



Climate Change

C3S evolution

Climate predictions and projections

Anca Brookshaw
ECMWF

Workshop with ECMWF Member States, 11-12 June 2020





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Climate predictions and projections

New activities on climate predictions and projections:

- Prototype **decadal prediction** service
- World-wide **CORDEX simulations** for the CDS, connected to the IPCC Climate Atlas
- **Link between CDS toolbox and the ESGF compute nodes:** design and implementation
- Inclusion of **CMIP6 data in the CDS catalogue**
- **Maintenance** of the C3S-related infrastructure at ESGF

Prototype decadal prediction service

Aligned to **user requirements** and designed in agreement with producers of predictions

Two topics:

- Identify **best practice** for interpreting decadal prediction model output (bias correction, verification, data encoding)
- Develop **case studies** for user-relevant applications
 - **Infrastructure** (*DWD*): management of water level and water quality of the upper catchment in North-Rhine-Westphalia
 - **Agriculture** (*BSC*): planning of crop yields (drought, heat waves), globally – JRC
 - **Energy** (*CMCC*): Production of hydropower and solar energy – ENEL (Italy and Spain)
 - **Insurance** (*UKMO*) : Risk associated with tropical and extra-tropical cyclones over the Atlantic basin – Willis Towers Watson





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Prototype product - example

headline results

This document provides forecasts of North Atlantic hurricane activity in the coming five years. Forecasts are for total ACE index from North Atlantic tropical cyclones and total insured loss over the USA and Caribbean. The current headline results are:

For the next 5 years (2015-2019):

- There is a 95% chance of above-average ACE index.
- There is a 75% chance of above-average USA and Caribbean insured losses.

ACE

(accumulated cyclone energy - meteorological measure of collective intensity of storms)

Background Information

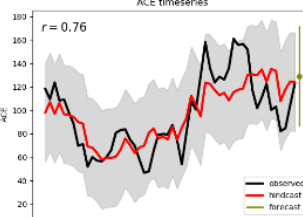
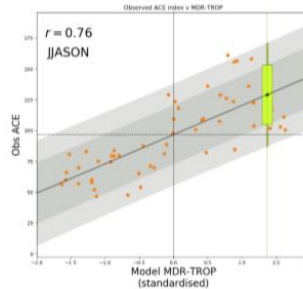
Total ACE index for 2015-2019 (hurricane season)

Seven decadal prediction systems, each with 10 ensemble members, have been used to produce this forecast for total ACE index over the next five years (calculated over the June-November North Atlantic hurricane season only). The model index used to predict the hurricane activity is the difference between the air temperature over the sea in the main hurricane development region and the tropics (MDR-TROP). The figure on the right shows the relationship between model hindcast MDR-TROP and observed ACE (HURDAT2) over the period 1963-2016, together with the correlation r and the forecast predicted using that relationship.

Individual years are shown as dots. The solid diagonal line shows the linear regression, with shading showing the 75% and 95% confidence intervals from the fit. The horizontal dotted line shows the climatological mean over this period.

The forecast (in green) is shown as a central estimate (o with vertical line), with uncertainty boxes showing the 75% and 95% confidence limits from the linear regression.

We also show the contingency table (right) for forecasts of above-average ACE index.



Above-average ACE index		Observed	
		Yes	No
Predicted	Yes	24 Hits	2 False alarms
	No	3 Misses	25 Correct rejections
Hit Rate:		90%	
False Alarm Rate:		5%	

1 of ??

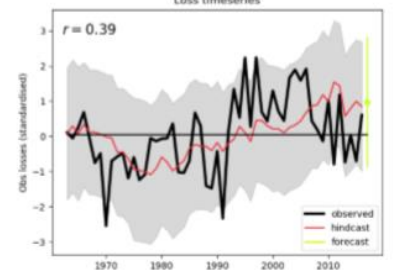
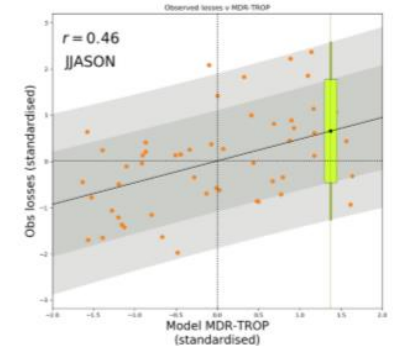
INTERNAL USE ONLY - NOT REAL FORECAST

Insured losses for 2015-2019

The figure on the right shows the forecast for total insured losses in the USA and Caribbean for 2015-2019, again using the index MDR-TROP from model ensemble mean as the predictor. The scatter plot shows the relationship between hindcast MDR-TROP and observed insured losses for the period 1963-2016. The horizontal dotted line shows the climatological mean over this period.

The ensemble-mean forecast is again shown in green, with the uncertainty given by the confidence limits on the fit.

The contingency table for forecasts of above-average insured loss is also shown.



Above-average 100m wind speed		Observed	
		Yes	No
Predicted	Yes	16 Hits	9 False alarms
	No	10 Misses	17 Correct rejections
Hit Rate:		60%	
False Alarm Rate:		35%	

2 of ??

INTERNAL USE ONLY - NOT REAL FORECAST

insured losses



forecast in the context of past cases (two views)

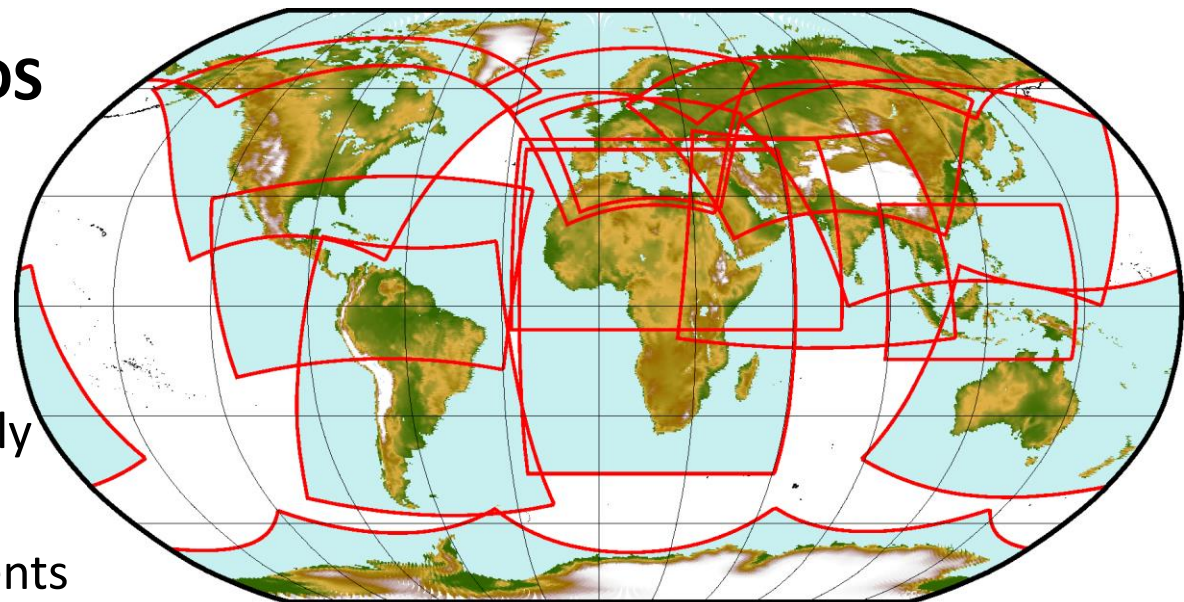
validation
(contingency tables)



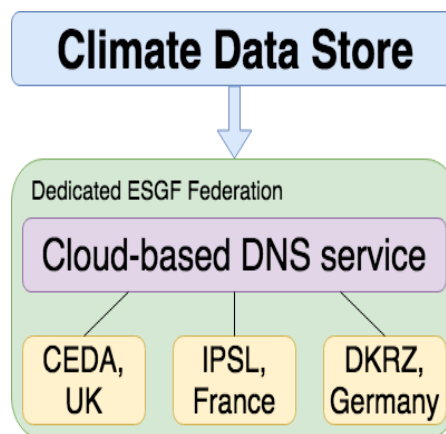
New data in the CDS

World-wide CORDEX simulations for the CDS

- Bring data already at ESGF in line with C3S requirements (paralleling quality control and service implemented for European CORDEX regions).
- Bring in ESGF data not yet available there (usually produced by 'other' modelling groups).
- Make available data from multi-region experiments (e.g. CORDEX-CORE).
- Establish operational connection with the IPCC climate atlas.



- **CMIP6 simulations**
 - climate change scenarios;
 - historical simulations;
 - initialised decadal predictions.

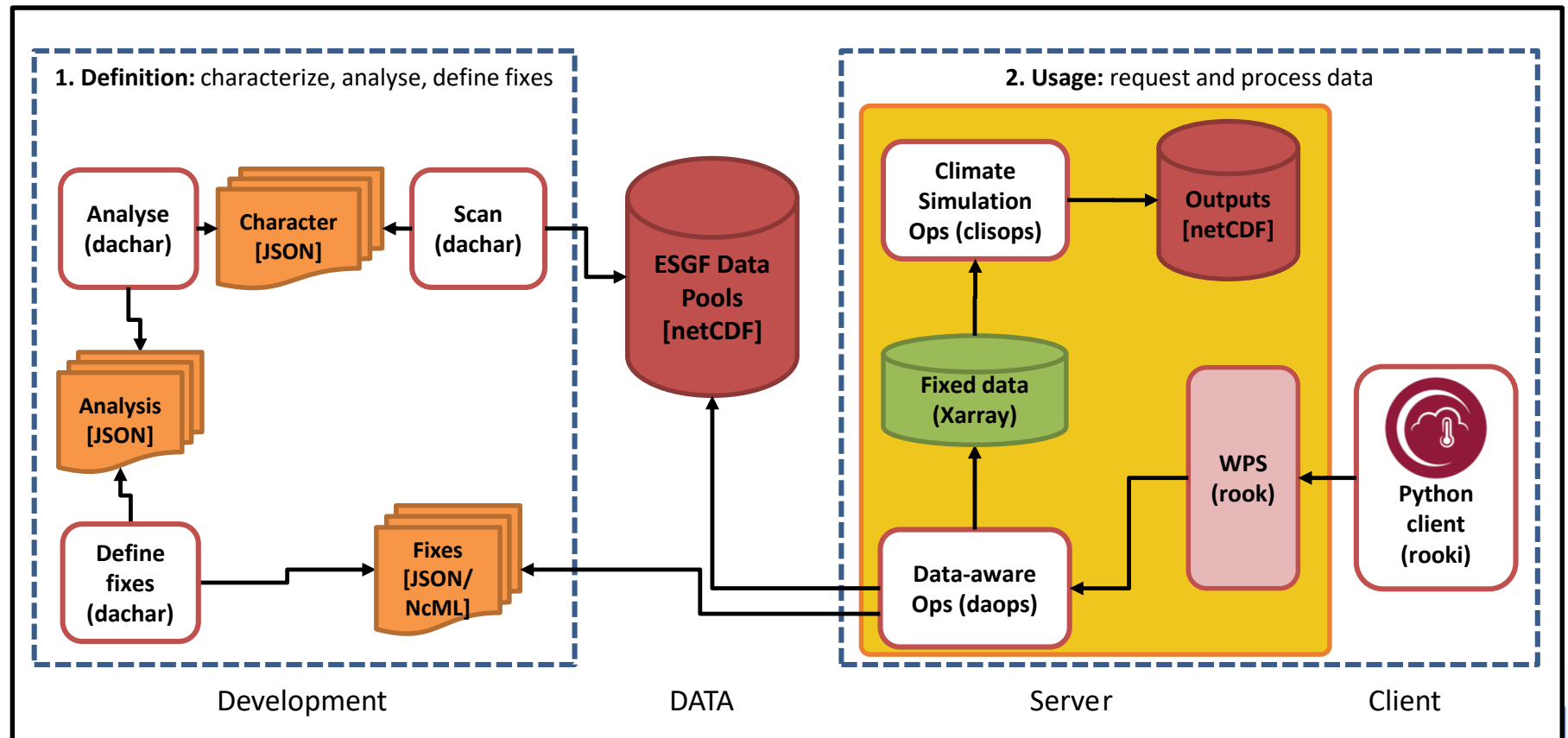




New operating capability in the CDS

Robust operations on CMIP/CORDEX climate projections through the CDS toolbox

- Design interface between CDS toolbox and ESGF compute layer
- Develop, test, implement Web Processing Services (WPS) for data volume reduction
- Ensure operational 'status' for this facility (reliable availability, parallel use, scalability...)



What does C3S work on climate projections bring to Member States and users around the world?

- ‘Operational’ access to a large set of data from climate projections;
- Supplementary quality control on climate projection data – global and regional, from CMIP5 and CMIP6 - for the benefit of climate services;
- Tools for processing climate projections in efficient manner (‘operational’ WPS);
- Regional climate projections:
 - supplementary projections for European CORDEX regions → better uncertainty estimates;
 - an unprecedentedly large set projections for non-European regions;
- Strong links with the IPCC assessments on regional climate change of relevance to climate services (IPCC climate atlas).



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C3S Evolution Sectoral Information System

Chiara Cagnazzo
ECMWF

Workshop with ECMWF Member States, 11-12 June 2020





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Sectors



Infrastructure, Transport
and Associated
Standards



Biodiversity



Energy



Disaster risk reduction



Health



Water management



Insurance



Coastal areas



Agriculture and forestry



Tourism



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Operational service for the water sector

Climate Impacts

Indicators and models

Indicator type

Water quantity | ▾

Impact indicator

River flow (mean) | ▾

Model

Ensemble | ▾

Settings

Spatial aggregation

0.5 degree grid (50 km) | ▾

Time period

2011-2040 | ▾

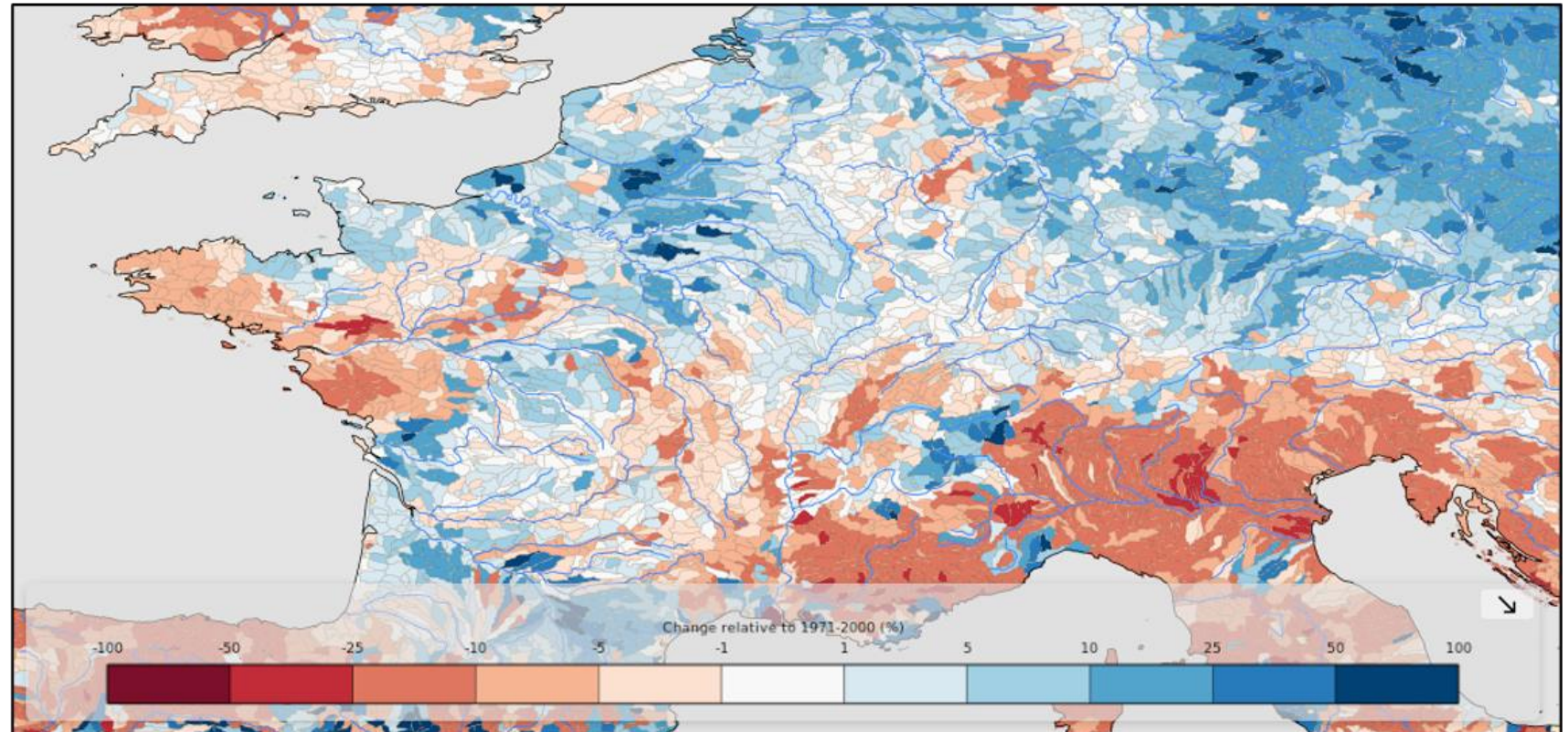
Emission scenario

Low (RCP 2.6) | ▾

Low (RCP 2.6)

Medium (RCP 4.5)

High (RCP 8.5)



<https://climate.copernicus.eu/operational-service-water-sector>

SMHI



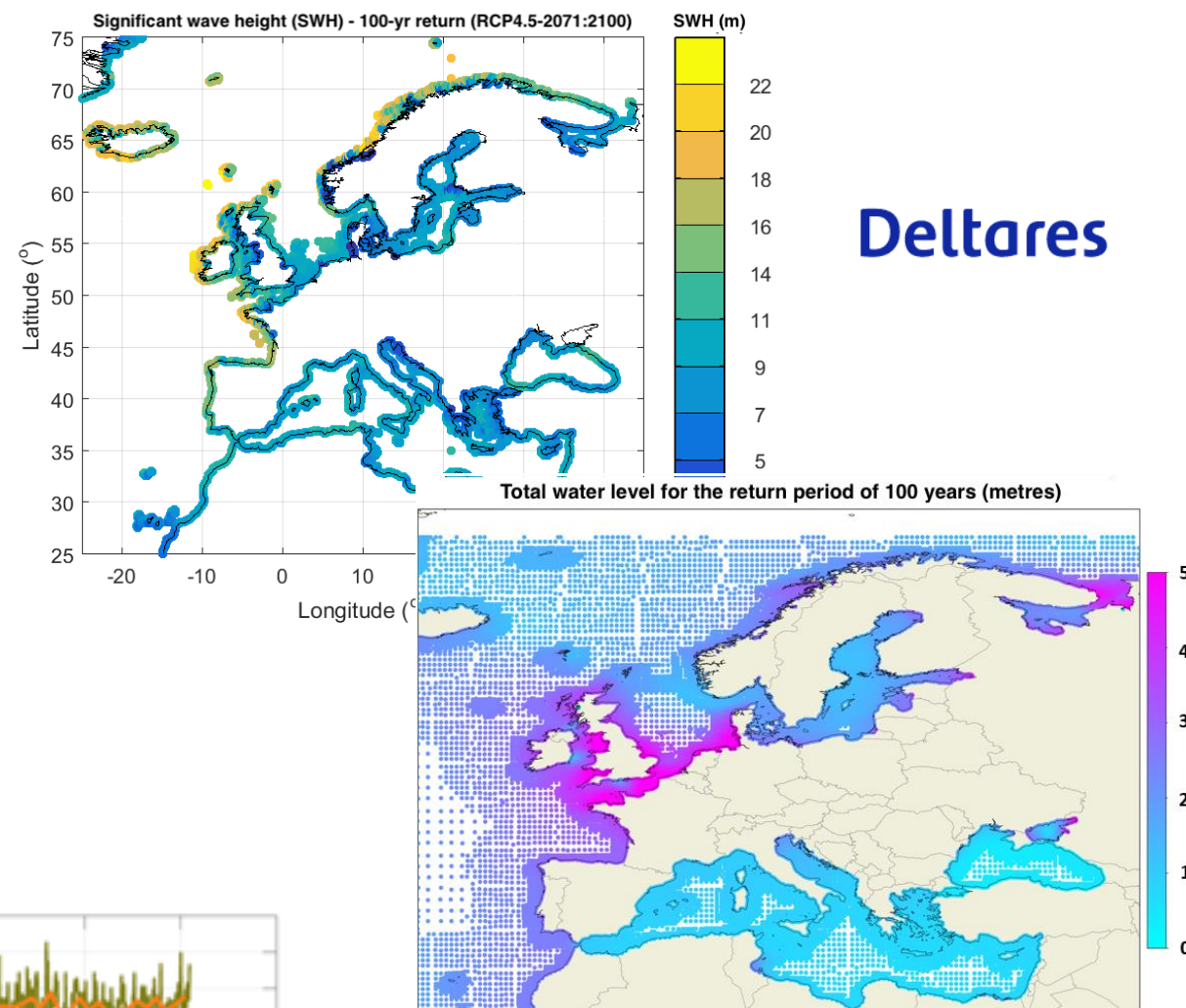
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European Storm Surges

<https://climate.copernicus.eu/european-storm-surges>

Case study : future climate change in the coastal **Baltic Sea** region of Køge Bay (Southern Copenhagen) :

- Return value of the storm surge events
- Wave heights
- Gate closure numbers



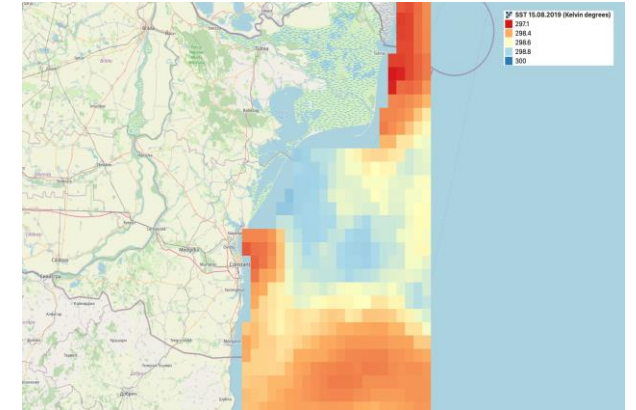
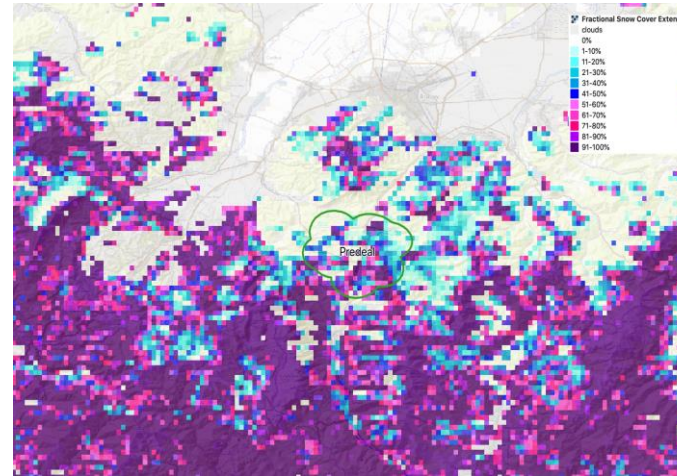
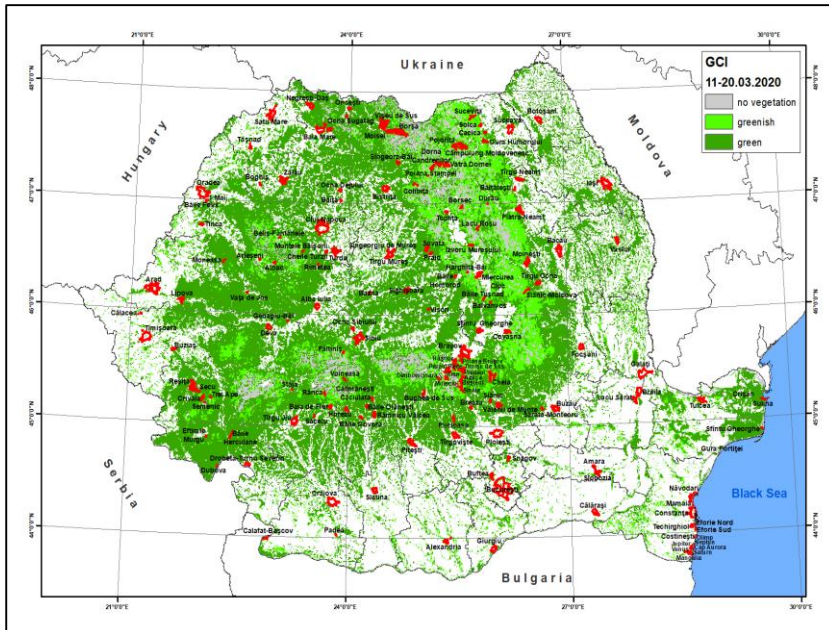
Deltares



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NRT Climate information for Tourism in Romania

- To develop and provide climate and environmental information tailored for touristic purposes
- Easy-to-use web based platform
- Adapted for 4 different touristic destinations types and for each month,
- 12 categories of indices, derived from C3S products and other Copernicus data sources (Copernicus Atmosphere Monitoring Service, Copernicus Global Land Services, Copernicus Marine Monitoring Service, Copernicus Open Access Hub).





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SIS evolution: benchmark & best practices

- Bias Adjustment
- Downscaling & Aggregation
- Extremes
- User defined skill & thresholds
- Climate Analogues

Essential climate variables for water sector applications derived from CMIP5 projections

WARNING: The structure of this dataset was modified on 2020-05-01. Please, review your API scripts if you were using them to download the data.

Near surface meteorological variables from 1979 to 2018 derived from bias-corrected reanalysis

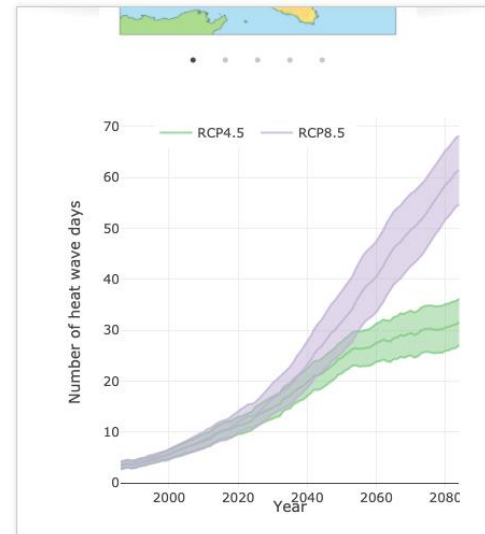
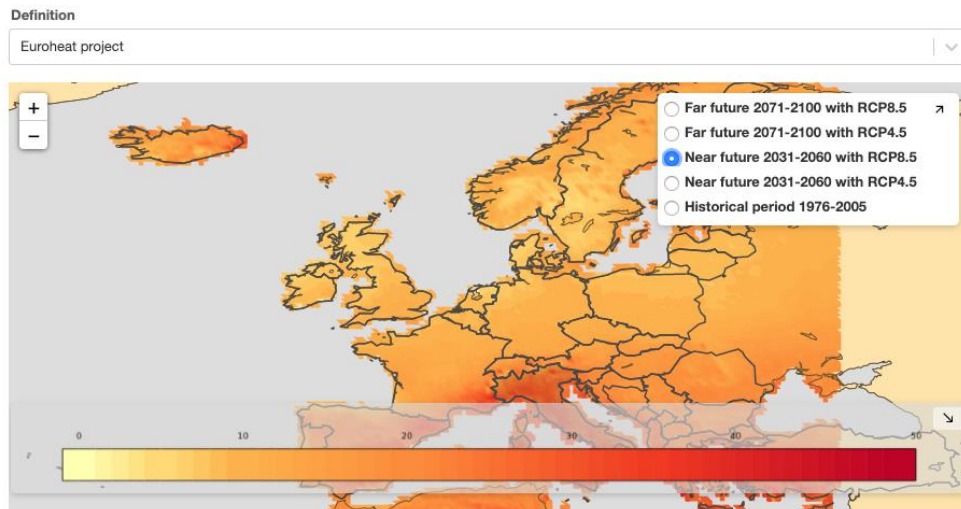
[Overview](#) [Download data](#) [Documentation](#)

Climate data for the European energy sector from 1979 to 2016 derived from ERA-Interim

[Overview](#) [Download data](#) [Documentation](#)

Temperature statistics for Europe derived from climate projections

Climate Data Store - Climate projections of the number of heat wave days for European countries

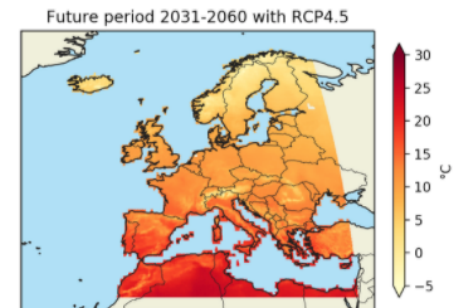


Version: 4.9.1 - build 4904109

Statistics for Europe (e.g. percentiles) derived from air temperature for the entire year, winter (DJF: Dec-July-August). These statistics were derived available for different future time periods and

meteorology and public health when defining health care health impacts, and they allow to identify a few cities/areas.

Statistics for the season winter and summer or for the DJF dataset. The statistics are averaged for 30 years. This results in a timeseries covering the period 2000-2080, averaged for the model ensemble and the standard



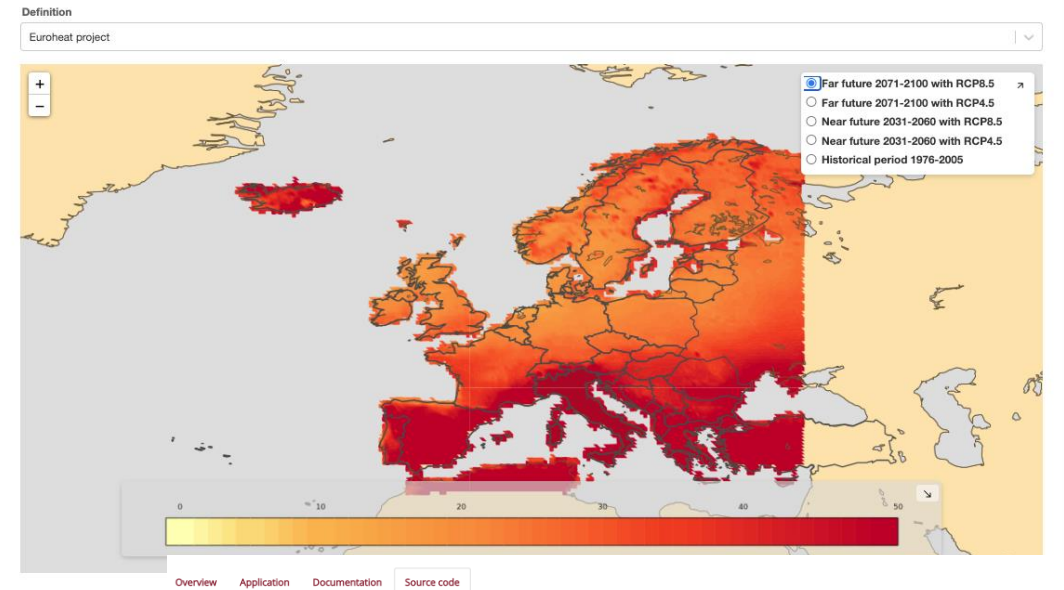


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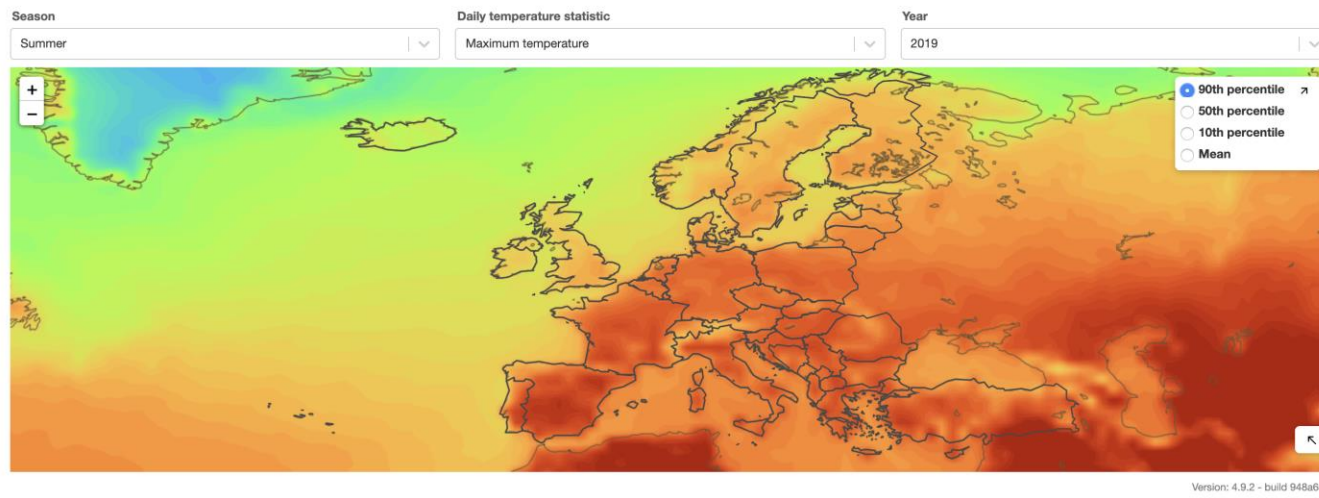
SIS evolution: benchmark & best practices

- Bias Adjustment
- Downscaling & Aggregation
- Extremes
- User defined skill & thresholds
- Climate Analogues

Climate Data Store - Climate projections of the number of heat wave days for European countries



Climate Data Store - European temperature statistics derived from ERA5 reanalysis



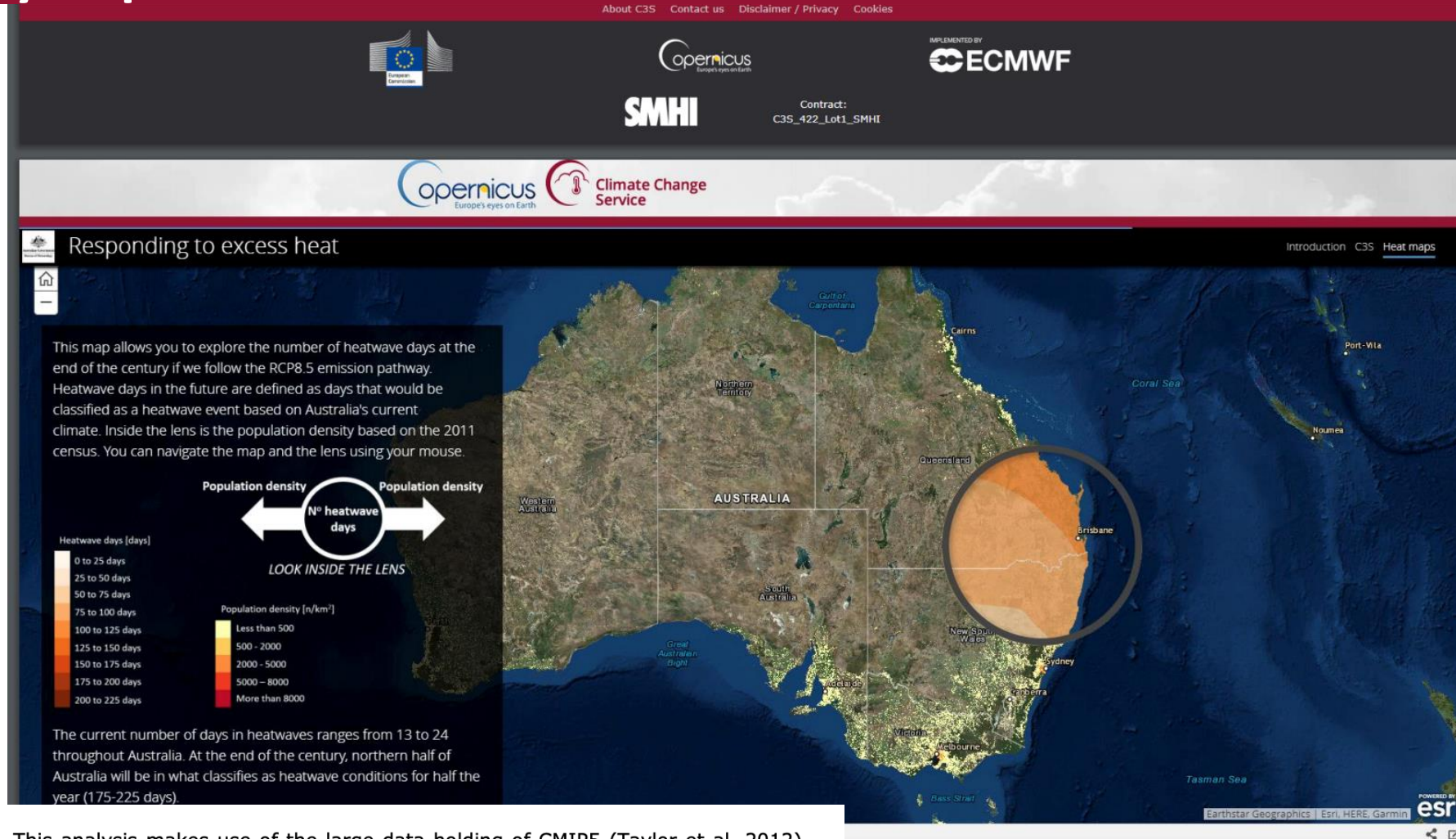
Application source code

```
1 import cdatoolbox as ct
2 import datetime as dt
3
4 now_year = dt.datetime.now().year
5 years=[str(w) for w in range(1979, now_year)]
6
7 dark_green = '51,160,44'
8 green = '178,223,138'
9 blue = '31,120,180'
10 orange = '255,127,0'
11 yellow = '245,245,77'
12 blorange = '143,124,90'
13
14 variables={'Minimum temperature':'Tmin',
15            'Mean temperature':'Tmean',
16            'Maximum temperature':'Tmax'}
17
18 statistics={'Mean':'mean',
19            '10th percentile': 10,
20            '50th percentile': 50,
21            '90th percentile': 90}
22 meancol = green
23
24 percentiles = {
25     10: {'name': '10th percentile', 'colour': blue},
26     50: {'name': '50th percentile', 'colour': blorange},
27     90: {'name': '90th percentile', 'colour': orange},
28 }
29
30 seasons={'Annual':{'months': ['01d'*(mth) for mth in range(1,13)]},
31          'Summer':{'months': ['06', '07', '08']},
32          'Winter':{'months': ['01', '02', '12']}}
33
34
35 #####
36 # CHILD APPLICATION#
37 map_layout = ct.Layout(rows=2)
38 map_layout.add_widget(row=0, content='Year')
39 map_layout.add_widget(row=1, content='output-0')
40
41 child_layout = ct.Layout(rows=1)
42 child_layout.add_widget(row=0, content='output-1', sm=6, md=7, lg=8)
43 child_layout.add_widget(row=0, content=map_layout, sm=6, md=5, lg=4)
44
```



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Storymaps



This analysis makes use of the large data holding of CMIP5 (Taylor et al. 2012) data and ERA5 reanalysis data (C3S 2017) at the Copernicus CDS. Additionally, we employed the high quality observational data set for maximum and minimum temperature for Australia (AWAP; Jones et al. 2009). Below is a workflow of the entire analysis and each step is being described in more detail.





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The evolution of SIS component of C3S

Useful, usable and used information (reliability, traceability, accessibility...)

SIS ambition

- a reference set of tools, applications, indicators, workflows, use cases, examples, stories
- fully built on the CDS data and technology
- fully embed the evaluation and quality control function
- User-centred



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C3S Evolution

Extreme events and attribution

Freja Vamborg
ECMWF

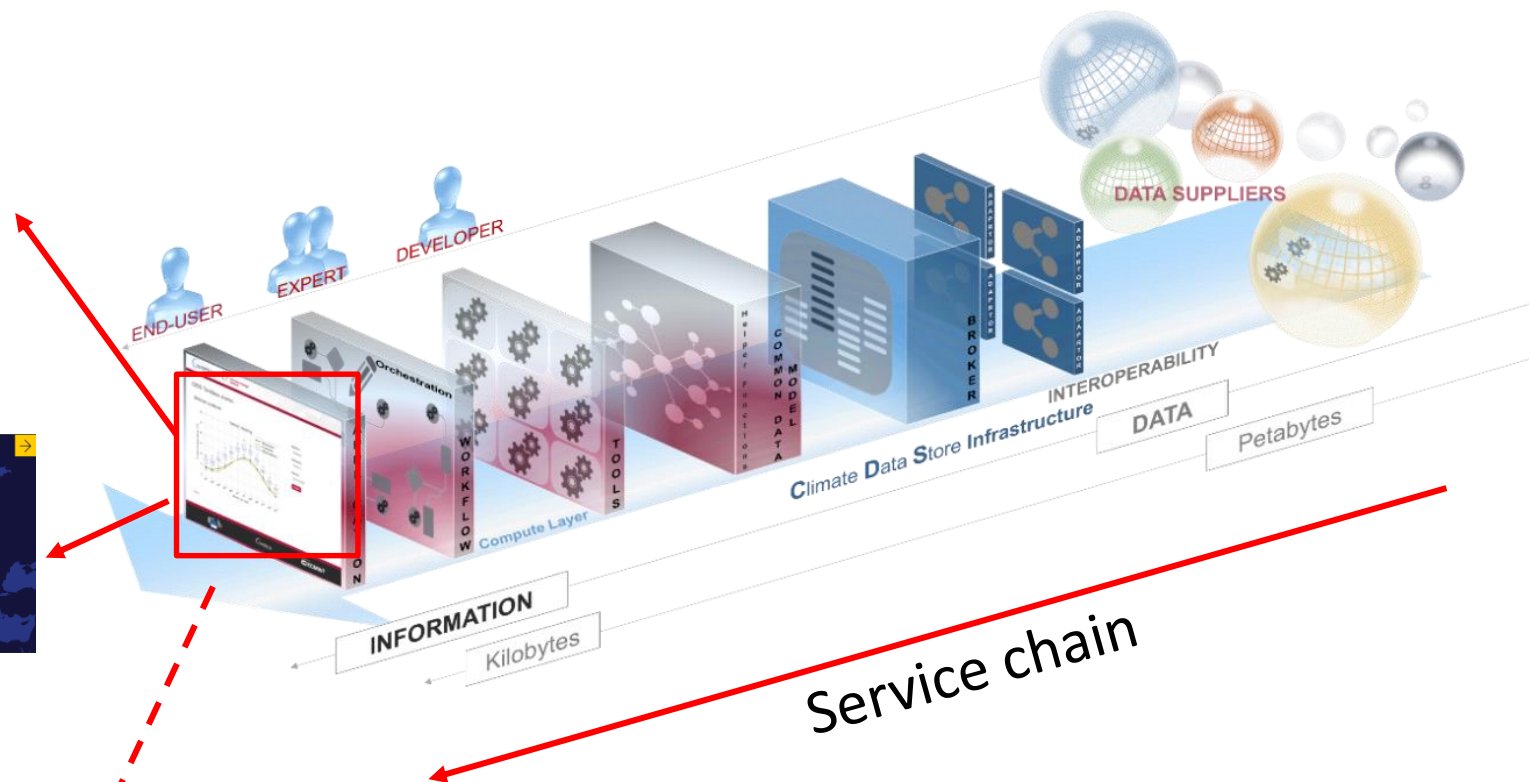
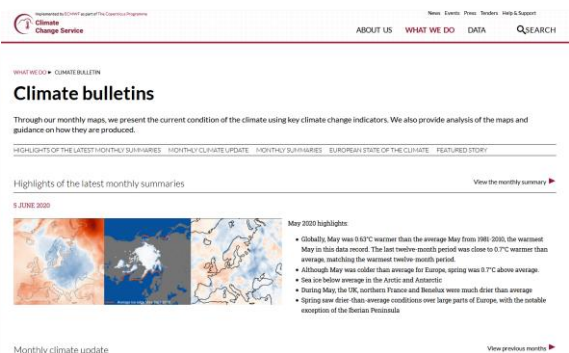
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Climate information and knowledge



Quality assured information and tools for users ranging from scientists to practitioners and policy makers.

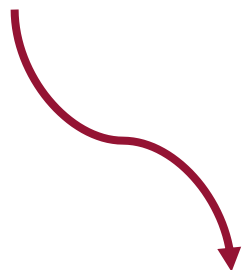


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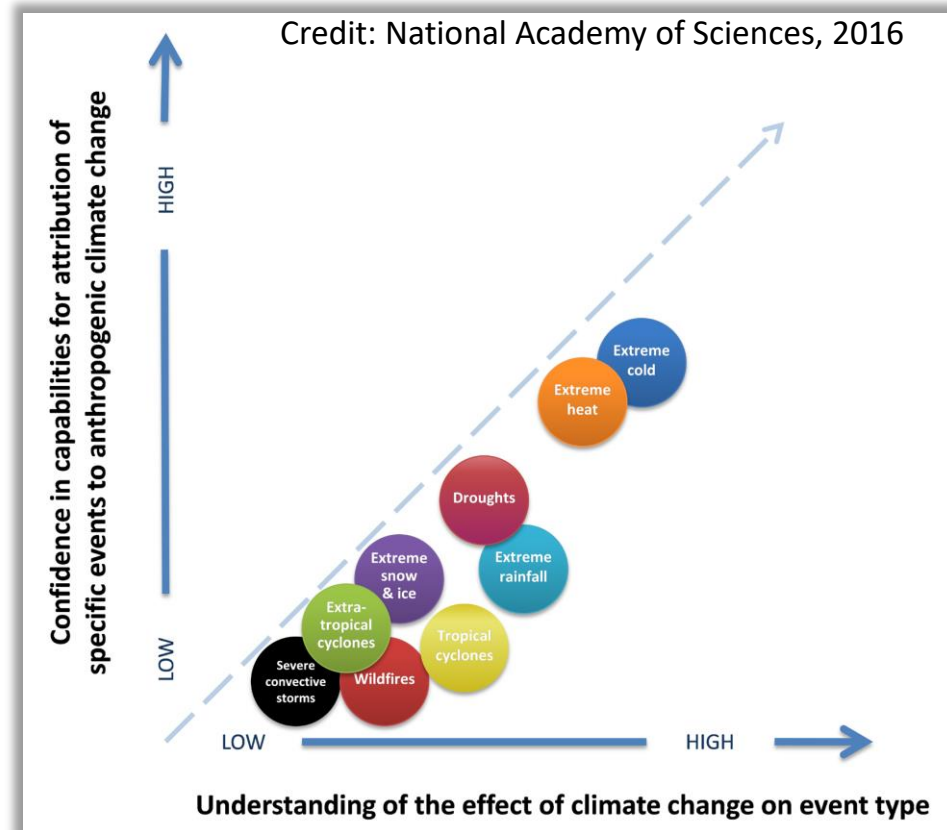
Extreme events and climate change attribution



Extreme event happens



Provide information about event in
the context of climate change with
as short a delay as possible
→ “Rapid service”





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Prototype activity – November 2019 to June 2021

Activities:



Target users for prototype:

- National met and hydro services
- Communication intermediaries

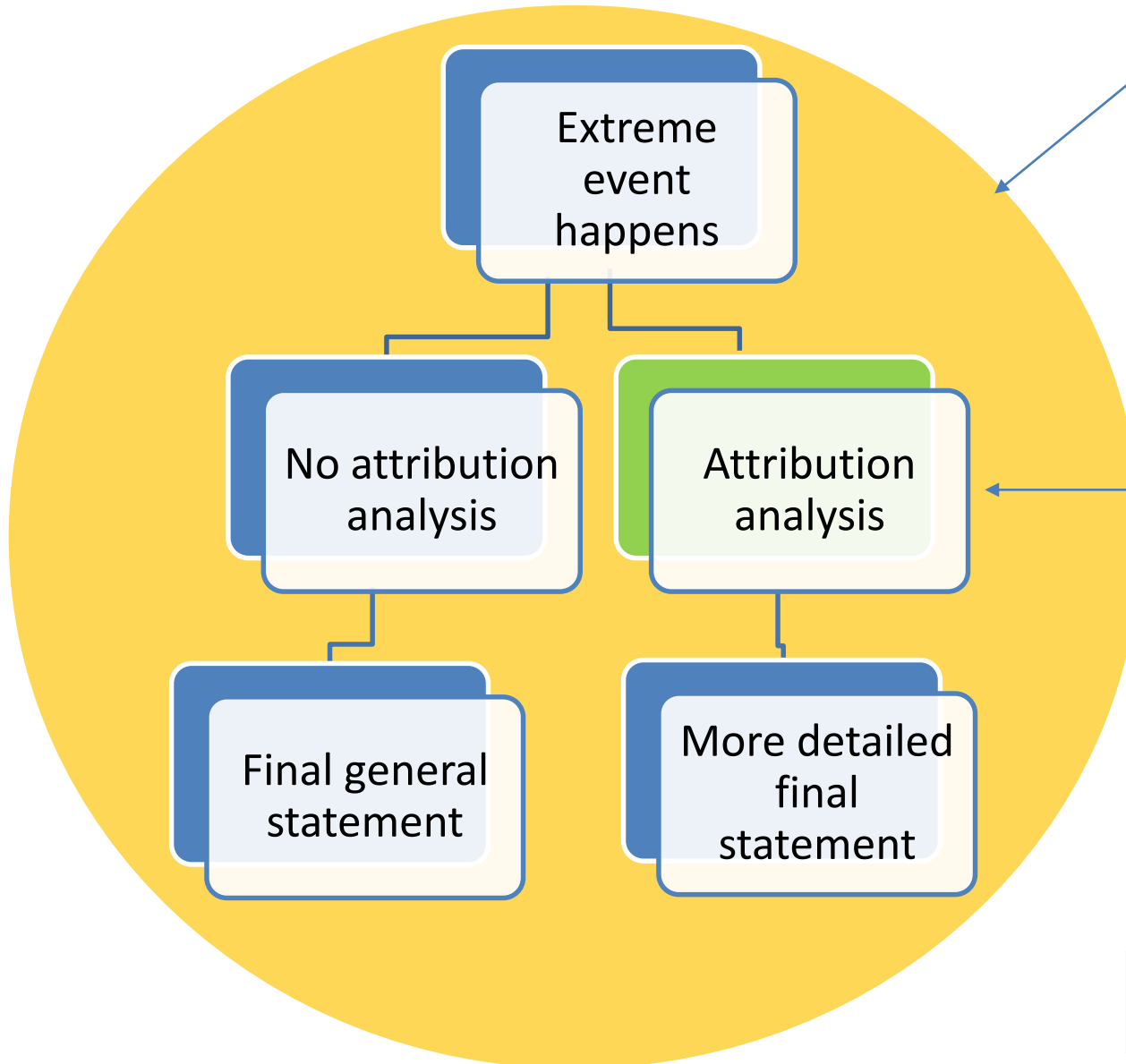




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Protocols

Service protocol



Communications protocol
Who? When? Where? How?
To whom? In what situation?



NMS1

NMS2

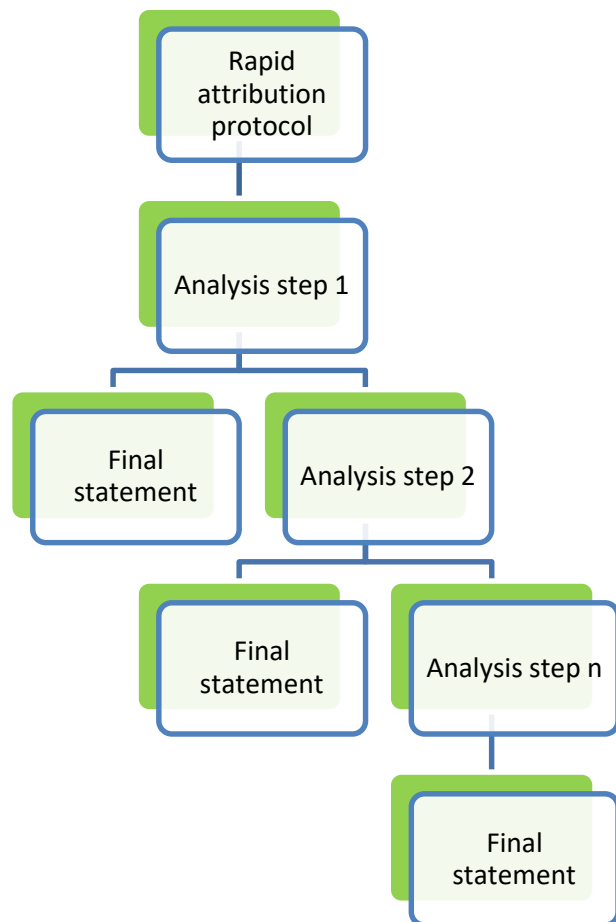
User

Rapid attribution protocol



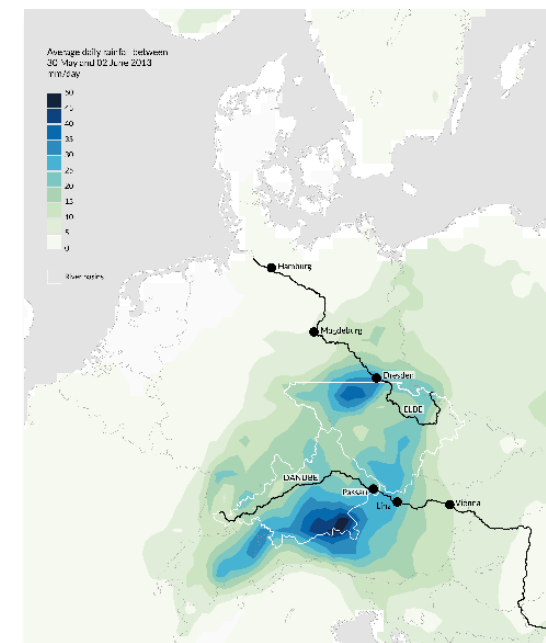
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Rapid attribution protocol



Testing of protocol with case studies

- ✓ 2018 heatwave in Europe
- ✓ 2013 Elbe flooding (precipitation)
- ...
- ...

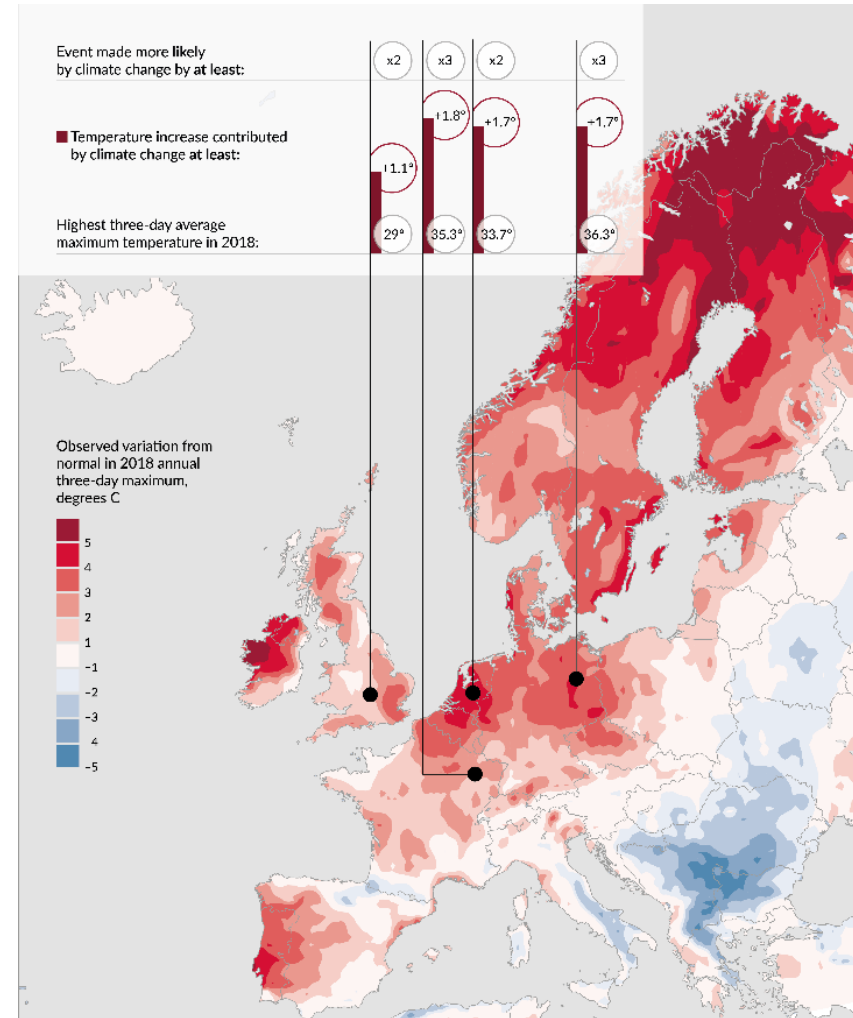




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Communication products

Draft products



Focus group

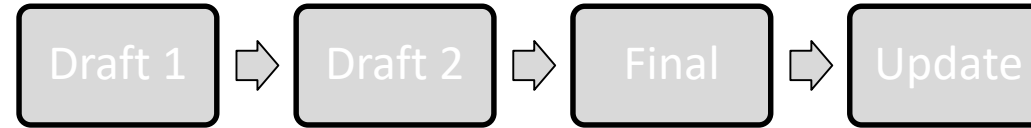


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Quality assurance for *all* parts of the service



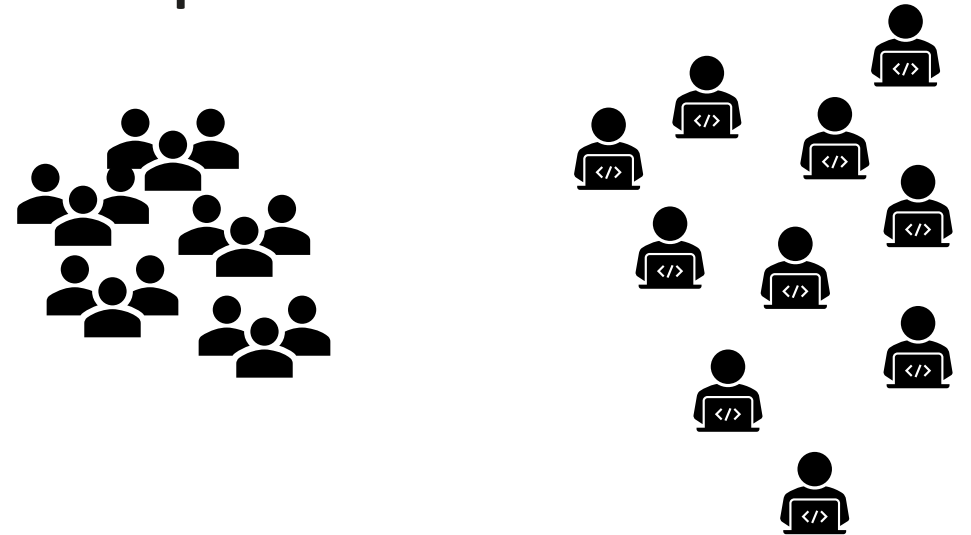
Multi-stage approach



Advisory board



Workshop 24-25 Nov 2020



EQC for data and tools

Move to operations contingent on QA ✓