(partner: Willis Re)

Predictions of 5-year N. Atlantic hurricane activity and US total insured losses



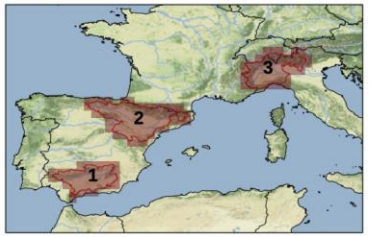


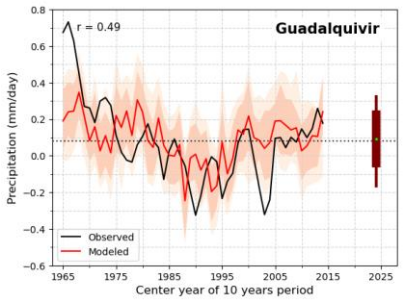


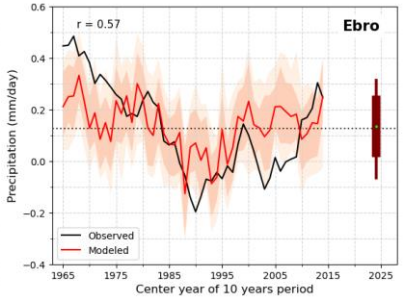
ENERGY

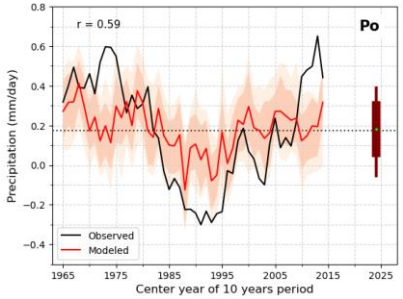
(partner: Enel)

Predictions of 10-year precipitation for hydropower industry





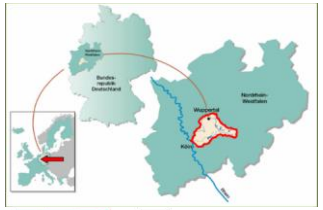


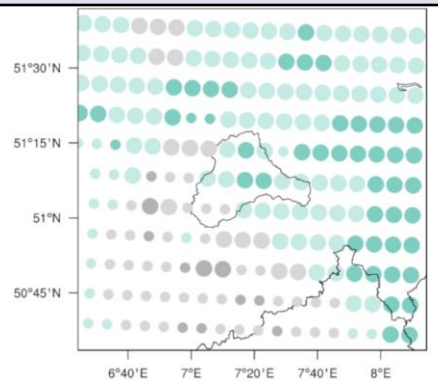


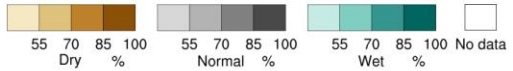
INFRASTRUCTURE

(partner: Wupperverband)

Predictions of 3-year high-resolution SPEI drought index for water management.







Probabilistic prediction for SPEI:
The colour represents the most probable category (dry/ normal/ wet) of the climate prediction (3-year mean) in comparison to the climate characteristics for 1995-2012. The brightness describes the probability of this category.

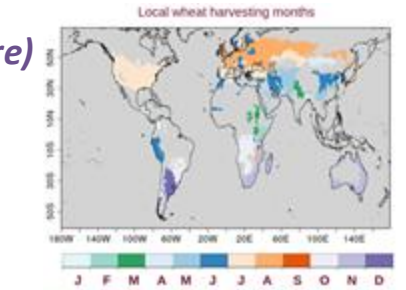
Prediction skill:
The size of the dots shows the skill in the evaluation period 1995-2012:

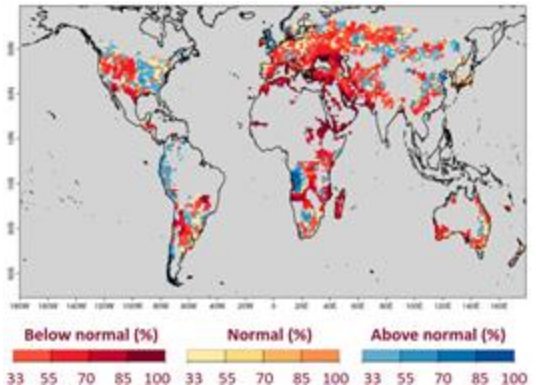
- significantly worse than the observed climatology
- comparable to the observed climatology
- significantly better than the observed climatology

AGRICULTURE

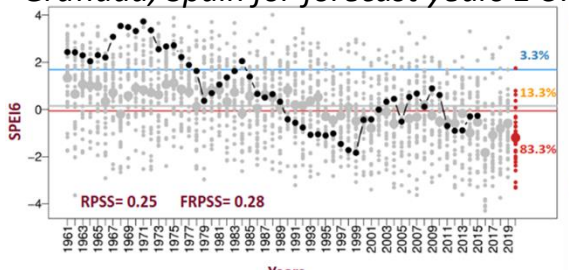
(partner: Joint Research Centre)

Predictions of 5-year SPEI drought for global wheat producing regions





Granada, Spain for forecast years 1-5:



C3S Decadal Predictions Prototype - lessons

A wide range of potential users: a range of 'products' is required, from direct model output to 'calibrated information'

Case studies (user feedback and conclusions of study)

- **User questions** are diverse, complex and 'ambitious'; they **go well beyond global average temperature, or trends**. Available prediction skill is at odds with some users' expectations.
- **Production schedule** needs to be tightened (some decisions have deadlines attached – e.g. re-insurance)
- Some users do not 'like' large ensembles – to convey the 'correct' forecast message, **calibrated products** will be needed.
- Downscaling GCM output does not create skill; **understanding where the skill comes from is essential for product generation** (e.g. case study used country-scale GCM atmospheric variables to create river basin-scale, 5km rainfall predictions, without improvement in skill)
- User contexts do not neatly differentiate between timescales; this means two things: for users, distinctions between 'decadal' and 'seasonal' are artificial, as are distinctions between intialised and uninitialised model runs.

(Operational) Service

- important - for society, and for scientists
- not trivial - from technical, or scientific perspective
- but not appropriately recognised….
- good source of new research questions