C3S status on Essential Climate Variables

Joaquín Muñoz Sabater
- with contributions from data providers and C3S technical officers -

CCI 9th Co-location Meeting, 25-28 March 2019, St. Hugh’s College, Oxford
**Objective**

- To provide users with full and timely access to observational records of essential climate variables derived from satellite observations

**which are**

- State-of-the-art products
- Long-term, consistent, complete (CDR)
- Regularly extended in time (ICDR)
- Gridded, aggregated
- Accessible & Tracible
  - Access through the Climate Data Store
  - Documentation
  - Evaluation and Assessment
  - User support
## Grided datasets

<table>
<thead>
<tr>
<th>ECV</th>
<th>Description</th>
<th>Contracts, ECVs</th>
<th>Start Date</th>
<th>End Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>C3S_312a</td>
<td>ECV products from satellite observations</td>
<td>9 contracts, 12 ECVs</td>
<td>Started 2016Q4</td>
<td>Ended 2018Q4</td>
</tr>
<tr>
<td>C3S_312b</td>
<td>ECV products from satellite observations</td>
<td>Additional 10 ECVs Organized in 5 Lots</td>
<td>Started 2018Q3</td>
<td>Will end 2021Q2</td>
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<tr>
<td>C3S_311a</td>
<td>In situ observations (Lot 4)</td>
<td>High-resolution ECV products for Europe</td>
<td>Started in 2017Q2</td>
<td>Will end 2021Q2</td>
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</tbody>
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## Reanalysis

<table>
<thead>
<tr>
<th>ECV</th>
<th>Description</th>
<th>Variable</th>
<th>Start Date</th>
<th>NRT Status</th>
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<tbody>
<tr>
<td>ERA5</td>
<td>Global atmospheric reanalysis</td>
<td>Atmosphere, land, sea state</td>
<td>Started 2016Q1</td>
<td>1979-NRT completed</td>
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<tr>
<td>ERA5-Land</td>
<td>High-resolution global land reanalysis</td>
<td>Land</td>
<td>Started 2018Q1</td>
<td>2000-NRT completed</td>
</tr>
<tr>
<td>ORA5</td>
<td>Global ocean reanalysis</td>
<td>Ocean, sea ice</td>
<td>Complete</td>
<td></td>
</tr>
</tbody>
</table>
# ECVs evolution in C3S (satellite data)

<table>
<thead>
<tr>
<th></th>
<th>C3S_312a</th>
<th>C3S_312b</th>
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</thead>
<tbody>
<tr>
<td><strong>Atmospheric physics</strong></td>
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<td></td>
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<tr>
<td>GCOS</td>
<td>2017</td>
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</tr>
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<tr>
<td></td>
<td>2021</td>
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<tr>
<td>Precipitation</td>
<td>4.3.5</td>
<td>Lot 1</td>
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<tr>
<td>Surface Radiation Budget</td>
<td>4.3.6</td>
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<tr>
<td>Water Vapour</td>
<td>4.5.3</td>
<td></td>
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<tr>
<td>Cloud Properties</td>
<td>4.5.4</td>
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<tr>
<td>Earth Radiation Budget</td>
<td>4.5.5</td>
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<tr>
<td><strong>Atmospheric composition</strong></td>
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<tr>
<td>Carbon Dioxide</td>
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<td>Methane</td>
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<td>4.7.4</td>
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<td>Aerosol</td>
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<td>Lakes</td>
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<td>Ice sheets and ice shelves</td>
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<td>Fire</td>
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Coordination:
- Coordination with CM- SAF / ROM SAF / ESA CCI / Uni. Maryland / NASA / NOAA
- Coordination with ESA-CCI and other national projects
- Coordination with ESA-CCI, GloboLakes, Arc-Lake, HydroWeb
- Coordination with ESA-CCI, CGL, QA4ECV, LSA-SAF
Combination of CDR/ICDR from several sensors for 5 ECVs.
Currently in year 1 of Phase 1 (KO in May 2018)
The consortium, led by DWD, has strong connections with ESA CCI (Cloud), EUMETSAT (CM SAF, ROM SAF), and USA (NOAA, NASA, University of Maryland).

Atmospheric physics

- Precipitation
- Surface Radiation Budget
- Water Vapour
- Cloud properties
- Earth Radiation Budget
**Atmospheric Physics**

**Precipitation**

*Service active since May 2018* → Currently brokering existing precipitation datasets (GPCP) to CDS.

**Products:**

**Next:**
ICDR production. Use of MW data. CDR version 2 (in-house) will be based on the integration between microwave imager and sounders precipitation rate estimates to provide a global precipitation product on a regular grid.

**Surface Radiation Budget**

*Service active since May 2018* → Currently brokering existing AVHRR-based datasets (CMSAF CLARA) to CDS.

**Products:**

**Next:**
ICDR production. Complement the AVHRR CLARA product brokered from CM SAF with the CCI_Cloud (A)ATSR data record, and include S3 SLSTR.
**Water Vapour**

*Service active since May 2018* → Currently brokering existing datasets from ROM SAF, CM SAF and ESA DUE GLOBVapour to CDS.

**Products:**
- CDR/ICDR of monthly mean of total column water vapour (TCWV), *specific humidity* (below 12km) from GPS RO and *upper tropospheric humidity* (UTH) from MW instruments, available from Oct 1996 onwards.

**Next:**
- ICDR production. Heritage from the ESA Due GLOBVapour, CCI+ WV for TCWV product.

**Cloud properties**

*Service active since May 2018* → Currently brokering existing datasets from AVHRR (CMSAF CLARA) and (A)ATSR (Cloud_CCI) to CDS.

**Products:**
- Daily and monthly means for *cloud amount*, *cloud-top*, *cloud optical thickness*, and *cloud water path* covering the period 1982-2015 from AVHRR and 1995-2012 from (A)ATSR.

**Next:**
- ICDR production. Complement the AVHRR CLARA product brokered from CM SAF with the CCI_Cloud (A)ATSR data record, and include S3 SLSTR.
Climate Change

Atmospheric physics

Earth Radiation Budget

Service active since May 2018 → Currently brokering existing ERB datasets (NASA CERES and Univ. of Maryland/NOAA HIRS, ESA Cloud_CCI (A)ATSR) to CDS.

Products:
- CDR/ICDR of TOA outgoing longwave radiation, TOA Reflected shortwave radiation, incoming solar radiation provided as monthly mean for the periods: 2000-onwards for the NASA CERES, from 1979-onwards from HIRS, 1995-2012 from (A)ATSR. Daily Total Solar Irradiance (TSI) will be generated as a multi-sensor composite product from 1984 to 2017.

Next:
- ICDR production. Incoming radiation and ICDR of TOA fluxes derived from SLSTR (Cloud_CCI).
Atmospheric composition

System based on a distributed ECV production, archive and data access. Deliver to the Climate Data Store a suite of Satellite-based datasets on atmospheric composition covering four Essential Climate Variables: ozone, aerosol properties, carbon dioxide (CO₂) & methane (CH₄).
### Ozone

**Service active since 2016**— Responsible entity: DLR

**Products:**
- Total ozone columns, ozone profiles from limb and nadir sensors and multi-sensor reanalysis from past and present sounders.

**Next:**
- Semi-annual extension into near real time.

### Aerosol Properties

**Service active since 2016**— Responsible entity: DLR

**Products:**
- Aerosol optical depth, layer height, single scattering albedo

**Next:**
- Recently added observation from SLSTR on Sentinel 3; regular updates of records into near real time
**Atmospheric Composition**

**Carbon Dioxide**

*Service active since 2016* – Responsible entity: DLR

*Products:*
- Level 2 column average carbon dioxide from individual sensors and merged

*Next:*
- Yearly reprocessing of entire data record

**Methane**

*Service active since 2016* – Responsible entity: DLR

*Products:*
- Level 2 column average methane from individual sensors and merged

*Next:*
- Inclusion of Sentinel 5p TROPOMI observations; Yearly reprocessing of entire data record
**Ocean**

**Sea Level**

Service active since 2016 – Responsible entity: CLS

**Products:**
- Ocean Dynamic topography and ocean geostrophic velocities (CDR/ICDR)
- 3 regions: Global ocean (0.25°), Mediterranean Sea (0.125°), Black Sea (0.125°)
- Daily products from 1993 onward updated every 6 months

**Next:**
- Integration of Sentinel-6/Jason-CS mission in production system to begin in 2020
- Fully reprocessed record planned for 2021 in cooperation with CMEMS
- Higher-resolution L4 gridded products for Medit. and Black Sea planned for 2021

**SST**

Service active since 2016

Responsible entities: UoReading and MetOffice (ICDR) + brokerage from SST CCI (CDR)

**Products:**
- Global sea surface temperatures (CDR/ICDR)
- Daily L3 and L4 products, 0.05° grid, from 1991 onward, ICDRs available within 5 days

**Next:**
- Upgrade of MetOp input stream to full resolution (1 km) planned for 2019
- Use of MetOp-C and Sentinel-3B/SLSTR will be considered (currently AVHRR data from NOAA-19 and MetOp-A are used).
**Sea Ice**

**Service active since 2016**
Responsible entities: Met Norway/DMI/AWI + brokerage from OSI-SAF for sea ice conc.

**Products:**
- **SI concentration** (CDR/ICDR): daily, 1978 onward, 12.5-km grid, N. and S. Hemis.
- **SI edge** (CDR/ICDR): daily, 2011 onward, 12.5-km grid, N. and S. Hemis.
- **SI type** (CDR/ICDR): daily, 1991 onward, 25-km grid, N. Hemis. only
- **SI thickness** (CDR/ICDR): monthly, 2002 onward, 25-km grid, N. Hemis. Only

**Next:**
- Thickness: Extension of CDR back to 1993 using ERS-1/2 in cooperation with ESA CCI+
- Edge/Type: Fully reprocessed records planned for 2021

**Ocean Color**

**Service active since May 2018** – Responsible entity: PMLApps

**Products:**
- **Chlorophyll-a** (CDR/ICDR)
- **Surface reflectance** (CDR/ICDR)
  Daily products on 4-km grid updated every 4 months
  ICDR from 2017 onwards to extend CDR product from Ocean Color CCI (1997-2016)

**Next:**
- Potential integration of Sentinel-3A/OLCI in production system
- Potential increase in spatial resolution from 4km to 1km
Figure 1: Service Timeline showing CPS set Up and CPS operations

- Glaciers
- Surface Soil Moisture
- Ice Sheets and Ice Shelves
- Lakes
**Soil Moisture**

*(Second phase) Service active since Nov 2018*—Timely generation of the ICDR within the 10 day production window.

**Products:**
- 3 Global products as CDR: **Passive** Sensors from 1978, **Active** sensors from 1991, **Combined** from 1978

**Next (CCI dependent):**
- Inclusion of SMAP in the CPS, update of L2 retrieval methods, improved error characterization, consistent use of GLDAS-Noah scaling reference

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**Lakes**

*Service active since Apr 2018*—CPS has been completed for both, LSWT & LWL and current transition to operations

**Products:**
- **Lake Surface Water Temperature** (CDR/ICDR), Targets 1000 lakes worldwide, from 1995, daily monitoring
- **Lake Water Level** (CDR/ICDR), Targets 155 lakes worldwide, from 1992, daily to decadal monitoring

**Next (Synergy with CCI+):**
- LSWT: brokering of the Globolakes CDR (v4.0) and its evolution to include Metop B AVHRR.
- LWL: Evolution with inclusion of SLSTR (S3-A). Assessment of S3B SLSTR and SRAL.
Glaciers

(Second phase) service active since Jan 2019

Products:
- **Glacier Area** CDR/ICDR - globally complete glacier outlines, > 30 years monitoring
- **Elevation Change** CDR /ICDR – CDR from 1900 to present, ICDR focus on 2000-15
- **Mass Change** CDR Annual update brokered from WGMS FoG database

Next:
New glacier inventories for around 2015 using S2A/B & Landsat 8, and from around 1985 from historic LTM data, improve RGI inventory around 2000. High-quality glacier elevation changes from DEMs & better assessment of glacier melt contribution to sea-level rise.

Ice Sheets

Service active since Apr 2018

Products:
- **Surface Elevation Change** (CDR/ICDR), Antarctic and Greenland from 1992, Monthly Updates
- **Ice Velocity** (CDR/ICDR), high resolution coverage, from 2014 for Greenland Ice Sheet
- **Gravimetric Mass Balance** (CDR), Antarctic and Greenland from 2002 to 2017, Monthly basin values

Next:
Delivery of 25+ consistent dataset, addition of S3A to CPS, refined previous work with ENVISAT and CryoSat-2 datasets, cross-calibration between missions, possible brokering of GRACE data, 2018 map of IV Greenland
(Second phase) service active since Apr 2018
- Continuous brokering v0 product from CGLS service & delivery of single-sensor CDRs v1.0 based on NOAA-AVHRR & SPOT-VGT, ICDR based on PROBA-V.

Products:
- **Albedo** (broadband/Spectral directional & hemispherical) CDR/ICDR - global product based on NOAA-AVHRR, SPOT-VGT & PROBA-V

Next:
- Pre-processing harmonization, consolidate CDRs towards multi-sensor approach (BRDF), Transition to S-3, ICDR provision with uncertainty and error propagation (1982-present)

(Second Phase) Service active since Apr 2018.
- Continuous brokering v0 product from CGLS service, delivery of single-sensor CDRs v1.0 based on NOAA-AVHRR & SPOT-VGT, ICDR v2.0 based on PROBA-V and TIP model.

Products:
- **LAI** CDR/ICDR, global product based on NOAA-AVHRR, SPOT-VGT & PROBA-V
- **fAPAR** CDR/ICDR, global product based on NOAA-AVHRR, SPOT-VGT & PROBA-V

Next:
- Pre-processing harmonization, consolidate CDRs towards multi-sensor approach, transition to S-3, ICDR provision with uncertainty and error propagation
Land Cover

Service active since Apr 2018 → Sustained production and operationalisation of the process developed in ESA-CCI. No full dataset reprocessing is planned for this contract.

Products:

Next:
- Transition to S-3, Build further the validation reference database, Pre-processing of surface reflectance 2019.

Fire

Service active since Apr 2018 → Sustained production and operationalisation of the process developed in ESA-CCI. No full dataset reprocessing is planned for this contract.

Products:
- **Burned Area LAI** (CDR/ICDR), brokered MODIS BA data set (2000-2016)
- **Fire Radiative Power** (ICDR) based on the algorithm of the operational FRP product of Sentinel-3 ground segment

Next:
- Brokering MODIS Fire CCI v5.1 Burned Area, adapting chains to S3 OLCI sensors. Extension of the reference perimeters to 2018-2019, bring FRP into the service and prepare a strategy for its further evolution in C3S, intercomparison with CGL products.
**ECVs operational services**

*With products that are*

- State-of-the-art products
  - Coordination with ESA CCI, EUMETSAT, etc., & other Copernicus services
- Long-term, consistent, complete (CDR)
  - Single/Multi sensor approach
- Regularly extended in time (ICDR)
  - Frequent updates of data records
- Gridded, aggregated
  - Meeting user requirements

- Accessible & Traceable
  - Access through the Climate Data Store
  - Creation of adaptors, integration in CDS Toolbox
  - Documentation
  - Frequently supporting documentation produced in C3S (ATBD, PQAD, ...)
  - Evaluation and Assessment
  - EQC, own QC procedures, benchmarking, evaluation of cross-ECV consistency
  - User support
    - Service desks opened for many services
And beyond ...

- Provision of datasets with estimation of uncertainty

- Creation of use cases on-going

- Promotional activities (Conferences, press releases, education events, workshops)

- Contribution to the European State of climate; demonstrate the effectiveness of the inclusion of CDRs in climate monitoring

- Contribution to the next IPCC AR6 report

- Already providing key climate information to key stakeholders and policy makers
Example of Dataset Integration in the CDS

Soil moisture gridded data from 1978 to present

The system session is complete. Please report any issues to user support.

Overview Download data Documentation

This dataset provides estimates of soil moisture over the globe from a large set of satellite sensors. It is based on the ESA Climate Change Initiative soil moisture version 03.3 and represents the current state-of-the-art for satellite-based soil moisture climate data record production, in line with the "Systematic observation requirements for satellite-based products for climate" as defined by GCOS (Global Climate Observing System). Data are on a regular latitude/longitude grid approximately with gaps in space and time.

When dealing with satellite data it is common to encounter references to Climate Data Records (CDR) and interim-COR (ICOR). For this dataset, both the ICOR and COR parts of each product were generated using the same software and algorithms. The COR is intended to have sufficient length, consistency, and continuity to depict climate variability and change. The ICOR provides a short delay access to current data where consistency with the CDR baseline is expected but was not extensively checked. The dataset contains the following products: "active", "passive" and "combined". The "active" and "passive" products were created by using scatterometer and radiometer soil moisture products, respectively. The "combined" product results from a blend based on the two previous products.

More details about the product are given in the Documentation section.

DATA DESCRIPTION

Horizontal coverage: Global
Horizontal resolution: 0.25°x0.25°
Temporal coverage: 1978 to present
Temporal resolution: Day, 10-day and month
Update frequency: Depends on the product: 10-day for the ICOR and 6 month for the COR
File format: NetCDF
Data type: Grid

MAIN VARIABLES

<table>
<thead>
<tr>
<th>Name</th>
<th>Units</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>Surface soil moisture</td>
<td>%</td>
<td>Content of liquid water in a surface soil layer of 2 to 5 cm depth expressed as the percentage of total saturation.</td>
</tr>
<tr>
<td>Volumetric soil moisture</td>
<td>m$^3$ m$^{-3}$</td>
<td>Content of liquid water in a surface soil layer of 2 to 5 cm depth expressed as m$^3$ water per m$^3$ soil.</td>
</tr>
</tbody>
</table>

Contact
copernicus-support@ecmwf.int

License
License to Use Copernicus Products

Publication Date
2018-10-15

Landing page
Example of Dataset Integration in the CDS

Retrieving data

Soil moisture gridded data from 1978 to present

Day

- 01
- 07
- 13
- 19
- 25
- 02
- 08
- 14
- 20
- 26
- 03
- 09
- 15
- 21
- 27
- 04
- 10
- 16
- 22
- 28
- 05
- 11
- 17
- 23
- 29
- 06
- 12
- 18
- 24
- 30

Select  Overall

Format
- Op file (.op)
- Compressed tar file (.tar.gz)

Type of sensor
- Active
- Passive
- Combined passive and active

Type of record
- CDR (Climate data record)
- ICDR (Intermediate-climate data record)

Version
- v201812.00
- v201708.00

Terms of use
- License to Use Copernicus Products
- View terms

Show API request
Not yet toolbox compatible
Example of Dataset Integration in the CDS

Soil moisture gridded data from 1978 to present

The system session is complete. Please report any issues to user support.

Overview | Download data | Documentation

- Algorithm theoretical baseline document v2.2 (3.2M PDF)
  Provides in-depth documentation on the algorithms used to derive the dataset(s).
- Product user guide and specification document v2.3 (1.9M PDF)
  Summarizes the characteristics of the dataset(s) in a concise manner with focus on: space and time extent and resolution; data formats, metadata and flags; description of variables, strengths and limitations.
- Product quality assurance document v1.1 (2.5M PDF)
  Describes the data quality assurance process applied by the data producer before release of the dataset(s).
- Product quality assessment report v1.1 (3.4M PDF)
  Provides the latest report on data quality obtained according to methodologies described in the product quality assurance document.
- Target requirements document v1.0 (845.7K PDF)
  Summarises the minimum requirements identified for the dataset(s) regarding, among others, data quality, timeliness and data format.
- Gap analysis document v1.0 (1.4M PDF)
  Discusses identified gaps of the dataset(s) with respect to their target requirements.
- System quality assurance document v1.1 (1.1M PDF)
  Describes the processing chain and procedures in place at the data provider.

Documentation
## ECVs in ESA - CCI & C3S

<table>
<thead>
<tr>
<th>CCI</th>
<th>CCI+</th>
<th>C3S</th>
</tr>
</thead>
<tbody>
<tr>
<td>AG-Biomass</td>
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<tr>
<td>Aerosol</td>
<td>Aerosol</td>
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<tr>
<td>Albedo</td>
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<td>Clouds</td>
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<tr>
<td>Earth Radiation Budget</td>
<td>fAPAR</td>
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<tr>
<td>Fire</td>
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<td>LAI</td>
<td></td>
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<tr>
<td>Lakes</td>
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- **Both in CCI and C3S**
- **In CCI/CCI+ and not in C3**
- **In C3S and not in CI/CCI+**

<table>
<thead>
<tr>
<th>CCI</th>
<th>CCI+</th>
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<td>Surface Radiation Budget</td>
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<td>Water Vapour</td>
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</tbody>
</table>

- **Both in CCI and C3S**
- **In CCI/CCI+ and not in C3**
- **In C3S and not in CI/CCI+**