Climate Change

Climate Change Service

Copernicus Climate Data Store Toolbox

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COPERNICUS

Copernicus, previously known as GMES (Global Monitoring for Environment and Security), is the **European Programme** for the establishment of a European capacity for **Earth Observation**

Budget of € 4.3 Bn for 2014-2020

SERVICE COMPONENT

USERS

opernicus

SPACE COMPONENT

IN-SITU COMPONENT

esa

EEA

Full, free and open access to data

Source: copernicus.eu, retrieved April 2014

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COPERNICUS SERVICES Component

- Atmosphere Monitoring;
- Marine Environment Monitoring;
- Land Monitoring;
- Climate Change;
- Emergency Management;
- Security.

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Mercator Ocean

European Environment Agency

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European Commission JRC

FRONTEX EUSC EMSA

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COPERNICUS Climate Change service - C3S

- The European Commission has **entrusted** ECMWF with the implementation of the **Copernicus Climate Change Service – C3S**

- The Copernicus Climate Change service will provide **information** to increase the **knowledge** base to support **adaptation** and **mitigation** policies.

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C3S in a nutshell

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International expert panel

from European commission e.g.,FP7 Space call, H2020

from EU Member States, ESA, EUMETSAT, EEA, WMO..

Outreach & Dissemination

Evaluation & QC function

Quality assurance
Integrity of Service
User requirements

Climate Data Store

Sectoral Information System

Stakeholders & users

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Climate Data Store - CDS

- 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**
- The CDS will contain **observations**, global and regional **climate reanalyses**, global and regional **climate projections** and **seasonal forecasts**
- The CDS will also provide an **authoritative set of software** (**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**

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Climate Data Store content

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Scientific basis:

- Essential Climate Variables as defined by GCOS
- GCOS Status Report and Implementation Plan
- IPCC, CMIP

- Action engaged
- In preparation (PIN or ITT out)
- Not started

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 (global and regional)	Reference set of climate projections for Europe

Climate Indicators

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Infrastructure and toolbox

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CDS Architecture

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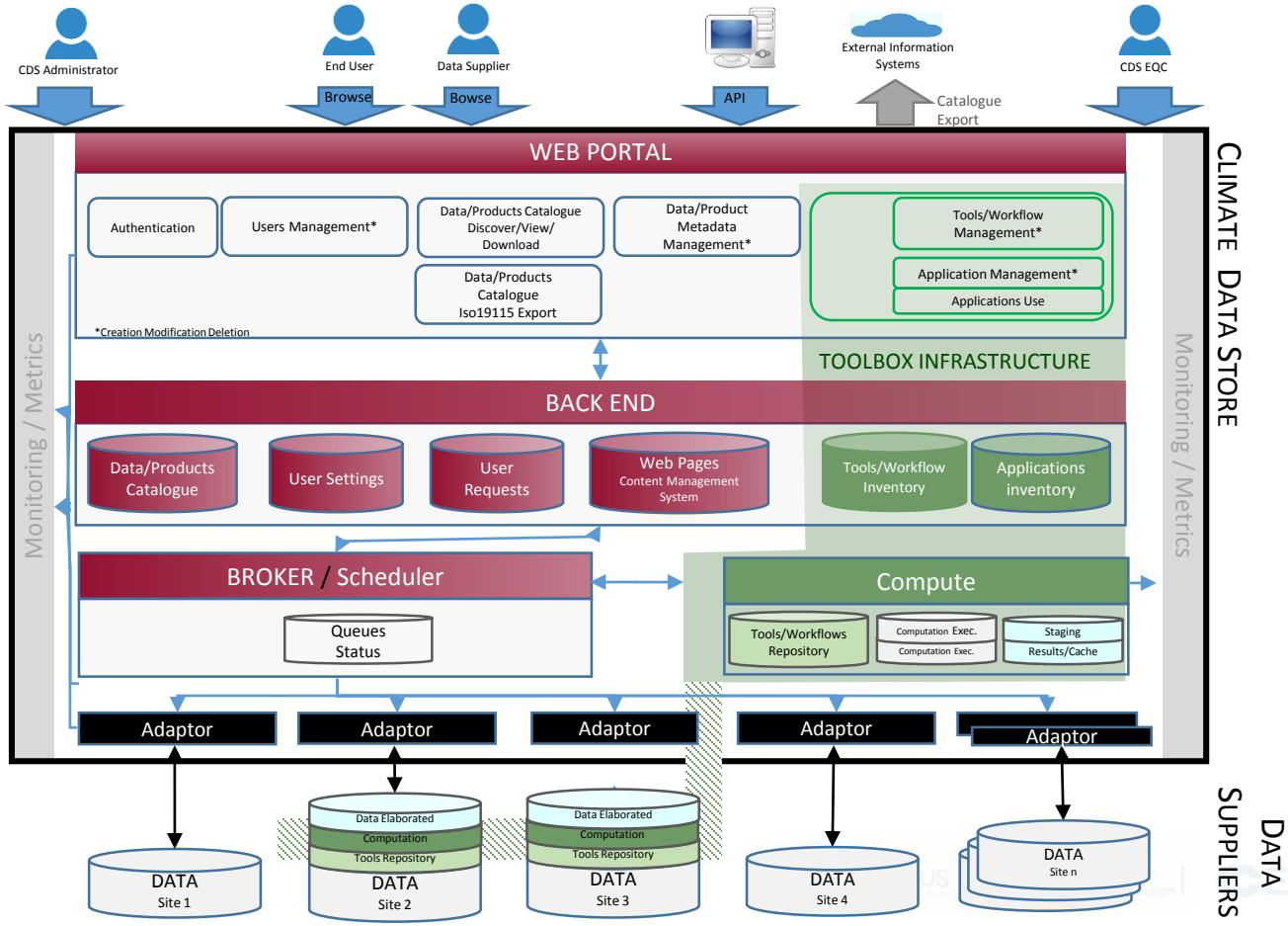

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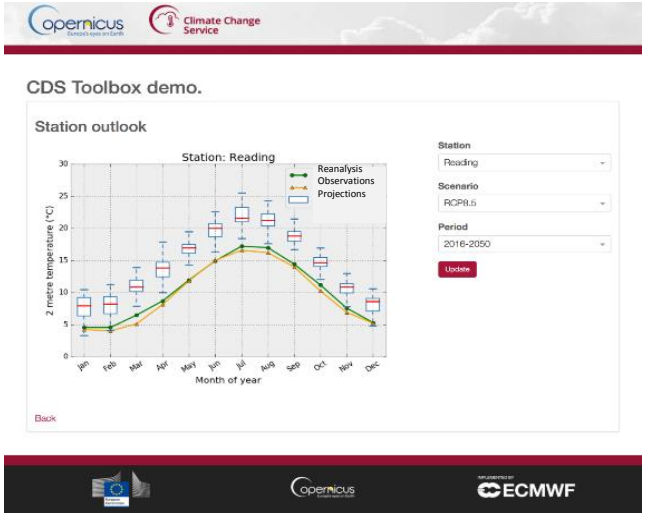
CDS infrastructure and toolbox: **Challenges**

- **Diversity** of users
- **Diversity** of data sets
- Very **large** data volumes
- **Distributed** Data Sources
- **Interoperability**, **Standard Compliance**
- Need for **interactivity**
- **Friendly Front-end**, **robust Back-end**.
- **User-defined** workflows
- **Variety** of presentation methods
- **Access** via API
- **User** management
- **Performance** monitoring
- System **Scalability**
- **Evolving requirements, adaptability**



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CDS infrastructure and toolbox

The **Toolbox** will be composed of:

- **Tools** that perform basic operations on data, such as the computation of statistics, sub-setting, averaging, value at points, etc.
- **Workflows** that combine tools by chaining them so that the output of some tools is used as input to others
- **Applications** that make use of workflows and selected data and products of the CDS, to build interactive web-pages allowing end-users to interact with the CDS

- **A Toolbox Compute layer:**
  - When possible tools will be executed next to the data (at the data suppliers)
  - Otherwise, computations will be performed in a dedicated compute layer
  - Use of cloud technologies
  - Compute layer will also hold intermediate results

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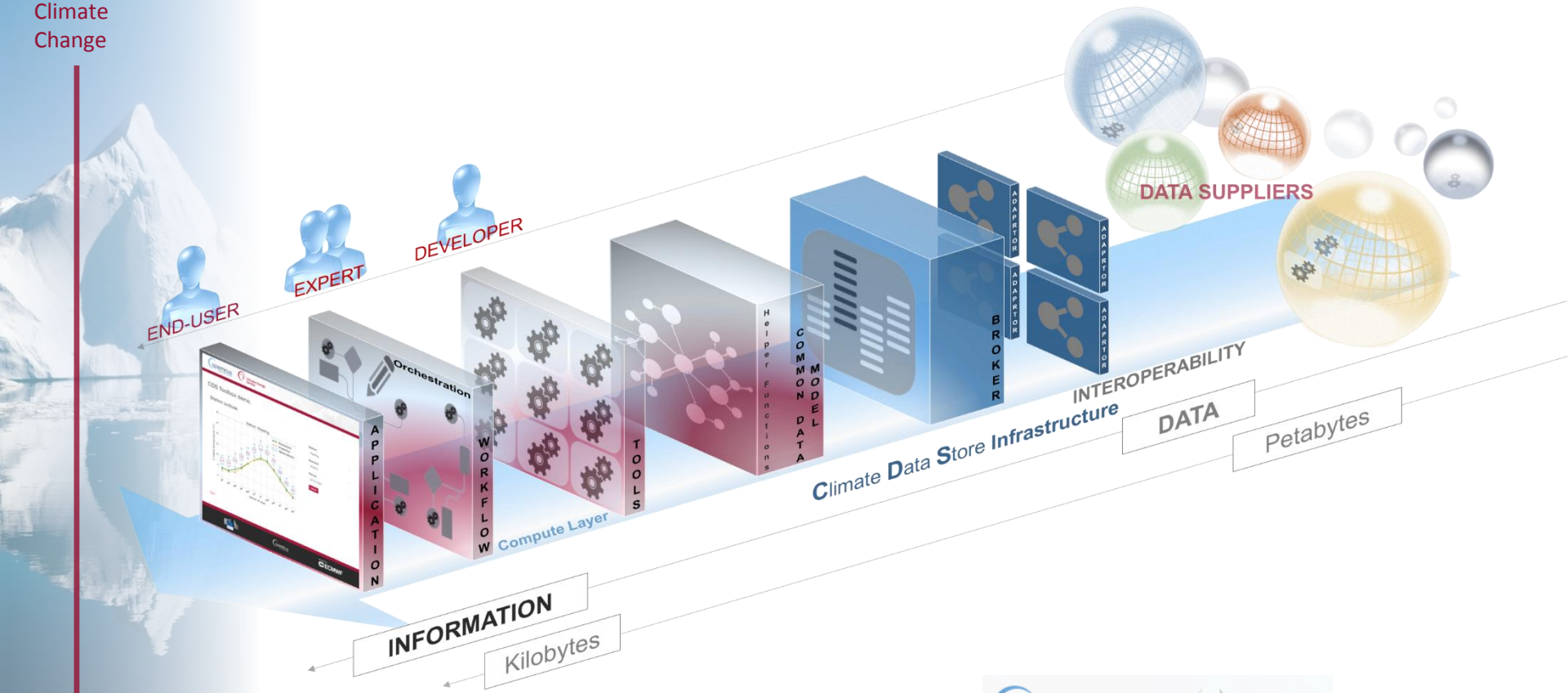
CDS infrastructure and toolbox



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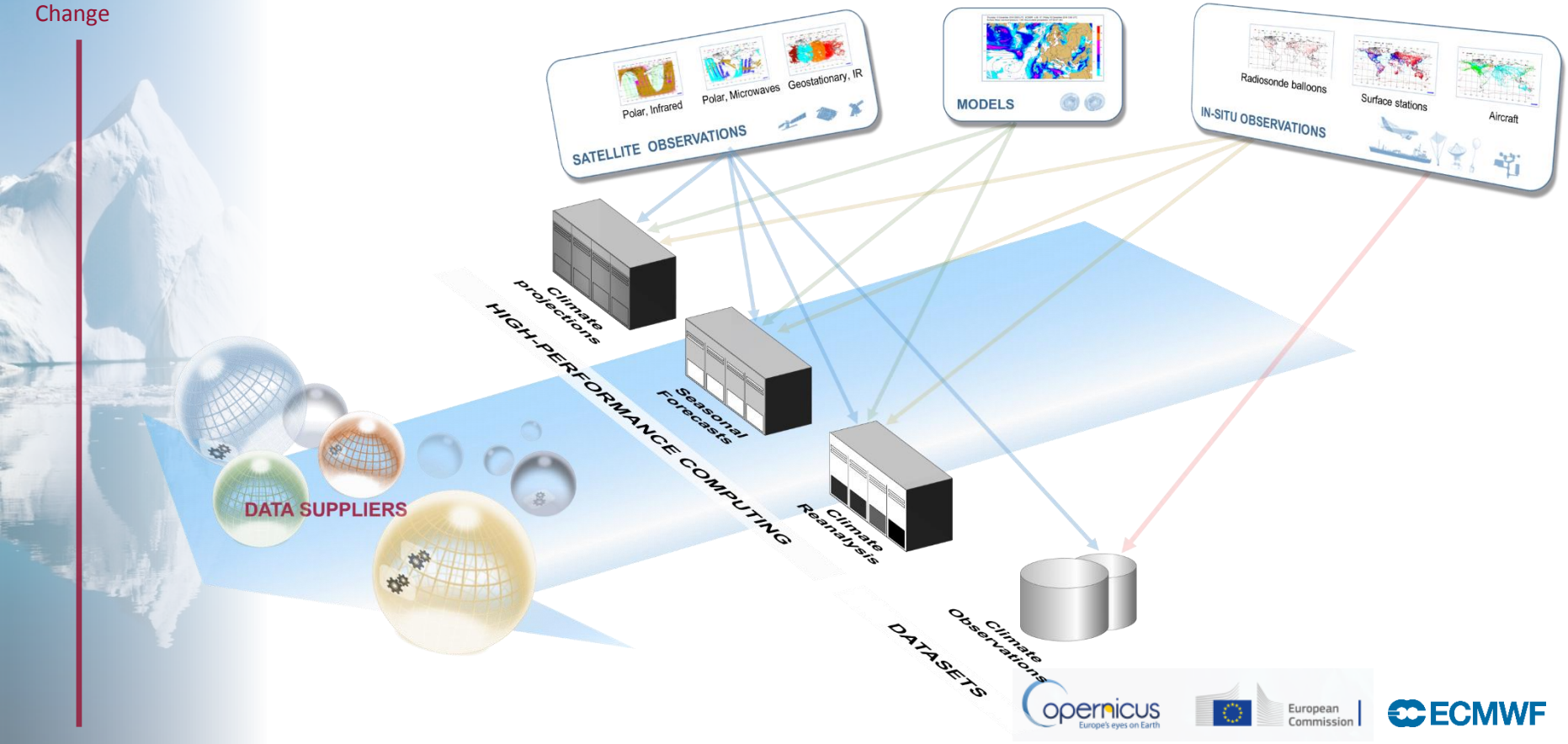
What do we mean by Data?



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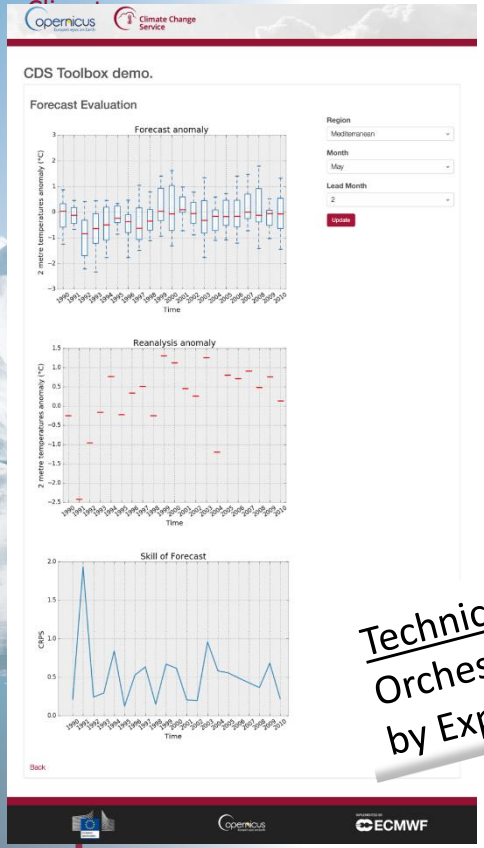
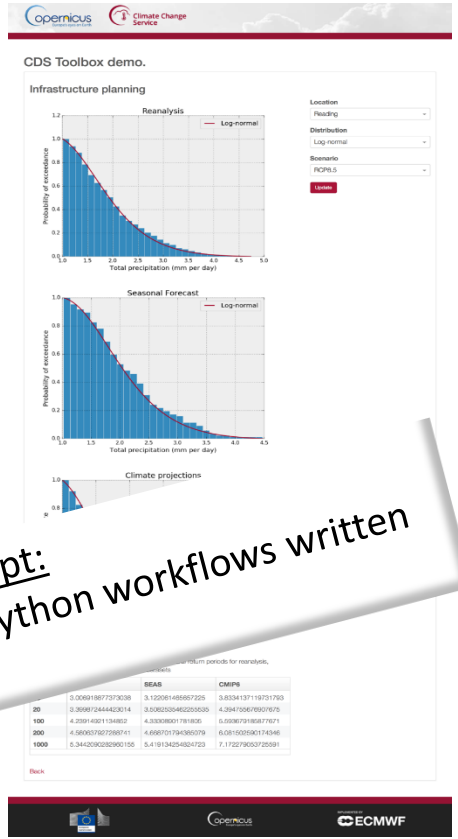
CDS toolbox: Application workflows



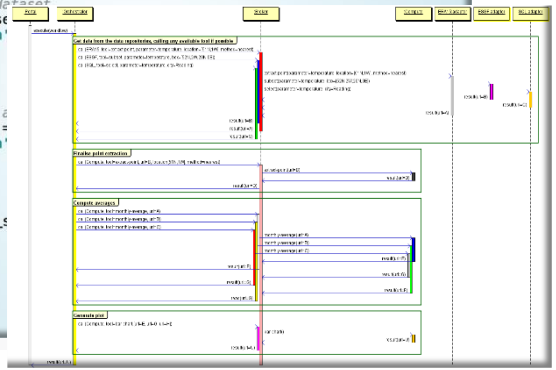


Workflow code 1/2

```
def CRPS(month_neme, lead_time_month=2, variable_name='T2m'):
    month = month_names.index(month_neme)  # month index starting from 1

    #
    # CDS queries
    #

    observations = c3s.queryDataset(
        name='OBSERVATIONS'
    ).timeFilter(
        time_interval=('1990-01-01', '2010.12.31')
    ).spatialFilter(
        bbox=(9, 38, 17, 45)  # Italy
    )

    lead_month = (month - lead_time_month) % 12 + 1  # NOTE: month start form 1
    seasonal_forcasts = c3s.queryEnsemble(
        name='SEASONAL_FORCASTS'
    ).ensembleFilter(
        lead_month=lead_month,
        lead_year=['%d' % year for year in range(1990, 2011)]
    ).spatialFilter(
        same_as=observations,  # requests same bbox and same coordinate system and spacing
        how='average',         # assuming observations is lower resolution
    )

[...]
```

Technical Concept:
Orchestrated Python workflows written by Experts

```
#
# Processing
#

# observations is one dataset
mean_observations = obse
    rule='M', how='mean'
).select(
    month=month,
)

# seasonal_forcasts is a
mean_seasonal_forcasts =
    rule='M', how='mean'
).select(
    month=month,
)

scores = c3s.CRPS(mean_s

#
# Return the raw data
#

return scores
```



CDS toolbox: Application framework

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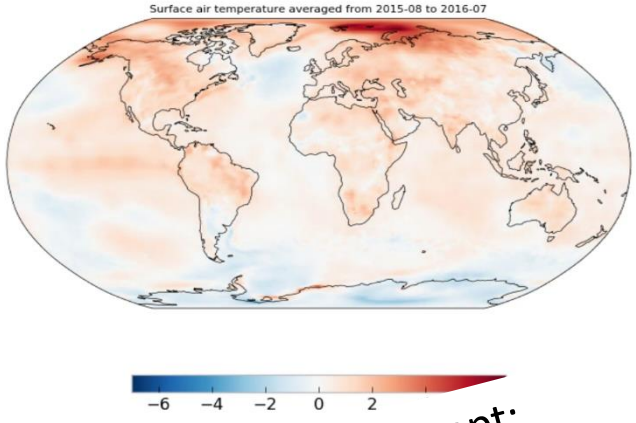
Surface air temperature



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JavaScript application code

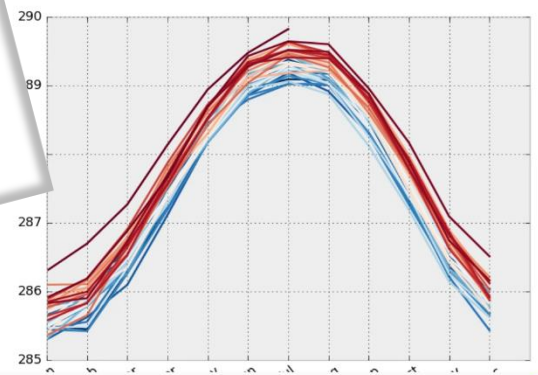
```
<!DOCTYPE html>
<html lang=""en">
    <head>
        <title>Evaluation of fitness for purpose of the Sectoral Information System</title>
        <script src="c3s.js"></script>
    </head>
    <body>
        <h1>Evaluation of fitness for purpose of the Sectoral Information System</h1>
        <p>Parameters: lead time month 2, variable: 2m temperature, time period 1990-2010</p>
        <h2>May</h2>
        <div id="may_plot"></div>
        <table id="may_table">
        </table>
        <script>
            var CRPSService = c3s.service({
                user: "alexamici",
                password: "secret",
                workflow: "CRPS"
            });

            var may_crps = CRPSService.query({month: "May"});

            c3s.table_component({
                renderTo: 'may_table',
                data: may_crps
            });

            c3s.plot_component({
                renderTo: 'may_plot',
                data: may_crps
            });
        </script>
    </body>
</html>
```

Technical Concept:
Easy JavaScript framework to implement customized applications



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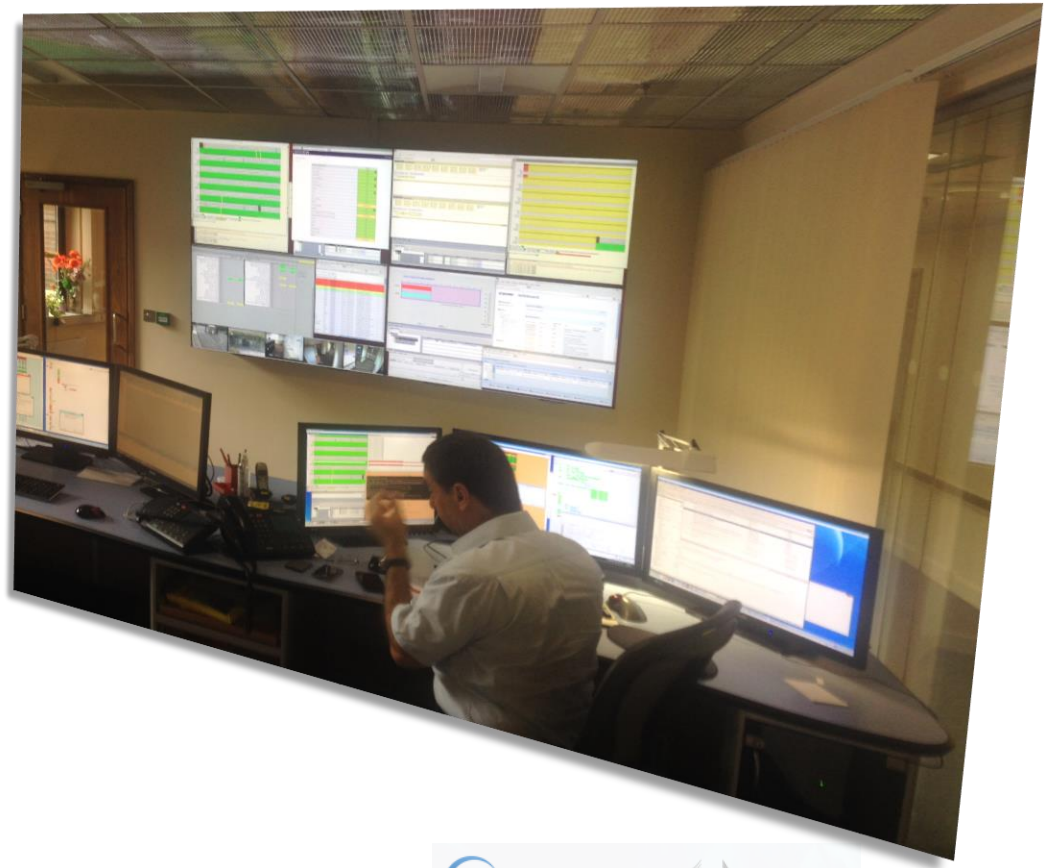
CDS Operations

- **Monitoring**
- **Reporting**
  - Capacity planning
  - Usage statistics

- Service level agreement
- On-call and support
- **Help desk**

- High-availability
- Backup



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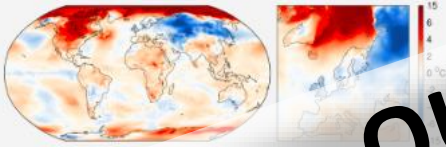
#OpenDataHack @ECMWF - explore creative uses of open data

13 Dec 2016

MONTHLY MAPS



Average surface air temperatures for November 2016

November 2016

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