Climate Change Service

An introduction

Carlo Buontempo, ECMWF
C3S in a nutshell

International expert panel

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

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

Climate Data Store

Sectoral Information System

Stakeholders & users
C3S - Development timeline

<table>
<thead>
<tr>
<th>Year</th>
<th>Stage 0/I - Proof of Concept/Pre-Operational</th>
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</thead>
<tbody>
<tr>
<td>2014</td>
<td>Stage II - Operational ~20 ECVs, ~5-6 Sectors</td>
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<tr>
<td>2015</td>
<td>Stage III - Operational ~30 ECVs, ~10 Sectors</td>
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<tr>
<td>2016</td>
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<td>2017</td>
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<td>2020</td>
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<td>2021</td>
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</table>
Building Upon National and European Investments

National investments: Modeling capabilities, in-situ observations, seasonal forecasts, …

ERA5, ERA6
Data rescue
Satellite reprocessing

Regional reanalysis workshop
Upcoming regional reanalysis ITT

EQA on gridded observations
ECV datasets production

Best practices
Vocabularies, provenance, metadata
User engagement

Workshop on Attribution in October 2017
to decide what next

Significant uptake on ECV datasets production
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Climate Data Store

Sectoral Information System

Stakeholders & users
Climate Data Store content

Scientific basis:
• Essential Climate Variables as defined by GCOS
• GCOS Status Report and Implementation Plan
• IPCC, CMIP

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

Action engaged
In preparation (PIN or ITT out)
Not started
Climate Data Store: Reanalyses

**ERA5 global reanalysis:**
- Atmosphere/land/wave parameters
- 31 km global resolution, 137 levels
- Hourly output from 1979 onward
- Based on IFS Cy41r2 (March 2016)
- Using improved input observations
- Ensemble data assimilation
- Providing uncertainty estimates

**Regional reanalysis:**
- European + Arctic domains
- Higher spatial resolution
- Workshop organised 2016 Q2
- Competitive call issued 2016 Q4, bids under evaluation

**EUMETSAT reprocessing activity**
Seasonal forecasts

The Copernicus Climate Change Service (C3S) is developing seasonal forecast products, with a target publication date of 25% of each month. These products are based on data from several state-of-the-art seasonal prediction systems.

The current proof-of-concept phase includes graphical forecast products for a number of variables (air and sea-surface temperature, atmospheric circulation and precipitation); the forecasts are updated every month and cover a time range of 6 months. The interface to the list of products offers links to maps or timelines for the forecast variables, and the facility to navigate the full set of graphics. Multi-system combinations, as well as predictions from the individual component systems, are available.

The centres currently providing forecasts to C3S are ECMWF, The Met Office and Météo-France; at a later stage Deutscher Wetterdienst and Centro Euro-Mediterraneo sui Cambiamenti Climatici will be added to the list.

http://climate.copernicus.eu/seasonal-forecast
Seasonal forecasts - content

Variables:
- sea-level pressure
- geopotential height
- precipitation
- air temperature

Type of plots:
- maps:
  - global
  - pre-defined regions
- time series

Publication schedule:
- monthly updates
- published on each 15th
Future releases and developments:

- new information: verification and documentation
- new diagnostics and products, informed by user requirements identified in EQC activity with focus on seasonal forecasts
- new data: contributions from DWD and CMCC
CDS infrastructure and toolbox
Technical Concept: Orchestrated Python workflows written by Experts

```python
# Workflow code 1/2

def CRPS(month_name, lead_time_month, variable_name='T2m'):  
    month = month_name.index(month_name) + 1  # month index starting from 1
    # CDS queries
    #
    observations = c3s.queryDataset(
        name='OBSERVATIONS'@
        timeFilter=lambda filters: ['1998-01-01', '2018-12-31']
        .seasonFilter(month=month, lead_time=lead_time_month)
    )
    # NOTE: month start from 1
    seasonal_forecasts = c3s.queryDataset(
        name='SEASONAL_FORECASTS'
        .ensembleFilter(month=month, lead_time=lead_time_month)
        .spatialFilter(year=year)
        .seasonFilter(month=month, lead_time=lead_time_month)
    )
    mean_observations = observations.select(month=month)
    mean_seasonal_forecasts = seasonal_forecasts.select(month=month)
    scores = c3s.CRPS(mean_observations, mean_seasonal_forecasts)
    return scores
```
CDS toolbox: Application framework

Surface air temperature averaged from 2015-08 to 2016-07

Technical Concept: Easy JavaScript framework to implement customized applications

```html
<html>
  
  <head>
    
  </head>

  <script>
    var CRPSService = c3.service(
      {user: 'example',
       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>
</html>
```
C3S in a nutshell

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Climate Data Store

Sectoral Information System

Stakeholders & users

Evaluation & QC function

Quality assurance Integrity of Service User requirements

Outreach & Dissemination

from European commission e.g., FP7 Space call, H2020
WHAT WILL THE INFORMATION BE USED FOR?

The wealth of climate information will be the basis for generating a wide variety of climate indicators aimed at supporting adaptation and mitigation policies in Europe in a number of sectors. These include, but are not limited to, the following:

1. **INFORMING**
   - Policy development to protect citizens from climate-related hazards such as high-impact weather events

2. **IMPROVING**
   - Planning of mitigation and adaptation practices for key human and societal activities

3. **PROMOTING**
   - The development of new services for the benefit of society

- **WATER MANAGEMENT**
- **AGRICULTURE & FORESTRY**
- **TOURISM**
- **INSURANCE**
- **TRANSPORT**
- **ENERGY**
- **HEALTH**
- **INFRASTRUCTURE DISASTER RISK REDUCTION**
- **COASTAL AREAS**
1) to provide practical examples of how C3S in general and CDS in particular could deliver information of relevance to specific sectors.

2) To provide examples of best practice. This means that the SISs should be built to the highest possible standards so that services developers could be inspired by them and look at them as quality benchmarks.

3) To provide information on users needs, and whenever possible address those. In particular SIS contract should develop and make available sector-relevant indicators and tools that were either unavailable or inaccessible before.
Focus Groups

Evidence Gathering

Capturing the Stakeholder View

Indicators

Interface

User Guidance

Case Studies

Stakeholder Engagement

Deliverables

SC Impact Indicators
User friendly interface
User guidance
Technical reports
Case Study fact sheets
Model output
SIS highlights

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, down scales, 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 S3C and CDS
12. Purveyor can extend business with more clients!!
Hydrological outlook

Relative change in annual Q90 for RCP 8.5
Cities
User relevant parameter for energy
Real-time forecast
**WISC – Storm Tracks and Footprints**

**Tracking Method**
Hodges (1994,1995) tracking algorithm
- Based on 850hPa relative vorticity at T42 resolution
- Vorticity centres used to calculate trajectory of individual extra-tropical cyclones (cyclones north of 30N)

Extra fields referenced back to vorticity fields at full resolution at each timestep
- Minimum MSLP within 6 degrees of vorticity centre
- Maximum wind within 6 degrees of vorticity centre
- Maximum land-wind within 3 degrees of vorticity centre (XWS ranking metric)

**Footprint Downscaling Method**

**Event identification**
- Extract data for +/- 36 hours from maximum wind value on track
- Select nearest 00:00 (12:00) as start time (ST)
- Where no track available, use user-specified start/peak date/time

**Boundary conditions for UKMO Unified Model**
from ERA-INT / 20C between ST-6 and ST+30h
Remove ‘spin-up’ period (ST-6 to ST+0)
Repeat 3 or 4 times
Concatenate into 72-hour footprint
Output as appropriate (geo-referenced and NetCDF)

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<td>Total Sectoral Insured Losses; 1990 to 2015 Total Windstorm Loss per Sector; 1990 to 2015</td>
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**Validation**
e.g. Storm 1990 storm Daria

**Bias correction**

**Comparison with station data**
10m gust

**Validation**
e.g. Storm 1990 storm Daria
A demonstrator is—in most cases—a tool to fulfil these objectives rather than a goal per-se.

C3S doesn't want to be a provider of services addressing every possible market niche available but rather a place where to access sectoral relevant information of the highest possible standard which can then be used to develop downstream services addressing market niches.

C3S shall develop tools and indicators (SCIIs) that are difficult or not economically viable for other to develop.
Preliminary results: vines
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Integrity of Service
User requirements

Outreach & Dissemination
Climate Change

EQC:
Ensures C3S is state-of-the-art
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
Contributes and develops URDB/SES/etc documents

Quality assurance for seasonal forecasts
Quality assurance framework for earth observations
Quality assurance for climate projections
Quality assessment of ECV products and reanalyses
Sectoral gap analysis and user requirements
EQC of operational SIS

Action engaged
In preparation (PIN or ITT out)
Not started
Technical challenges:

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

CDS infrastructure (Telespazio UK):
alpha version Jan 2017, beta version summer 2017

CDS toolbox (B-open, IT):
incremental until 2019
What do we mean by Data?
WISC – Windstorm Information Service (Copernicus)

- WISC provides transparent, authoritative data to improve understanding of windstorm risk from Extra-Tropical cyclones
- Approach and outputs:

Team:

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WISC - Event Set, Vulnerability and Loss

Hazard - Event Set
• Spatial resolution: 25km; Temporal resolution: 6 hours; 5 ensembles; 6600 significant storms
• UPScale (1985 to 2011), based on HadGEM3 GA3 and GL3 configurations of Met Office Unified Model

Exposure / Vulnerability
• CORINE – 45 land classes
• PAGER – 106 construction types – aggregated to 6 types
• Fragility curves applied for these 6 types
• Fragility curves to vulnerability curves via reconstruction costs
• GDP per NUTS3 region applied

Process for Loss Assessment
• Datasets clipped to NUTS3 regions before loss calculations applied (EU: 276 NUTS 2 & 1,342 NUTS3 regions)
• Loss per hazard (max gust speed) from fragility curves
• Loss ratio multiplied by reconstruction cost per building type
• Losses adjusted by GDP per region
• Validate losses vs actuals