Climate services landscape in Europe

Carlo Buontempo

European landscape of climate activities

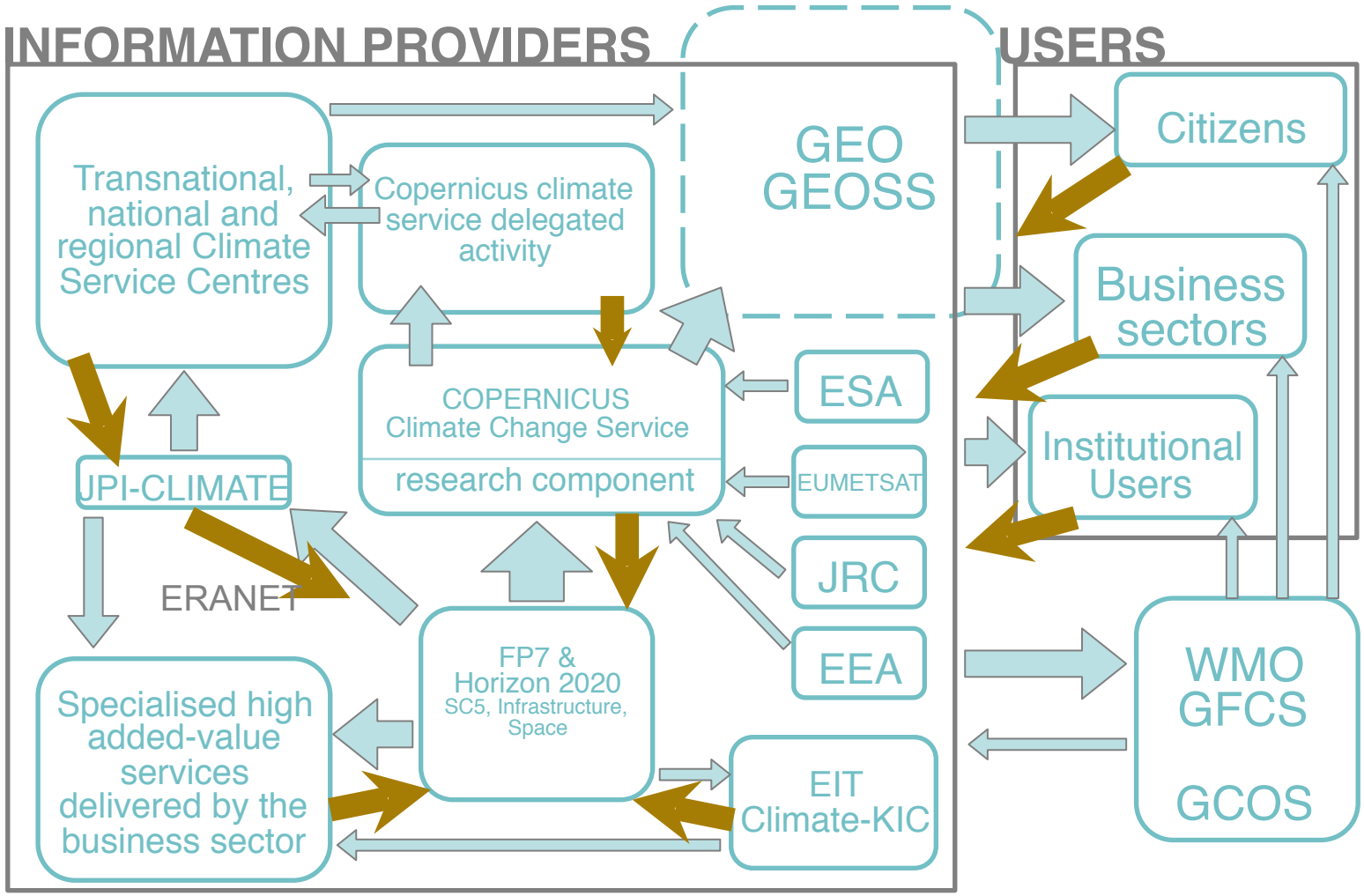


Figure adapted from one provided by Andrea Tilche, European Commission

European landscape of climate activities

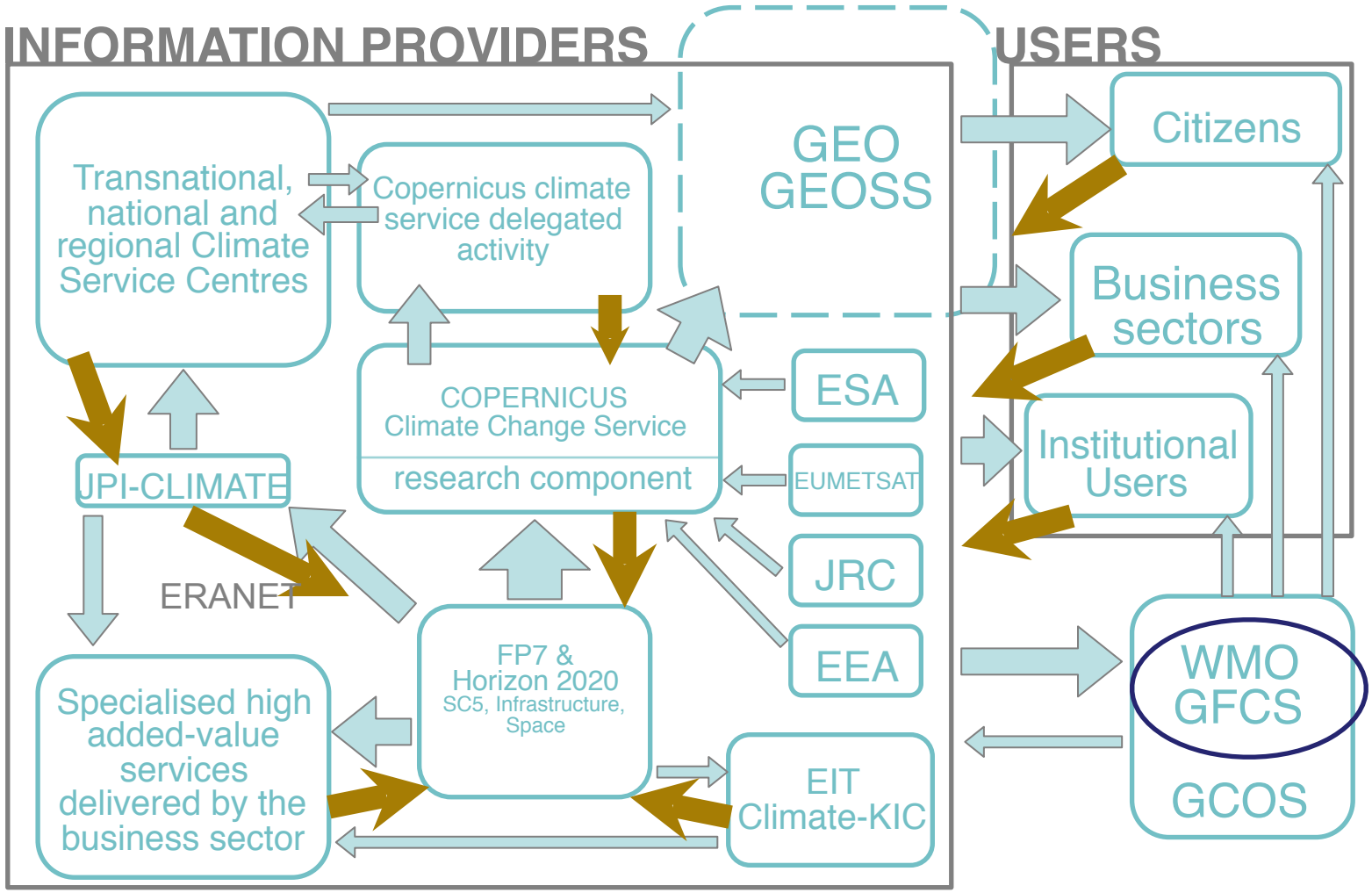


Figure adapted from one provided by Andrea Tilche, European Commission

GFCS
GLOBAL FRAMEWORK FOR CLIMATE SERVICES

Progress with GFCS Implementation

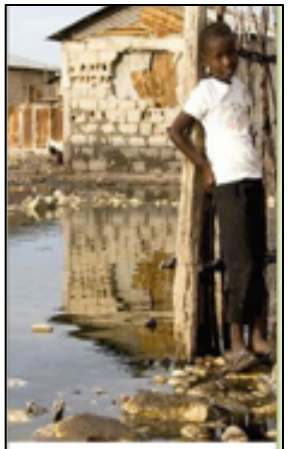
flucio@wmo.int

GFCS
GLOBAL FRAMEWORK FOR CLIMATE SERVICES

Vision

Enable better management of the risks of climate variability and change and adaptation to climate change, through the development and incorporation of science-based climate information and prediction into planning, policy and practice on the global, regional and national scale

Agriculture and food security



Disaster risk reduction

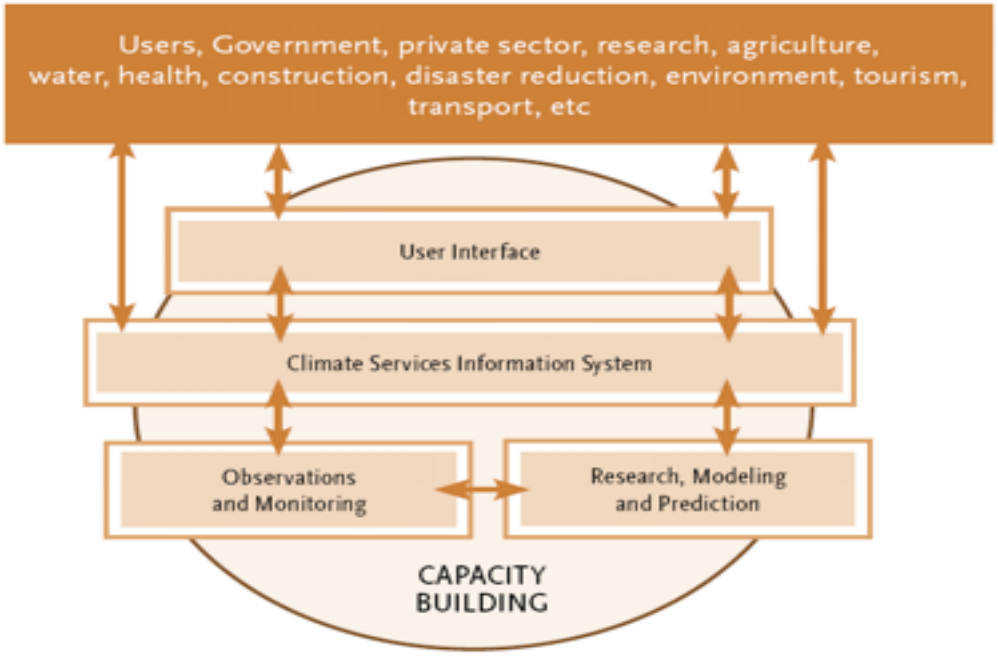
Water

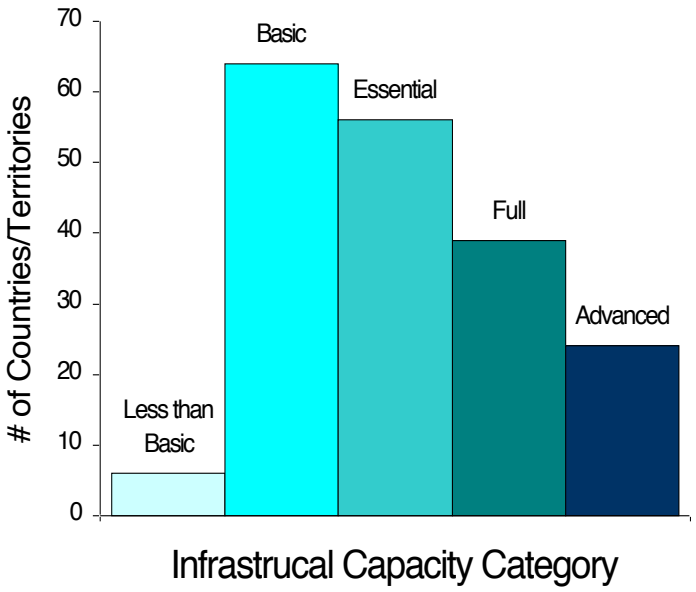
Health

Energy

GFCS
GLOBAL FRAMEWORK FOR CLIMATE SERVICES

GFCS Pillars





Many countries lack the infrastructural, technical, human and institutional capacities to provide high-quality climate services.

GFCS is a partnership

Joint Offices

European landscape of climate activities

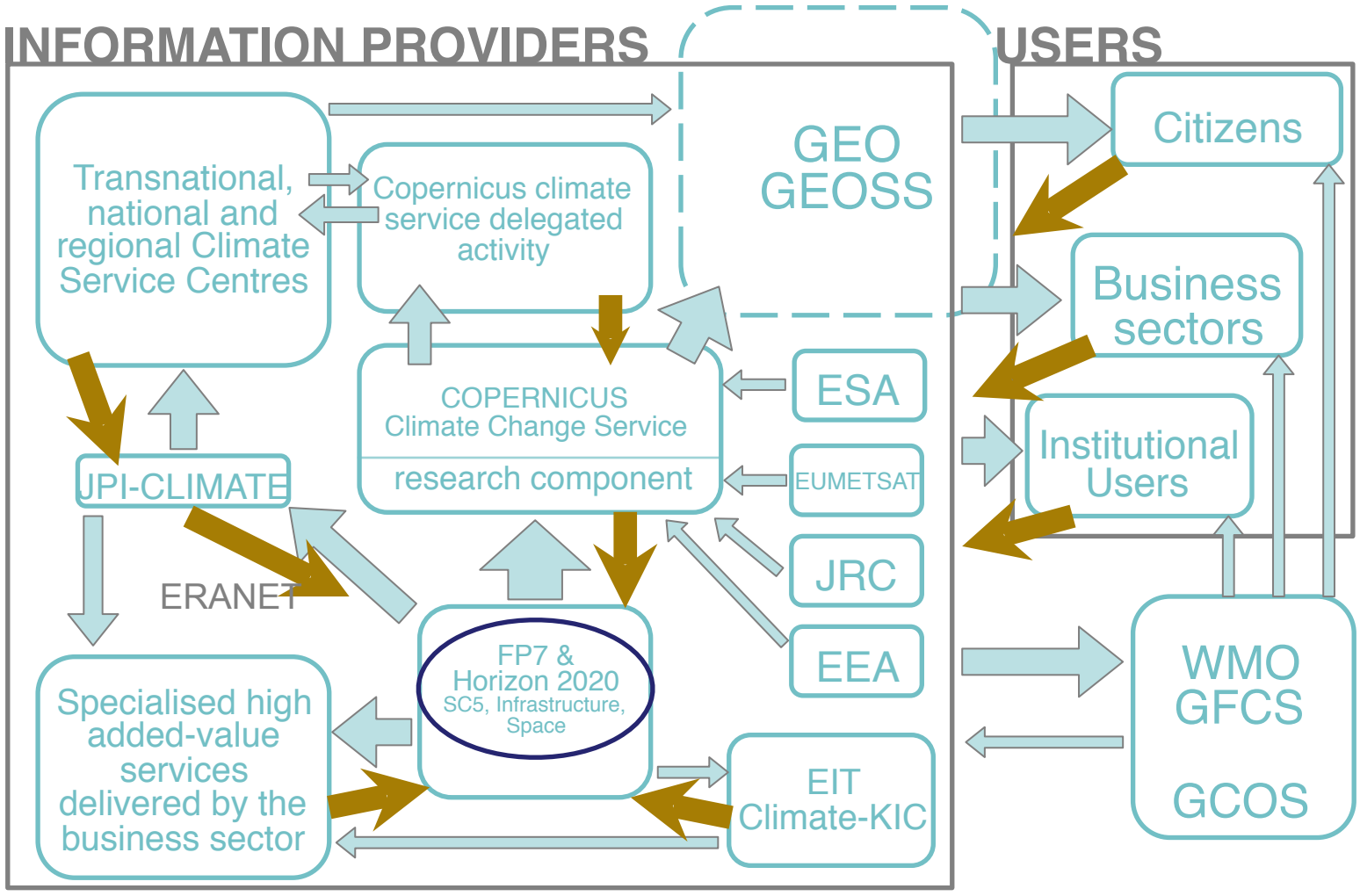


Figure adapted from one provided by Andrea Tilche, European Commission

European Roadmap for Climate Services

Challenge 1: Enabling market growth
1.1: Assessing the nature of climate services market
1.2: Growing the climate services market
1.3: Demonstrating added value

Challenge 2: Building the market framework
2.1: Communities and infrastructures to support and grow the climate services market
2.2: Standards, quality assurance and control, access and legal aspects
2.3: International cooperation

Challenge 3: Enhancing the quality and relevance of climate services
3.1: Information frameworks in support of climate services
3.2: Strengthening the scientific basis and relevance of climate services
3.3: Climate information and end-users' needs: innovations and products

EUPORIAS

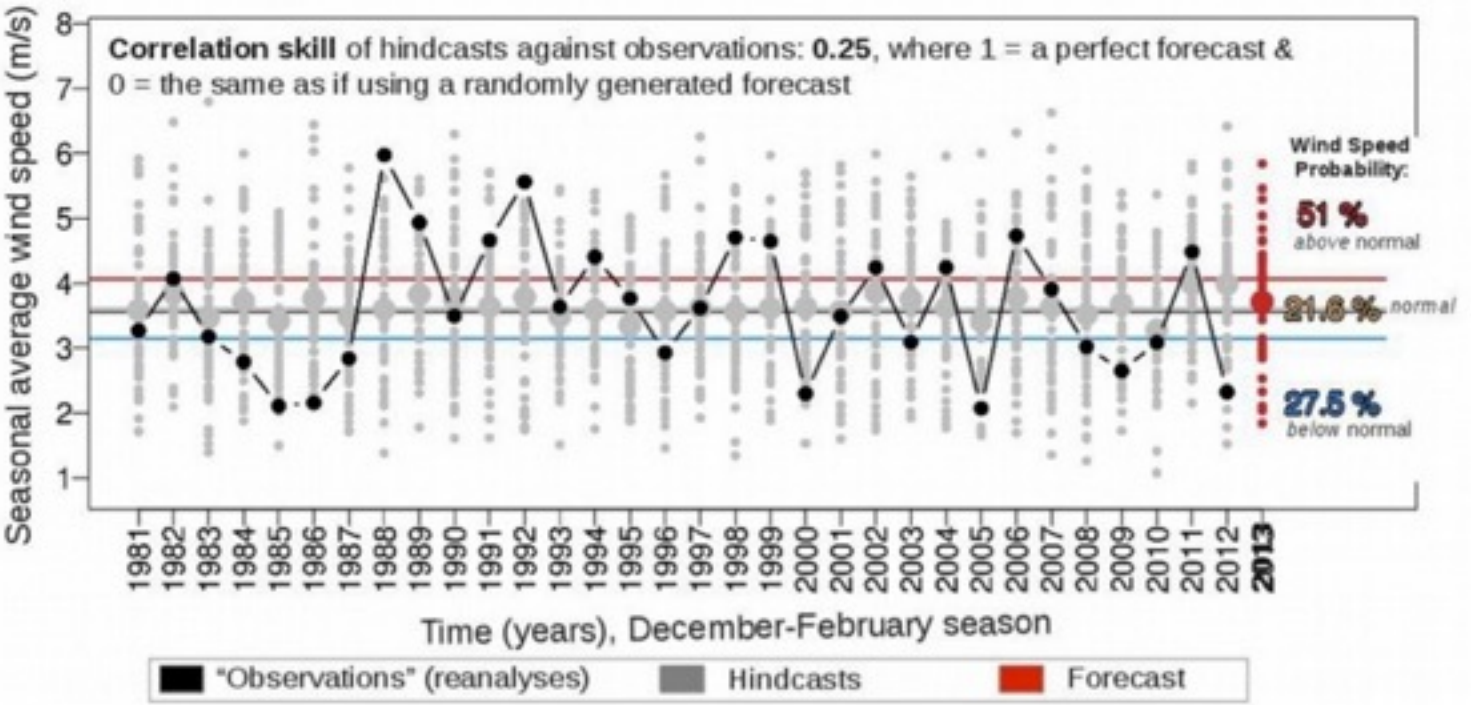
Increase the resilience of society to climate change by supporting the development of prototype climate services built on seasonal to decadal (S2D) predictions. (Thanks to Drew Hemment for these slides)

PROJECT Ukko

REsilience Prototype IC3

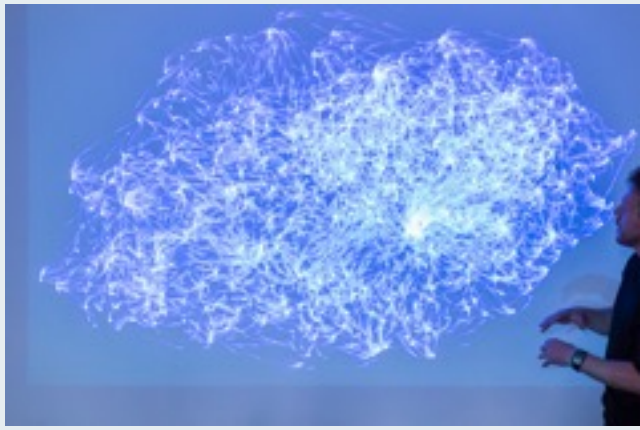
Climate forecast system:ECMWF S4
10m wind speed "observations": ERA-Interim
1 month forecast lead time: Started 1st Nov
Simple bias correction

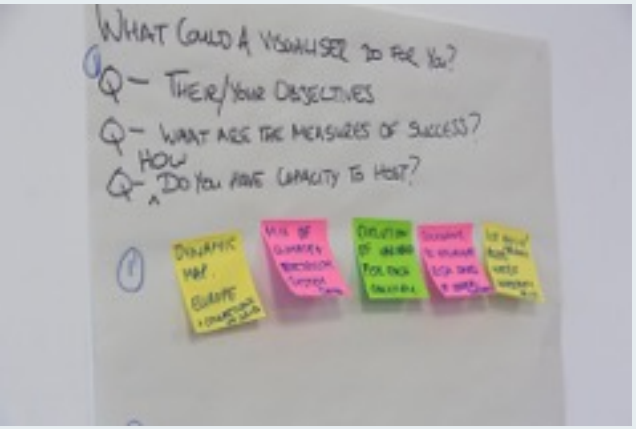
North-Sea Example
Seasonal Average Wind Speeds
Winter 2013/4 Forecast: December-February (inclusive)



PROJECT Ukko

Design challenge





Demonstrate the possible applications of recent advances in S2D climate predictions, by putting probabilistic information into usable form for decision makers in industry, through the application of art and design.

Results – Domain characterisation

PROJECT Ukko

Use cases, personas and scenarios developed in user requirements workshop.

1. Wind farm manager looking for windows of opportunity (low wind conditions) to schedule wind turbine maintenance. The cost of maintenance is very expensive for offshore wind farms, hampered by bad sea conditions caused by wind, and so accuracy of predictions is important.
2. Energy grid manager needing to balance the grid in view of predicted changes in supply and demand over time. They take decisions based on projected availability of energy resources across regions (e.g. wind power forecasts for producing countries) and over the coming seasons (e.g. hydro power as a function of winter temperature and Spring and Summer precipitation). A decision in a cold winter might be to purchase wind energy from other countries or use water in dams for hyro power.
3. Energy trader who needs to know how much wind power is available in regions with wind farms installed. The information would be used to inform trading prices, in view of the impact of above or below average wind power on energy price within a country.

Present practices include using historical data alone (wind farm manager) or combining a hybrid of historical climatology data and current wind speeds to create a notional forecast (energy trader).

A recurring theme was the importance of extreme changes in conditions in a specific region. The end users tended to be analysts not the senior decision makers, so the tool would be used by expert users on a recurring basis. Another insight was the value of negative information, that is to say, it is useful to communicate what is not predictable.

Discover – Problem characterisation

PROJECT Ukko

DSM Stage:

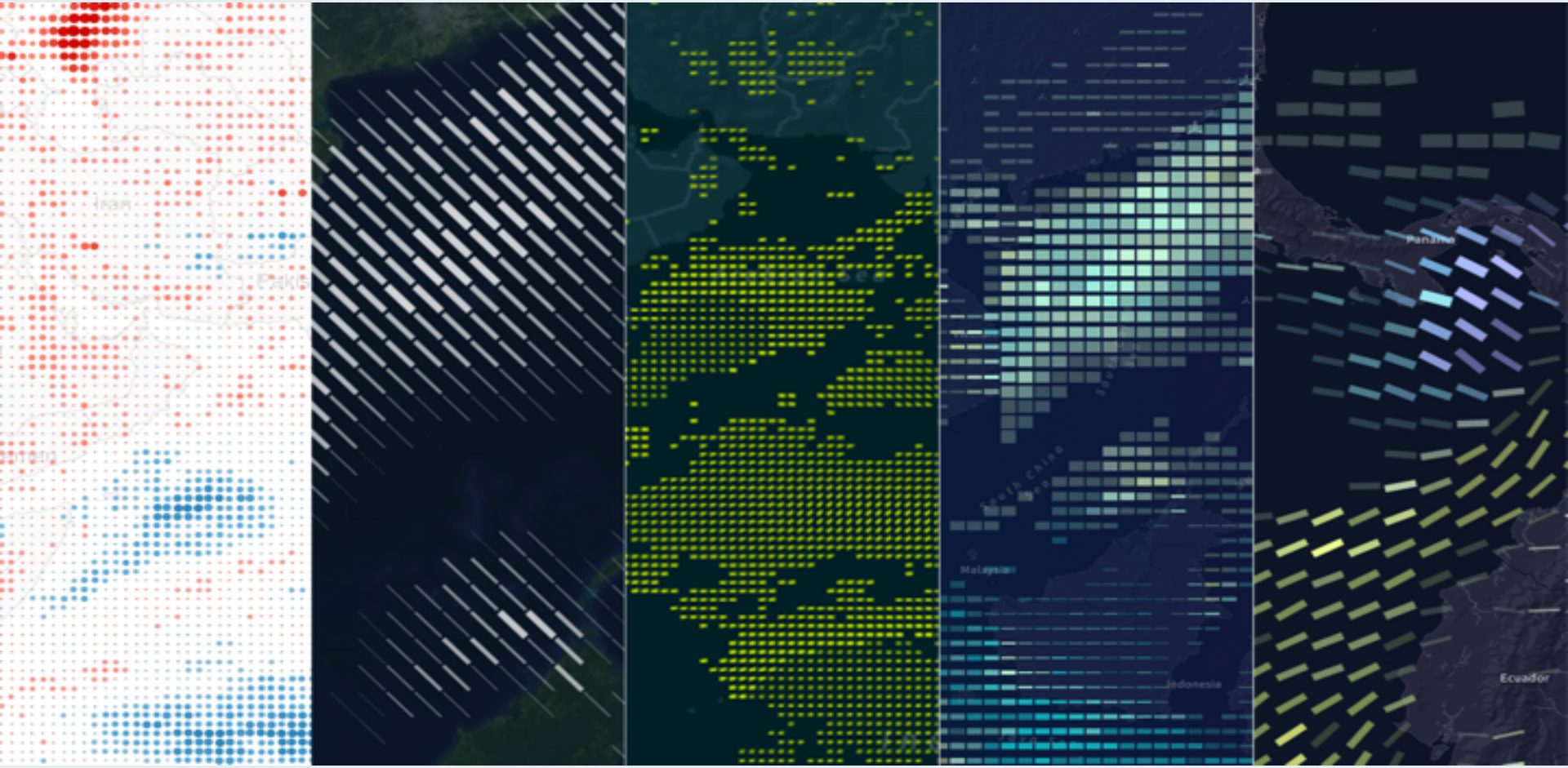
Discover

Outcomes:

Identify use cases for seasonal wind predictions
Understanding of users, their context and data situation

Design – Data & design explorations

PROJECT Ukko



DSM Stage:

Design

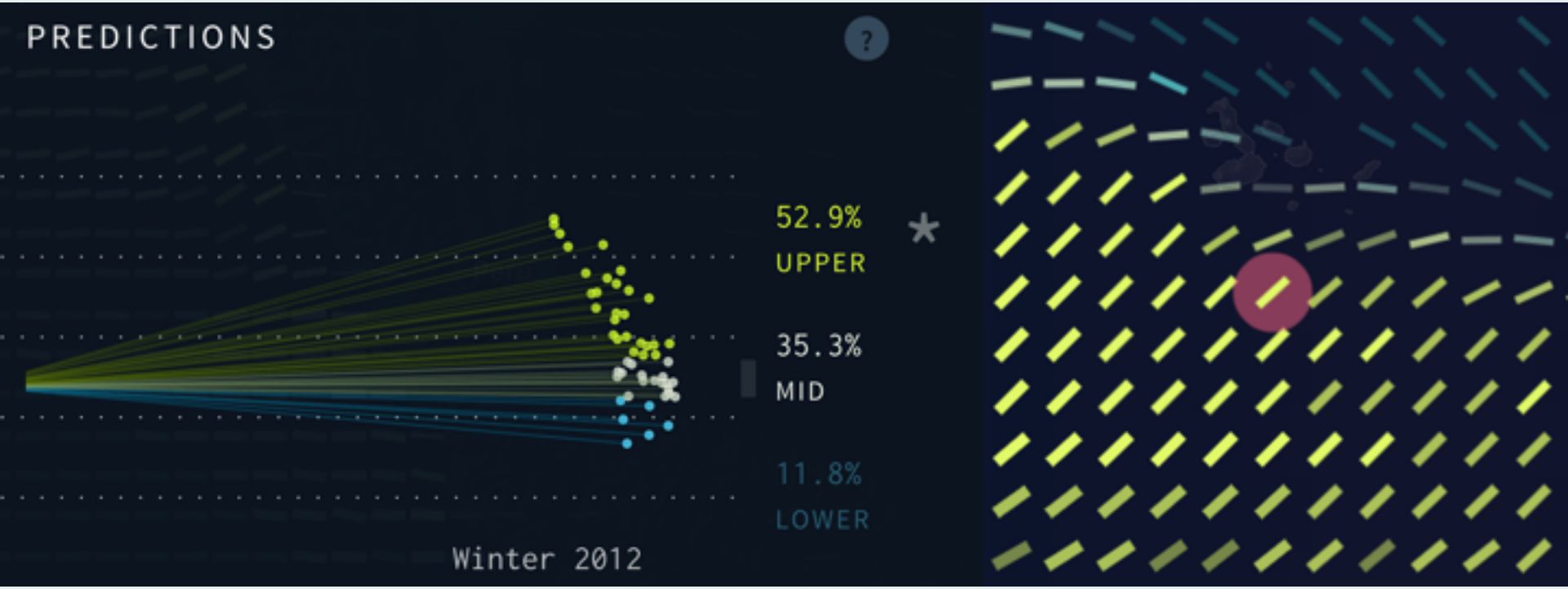
Outcomes:

Finding a coherent design language
Information architecture
Theoretical exploration


2.1.0
PROJECT
Ukko
Nicaragua
Costa Rica
Panama
Ecuador
+
−
OBSERVATIONS
Seasonal average wind speeds in m/s
6.0
5.0
4.0
3.0
2.0
Median
3.8
1981
2011
PREDICTIONS
Winter 2012
45.1%
UPPER
23.5%
MID
31.4%
LOWER
SKILL
16.0%
INSTALLED WIND POWER
0 KW

Implement – Visualisation interface

PROJECT Ukko



DSM Stage:

Implement

Visualisation interface:

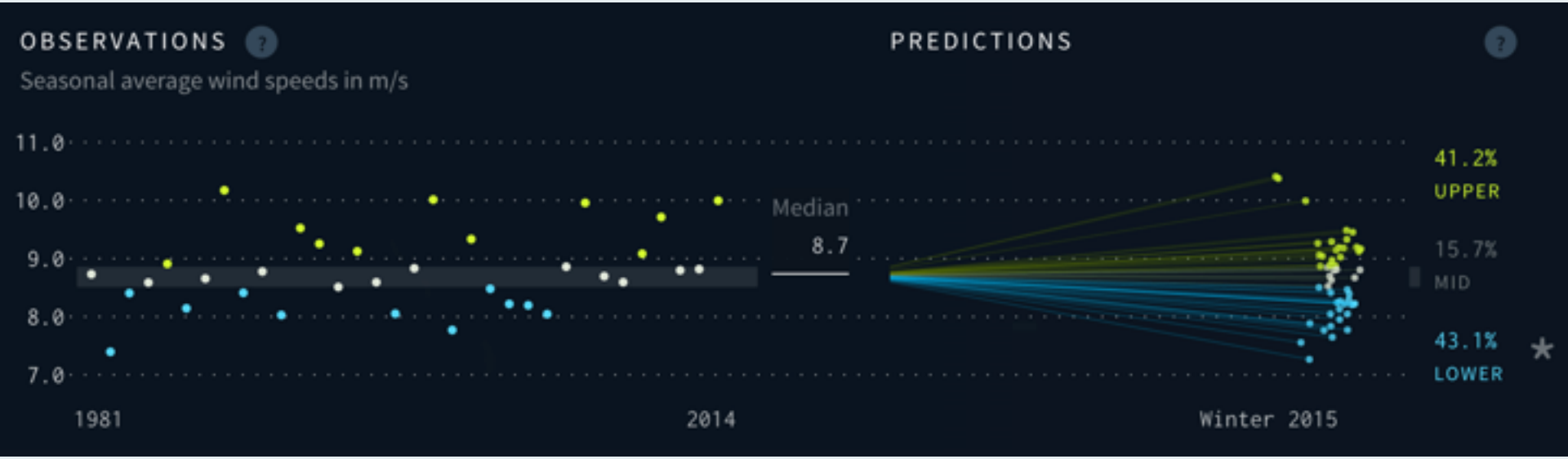
An information-rich, scannable interactive map.

Lines represent prediction skill, wind speed, change in wind speed.

A novel visual device to communicate distributions of probabilistic prediction values.

Results – Visualisation and interface

PROJECT Ukko



Probability cone – A tailored visual device (probability cone) presents a novel visual model to communicate distributions of probabilistic prediction values, and informed the development of a coherent visual language for the whole project.

- **To present past data as well as an array of predictions (resulting from different simulation runs, all representing equally probable future scenarios), it made conceptual sense to plot time from left to right, and visualise the future predictions as a cone of rays emanating from the typical (median) value of the historic data.**

European landscape of climate activities

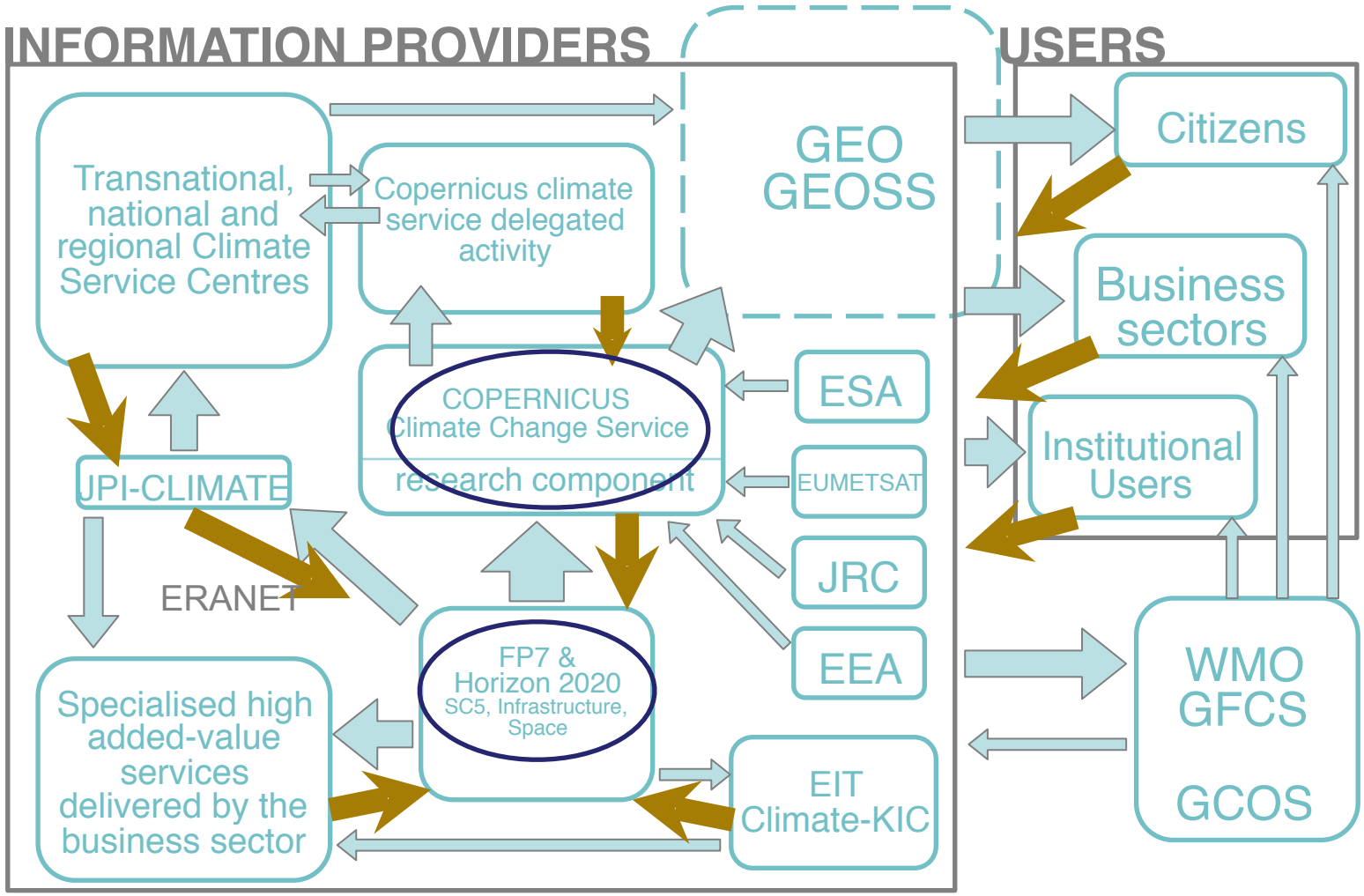


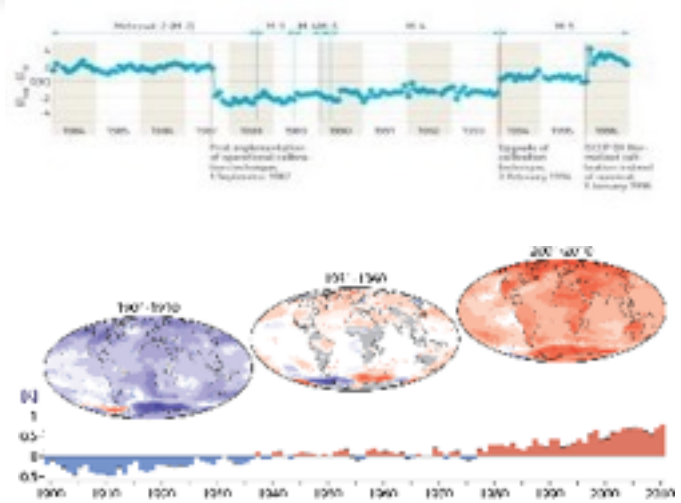
Figure adapted from one provided by Andrea Tilche, European Commission

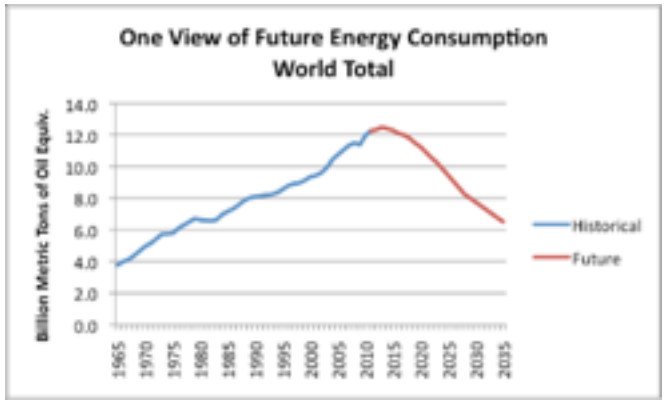
Copernicus Climate Change Service

Jean-Noël Thépaut
Dick Dee
David Armstrong
Carlo Buontempo

C3S Vision

- To be an authoritative source of climate information for Europe
- To build upon national investments and complement national climate service providers
- To support the market for climate services in Europe





Questions addressed in the Service

- How is climate changing?
  - Earth observations
  - Reanalyses
- Will climate change continue/ accelerate?
  - Predictions
  - Projections
- What are the societal impacts?
  - Climate indicators
  - Sectoral information

Climate Data Store

- ECVs past, present and future
- Observed, reanalysed and simulated
- Derived climate indicators
- Tools to support adaptation and mitigation at global and European level
- **Open and free access**

Sectoral Information System

Evaluation and Quality Control

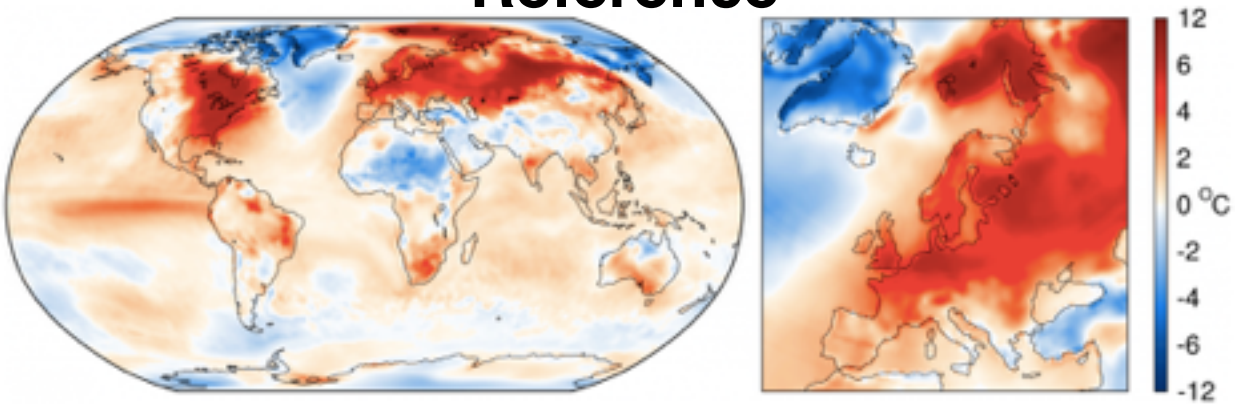
- Monitors **quality of C3S products and services**
- Ensures C3S delivers state-of-the-art climate information to users
- Identifies gaps in service provision
- Bridges Copernicus with the research agenda in Europe (e.g. H2020, national research projects)

Outreach and Dissemination

- Web content
- Public outreach
- Coordination with national outreach
- Liaison with public authorities
- Conferences, seminars
- Training and education

Demonstrator of a European Climate Service of Reference

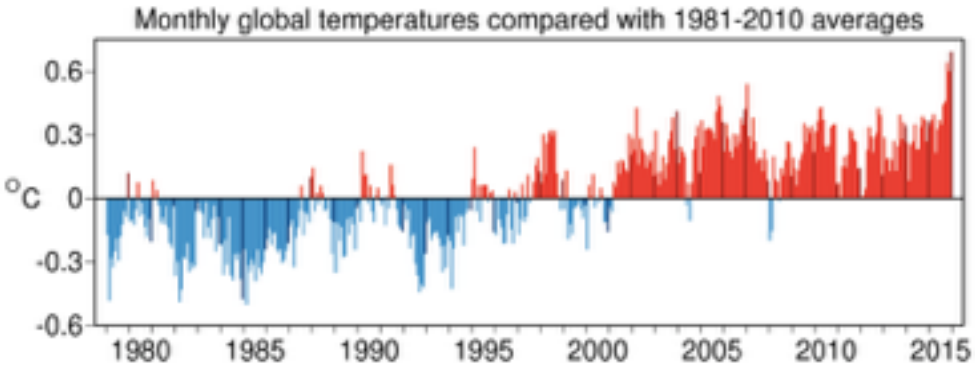
+ ~0.44ºC



Surface air temperature anomaly for December 2015 relative to the December average for the period 1981-2010. Source: ERA-Interim.

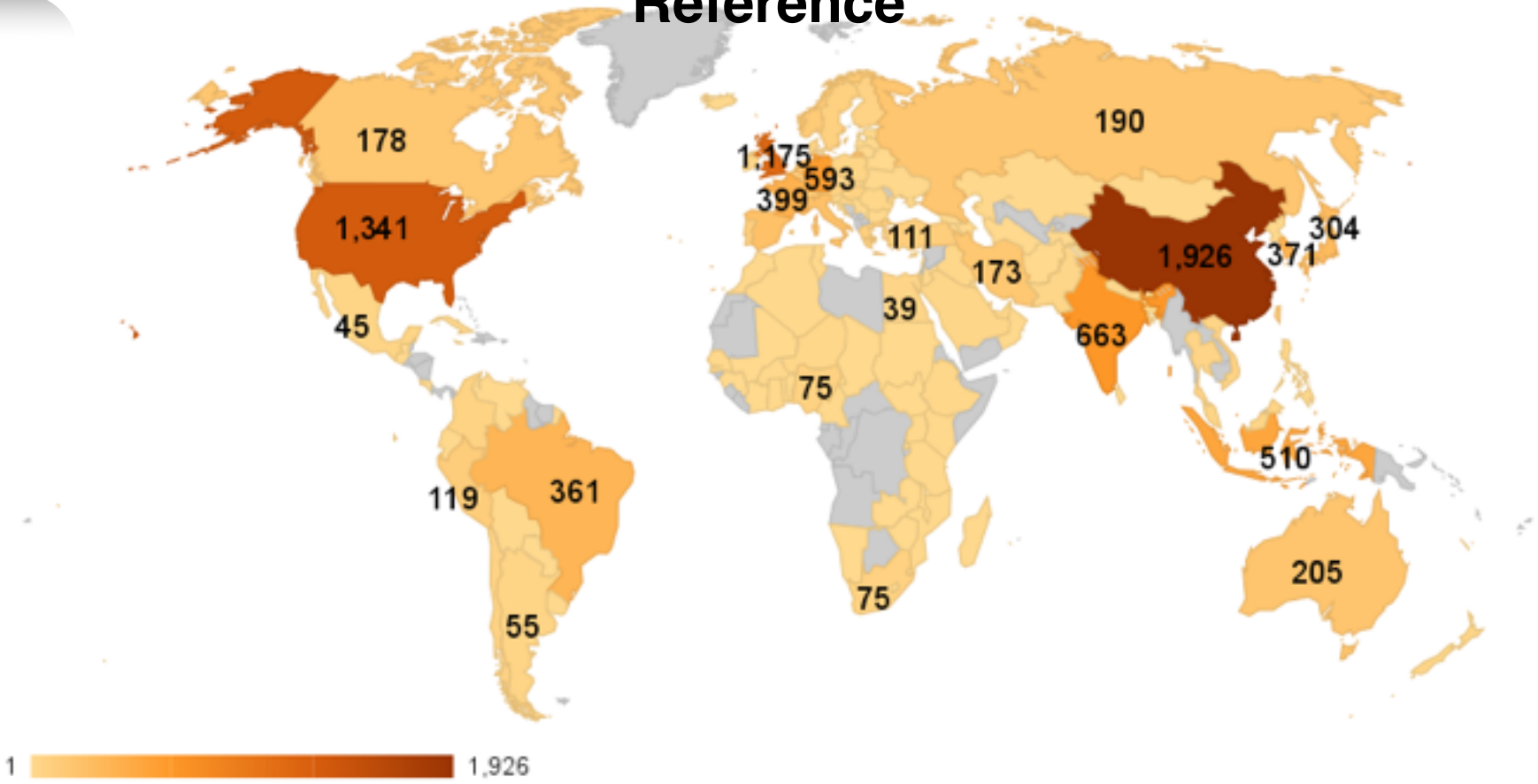
Combining models and observations

The 16 warmest years on record: 1998 and 2001-2015

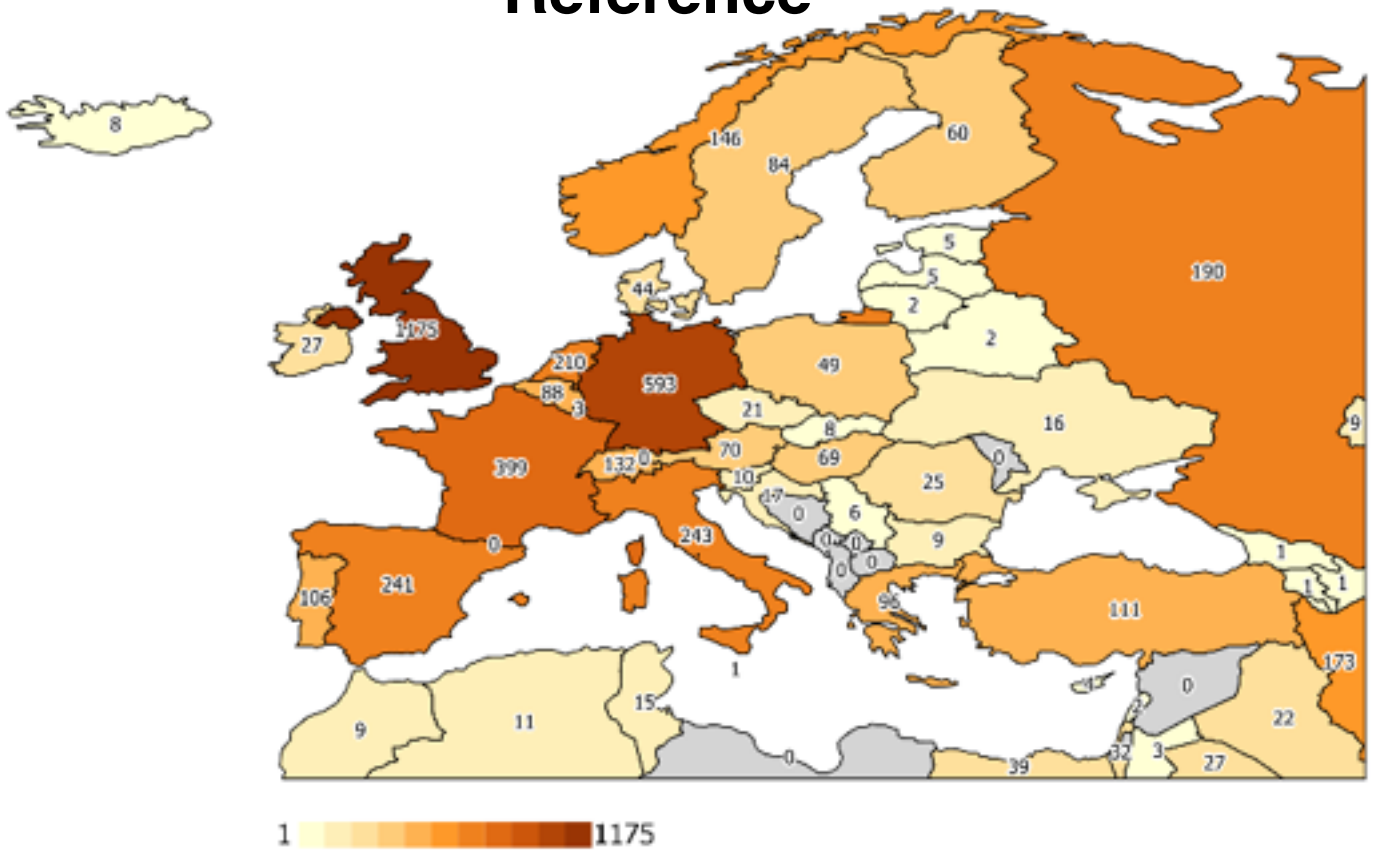


Press release issued on 8 January 2016

Demonstrator of a European Climate Service of Reference



Demonstrator of a European Climate Service of Reference



Climate Data Store

- ECVs past, present and future
- Observed, reanalysed and simulated
- Derived climate indicators
- Tools to support adaptation and mitigation at global and European level
- **Open and free access**

Sectoral Information System

Evaluation and Quality Control

- Monitors **quality of C3S products and services**
- Ensures C3S delivers state-of-the-art climate information to users
- Identifies gaps in service provision
- Bridges Copernicus with the research agenda in Europe (e.g. H2020, national research projects)

Outreach and Dissemination

- Web content
- Public outreach
- Coordination with national outreach
- Liaison with public authorities
- Conferences, seminars
- Training and education

★The **Climate Data Store** will be at the heart of the C3S infrastructure and will provide information about **past**, **present** and **future** climate in terms of **Essential Climate Variables** and derived **climate indicators**.

★The CDS will be designed as a **distributed system**, providing improved access to **existing datasets** through a **unified web interface,** compliant with **INSPIRE**.

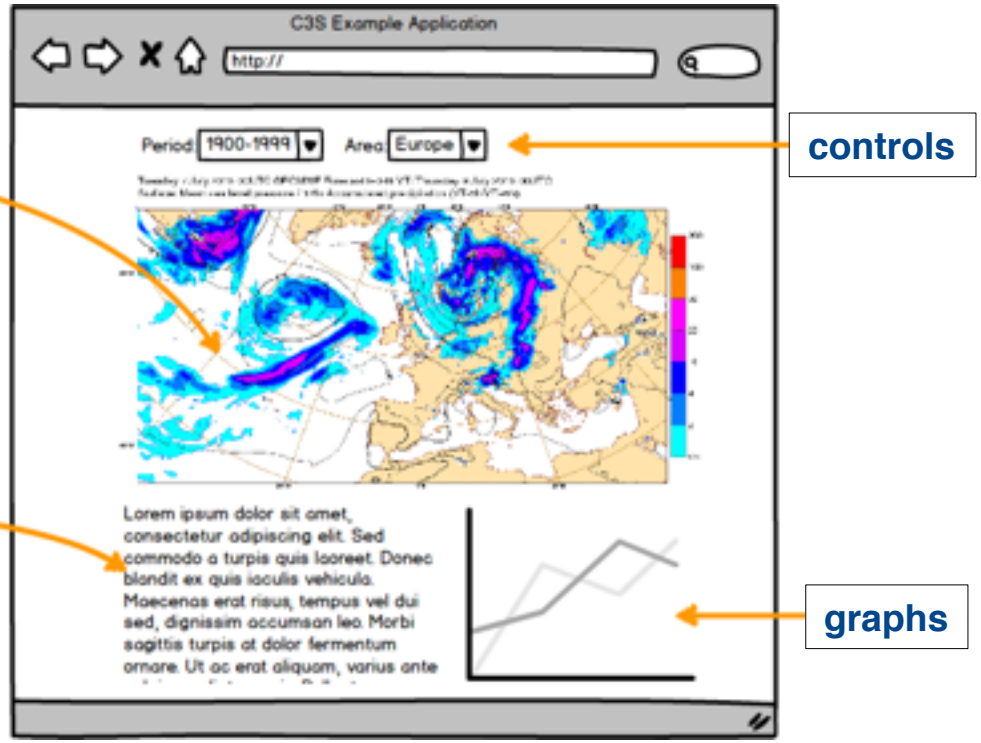
★The CDS will contain **observations**, global and regional **climate reanalyses**, global and regional **climate projections** and **seasonal forecasts**.

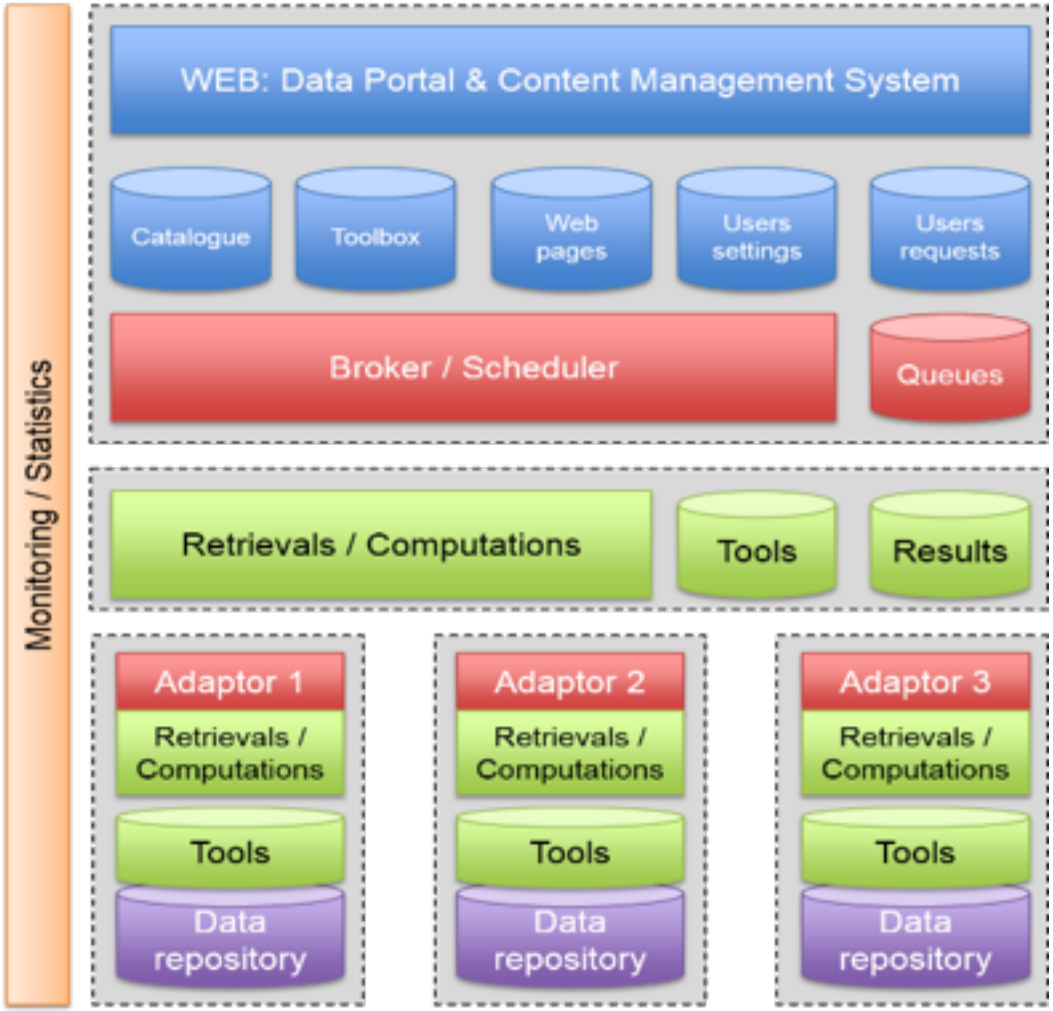
★The CDS will also provide an comprehensive set of software tools (**toolbox**) that will allow the users to **develop applications** that will make use of the content of the CDS.

★This service will accommodate the needs of the highly **diverse set of users** that will include **policy makers**, experts as well as **scientists**.

Building the Climate Data Store

- Diversity of users
- Diversity of data sets
- Very large data volumes
- Data residing at different location
- Interoperability, efficiency
- User-defined workflows
- Variety of presentation methods
- Need for interactivity
- Access via API
- User management
- Performance monitoring





Development of CDS software infrastructure

2016 Q2: Start of contract

2016 Q4: Initial release of working prototype for limited testing

2017 Q1: First functional release exposed to a large user group, then quarterly releases with added functionality

2018 Q1: Final release

Development of CDS toolbox

2016 Q2: Start of contract

Climate Indicators

Observations
- Global estimates of ECVs from satellite and in-situ observations
- Reprocessed CDRs, reference observations
- Support for data rescue, climate data collections

Climate reanalysis
- Global atmosphere, ocean, land
- Regional reanalysis for Europe
- Coupled climate reanalysis for 100 years

Model output
- Multi-model seasonal forecast products
- Access to CMIP data and products
- Reference set of climate projections for Europe

Science basis:
- Essential Climate Variables as defined by GCOS
- GCOS Status Report (GCOS-195)
- IPCC, CMIP, FP7/H2020, ESA CCI, …

Upcoming invitations to tender (ITTs) related to observations and reanalysis

(approx. 40 contracts, total value 10Meuro/year)

ITT number	Public	Topic	Description
C3S_311a	2016 Q2	*In situ* observations	Data rescue registry and services; Access to data collections; Access to reference networks; High-resolution gridded products and time series
C3S_311b	2016 Q2	Level-1b satellite data reprocessing	FCDRs; direct negotiation with EUMETSAT
C3S_311c	2016 Q4	Satellite data rescue	Service requirements TBD; legacy ERA-CLIM(2)
C3S_312a	2016 Q1	Observational gridded products phase 1	9 contracts for delivery of global CDRs and ICDRs addressing12 ECVs: SLH, SST, SI, O3, Aerosol, GHG, SM, Glaciers and Ice Caps, Albedo, FAPAR, LAI
C3S_312b	2017 Q1	Observational gridded products phase 2	Similar to C3S_312a for additional ECVs
C3S_322	2016 Q4	Regional	19-20 May workshop to define user requirements

ECV roadmap

European Commission | Copernicus Climate Change Service

ECV roadmap for C3S		2016	Q2	Q3	Q4	2017	Q2	Q3	Q4	CAMS	CMEMS	CLMS	SAFS	GCOS Status Report
Work in progress		Services in development						Operational data services						
1 Feb 2016		Data access via ECMWF/providers						Data access via CDS						
C3S Phase 1	Atmosphere	Surface Air Temperature	ERA5											4.3.1
		Surface Precipitation	ERA5										✓	4.3.5
		Surface Humidity	ERA5											4.3.3
		Surface Radiation Budget	ERA5										✓	4.3.6
		Earth Radiation Budget	ERA5										✓	4.5.5
		Carbon Dioxide		C3S_312(a)						✓				4.7.1
		Methane		C3S_312(a)						✓				4.7.2
		Ozone		C3S_312(a)						✓			✓	4.7.4
		Aerosol		C3S_312(a)						✓				4.7.5
		Cloud Properties					C3S_312(b)						✓	4.5.4
		Wind Speed and Direction	ERA5											4.3.2
	Ocean	Ocean Colour					C3S_312(b)				✓			5.3.7
		Sea Ice		C3S_312(a)							✓		✓	5.3.5
		Sea Level		C3S_312(a)							✓			5.3.3
		Sea-Surface Temperature		C3S_312(a)							✓			5.3.1
		Global Ocean Heat Content			ORA5									5.4.1
	Land	Snow Cover	ERA5											6.3.5
		Glaciers and Ice Caps		C3S_312(a)										6.3.6
		Albedo		C3S_312(a)									✓	6.3.9
		FAPAR		C3S_312(a)										6.3.11
		Fire Disturbance					C3S_312(b)							6.3.15
		Ice Sheets					C3S_312(b)							6.3.7
C3S Phase 2	Atmo	Upper Air Temperature	ERA5											4.5.1
		Other Long-Lived Greenhouse Gases					C3S_312(b) ?			✓				4.7.3
	Ocean	Carbon Dioxide Partial Pressure			C3S_311(a) ?									5.3.8
		Ocean Acidity			C3S_311(a) ?									5.4.6
		Ocean Currents			ORA5						✓			5.3.6
		Ocean Salinity			ORA5						✓			5.4.2
	Land	Lakes					C3S_312(b) ?							6.3.4
		Permafrost and seasonally frozen ground					C3S_312(b) ?							6.3.8
		Land Cover (including Vegetation Type)					C3S_312(b)					✓		6.3.10
		Leaf Area Index (LAI)		C3S_312(a)										6.3.12
		Soil Moisture		C3S_312(a)									✓	6.3.16

Key features of ERA5

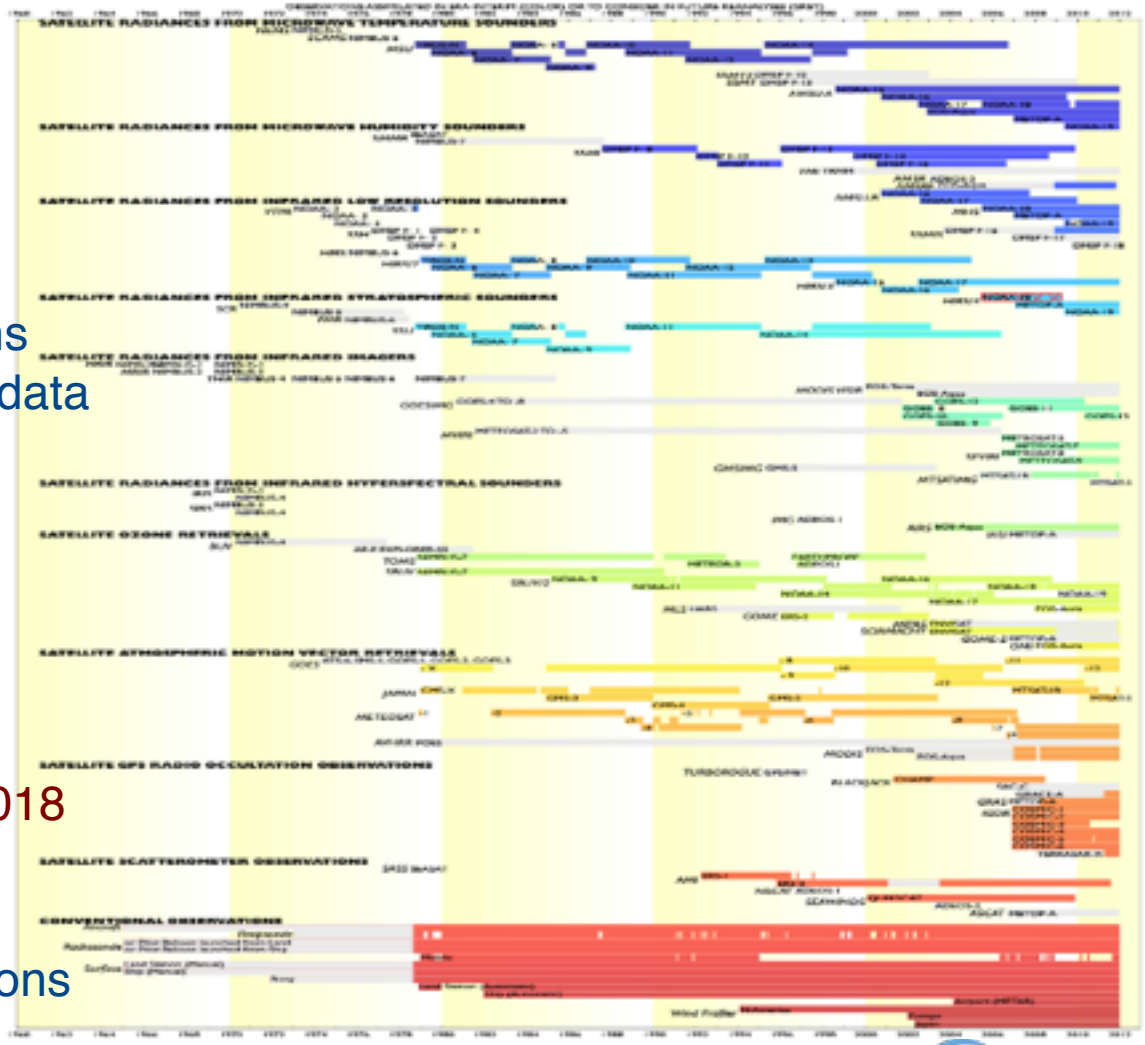
- 32km global resolution
- Uncertainty estimates
- Improved use of observations
- Newly reprocessed satellite data

Initial data release: end 2016

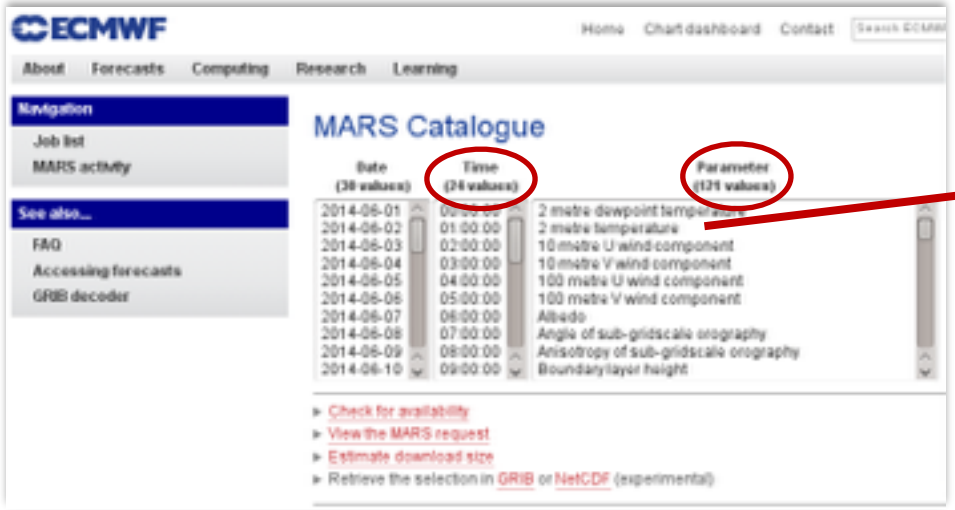
- Hourly data from 2009
- Daily updates NRT

Final release: end 2017/start 2018

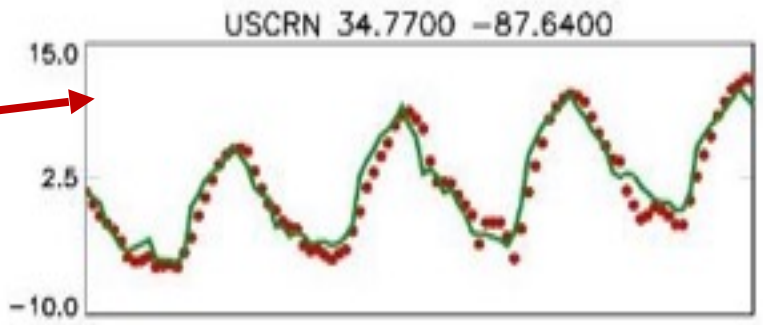
- Hourly data from 1979-NRT
- Access to all input observations



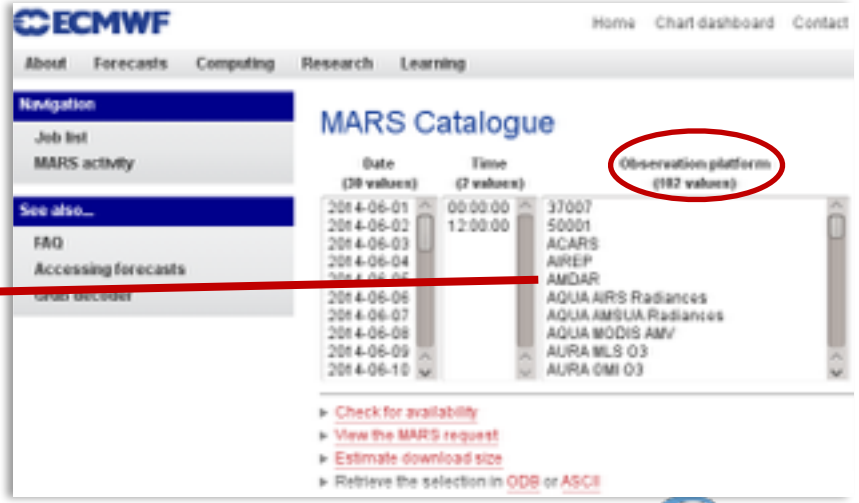
Hourly estimates of weather parameters

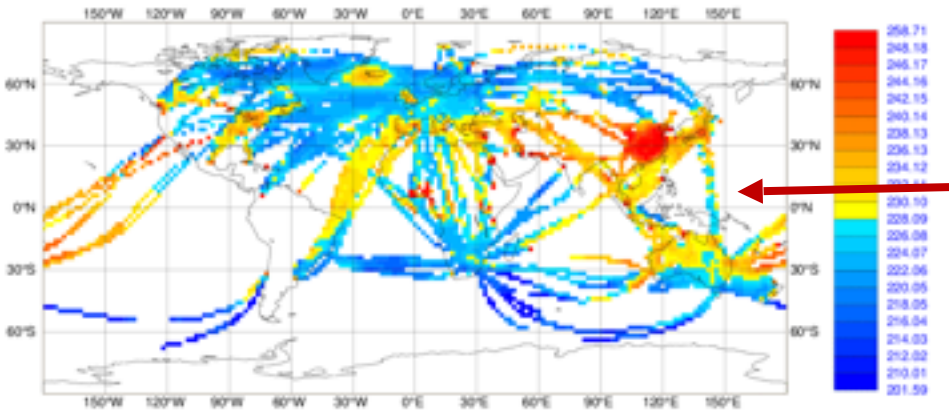


ERA5 *2-metre temperature compared to independent observations*



Access to all input observations

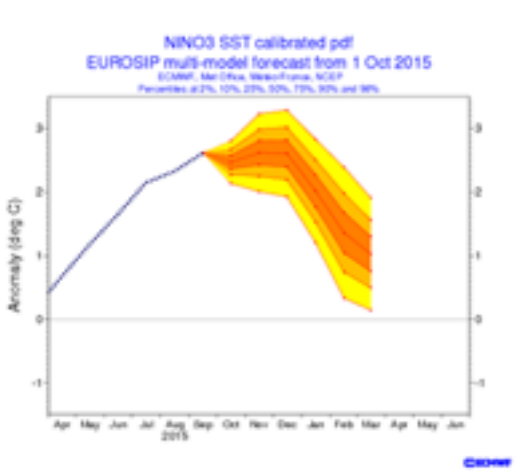


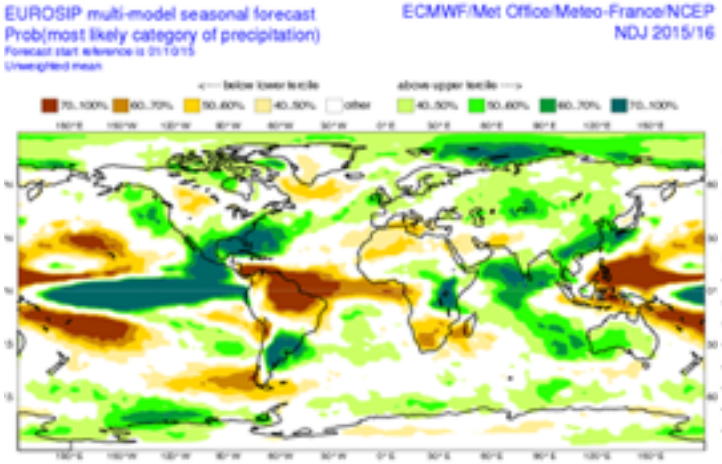


Aim: to generate multi-model seasonal forecast products based on the best information available, to an operational schedule, and make them publicly available.

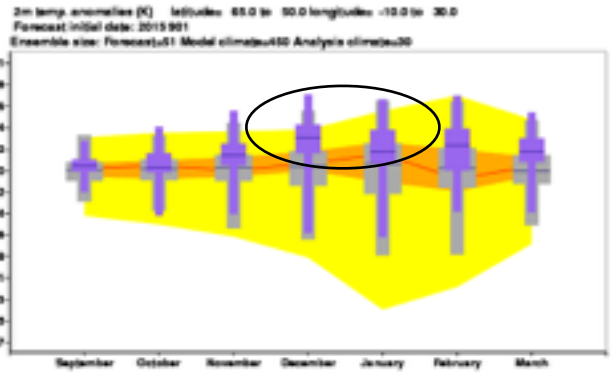
Components of the seasonal service:

- ★ Forecast data: a list of atmosphere (and ocean) variables, on 1x1 degree grid, at daily or sub-daily resolution, from 6-month forecasts
- ★ Graphical products (e.g. time series for indices, maps, climagrams)





Northern Europe; from September 2015



- ★ Processed data (e.g. indices, probabilities, inputs for SIS)
- ★ First set of products will be available starting Q3 2016

Climate Data Store

- ECVs past, present and future
- Observed, reanalysed and simulated
- Derived climate indicators
- Tools to support adaptation and mitigation at global and European level
- **Open and free access**

Sectoral Information System

Evaluation and Quality Control

- Monitors **quality of C3S products and services**
- Ensures C3S delivers state-of-the-art climate information to users
- Identifies gaps in service provision
- Bridges Copernicus with the research agenda in Europe (e.g. H2020, national research projects)

Outreach and Dissemination

- Web content
- Public outreach
- Coordination with national outreach
- Liaison with public authorities
- Conferences, seminars
- Training and education

Sectoral change indicators

Proof-of-concept development: Tools for sectoral applications

Seven proof of concept SIS contracts have been awarded:

- SIS water management:
  - SWICCA (Service for Water Indicators in Climate Change adaptation) – **lead SMHI (Sweden)**
  - EDgE (End-to-End demonstrator for improved decision making in the water sector in Europe) – **Lead CEH (UK)**
- SIS energy:
  - CLIM4ENERGY (Climate for Energy) – **Lead CEA (France)**
  - ECEM (European Climatic Energy Mixes) – **Lead UEA (UK)**
- SIS others:
  - AgriCLASS (Agriculture Climate Advisory Services) – **Lead Telespazio – Vega (UK)**
  - WISC (Windstorm Information Service) – **Lead CGI (UK)**
  - URBAN-SIS (touching health, infrastructure, water) – **Lead SMHI (Sweden)**

1. Water Manager has climate issue

2. Water Manager consults Purveyor

3. Purveyor understands issue and goes to C3S

4. Purveyor consults Data provider/ CDS

5. Data provider search and extracts data to Purveyor

6. Purveyor tailors, downscales, merges, repurposes datasets

7. Purveyor extracts, explains, visualises relevant information to water manager

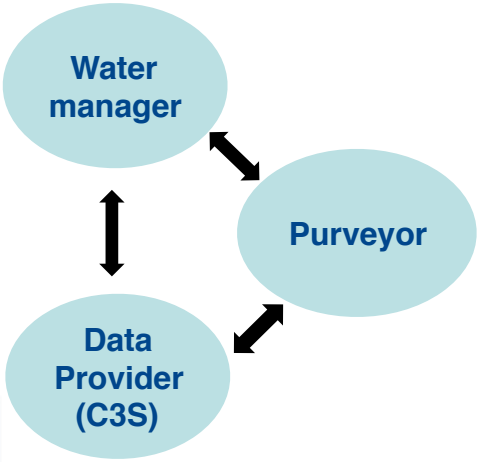
8. Water manager makes decision and business improves !

9. Purveyor reports on needed climate indicators to data provider

10. Data Provider produces new pan-EU climate indicators

11. New climate indicators are readily available in C3S and CDS

12. Purveyor can extend business with more clients !!



Managing increasing sensitivity of supply-demand balance to weather and climate variability

Evaluating risk changes

Evaluating renewable resources for investment

Accounting for sea-level rise

Evaluating changes in operating conditions

Calibrated ECVs (WP2)

Temperature
Rainfall
River Discharge
Wind Speed
Cloud Cover
Solar Radiation
Others ?

+Ancillary

Define Models / Transfer Functions
Select / Gather relevant Datasets

ESCIIs

Demand
Hydro Power
Wind Power
Solar Power
Thermal Power

Skill & Reliability Assessment of Seasonal Forecasts of ESCIIs

+ Extreme Events Case Studies

Impacts of Climate Variability & Change on ESCIIs

- Country Scale
- Historical Period
- Seas. Fcst
- Clim. Proj.

WP4

C3S components

European Commission | Copernicus Climate Change Service

Climate Data Store

- ECVs past, present and future
- Observed, reanalysed and simulated
- Derived climate indicators
- Tools to support adaptation and mitigation at global and European level
- **Open and free access**

Sectoral Information System

Evaluation and Quality Control

- Monitors **quality of C3S products and services**
- Ensures C3S delivers state-of-the-art climate information to users
- Identifies gaps in service provision
- Bridges Copernicus with the research agenda in Europe (e.g. H2020, national research projects)

Outreach and Dissemination

- Web content
- Public outreach
- Coordination with national outreach
- Liaison with public authorities
- Conferences, seminars
- Training and education

ECMWF

Copernicus Europe's eyes on Earth

C3S Service elements:

Evaluation and Quality Control

- Ensures C3S delivers state-of-the-art climate information to end-users
- Identifies gaps in the Service
- Bridges Copernicus with Research Agenda in Europe (e.g. H2020, national research projects)
- Monitors continually, quality of C3S products and services
- "Quality Assurance" body

Will be the instrument to develop the URDB/SES/etc. documents

Strong link with F4P function

Climate Data Store

- ECVs past, present and future
- Observed, reanalysed and simulated
- Derived climate indicators
- Tools to support adaptation and mitigation at global and European level
- **Open and free access**

Sectoral Information System

Evaluation and Quality Control

- Monitors **quality of C3S products and services**
- Ensures C3S delivers state-of-the-art climate information to users
- Identifies gaps in service provision
- Bridges Copernicus with the research agenda in Europe (e.g. H2020, national research projects)

Outreach and Dissemination

- Web content
- Public outreach
- Coordination with national outreach
- Liaison with public authorities
- Conferences, seminars
- Training and education

Communication: outreach & dissemination

- The aims of the ECMWF Copernicus team:
  - Support the European Commission in raising the profile of the Copernicus brand and the Copernicus programme
  - Raise awareness of the Copernicus Climate Service and Copernicus Atmosphere Monitoring Service specifically
  - Increase interaction with the services whether participation in events or access to the data
  - We spent 2015 laying the foundations…

European landscape of climate activities

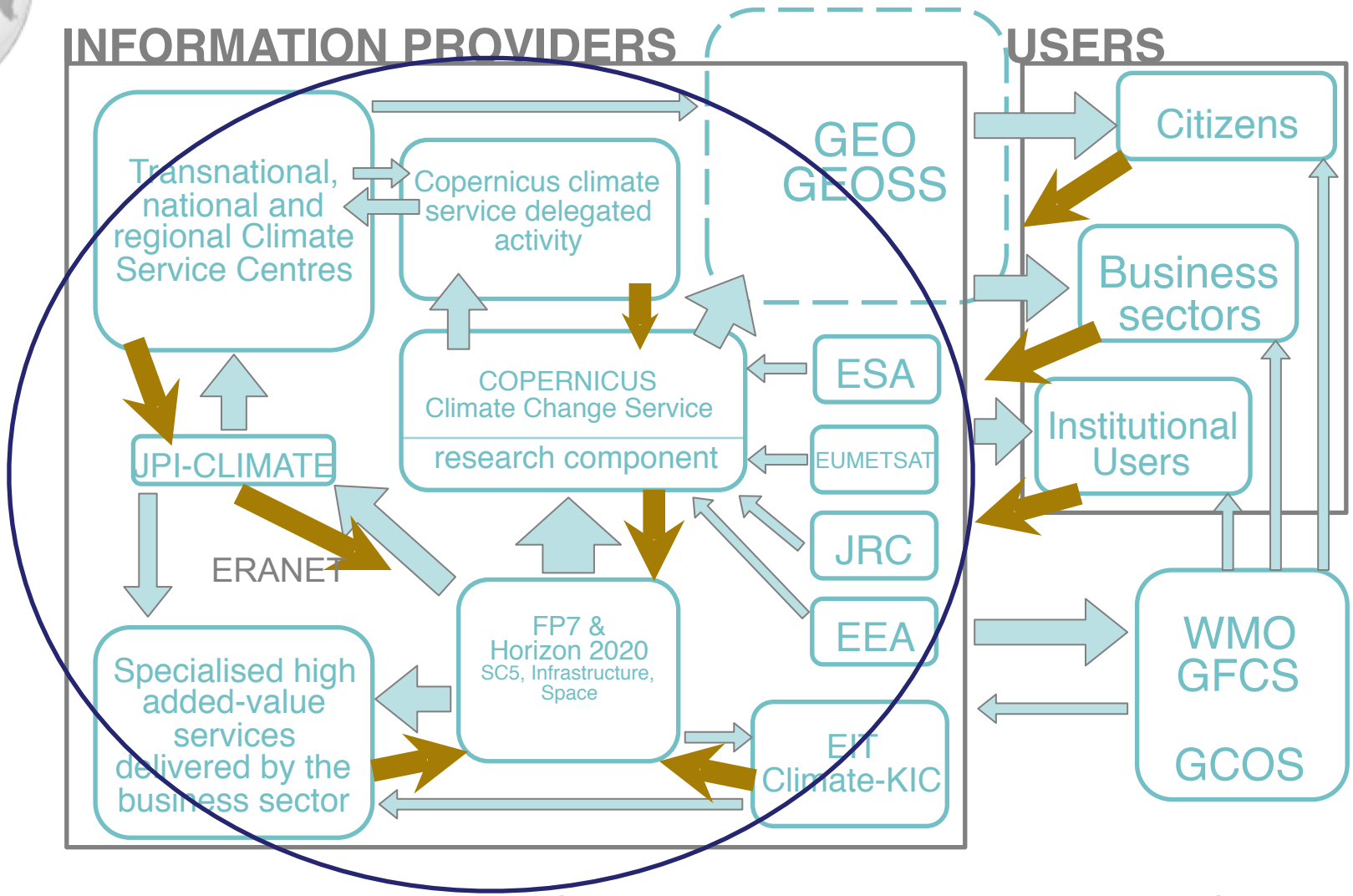


Figure adapted from one provided by Andrea Tilche, European Commission

climateurope
Linking science and society

Develop a Europe-wide managed network for Earth-system modelling (ESM) and climate service (CS) activities.

Use this network to:

1. Coordinate and integrate European climate modelling, observations and infrastructure initiatives.
2. Establish expert groups to assess ESM and CS in Europe. Identify gaps, new challenges and emerging needs.
3. Enhance communication and dissemination activities with stakeholders.

Met Office ANR cnrs SMHI cmcc GERICS ECMWF Imperial College London Koninklijk Nederlands Meteorologisch Instituut Ministerie van Infrastructuur en Milieu BSC Barcelona Supercomputing Center Centro Nacional de Supercomputación

climateurope
Linking science and society

- Contribute to implementation of the CS Roadmap
- Started 1st December 2015 for 5 years
- Build upon activities that already exist, including:
  - Climate-KIC
  - JPI-Climate and ERANET for climate services
  - Copernicus Climate Change Service (C3S)
  - European Network on Earth System Modelling (ENES)
  - European Climate Research Alliance (ECRA)
  - FP7 and H2020 research projects
  - Link to IPCC Modelling activities (CMIP)
  - Link to GFCS
  - Etc.

Climate Change Service
JPI Climate
eit Climate-KIC
enes
GFCS
ECRA
HORIZON 2020

climateurope activities/deliverables

Map and analyse ESM and CS activities. 3 reports :

1. State-of-the-art of European ESM (due Feb.2017)
2. Update, and progress integrating climate services and ESM (2018)
3. Update, and match new demands of climate services with ESM, including usage of CMIP6 and CORDEX for climate services (2020)

Forward-looking recommendations from expert groups:

- Assess new challenges and emerging needs for ESM and climate services
- Recommendations on future research needs

3 Festivals to:

- Showcase climate services and ESM in European Climate Services
- Reflect on gaps (from activities listed above)
- Improve uptake of science-based services
- Networking

climateurope
Linking science and society

Met Office
Hadley Centre

Thanks for listening

Any questions?