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Climate Modelling User Group

Deliverable 7.1

Climate Service Interface – Requirements and Roadmap

Centres providing input: Met Office, ECMWF, IPSL, Météo France, MPI-M, SMHI, BSC, DLR

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Climate Service Interface – Requirements and Roadmap

Contents

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1. Introduction

The purpose of this document is to examine current uptake of the CCI ECV[1] products by climate services and identify how this can be improved and extended. At the time of writing the main climate service accessing CCI data is the Copernicus Climate Change Service (C3S). The present status of this relationship is summarised and recommendations made on how it can be improved. Suggestions are made for providing the CCI data to other climate services such as CMA, JMA, NOAA and others and a roadmap is presented for CMUG's plans to facilitate this. This report builds upon an earlier CMUG report on CCI interactions with Climate Services (CMUG, 2017).

1.1 CCI Climate Modelling User Group (CMUG)

CMUG is the Climate Modelling User Group of the Climate Change Initiative (CCI) of the European Space Agency (ESA). CMUG assesses the CCI datasets through their use in climate models and reanalyses applying a range of applications and techniques. It examines climate consistency between CCI datasets and develops tools for evaluating both models and data. CMUG has recently conducted an extensive survey of user requirements (CMUG URD, 2021)[2], and maintains a dialogue with key international coordinating bodies and research centres with a specific interest or stakeholder role in climate services (ECMWF, EEA, JRC). These CMUG activities were used to inform this report.

The CMUG was established in 2009 to provide independent feedback on the CCI ECV data for climate modelling. This followed a recommendation of the CCI Climate Science Advisory Body and ESA's Earth Science Advisory Committee to "Bring an integrated climate system perspective within the CCI programme and to provide a forum for the Climate Modelling Community (CMC) and Re-analysis community to work closely together with the data providers". This motivation is just as relevant to climate services as users of climate data.

C3S and other climate services require climate data for their operational provision, the CCI can be an important source of such datasets and CMUG is in an ideal position to provide an interface

[1] See Section 6 for a list of acronyms.
[2] https://climate.esa.int/media/documents/CMUG_Baseline_Requirements_D1.1_v2.2_EUBGoPz.pdf

between the CCI projects and climate service providers. The CMUG partners are located in institutions across Europe and have a wide network in the climate community across the world, providing the contacts needed to set up and maintain a relationship which will be beneficial to CCI and the climate service providers. This document investigates what might be required of an interface between CCI and climate service providers and suggests a path by which CMUG can fill this role.

1.3 Climate Services

There are various climate services situated around the world. These are often part of a National Met Service (NMS), with notable examples being JMA, CMA, Met Office. To date C3S is the main climate service provider with which CCI projects interact. While we intend to broaden this to other providers this version of the report will focus most heavily on the current state of the relationship with C3S and how it can be improved.

1.4 Copernicus Climate Change Service (C3S)

The Copernicus Climate Change Service (C3S) forms part of the larger Copernicus programme, the European Union (EU) Earth observation programme for operational, independent and accurate data and information on environmental and security matters for Europe which started in April 2014. Copernicus consists of the six main components (Figure 1) structured as a user driven programme, built on existing national and European capacities, providing continuity with past and current activities. C3S, which is now operational, but still being developed, provides Essential Climate Variables (ECVs), climate analyses, projections and indicators at temporal and spatial scales relevant to adaptation and mitigation strategies for the different sectoral and societal areas of importance to the EU and other European countries. Information on how the CCI can support the C3S comprises the largest part of this report although other Copernicus services (e.g. Land, Atmosphere, Marine) are also included when relevant.

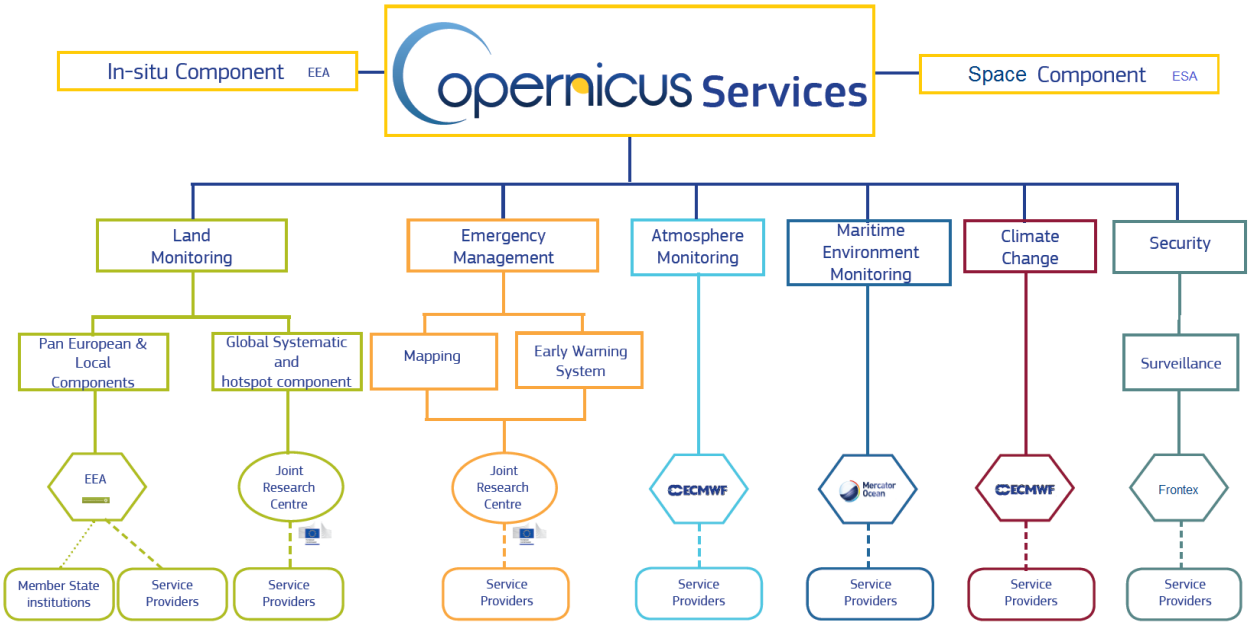


Figure 1: Organisation of the Copernicus Services. C3S is highlighted with a red box.

The C3S requirements for the ECV datasets are specified in the C3S ITT call C3S_312a published on 24 February 2016, and its follow-on ITT call C3S_312b published on 16 June 2017.

In its initial phase (C3S_312a), C3S had issued nine ITTs (one per ECV) and selected the nine consortia to deliver operational ECVs of SI, SSH, SST, O3, Aerosol properties, GHG, SM, Glaciers, and Albedo/FaPAR/LAI. Eight CCI consortia successfully responded to C3S ITT calls to transfer their operational activities to the C3S. In a second phase (C3S_312b), C3S issued a call for five consortia to cover 10 new ECVs on top of the existing ones. Each consortium, called "Lot", combines multiple ECVs related to atmospheric physics (Lot 1), atmospheric composition (Lot 2), ocean (Lot 3), land hydrology and cryosphere (Lot 4) and land biosphere (Lot 5). All except Lot 2 include one or more ECVs not yet covered by C3S_312a; all except Lot 1 include one or more ECVs already addressed by C3S_312a.

Other areas of common interest between CCI and C3S are the activities related to the Evaluation and Quality Control (EQC) of operational products included in the C3S data store and the sectoral information system products. A comparison of the C3S EQC ITT (2015) and the CCI CMUG Statement of Work (2014) highlights some elements of connection between these two activities. However, there are fundamental differences. For example, CMUG activities are oriented at assessing datasets under development in CCI and at no point evaluate the datasets in the CDS, which are the domain of the ECQ contactors. An account of the differences between

the C3S EQC and CCI CMUG is presented in Table 1.

There is clear synergy between the CMUG and C3S EQC that can be exploited to the benefit of both activities, for instance in the definition and application of evaluation and quality control best practices. From the CCI perspective, the use of a standardized, common methodology could facilitate the future uptake of new research products or of product upgrades by the operational service. A good overview is provided in Nightingale et al., (2019). From the C3S perspective, selection of new products would be eased if these were assessed with the same metrics and methods used by the EQC on the operational data. For an update on the EQC status please see https://climate.copernicus.eu/quality-assurance-copernicus-climate-change-service (accessed: 09/02/2021).

EQC mandate (C3S_51 ITT)	CMUG mandate (SoW ESA-CCI-EOPS-PRGM-SOW-18-0118)
EQC will conduct activities to monitor the technical service performance using standard key performance indicators (e.g., timeliness, data access and availability, etc.) as well as the scientific quality of the delivered products.	***The CMUG project team will independently assess the quality and impact that multiple CCI ECVs have in climate modelling and reanalysis … the CCI CMUG (is) pivotal to product validation and establishing community consensus.***
The EQC function will design routine reporting procedures to inform ECMWF and the Commission about the outcome of its investigations and propose appropriate ways to improve the service.	***CMUG shall coordinate a Climate Science Working Group (CSWG). This shall include key climate users from each ECV project. At least one member of the project's CRG shall participate in the CSWG session during the annual CMUG Integration Meeting.***
This [EQC function] includes identification of priorities for updates, upgrades and modifications of the operational production chain.	***Requirements analysis shall take into account the priorities of international climate assessments (e.g. IPCC AR6 WG1), and specific user requests for ECV data products, such as for use in e.g. model intercomparison exercises, climate services, or model down-scaling. The analysis shall take account of the latest GCOS status and implementation plan updates [RD-5], [RD-6] and GCOS guidelines [RD-2], feedback from GCOS and its panels (AOPC, OOPC, TOPC), relevant CMUG outputs, and results of***

	the on-going assessment of the WGClimate ECV Inventory.
This [EQC function] also includes a proactive engagement with users (via surveys, reports, structured/unstructured interviews and workshops) to ensure that user requirements are appropriately reflected in the design and content of the CDS.	***The CMUG will establish working links and information exchange between the CCI programme and the global climate modelling community at large, coordinating with relevant international activities related to climate modelling, such as WCRP, CMIP, Obs4MIPs, H2020 projects (e.g. FIDUCEO, GAIA-CLIM) and infrastructures such as IS-ENES2***
The EQC will also provide recommendations to the European Commission about needs for additional R&D efforts.	***GCOS provides the high-level specification of the target requirements for the Cloud ECV products in the GCOS Implementation Plan (2016, RD-1). These requirements have been further elaborated by CMUG.***

Table 1: Side-by-side comparison of the C3S EQC[3] and CMUG mandates as defined and in the CMUG Statement of Work (*SoW) 2018.*

Another area where C33 and CCI could mutually benefit from collaboration is in the definition of user requirements. Both programs have a strong basis in this activity which is conducted regularly. Although C3S requirements might include more service-oriented aspects, such as the request for operational data provision, some fundamental requirements related to the quality of the datasets or the type of variables that are of interest for climate applications should be examined in coordination.

1.4.1 CMUG partners working in C3S

Partners most involved with C3S are Angela Benedetti at ECMWF and Pablo Ortega at BSC.

In her position as an ECMWF scientist in the Research Department and with ECMWF being the entrusted entity which runs C3S, Angela Benedetti works very closely with C3S in terms of the exchange of ideas on aspects related to climate monitoring and ECVs. Moreover, the Climate Monitoring Facility, funded by CCI, is being included in the C3S Toolbox which is being developed by ECMWF. Angela coordinates the scientific aspects of that activity and Iryna Rozum who is part of the Copernicus Department / C3S team takes care of the technical aspects.

[3] https://climate.copernicus.eu/sites/default/files/2019-11/06%20Obregon_EQC_GA.pdf

Complementary climate prediction research activities in CMUG and C3S are undertaken by BSC. CMUG contributions have a more scientific focus and include an exploration of the benefits of assimilating sea ice data on the forecast skill, as well as a forecast evaluation of the latest decadal prediction system with EC-Earth, using the longest ESA CCI products available. BSC contributions to C3S are through the C3S_34c contract which aims to develop a prototype service for decadal climate predictions. This involves the production of single-model and multi-model forecast probabilistic products, which include the same EC-Earth decadal prediction system developed and evaluated in CMUG. This implies that forecast improvements enabled by CMUG research will have a positive impact on the final products developed in C3S_34c.

At DLR Birgit Hassler is involved in C3S_511 ("Quality Assessment of ECV Products"). The main task in this C3S service consists of performing independent quality checks of products available at the climate data store (CDS), which are then summarized in "single product quality briefs". The 511 service is still ongoing and current work consists mainly of assessing ERA5 reanalysis data. In the past, former ESA CCI GHG datasets XCO2 and XCH4 have been assessed and summarized in single product quality briefs.

Jean-Christophe Calvet at Meteo-France has used ERA5 from C3S to force their land surface model in offline applications. However, they have been unable to use the last C3S version of the LAI product because this is "effective" LAI and not the "true" LAI, which is required.

1.5 Structure of report

Section 2 outlines the scientific and technical features of CCI products. More detailed analysis for each ECV can be found in the Phase 2 version of this report (CMUG, 2017) and the four previously published Quality Assessment Reports (QARs) (CMUG, 2016; CMUG, 2017a; CMUG, 2017b; CMUG, 2020) and will not be repeated here. A second version of CMUG Phase 3 QAR is due in June 2021.

Section 3 identifies which CCI products are being generated in a production environment by C3S and then discusses any gaps or deficiencies in these existing datasets.

Section 4 summarises current interactions between C3S and CCI and suggests ways in which this could be improved.

Section 5 outlines a roadmap for next steps to improved collaboration and communication between CCI and Climate services other than C3S (e.g. JMA, CMA, NASA etc.). This will involve taking stock of their requirements and facilitating an exchange of ideas and data with the CCI projects.

2. Scientific and Technical features of CCI data relevant to Climate Services

2.1 General scientific features of CCI data

The current set of 23 CCI ECVs have achieved, or are, with a few exceptions, working towards achieving the following specifications:

- decadal or longer time scale datasets
- good global and regional coverage
- high temporal resolution (sub-daily to monthly) [not applicable to LC and HRLC – yearly data at most]
- comprehensive characterisation of uncertainties (including estimates of random errors)
- accurate and realistic climate variability
- reliable estimates of long-term climate trends
- validated (often against *in situ* data) homogenous, high quality climate data
- excellent provenance to source
- already well linked to user communities (mostly research but includes others)

2.2 Specific features of CCI data

A number of specific features characterize the CCI ECVs that are desirable in any dataset which an operational, user-driven climate service would provide, in addition to the general features summarized in section 2.1. These include:

- **User requirement-based datasets:** The user requirements set by GCOS were considered as starting goal requirements for the ECVs. In addition, potential CCI ECV users are periodically engaged to provide application-specific user requirements for each ECV. These requirements are independently collected by CMUG and each CCI team from as many users and sectors as possible, they are documented and periodically revised. Many of these user requirements have now been met.
- **Algorithm Maturity:** Most CCI teams have reached a good algorithm maturity resulting from i) objective algorithm selection through Round-Robin inter-comparisons of available European models, ii) identification in the selected algorithm(s) of areas in need of improvements to meet the user requirements, iii) fully documented ATBDs, iv) fast turn-around with typically one-year cycle required to go from updating the algorithm to releasing validated datasets to users for most CCI ECVs. Some CCI+ teams are still working on achieving some of these goals.
- **Data Maturity:** Each dataset is fully characterized. Metadata are included with each product and fully documented uncertainty characterization with quantitative estimates

at pixel level for Level 2 data in most cases. User-friendly flags are routinely included in ECV product format and specification with datasets validated by each ECV Climate Research Group and independently by CMUG. Details on data format, data compliancy, levels of processing, and data access are given in chapter 3. Many CCI ECVs were both self-assessed and assessed by the Core-CLIMAX[4] consortium using the Core-CLIMAX Data Maturity Matrix before and during the 2014 Core-CLIMAX Workshop[5].

- **Temporal coverage:** An important element of CCI was to create long, consistent time series of ECVs exploiting a number of available satellite instruments. This was achieved by applying the ECV state-of-the-art algorithm selected through the round-robin exercise to different sensors. Whenever applicable, the single-sensor datasets were merged together to produce longer time series. Attention was paid to inter-instrumental biases to avoid sudden, unphysical jumps in the obtained records.
- **Consistency:** This aspect is considered at many levels. In Phase 1, all CCI teams were encouraged to use the same source of a priori information, namely the ERA-Interim reanalysis. This aspect was achieved throughout the CCI. A Land-Sea Mask (LSM) and a Freshwater Mask have been produced by the Land Cover project and other CCI teams and independent researchers are encouraged to use these masks for consistency. (see also section 3.5). Examples of improved internal consistency with other model variables and/or non-CCI observations used in the user models has been already documented (e.g. the assimilation of the CCI GOME-2 ozone profiles improved the fit to the assimilated AIRS ozone-sensitive radiances, CMUG QAR 2015). Activities are also on-going to improve across-ECV consistency. For instance, Aerosol-CCI and Cloud-CCI collaborate to ensure a consistent interpretation in their own algorithms of the same measurements when they are found to be either cloud-affected or aerosol-affected pixels.
- **Added value:** Many of the assessments performed to date confirm the quality of most CCI ECVs and their potential added value to several applications. This is corroborated by the wide use of many CCI datasets in international assessments like the IPCC AR5 and the 2014 WMO Ozone Assessment, as well as by the usa of, for instance, many O3-CCI products in the C3S ERA5 reanalysis.
- **Documentation:** For each CCI ECV, the following documents are publicly available and periodically updated: i) Algorithm Theoretical Basis Document; ii) Uncertainty Characterization Report; iii) Product User Guide**;** iv) Product Validation Plan; v) Product Validation Inter-comparison Report; vi) Climate Assessment Report (CAR); vii) System Specification Document. Results are also documented in peer reviewed papers (an excess of 700 papers have already been published by the CCI). All the above

[4] https://www.ecmwf.int/en/research/projects/core-climax
[5] https://cordis.europa.eu/project/id/313085/reporting

documents are reviewed by CMUG. In addition to the ECV CAR, periodic assessments are independently carried out by CMUG (CMUG QAR 2015, see also section 2.3).

In addition to the value of each single ECV, it is worth mentioning and should not be underestimated that the CCI programme has brought together scientists from very diverse backgrounds dedicated to tackle specific scientific questions, creating a closely-linked community. This community has blossomed with time and has promoted a number of cross-ECV studies to improve their products (as discussed above between Aerosol and Cloud-CCI), and to address and explain some of today's climate change signatures. An example of the latter is represented for instance by the CCI project set up to investigate Sea Level Budget Closure (SLBC). Phase one of this project concluded in 2019 and a second phase is currently under preparation. The SLBC project involves all CCI teams that work with ECVs relevant, or could be related, to Sea Level changes, for instance Glacier-CCI, and might also provide information relevant to climate change services and their users.

2.3 Potential applications for CCI data in Climate Services

Climate services are concerned with a variety of users and sectors, including:

- Climate monitoring and attribution
- Reanalyses
- Seasonal forecasts
- Climate data applications
- Adaptation community (including EEA)
- Mitigation community (including national governments and the EC)
- System users (for instance town planner, governments, Climate services at a national level, (for example the UK Climate Change Risk Assessment defines user requirements with respect to addressing climate change in different systems and sectors)
- Sectoral users in the following sectors: water, agriculture, forestry, fisheries, energy, health, insurance, tourism, transport, infrastructure, natural environment, and others

All CCI ECVs are potentially useful in several of these applications and sectors.

It is recognized that each category of data users and sector listed above have very specific data requirements and the CCI has put user-requirements at the centre of its activity. Detailed user-requirements have been collected independently by CMUG and by each CCI team through surveys and one-to-one interviews with expert users, these are documented and periodically reviewed and can be found on the project web sites[6].

[6] https://climate.esa.int/en/projects/

Here, we want to link the applications and validation work performed by CMUG on the CCI ECVs to the above list to demonstrate how the CCI climate datasets can support the aims and objectives of climate services.

In Phase 3 CMUG deals with many ECVs, often simultaneously. These are used in assimilation or model evaluation, including boundary conditions, using both global and regional climate models. Different levels of data processing are also considered. The overall work is summarised in Table 2 where the penultimate column gives an indication of potential climate users and applications these assessments could be relevant to.

	Ocean						Atmosphere					Land															
CMUG model	**SST**	**SSS**	**Sea State**	**Sea Level**	**Sea Ice**	**Ocean Colour**	**Water Vapour**	**Ozone**	**GHG**	**Clouds**	**Aerosols**	**Soil Moisture**	**Snow**	**Permafrost**	**LST**	**MRLC**	**Lakes**	**Ice Sheets**	**HRLC**	**Glaciers**	**Fire**	**Biomass**		**CMUG Assessment**	**Climate data users, applications, sectors and International Studies**	**Model used by which CMUG partners?**
IPSL-CM (Atmosphere-Land) component													X	X		X	X					X		Process oriented evaluation		IPSL
ISBA Land Surface Model													X	X	X	X								Reanalysis, Benchmarking	CMIP6, NWP, climate services (e.g. drought monitoring)	Meteo-France
NMMB-												X					X			X				Assimilation		BSC
EC-Earth	X	X		X	X						X	X					X							Assimilation, Seasonal-to-decadal	CMIP6/DCPP, WMO-endorsed operational Anuual-to-decadal climate predictions	BSC
ECMWF IFS composition configuration									X			X												Assimilation and feedback to reanalysis	CAMS users (solar energy, boundary conditions for European air quality, global pollution, etc)	ECMWF
ECMWF IFS NWP configuration									X															Assimilation and feedback to reanalysis	C3S users/sectorial applications	ECMWF
MPI-ESM/CMIP6	X	X				X								X		X								Statistical	CMPI6	MPI
JULES													X			X	X			X			X	Statistical Analysis	CMIP6	MO
UKESM1	X	X	X	X	X	X							x			x							x	Process oriented evaluation. Assimilation, reanalysis, benchmarking	CMIP6, reanalyses, operational forecasting	MO
ERA-interim re-analysis downscaled with the HadREM3-GA7.05 regional																		X						Process oriented evaluation	Climate Model Evaluation (C3S)	MO

Table 2. Overview of the CMUG Phase 3 models and assessments in relation to potential C3S users and applications, as well as international assessments.

CMUG has contributed to the development of **ESMValTool**[7] and the **CMF**[8], two tools relevant to assessments of climate products. ESMValTool is used to evaluate CMIP climate models through the definition of model evaluation diagnostics which include CCI ECV data; the CMF allows rapid investigation of the homogeneity and consistency of climate data sets by comparing pre-defined products.

[7] https://www.esmvaltool.org/
[8] https://apps.ecmwf.int/climate-monitoring/

A Quality Assessment Report will be published every year providing updates on the Table 2 assessments. The first CMUG Phase 3 (CCI+ Phase 1) report was published in March 2020, an update is due in March 2021 (currently delayed due to impact of COVID-19), and the final version in January 2022.

2.4 Data formats and conventions

All CCI ECVs are produced in CF compliant NetCDF format. Metadata are provided with each product. To meet different users and application requirements, the CCI ECVs are provided at different levels of processing (see section 2.7). Fully documented uncertainty characterization with quantitative estimates at data level (i.e. at pixel level for the L2 datasets) are provided in many cases. Data versioning is used with all CCI ECV datasets, with agreement on the need for using DOI identifiers for each ECV release to ensure data traceability and how these identifiers can be obtained.

A **PSD** (Product Specification Document) and a **PUG** (Product User Guide) are available for all products to guide users on how to best use the CCI ECVs. These are in addition to the **CRDP** (Climate Record Data Package) which contains information for users about the data.

For some CCI ECVs, gridded products from the latest release are also produced in the obs4MIPs format and are available through the obs4MIPs website for use in evaluating climate models. CMUG continues to work towards including mature CCI datasets on obs4MIPs with the aim that all relevant datasets should be available through this database.

2.5 Metadata

Metadata are required with the satellite CDRs, and these must be clearly documented. Examples include a timeline of both satellite and instrument related anomalies, documentation on version of level 1 processing, what ancillary datasets have been used in the level 2 processing, and processing algorithm versions at all levels.

Every dataset and/or service provided by climate services will have to be documented using the appropriate metadata standards (ISO19115, source C3S_23a). All CCI ECVs have been enriched with detailed metadata, but whether this adheres to the required standards will need to be ascertained.

2.6 Data access

Access to the CCI ECVs is free and open, although some do require registration before access is granted. The CCI data portal provides users easy access to all CCI data and it is currently being populated with the latest CCI releases (https://climate.esa.int/en/odp/#/dashboard).

Although many users might not need software and tools to display the CCI data, for those that do the Climate Monitoring Facility (CMF, https://apps.ecmwf.int/climate-monitoring) is currently under further development and will become part of the C3S toolbox. The CMF is an interactive interface to visualize and facilitate confronting models with L3 observation products with a focus on multi-annual variability of statistical averages (monthly/regional means) based on pre-calculated mean statistics. It relies on a database (CMFDb) populated with pre-calculated statistical averages of an excess of 100 distinct variables defined over 32 different geographical regions, 12-18 layers (if applicable), and several data streams (various reanalyses and several CCI datasets).

This tool could be useful to understand the low-frequency variability of the CCI ECV, and contrast it to that of equivalent ECV model and reanalysis products, determine the long-term homogeneity of the various datasets in terms of regional monthly means and perform a consistency analysis between different CDRs. However, caution should be used when drawing conclusions from these comparisons, as differences may occur in the data coverage of different data sets used to produce those averages.

2.7 Level of processing

To meet different user and application requirements, the CCI ECVs are provided at different levels of processing.

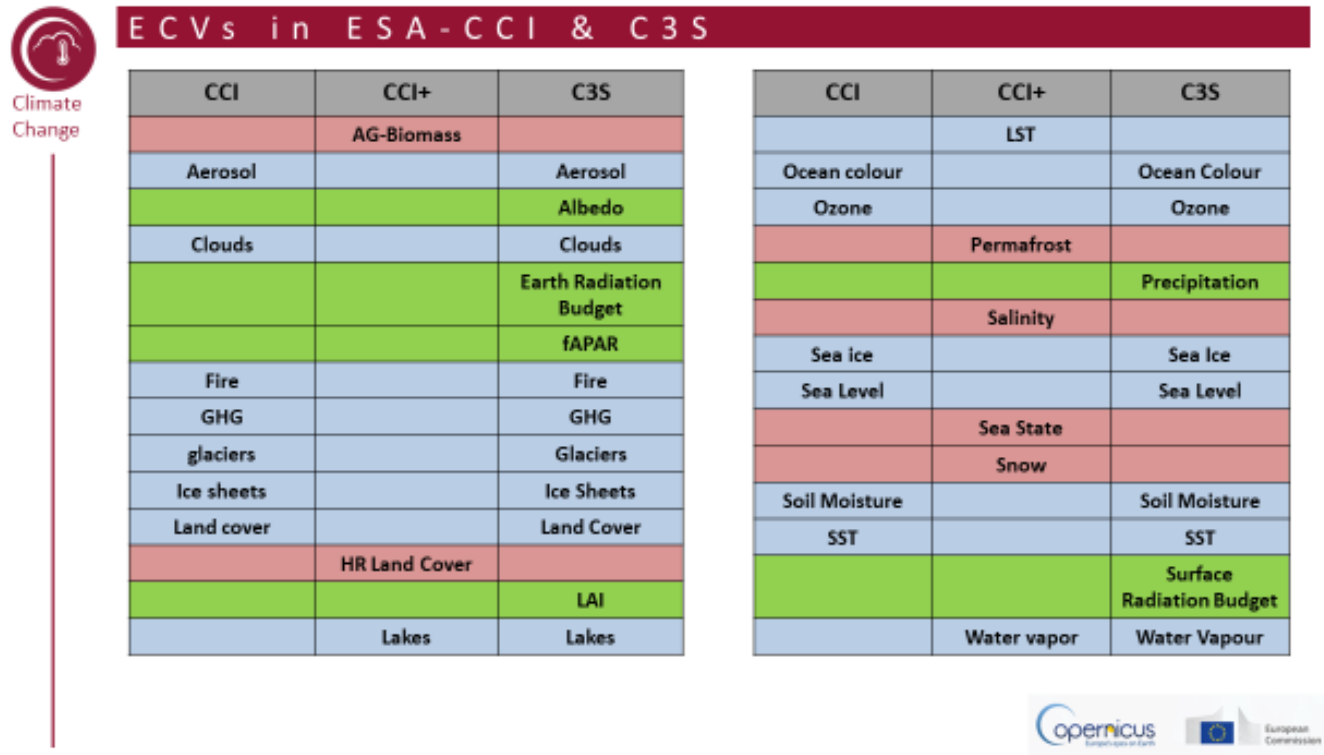
Level 0-1 processing and the implementation of Level 0-1 algorithm improvements is carried out by the ESA sensor Quality Working Groups (QWGs). CCI gives feedback on Level 0-1 processing, to report issues and propose solutions, but it is assumed that appropriate Level 1 (L1) data exist. Level 1-2 and Level 2-3 processing to produce orbit-based and gridded ECVs are responsibilities of the CCI projects.

The CCI ECV data sets are derived globally whenever applicable and whenever measurements are provided globally. Vertically resolved ECV products are also available when the instrument information content permits it. CCI L3 daily and/or monthly mean gridded products are available whenever applicable. These averaged products also include information on their uncertainties. Discussions and workshops have been organized by CCI teams to characterize user requirements for uncertainties, and best practices.

3. CCI products currently used by C3S

Most CCI products are being extended in C3S and work has begun on including some ECVs from CCI+. A list is provided below in Table 3. Blue rows indicate the ECVs provided by CCI/CCI+ and extended by C3S.

For each ECV C3S uses it has produced a Gap Analysis Document (GAD) which contains information on where the gaps or areas for improvement lie for each dataset, links to these documents can be found in the CDS[9]. CMUG recommends that CCI projects read and act on this Gap analysis, if they do not already.



CCI	CCI+	C3S
	AG-Biomass	
Aerosol		Aerosol
		Albedo
Clouds		Clouds
		Earth Radiation Budget
		fAPAR
Fire		Fire
GHG		GHG
glaciers		Glaciers
Ice sheets		Ice Sheets
Land cover		Land Cover
	HR Land Cover	
		LAI
	Lakes	Lakes

CCI	CCI+	C3S
	LST	
Ocean colour		Ocean Colour
Ozone		Ozone
	Permafrost	
		Precipitation
	Salinity	
Sea ice		Sea Ice
Sea Level		Sea Level
	Sea State	
	Snow	
Soil Moisture		Soil Moisture
SST		SST
		Surface Radiation Budget
	Water vapor	Water Vapour

Table 3: CCI ECVs currently extended by C3S *(pers. Comm. Joaquin Munox Sabater)*

At present (March 2021) C3S are not in a position to begin take up of any new datesets, but land ECVs will be the priority when work begins on this again (*pers. Comm*. Joaquin Munox Sabater).

[9] https://cds.climate.copernicus.eu/cdsapp#!/dataset/

4. Priorities for future use of CCI data by C3S

As shown in Section 3 fifteen CCI ECVs are currently extended by C3S: Aerosol, Cloud, Fire, GHG, Glaciers, Ice Sheets, Land Cover, Lakes, Ocean Colour, Ozone, Sea Ice and Sea Level, Soil Moisture, SST and Sea Level. These projects should be encouraged to read the gap analysis provided by C3S and take into account this analysis when planning future phases.

Six of the CCI ECVs are not extended by C3S: Biomass, HRLC, Permafrost, Salinity, Sea State and Snow. These are all CCI+ projects and as such are still in their main research and development phase. For future planning they should be considering climate service requirements as listed in Section 2.1 and 2.2.

Six ECVs extended by C3S are not provided by CCI: Albedo, Earth Radiation budget, FAPAR, LAI, Precipitation and Surface Radiation Budget. These ECVs might be considered by the CCI for future phases.

Communications are already good at a top level between CCI and C3S and some CCI ECV projects have an established relationship. The newer CCI+ projects are unaware of the procedure for providing data to C3S and CMUG can help here. CMUG will proactively approach these projects to provide advice and facilitate communications with C3S.

5. Roadmap for use of CCI data in Climate Services beyond C3S

For version 2 of this report CMUG will gather information on interactions between the CCI+ and climate services other than C3S, this will establish the current status of interactions and identify any gaps. CMUG will then encourage and facilitate communication between the climate services not already in contact with CCI and the relevant projects. CMUG will also contact the main climate services (list to be confirmed) and request information on their needs in terms of climate datasets with the aim of facilitating provision of these datasets by CCI where appropriate. A timeline for the CMUG plans is shown in Figure 2.

Timeframe	Action	CMUG partner responsible	Desired outcome
May-June	Contact Climate Services	Angela Benedetti (ECMWF)	Build a network of contacts
May-June	Survey CCI projects	Amy Doherty (MO)	Gather information on existing interactions with climate services
June-July	Survey CS	Angela Benedetti (ECMWF)	Gather information on dataset needs
July-Aug	Analyse results of both surveys	Amy Doherty (MO)	Match up CS requirements with products provided by CCI projects
Sept-Oct	Follow up requests for information	Amy Doherty (MO)	As above
Nov-Dec	Write up results of analysis and communications	Amy Doherty (MO) and Angela Benedetti (ECMWF)	Version 2 of this report

Figure 2: CMUG timetable for the next version of this report.

6. Acronyms

AAI	Absorbing Aerosol Depth
AATSR	Advanced Along-Track Scanning Radiometer
AE	Stratospheric Extinction Profile
ADV	AATSR Dual-View
AGB	Above Ground Biomass
AOD	Aerosol Optical Depth
AERONET	AErosol RObotic NETwork
ATBD	Algorithm Theoretical Baseline Document
AVISO	Archiving, Validation and Interpretation of Satellite Oceanographic data
BSC	Barcelona Supercomputing Centre
C3S	Copernicus Climate Change Service
CAR	Climate Assessment Report
CC	Cloud Cover
CCI	Climate Change Initiative

CCIAV	Climate Change Impacts, Adaption and Vulnerability
CF	Climate and Forecast
CDO	Climate Data Operator
CDR	Climate Data Record
CDS	Climate Data Store
COT	Cloud Optical Thickness
CMA	China Meteorological Administration
CMC	Climate Modelling Community
CMF	Climate Monitoring Facility
CMIP	Coupled Model Inter-comparison Project
CMUG	Climate Science Working Group
CRDP	Climate Record Data Package
CSS	Climate Safeguards System
CTH	Cloud Top Height
CTP	Cloud Top Pressure
CTT	Cloud Top Temperature
DLR	German Aerospace Centre
EC	European Commission
ECV	Essential Climate Variable
EEA	European Environment Agency
ECMWF	European Centre for Medium Range Weather Forecasting
ENSO	El Niño–Southern Oscillation
EO	European Earth Observation
ESMValTool	Earth System Model eValuation Tool
EQC	Evaluation and Quality Control (of the C3S)
EU	European Union
GCOS	Global Climate Observing System
GHGs	Greenhouse Gases
GRADS	The Grid Analysis Display System
HRLC	High Resolution Land Cover
IPCC	Intergovernmental Panel on Climate Change
ISO	International Organisation for Standardisation
ITT	Invitation To Tender
IWP	Ice Water Path
JMA	Japan Meteorological Agency
JRA	Japanese Reanalysis Project
JRC	Joint Research Centre
KPIs	Key Performance Indicators

LC	Land Cover
LP	Limb Profile
LSM	Land-Sea Mask
LST	Land Surface Temperature
LWP	Liquid Water Path
MACC	Monitoring Atmospheric Composition and Climate
MERRA	Modern-Era Retrospective Analysis for Research and Applications
MODIS	Moderate Resolution Imaging Spectroradiometer
NASA	National Aeronautics and Space Administration
NCEP	National Centres for Environmental Prediction
NMS	National Meteorological Services
NP	Nadir Profile
NRT	Near-Real-Time
NSIDC	National Snow and Ice Data Centre
O3	Ozone
OC	Ocean Colour
OGC	Open Geospatial Consortium
ORA-S4	ECMWF Ocean Reanalysis – System 4
PSD	Product Specification Document
PUG	Product User Guide
QWGs	Quality Working Groups
REF	Cloud Effectiveness Radius
RCA	Rossby Centre Regional Climate model
SI	Sea Ice
SIC	Sea-Ice Concentration
SICCI	Sea-Ice Climate Change Inituative
SIE	Sea-Ice Extent
SIT	Sea-Ice Thickness
SLBC	Sea Level Budget Closure
SM	Soil Moisture
SMR	Sub-Millimetre Radiometer
SRD	Systems Requirements Document
SSH	Regional Sea Level
SSS	Sea Surface Salinity
SST	Sea Surface Temperature
SU	Swansea University
TO	Total Column
UERRA	Uncertainties in Ensembles of Regional ReAnalysis (ECMWF)

URD	User Requirements Document
WMO	World Metrological Organisation
WV	Water Vapour
XCH4	Methane
XCO2	Carbon Dioxide

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