ECMWF Copernicus Procurement

Invitation to Tender

Copernicus Joint Services

Web Application for Interactive Visualisation of Satellite-Derived Essential Climate Variables

Volume II: Specification of Requirements

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1 Introduction

1.1 Rationale

The European Centre for Medium-Range Weather Forecasts ("ECMWF") issues this Invitation To Tender (ITT) to obtain proposals for a web application for interactive visualisation of the satellite-derived Essential Climate Variables (ECVs) provided by the Copernicus Climate Change Service (C3S).

The Copernicus Programme is the European Union's (EU) flagship programme that aims to support policymakers, businesses, and citizens with enhanced environmental information. The C3S is a component of the Copernicus Programme and is implemented by ECMWF on behalf of the European Commission (EC). It provides authoritative information in support of climate change adaptation and mitigation strategies.

The primary C3S mission is to provide relevant climate information to a broad audience, from researchers and stakeholders to media, the public, and the private sector. It aims to a) inform policy development to protect citizens from climate-related hazards such as high-impact weather events, b) improve the planning of adaptation practices for key human and societal activities, and c) promote the development of new applications and services for the benefit of society.

To support this mission, the C3S provides a wide array of high-quality climate data products, including long-term, consistent records of ECVs as defined by the Global Climate Observing System (GCOS, 2021). GCOS has specified a list of 55 ECVs representing measured quantities deemed essential to collectively provide a comprehensive view of Earth's climate, its variability, and trends (Bojinski, et al., 2014). At present, the C3S ECV portfolio includes approximately 40 products across 21 ECVs, all derived from satellite observations. In the future, there is planned expansion both in the number of ECVs covered and the number of products offered per ECV.

Alongside an array of other quality-controlled climate datasets, these ECV products are made publicly available via the Copernicus Climate Data Store (CDS). The CDS is the vehicle that C3S uses to provide free, open and reliable access to climate datasets, as well as a variety of high-level utilities to process them. Including those related to the ECVs, these datasets often comprise high volumes of data. Though highly experienced users have the necessary knowledge and tools to handle such volumes of data, many other users find it challenging to access and use the data effectively. Furthermore, while most ECV datasets offer temporal and spatial aggregations that reduce data volume, some users prefer minimal data processing and instead seek concise information in a graphical form.

The above highlights a clear opportunity to better serve the diverse user base by offering an alternative way to derive insights from the ECV datasets, one that strikes a balance between user-friendliness and informational depth. Accordingly, interested parties are invited to submit proposals for the development of an interactive web application to visualise the data from the satellite-derived ECV CDS catalogue entries.

Useful links in the context of this ITT Volume II:

Reference	**Link to site**
ECMWF	https://www.ecmwf.int/en/about/what-we-do
Copernicus Climate Change Service (C3S)	https://climate.copernicus.eu
Climate Data Store (CDS)	https://cds.climate.copernicus.eu
Climate Data Store Background Information	https://cds.climate.copernicus.eu/background
Essential Climate Variables (ECVs)	https://gcos.wmo.int/site/global-climate-observing-system-gcos/essential-climate-variables
Earthkit	https://github.com/ecmwf/earthkit

Examples of Interactive Visualisation Applications	
C3S Applications	https://cds.climate.copernicus.eu/applications
Copernicus Interactive Climate Atlas	https://atlas.climate.copernicus.eu/atlas
UN Teal Tool	https://www.uncclearn.org/teal-tool-climate-data-for-everyone
NASA Sea Level Explorer	https://earth.gov/sealevel/sea-level-explorer/?view=map
NOAA View Global Data Explorer	https://www.nnvl.noaa.gov/view/globaldata.html

1.2 Background Information

1.2.1 Essential Climate Variables (ECVs)

Each of the 55 ECVs has been selected by GCOS (GCOS, 2021) as a critical indicator for monitoring Earth's climate. Together, they offer a comprehensive view of the climate system, enabling the study of climate evolution and providing insights for assessing climate risks, guiding adaptation and mitigation efforts, and supporting climate services.

All ECVs are placed into one of three broad categories (atmosphere, ocean, land), and then further divided by domain (e.g. Atmospheric Composition, Ocean Biogeochemistry). The 55 ECVs contained within these domains have constituent ECV products, which are measurable parameters needed to characterise the ECV. These ECV products are subject to requirements, and must meet certain standards in areas like horizontal, spatial and temporal resolution, as well as timeliness and uncertainty characterisation (GCOS, 2022).

1.2.2 C3S Services for ECVs

At present, the C3S provides satellite-derived datasets for 21 of the 55 ECVs (see Appendix A). This figure will eventually rise to 31, with six additional datasets planned in the near term and an additional three in the longer term; this is close to the maximum achievable with current satellite technology. These datasets are made available to the public via the CDS. Comprehensive documentation is provided alongside the datasets. This includes detailed descriptions of the operational algorithms used in the product generation, results from quality assessments, a user guide and training materials.

The work outlined in this ITT Volume II is a key part of a wider effort to improve the visibility, accessibility, and usability of the satellite-derived ECV products provided by the C3S. Alongside this project, a comprehensive redesign of the ECV section of the C3S website will be undertaken to create a revitalised, dedicated space for ECVs that is both highly visible and easily navigable. Other planned enhancements include the development of an ECV dashboard that will present key climate indicators using ECV products and short pieces of accompanying text.The DSS Infrastructure

The Data Stores Service (DSS) is a vital conduit between users and a vast network of distributed climate data sources, providing centralised, streamlined access to datasets that can sometimes comprise many petabytes of data. The DSS is a specific deployment of a modular, cloud-native architecture designed by ECMWF and run on the ECMWF Common Cloud Infrastructure (CCI) that is physically located at the ECMWF Bologna Data Centre. It is comprised of the following main architectural components:

- **Data layer**: Comprises both data hosted within and outside of the CCI, known as internal and external data respectively. Includes an Analysis Ready, Cloud Optimised (ARCO) data lake.
- **System layer:** The core engine, comprising software components that deploy and run together to expose the catalogue contents and serve the data to users in a fair and reliable way.
- **Business layer:** This provides the DSS instantiation of the above as a branded Data Store, such as the Climate Data Store (CDS) and Atmosphere Data Store (ADS)

Alongside the DSS are several interlinked components, such as Earthkit and the C3S applications. Earthkit is an open-source Python project led by ECMWF that provides a set of expert libraries optimized for the Copernicus data sources. The C3S applications offer a visual and interactive interface the data products available in the CDS, a notable example being the Copernicus Interactive Climate Atlas (C3S Atlas).

1.3 Contract Vision and Objectives

Vision: An interactive web application that displays all the satellite-derived ECV products provided by the C3S, enables user-initiated computations to deliver tailored metrics, and allows users to download visualisations and data.

As outlined in section 1.2.2, the creation of the ECV visualisation application is part of a wider effort to improve the visibility and accessibility of the ECV information and services provided by the C3S. Accordingly, the guiding objective of this project is to improve the accessibility of the ECV information, providing the opportunity to explore the satellite-derived ECV datasets available on the CDS to users with all levels of data-handling experience.

At the same time, the visualisation application should showcase the importance of satellite-derived ECVs in understanding the Earth's climate evolution by emphasising their strengths with regards to their spatial and temporal coverage, and complementary nature. This will be achieved through the implementation of various functionalities, such as a point timeseries capability and interactive temporal exploration as described in section 2.3.

It is anticipated that the project will be delivered in four phases:

1. The **first phase** will focus on the development of a proof-of-concept (POC) application that meets the POC requirements detailed in section 2, and which will visualise a pre-determined set of priority (of 'flagship') ECV products described in section 3.23.2. This first phase will allow both parties to evaluate the application's basic functionality, usability, and alignment with the agreed requirements.

   Upon mutual agreement and ECMWF's request for service (see also section 3.2 last boxed text), the **other phases** will begin:

2. The **second phase** will focus on implementing all required functionalities, resulting in a fully functional web application featuring the flagship ECVs.

3. The **penultimate phase** will expand the scope of the application by incorporating the full range of satellite-derived ECV products provided by C3S. During this phase the Successful Tenderer will also have the opportunity to explore the use of Artificial Intelligence (AI) to improve the usability of the application.

4. the **final phase** will see the application maintained through the integration of new data.

Given the information above, the broad objectives can therefore be summarised as follows:

- Generation of the pre-calculated metrics for the flagship ECV products (described in section 3.2)
- Creation of a proof-of-concept web application, that delivers functionalities fulfilling the POC requirements for the flagship ECV products
- Further development of the application to incorporate the full range of required functionalities
- Expansion of the scope of the fully functional application to incorporate the full range ECV products provided by C3S
- Maintenance of the application through integration of data updates and newly available ECVs

To realise this vision and achieve these objectives, the C3S seeks external expertise for the creation of this application, which should meet the requirements described in section 2.

1.4 Glossary

Name	Definitions
API	Application Programming Interface
Application	An interactive web page that displays maps, graphs and/or textual information that are the results of computations performed on the data and products of the Data Stores
CCI	Common Cloud Infrastructure
CDR	Climate Data Record
CDS	Copernicus Climate Data Store
FCRS	Coordinate Reference System
C3S	Copernicus Climate Change Service
C3S Atlas	Copernicus Interactive Climate Atlas
DSS	Data Stores Service
ECMWF	European Centre for Medium Range Weather Forecasts
ECV	Essential Climate Variable
ECV Product	The constituent products of each ECV. For example, the Fire ECV has the products Burned Area, Active Fires, and Fire Radiative Power (FRP).
EU	European Union
FAIR	Acronym for Findable, Accessible, Interoperable, Reusable
Functional Requirement	Functional requirements specify what the application should do to meet user needs
GCOS	Global Climate Observing System
ICDR	Interim Climate Data Record
ITT	Invite To Tender
KOM	Kick-off Meeting
KPI	Key Performance Indicator
Metric	In the context of this ITT, a quantifiable measure used to describe specific characteristics of an Essential Climate Variable (ECV) product, such as uncertainty values, indices, trends, or other statistical indicators that support evaluation, comparison, and decision-making.
MVP	Minimum Viable Product
MoM	Minutes of Meeting
Non-Functional Requirement	Non-functional requirements define the quality attributes and constraints under which the application must operate
WMO	World Meteorological Organisation
WP	Work Package

2 Project Requirements

2.1 Introduction

The following sections detail the project requirements, outline the envisaged technical stack and describe the anticipated functionalities of the web application. The requirements are divided into non-functional and functional requirements. The former define the quality attributes and constraints under which the application must operate, while the latter specify what the application must do to meet user needs.

All enumerated requirements describe a baseline of how ECMWF envisages the application to be implemented. They are by no means a constraint for the solution to be proposed by the Tenderer but shall serve as a guide to define the scope of the proposal.

2.2 Non-Functional Requirements

The proposed solution shall meet the following set of Non-Functional Requirements:

Compatibility with DSS infrastructure: It is anticipated that all delivered components will ultimately be hosted and run in the in-house Cloud Infrastructure physically located in ECMWF premises in Bologna (Italy). Therefore, delivered components must include a reproducible, transferable deployment mechanism, preferably based on technologies that ECMWF are familiar with (i.e. Kubernetes, Helm, and Docker). ECMWF will facilitate the computing and storage resources required for the development and operational implementation of the application and will support technical requirements at Cloud level. The suitability and costs associated with the required infrastructure will be part of the evaluation criteria.

Software Stack: Tenderers shall propose software solutions which are the most practical and cost effective for ECMWF's intended use and future evolution and maintenance. Use of open-source software is greatly preferred whenever possible. For the front-end component, use of TypeScript and modern React tools is encouraged, and implementation of Matamo is expected for tracking user interactions and usage. It is anticipated that the backend will be developed in Python and so should be achievable using entirely open-source technologies; however, ECMWF remains open to alternative open-source technologies that can meet the project's requirements.

Testing: The Successful Tenderer shall implement a robust testing strategy to ensure the reliability, accuracy and usability of the application. Standard unit tests for the backend are expected, preferably using Pytest.

Scalability: As detailed in section 3, in the third phase the scope of work broadens to incorporate all the other ECV datasets available via the CDS. Therefore, the proposed architecture needs to ensure scalability for all the satellite-derived ECV datasets to be accommodated.

Performance: The application shall be performant, with minimal latency during interactions, and timely transitions between different datasets. Fast data retrieval, processing and rendering are expected - for example, it shall take less than two seconds to load a timeseries or render a variable on the globe.

User Interface and Visual Design: The application must have a visually appealing, user-friendly, and consistent user interface. This includes consistent design elements and colour schemes that are visually appealing to users, without detracting from functionality or accessibility. Upon initial launch, the application shall feature a striking pre-defined visualisation, such as global surface soil moisture projected over a rotating 3D globe.

User Experience (UX): The Successful Tenderer shall ensure the application provides a smooth and responsive user experience. It shall support interactivity, with users able to make various selections including different ECVs, projections, colourmaps and timeseries.

Accessibility: The application shall be thoughtfully designed to accommodate users with disabilities. Tenderers shall provide evidence of how this has been considered, including support for colour blindness and other common accessibility needs.

Cross-Browser Compatibility: Compatibility with all major browsers (Chrome, Firefox, Safari, Edge) is required. The application shall function across a reasonable range of browser versions, to ensure a broad reach of users.

Cross-Platform Compatibility: The application shall be accessible and responsive across various operating systems (i.e. Windows, macOS, Linux, Android, IOS) and across various devices such as desktops, tablets and smartphones. While smartphone access is expected, it is understood that certain features or functionalities may not be optimised or available on mobile devices.

Documentation: Tenderers shall provide comprehensive and well-structured documentation. This shall include detailed technical documentation, such as a description of the system architecture, alongside comprehensive explanations of any post-processing done to the ECV datasets. This requirement also covers outward-facing documentation suitable for end-users covering topics such as interacting with the application, explanations of terminology (e.g. reference period, standardised anomalies), and information on the post processing at suitable level of detail and complexity. This requirement is associated with Work Package 5 (see section 3.6).

Error Handling and Issue Logging: The application shall implement mechanisms to ensure that errors are clearly captured and made visible to system maintainers. Examples of errors include failed visualisations, data loading and download issues, system faults, and browser compatibility issues. Fallback messages shall also be provided to users.

Proof-of-concept (POC) Requirements: All non-functional requirements listed above are considered part of the POC requirements, as they ensure basic functionality, usability and reliability of the application.

Ref.	Requirement	Remarks and suggestions
1.	Compatibility with DSS Infrastructure	Preference for Helm, Kubernetes, Docker
2.	Software Stack	Preference for Typescript, React, and Python. Matamo.
3.	Testing	Preference for Pytest if Python-based backend
4.	Scalability	
5.	Performance	
6.	User Interface and Visual Design	
7.	User Experience	User-centric, Interactive
8.	Accessibility	Accounts for colour blindness and other common accessibility needs
9.	Cross-Browser Compatibility	Chrome, Firefox, Edge, Safari – and across a reasonable range of browser versions
10.	Cross-Platform Compatibility	Desktop, tablets, smartphones
11.	Documentation	Both technical and end-user documentation
12.	Error Handling and Issue Logging	

Table 1: Non-functional requirements

2.3 Functional Requirements

The points below describe the anticipated functionalities of the application, which are expected to fulfil the guiding objective outlined in section 2. Unlike the non-functional requirements, not all the functional requirements are considered necessary for the POC application described in Work Package 1 (see section 3.2). Those which are required as part of the POC application are marked with an asterisk (*****):

Multiple climate data formats*: The application shall support the processing and visualisation of the C3S ECV data formats, primarily NetCDF-4 alongside CSV and shapefiles; see '**Appendix A** – List of ECV Products available on the CDS' for the full list of current products and their data formats. Tenderers must note that, to ensure a performant web application capable of fast data retrieval, processing and rendering, it is anticipated that the data will need to be Analysis-Ready, Cloud-Optimised (ARCO), likely in Zarr format. Therefore, the application shall support ARCO data. In addition, the Successful Tenderer will be required to ensure that all datasets are made ARCO-compliant, where they are not already.

Pre-calculated metrics*: For each dataset, key metrics shall be pre-processed and stored to ensure fast access during user interaction. These metrics shall include, for example, temporal averages (monthly, seasonal means), trends, and number of valid pixels (where applicable). This will reduce the amount on on-the-fly computations that need to be performed.

User-Initiated Computations: The application shall support on-the-fly computations based on user-defined inputs. This includes the ability to compute metrics such as average, trends and anomalies over user-selected time periods.

Ingestion of new data: As new data, for example Interim Climate Data Records (ICDRs), become available to C3S, it shall be possible to incorporate them into the application without requiring significant redevelopment. The ingestion shall ensure new data can make use of existing processing and visualisation workflows whenever possible, and shall include reprocessing of pre-calculated metrics where necessary.

Visualisation of ECV products in 2D and 3D spatial formats*: The application must be capable of displaying data in both 2D and 3D graphics. For 2D, this means presenting graphs and maps of the ECV data, and vertical profiles where applicable. For 3D, the data shall be projected onto a globe which can rotate.

Support for multiple Coordinate Reference Systems (CRS)*: The solution proposed must accommodate the various CRS used in the ECV datasets. Typically, the data are on a regular latitude-longitude grid. However, there are exceptions, such as the ECV datasets related to polar regions, which often use stereographic projections. The solution must also support data reprojection upon user request. See **Appendix A** – List of ECV Products available on the CDS' for the current list of ECV products and their CRS.

Zoom functionality*: One of the foundational features of the application will be the zoom functionality, allowing users to explore the ECV data records at all spatial scales – from global to local. It must be optimised to minimise loading times and reduce resource usage.

Interactive temporal exploration*: The application shall provide the ability to explore changes through time in the ECV data records, using a feature such as an intuitively designed scroll bar. It shall include the capacity to run animations depicting changes over a period selected by the user, with a changeable animation speed.

Ability to display data with varying temporal aggregations*: The application must be capable of displaying and seamlessly transitioning between data of varying temporal aggregations. For example, it must smoothly switch from visualising lower frequency data, such as monthly or annual averages, to those of higher frequency, like daily averages.

Multi-parameter visualisation*: Multi-parameter analysis is an important planned functionality of the application, as it will enable users to see how one parameter evolves in relation to another. This will require the ability to display multiple layers of data simultaneously, with adjustable transparency levels for each.

Point timeseries capability: A key functionality of the application will be its ability to provide an interactive time series of a variable upon the user's selection of a specific map point location or area. This is considered particularly important as it highlights the value of ECVs with respect to the longevity of the ECV data records when compared with data that is only near real time. To provide users with climatological context, this functionality also needs to incorporate various visualisation options, such as displaying monthly means, percentiles, or annual curves. Additionally, users shall be able to display multiple plots simultaneously, as well as display two variables on one graph when appropriate.

Selectable colourmaps*: Users will have the option to visualise their variable(s) using a selection a predefined colourmaps. Some Earth system properties have colourmaps that are widely regarded as optimal for representing that specific property. For example, sea surface temperatures are often represented using a diverging blue-red colourmap; this colourmap must be available alongside other alternatives for those suffering from the related colour-blindness. These standard practices shall be considered when defining the colourmaps; ECMWF will provide guidance on this whenever possible.

Dynamic variable value range: As users move between broader and finer geographic scales, it will be possible for them to change the range of values represented within their chosen colourmap. For example, to inspect small scale variability (i.e. at the local level), they must be able to narrow the range of values mapped to their chosen colourmap to provide more detailed insights.

Customisable reference periods: The default reference period is to be the entire data record, unless one is specified for the dataset (e.g. for sea level the standard reference period is from 1993-2012). However, users must have the option to (i) change to the 1991-2020 standard reference period and (ii) define their own reference period. The latter will ensure the data shown is relevant for their specific use case.

Visual Indications of Uncertainty, Flagged Data and Gaps in Coverage*: The application shall provide the option to visualise areas of high uncertainty or that have been flagged for quality or reliability concerns. This is expected to include hatching or shading to distinguish these regions, and the ability to adjust the visibility of this feature including toggling on/off. In addition, the user interface shall clearly indicate any spatial and/or temporal gaps in the data records, ensuring users are aware of any incomplete coverage.

User-defined Area of Interest (AOI) Selection: Users shall be able to define their own AOI by drawing a custom bounding box directly on the map interface. The application must be capable of spatially-targeted analyses of these AOIs, such as computing the areal average and generating the associated timeseries plots.

Supplementary data: To support analyses, the application shall provide the option to view supplementary data alongside the ECV data. This supplementary data is expected to include (i) country border and (ii) NUTS regions for Europe. In addition to these, the application may incorporate other relevant datasets that the Tenderer considers valuable for users, such as detailed political maps (i.e. showing settlements and major infrastructure). When possible, the solution should also make it possible for users to aggregate the data by these regions.

Coordinate Pins: Users shall be able to specify precise locations of interest by entering latitude and longitude coordinates, which drop a pin on the corresponding point on the map. The application should support placement of multiple pins, that can be individually labelled by users.

Download capability*: An important functionality of the application will be the ability for users to download the visualisation currently displayed, and/or the data underlying it. For the former, this includes both static images (e.g. global map, point timeseries) and animations, in common formats such as PNG, JPEG, GIF and MPG. Exported multimedia is to have a C3S watermark to show data provenance. For the underlying data, this must be in a format appropriate for the original data source. Please note that for the POC application, only downloads of visualisations are required; the ability to download the underlying data would only be expected to be implemented during WP2.

Product information*: The application must include descriptions of the variables, as well as a prominently placed link to the corresponding CDS catalogue entry for the variable(s) being displayed by the user. A concise description shall accompany the link, specifying that the link provides download access to the full data record and to supporting documentation such as information on quality assessments.

Help and Guidance*: There must be easily accessible information that guides users on navigating the interface and using the applications features. This is thought likely to include tooltips and a dedicated help section. This content shall be sufficiently clear to support novice as well as experienced users.

Data Licensing Acknowledgement*: Before downloading data or imagery from the application, users must be prompted to acknowledge that the content may be subject to licensing other than the standard CC-BY licence. The system must require users to confirm that they have read and accepted the applicable license terms and conditions. The prompt shall provide information on where the licences are found.

ECMWF foresees one of the main challenges for the Successful Tenderer being the handling of the somewhat diverse group of datasets that comprise the C3S ECV portfolio, owing their different temporal and spatial aggregations, formats, structures, etc.

Furthermore, it is understood that for some ECV products it may not be technically feasible to implement all functionalities described in this section due to their inherent characteristics (e.g. file format, temporal coverage, resolution, etc). However, the Successful Tenderer shall ensure that the functionalities are applied to as many products as possible across the C3S ECV portfolio, to make the web application useful for the diverse user base that has varied interests in the ECV products.

Ref.	Requirement	Remarks and suggestions
13.	Multiple climate data formats (*)	NetCDF-4 and ARCO (i.e. Zarr), etc.
14.	Pre-calculated metrics*	
15.	User-initiated computations	
16.	Ingestion of new data	Ability to incorporate ICDRs and new CDRs
17.	Visualisation of ECV products in 2D and 3D spatial formats*	3D to include a rotating globe
18.	Support for multiple coordinate reference systems*	Includes reprojection
19.	Zoom functionality*	
20.	Interactive temporal exploration*	
21.	Ability to display data with varying temporal aggregations*	
22.	Multi-parameter visualisation*	
23.	Point timeseries capability	
24.	Customisable colourmaps*	
25.	Dynamic variable value range	
26.	Customisable reference periods	
27.	Visual indications of uncertainty, flagged data and gaps in coverage*	
28.	User-defined Area of Interest (AOI) selection	
29.	Supplementary data	NUTS regions, country borders, etc.
30.	Coordinate pins	
31.	Download capability*	Static images, animations, underlying data
32.	Product information*	
33.	Help and guidance*	
34.	Data licensing acknowledgement*	Prior to data or image download

Table 2: Functional requirements

3 Contract Structure and Implementation

3.1 Contractual Approach

The primary objective of this Framework Agreement and associated Service Contract(s) is to design, implement, and test the system components of a web application to enable interactive visualisation of the satellite-derived ECV datasets, while also allowing user-initiated computational requests for on-demand analyses.

This objective will be achieved through completion of seven work packages (WP), which are broadly divided into technical (WP1 to WP6) and managerial (WP0) components.

As outlined in section 1.3, it is expected that the project will be delivered in four phases:

- a first phase composed of the initial proof-of-concept (POC) application (WP1),
- a second phase that implements full functionality (WP2),
- a third phase that expands the scope of the fully functional application by incorporating all satellite-derived ECV datasets (WP3), and provides the Successful Tenderer with an opportunity to explore the use of Artificial Intelligence (AI) (WP6), and
- a final fourth phase for application maintenance centred on data updates (WP4).

Alongside the above, there is a work package for documentation (WP5), which is expected to run in parallel with WP2 – WP4 (including optional WP6) to ensure continuous and up-to-date documentation throughout the second Service Contract, should it be.

These work packages, along with their associated Deliverables and Milestones, are described in detail in sections 3.2 to 3.8. **Please note, the Tenderers are welcome to adjust the suggested due dates, which were provided to broadly indicate their relative sequence and timing of Deliverables in the specific Work Package, rather than impose fixed deadlines.**

In their proposals, the Tenderers may suggest alternative or additional approaches to the ones proposed in the following Work Packages, provided these are supported by clear and well-reasoned justification. Where such proposals deviate from the outlined Work Packages, Tenderers shall explicitly identify and explain the differences.

3.2 Work Package 1: Design and Implementation of a proof-of-concept web application

WP1 will begin with the Successful Tenderer reviewing good practices and lessons learned from similar applications available. These will be used to inform the next stage, an iterative process to design and implement the initial POC web application that meets all of the POC requirements listed in sections 2. This process will be done in collaboration with the ECMWF Climate Intelligence team, who shall provide feedback to help guide iterations of the application.

This WP encompasses the following tasks:

- A review of existing similar solutions to inform design process.
- Creation of a draft design of the application. In this early stage, an initial design must be created, that accounts for all the POC requirements. Where possible, multiple solutions should be presented along with their respective advantages and limitations, to be discussed collaboratively with ECMWF.
- After the initial design, iterative development and implementation of the software components is expected. This will be done in line with the requirements detailed in section 2; for example, the need for compatibility with ECMWF's DSS infrastructure (Requirement 1) should be accounted for.

- Fortnightly meetings that are anticipated to align with Agile sprints or other methodology-driven meetings. These will be for discussing progress, gathering feedback from the Climate Intelligence team, addressing blockers (if any), and proposing tasks for the next sprint. Alongside this, these meetings shall serve as valuable opportunities for technical exchange; as the satellite-derived ECV products vary significantly in their technical characteristics, it is anticipated the Successful Tenderer may have questions and/or require clarifications during the integration and processing of the products.
- The two pre-selected Flagship ECV datasets shall be prepared for inclusion in the application. This includes producing the pre-calculated metrics (Requirement 1214), see box below for further information.
    - **ECV Flagship dataset 1:** "Soil moisture gridded data from 1978 to present" (Available on the CDS; also shall include Root-Zone Soil Moisture and Freeze/Thaw)
    - **ECV Flagship dataset 2:** "Earth's radiation budget from 1979 to present derived from satellite observations" (Available on the CDS)
- Completion of the initial application, featuring the two Flagship ECV datasets and meeting all the POC requirements.
- Validation and testing of delivered components and final outputs.
- Delivery of software components comprising the POC application through Git repositories (e.g. GitHub, GitLab, etc) that are shared with ECMWF.

The above is expected to be completed over a **five-month period**, which is anticipated to be sufficient time for the development and iterative refinement of the POC web application, as well as delivery of all related deliverables and milestones.

Flagship ECV Metrics

As part of this WP, the Successful Tenderer will be required to produce the pre-calculated metrics for the Flagship ECV products. The specific details of each metric will be discussed and agreed by ECMWF and the Successful Tender prior to the start of the contract. It is expected that, at the same time, metrics for the remaining ECV products will be discussed and agreed in principle. It should also be noted that ECMWF is open to suggestions from Tenderers regarding metrics they believe may be of interest to users, and Tenderers are encouraged to include these in their Tender if they wish.

The following provides an example of the metrics expected for the flagship variables; those which the Successful Tenderer will be required to calculate are marked with an Asterix (*):

- Absolute values (e.g. daily and monthly means for outgoing shortwave/longwave radiation)
- Uncertainties (e.g. available for daily soil moisture data)
- Means* (e.g. it is expected that the Successful Tenderer will calculate seasonal means from the daily absolute values of soil moisture)
- Percentiles* (e.g. 10^{th}, 33.3^{rd}, 50^{th}, 66.6^{th}, 90^{th}, 95^{th}, 99^{th})
- Trends* (over full data record, over standard climate reference period 1991-2020)
- Anomalies* (e.g. %, standardised)
- Variable specific metrics* (e.g. soil wetness index and soil wetness index anomaly for volumetric soil moisture, and net radiation calculated from Earth Radiation Budget products)

It is expected that the above categories of metrics will also be applicable to the majority of the other ECV products that will be featured on the application.

ECMWF proposes the **Agile methodology** but welcomes suggestions from the Tenderer on what methodology they propose to apply for the different phases of the work, based on their knowledge and experience with projects of a similar nature. The Tenderer must provide examples of how they have applied this approach in similar projects they have previously worked on.

The methodologies proposed by the Tenderer must ensure that final deliverables and milestones are fit for purpose, aligned with the project vision, and remain within project budget and schedule.

WP1 Deliverables						
Deliverable ID	**Main contributor**	**Nature**	**Deliverable title**	**Content / Purpose**	**Primary Audience**	**Due date (relative to each WP)**
List of Deliverables						
D1.1.1	Tenderer	Presentation / Other	Application design draft	The final visual design draft for the application, agreed upon by both ECMWF and the Successful Tenderer.	ECMWF	WP1 start + 1
D1.1.2	Tenderer	MoM	Regular meeting minutes	Meeting minutes from the fortnightly meetings that align with Agile sprints or other methodologies. The MoM are for tracking technical exchanges, monitoring progress, and recording feedback and blockers etc.	ECMWF	Throughout
D1.1.3	Tenderer	Data	Pre-processed metrics – Flagship ECVs	Provision of the pre-processed metrics for the Flagship ECV datasets, and any other associated datasets, that are used in the POC web application - if not already stored on ECMWF infrastructure.	ECMWF	WP1 start + 4
D1.1.4	Tenderer	Code	POC Application software	Provision of the code base for the POC web application. Delivered through Git repositories shared with ECMWF, as detailed in WP tasks above.	ECMWF	WP1 start + 5
D1.1.5	Tenderer	Report	Application testing summary	A report detailing the testing procedures and results. Where applicable, links to automated backend test results and relevant documentation in the code repository are to be provided.	ECMWF	WP1 start + 5
D1.1.6	Tenderer	Other	Self-hosted application	The proof-of-concept application hosted by the Successful Tenderer and viewable by ECMWF.	ECMWF	WP1 start + 5
D1.1.7	Tenderer	Demonstration and MoM	POC web application showcase	A live, recorded demonstration of the web application, presenting all		WP1 start + 5

				POC functionalities and the flagship ECV products. To be followed with MoM detailing what was presented, ideas discussed, improvements requested (if any), etc.		

Table 4: WP1 deliverables

As the development will follow an Agile (or similar) methodology, POC requirements will be addressed iteratively, with functionality refined and validated throughout the process. Once the POC web application is completed under the Service Contract No 1, both parties will confirm that it is satisfactory. Upon mutual agreement by both ECMWF and the Successful Tenderer, the Successful Tenderer will proceed with the remaining activities (i.e. WP2-WP5, and optional WP6 if activated by ECMWF) under the Service Contract No 2.

3.3 Work Package 2: Implementation of full functionality including user-initiated computations

WP2 will begin following mutual agreement on the successful completion of the initial proof-of-concept application developed under WP1. The focus of this work package is to implement the full range of functional requirements described in section 2.3, with the result being a web application where these functionalities can be applied to the Flagship ECV products.

This WP therefore includes the following tasks:

- Similarly to WP1, regular meetings are expected, anticipated to align with Agile sprints or other methodology-driven meetings. These will be for discussing progress, gathering feedback from the Climate Intelligence team, addressing blockers (if any), and proposing tasks for the next sprint. Alongside this, these meetings shall serve as valuable opportunities for technical exchange; as the satellite-derived ECV products vary significantly in their technical characteristics, it is anticipated the successful tenderer may have questions and/or require clarifications during the integration and processing of the products.
- Progressive addition of the functionalities beyond those required for the POC. Importantly, this task will include the development and implementation of software components to enable user-initiated computations (requirement 15).
- Validation and testing of the delivered software components and final outputs.
- Delivery of software components comprising the fully functional application through Git repositories (e.g. GitHub, GitLab, etc) that are shared with ECMWF.

WP2 Deliverables						
Deliverable ID	**Main contributor**	**Nature**	**Deliverable title**	**Content / Purpose**	**Primary Audience**	**Due date (relative to each WP)**
List of Deliverables						
D2.1.1	Tenderer	MoM	Regular meeting minutes	Meeting minutes from the fortnightly meetings that align with Agile sprints or other methodologies. The MoM are for tracking technical exchanges, monitoring	ECMWF	Throughout

				progress, and recording feedback and blockers etc.		
D2.1.2	Tenderer	Code	Fully-functional, Flagship ECV Application software	Delivery of the code base for the fully functional, Flagship ECV web application. Delivered through Git repositories shared with ECMWF, as detailed in WP tasks above.	ECMWF	WP2 start + 3
D2.1.3	Tenderer	Report	Application testing summary	A report detailing the testing procedures and results. Where applicable, links to automated backend test results and relevant documentation in the code repository are to be provided.	ECMWF	WP2 start + 3
D2.1.4	Tenderer	Other	Self-hosted application	The application, featuring full functionalities for the Flagship ECVs, hosted by the Successful Tenderer and viewable by ECMWF.	ECMWF	WP2 start + 3
D2.1.5	Tenderer	Demonstration and MoM	Showcase of fully functional web application for Flagship ECVs	A live, recorded demonstration of the web application, presenting full functionality for the flagship ECV products. To be followed with MoM detailing what was presented, ideas discussed, improvements requested (if any), etc.	ECMWF	WP2 start + 3

Table 5: WP2 deliverables

As detailed in Section 4.1, the Framework Agreement will last for a total of **24 months**. **WP1** is expected to be completed over a **five-month period**, **WPs 2 and 3** are then anticipated to account for the following **12 months**, and the **final 6 months** is planned for **maintenance** (**WP4, see Section 3.5)**.

3.4 Work Package 3: Addition of all satellite-derived ECVs in the C3S ECV portfolio

WP3 focuses on expanding the scope of the application beyond the Flagship ECVs to include all satellite-derived ECV products on the CDS. As described in section 2.3, it is understood that for some ECV products it may not be technically feasible to implement all functionalities due to their inherent characteristics (e.g. file format, temporal coverage, resolution, etc). However, the Successful Tenderer shall ensure that the functionalities are applied to as many products as possible across the C3S ECV portfolio, to make the web application useful for the diverse user base that has varied interests in the ECV products.

This WP therefore includes the following tasks:

- Similarly to WPs 1 and 2, meetings are expected for technical exchange, discussing progress, gathering feedback from the Climate Intelligence team, addressing blockers (if any), and proposing tasks for the next sprint. At this stage of the project, such meetings are anticipated to be ad-hoc, but suggestions for regularly scheduled meetings are also welcomed.
- A meeting with the relevant team within ECMWF to discuss hosting and deployment strategy (if required).
- Production of the pre-calculated metrics for all satellite-derived ECV products available via the CDS, excluding those of the Flagship products which were produced as part of WP1. The pre-calculated

metrics to be produced for the remaining ECV products will be agreed between ECMWF and the Successful Tenderer.

- Incorporation of all the satellite-derived ECV products into the web application.
- Validation and testing of all delivered application components and final outputs.
- Delivery of software components comprising the full-scale, production-ready application through Git repositories (e.g. GitHub, GitLab, etc) that are shared with ECMWF.

At the end of this WP, the full-scale, production-ready application must be complete, and incorporate the all the satellite-derived ECV products. Additionally, all Functional and Non-Functional requirements listed in sections 2.2 and 2.3 shall be fully implemented (where technically possible), with the exception of those related to documentation (Requirement 11, covered in WP5).

WP3 Deliverables						
Deliverable ID	**Main contributor**	**Nature**	**Deliverable title**	**Content / Purpose**	**Primary Audience**	**Due date (relative to each WP)**
List of Deliverables						
D3.1.1	Tenderer	MoM	Meeting minutes	Meeting minutes shall be delivered in line with the agreed meeting cadence. The MoM are for tracking technical exchanges, monitoring progress, and recording feedback and blockers etc.	ECMWF	Throughout
D3.1.2	Tenderer	Data	Pre-processed metrics – Additional ECVs	Provision of the pre-processed metrics for all ECV datasets (excluding Flagship), and any other associated datasets, that are used in the full scale web application - if not already stored on ECMWF infrastructure	ECMWF	WP3 start + 2
D3.1.3	Tenderer	Code	Application software	Provision of the code base for the full-scale, production-ready web application.	ECMWF	WP3 start + 3
D3.1.4	Tenderer	Report	Application testing summary	A report detailing the testing procedures and results. These are to include tests on a range of ECV products. Where applicable, links to automated backend test results and relevant documentation in the code repository are to be provided.	ECMWF	WP3 start + 3
D3.1.5	Tenderer	Other	Self-hosted application	The full-scale, production ready application should be hosted by the Successful Tenderer and viewable by ECMWF.	ECMWF	WP3 start + 3
D3.1.6	Tenderer	Meeting	Hosting and deployment strategy discussion	A meeting between the Successful Tenderer and the relevant team at ECMWF to discuss hosting and deployment by ECMWF.		WP3 start + 3

D3.1.7	Tenderer	Demonstration and MoM	Edge-case ECV product application showcase	A live, recorded demonstration of the web application, presenting the functionalities available for one or more of the edge-case ECV products where full functionality is not available. This is expected to include at least one ECV product that is not provided in NetCDF-4 format. To be followed with MoM detailing what was presented, ideas discussed, improvements requested (if any), etc.	ECMWF	WP3 start + 3
D3.1.8	Tenderer	Demonstration and MoM	Full-scale, production ready application	A live, recorded demonstration of the fully-functional, production-ready web application that has full functionality for all the ECV products (whenever technically feasible). To be followed with MoM detailing what was presented, ideas discussed, improvements requested (if any), etc.	ECMWF	WP3 start + 3

Table 6: WP3 deliverables

3.5 Work Package 4: Maintenance of the application

Upon timely and successful completion of the previous Work Packages, WP4 will begin, and will ensure the continued functionality and relevance of the application after its public release. This will be achieved by maintaining the application and integrating new data as they become available to C3S. The application is expected to be developed in such a way that this will be possible without requiring significant ad-hoc software development.

This WP therefore includes the following tasks:

- Development of a maintenance strategy. ECMWF will support this by providing the Successful Tenderer with a timeline of the planned updates of the existing ECVs (ICDRs and new CDRs), as well as the approximate expected release dates of new ECV Products.
- Ad-hoc meetings for technical exchange and discussing progress with ongoing data integration

  of new data, such as ICDRs, new CDRs, and new ECV products (for the latter, see 'Appendix A – List of ECV Products available on the CDS'). This shall include any software development necessary to enable this, as well as making the data ARCO-compliant if necessary. '
- Recalculation of pre-processed metrics when required, to be agreed between the Successful Tenderer and ECMWF.
- Incorporation of changes resulting from the GCOS rationalisation process. Currently, GCOS is reformulating the ECV framework based on the experience gathered in the recent years and on feedback from relevant stakeholders. This rationalisation process will necessarily impact the downstream services like C3S, namely because it introduces new concepts (like "ECV quantity"), aggregation/separation of current products and reorganisation between major categories. The Tenderers will be required to incorporate these changes when once they become applicable.

The above is expected to be completed the **final six-months of Service Contract 2**,

WP4 Deliverables						
Deliverable ID	**Main contributor**	**Nature**	**Deliverable title**	**Content / Purpose**	**Primary Audience**	**Due date (relative to each WP)**
List of Deliverables						
D4.1.1	Tenderer	Report/Other	Maintenance strategy	A strategy document detailing the planned maintenance for the duration of WP4. It shall clearly demonstrate how the Successful Tenderer aims to integrate new data in a timely manner to keep the application up-to-date.	ECMWF	WP4 start + < 1
D4.1.2-MIP-YYYY-MM	Tenderer	Report	Quarterly maintenance report	A quarterly report that summarises all maintenance activities completed during the previous three months. It shall include information on recalculated metrics, and number integrations completed. The report shall also outline the planned maintenance for the upcoming three months.	ECMWF	Due quarterly
D4.1.3-MS-YYYY-MM	Tenderer	Code	Maintenance software	If additional software development is necessary for an integration, the updated code base should be provided to ECMWF on a regular basis (frequency to be agreed between ECMWF and the Successful Tenderer).	ECMWF	As required

Table7: WP4 deliverables

3.6 Work Package 5: Documentation

WP5 will ensure the software developed under this Framework Agreement and associated Service Contract(s) is fully documented to enable its continued use, as well as its maintenance and possible enhancement by ECMWF beyond the duration of this contract. This WP is structured to reflect the progressive nature of the project. If the second Service Contract is signed, comprehensive documentation will be provided throughout, as WP5 will run in parallel with WPs 2–4 (and the optional WP6), ensuring continuous documentation as the application expands in functionality and scope.

The documentation shall not be limited to the following but shall include:

- **Technical documentation**, including:
  - A comprehensive description of any pre- and post-processing steps applied to the ECV products, including all calculations such as the computation of seasonal averages, trends or other metrics. Documentation for this must provide a detailed description of the methodologies and underlying assumptions, as well as any algorithms and data sources used. This is to ensure transparency and reproducibility.
  - A detailed description of the architecture and inner workings of all software components (frontend, backend).
  - Deployment instructions for the web application, including configuration, environment setup, and update procedures.
  - Maintenance instructions covering tasks described in WP4.

- **Comprehensive end-user documentation** that is clear, accessible and suitable for a broad audience. It shall:
    - Effectively guide users in interacting with the web application and in understanding its functionalities.
    - Ideally include explanations of terminology (e.g. reference period, standardised anomalies, etc).
    - Contain information on the post processing (described in detail in the technical documentation), at a suitable level of detail and complexity for end users. This is to encourage transparency and aid user understanding of the data displayed in the web application.
    - Be developed on ECMWF's Atlassian Confluence space.

WP5 Deliverables						
Deliverable ID	**Main contributor**	**Nature**	**Deliverable title**	**Content / Purpose**	**Primary Audience**	**Due date**
List of Deliverables						
D5.1.1	Tenderer	Other (Confluence)	End-user guide	A clear and accessible guide provided to support users in interacting with the web application and understanding its functionalities.	External Users	End of WP 2, with an update expected at the end of WP3
D5.1.2	Tenderer	Other (Confluence)	Description of data post-processing methods and calculations	A comprehensive description of the post-processing methods and calculations performed on the ECV products. Provided to enable reproducibility, and transparency for users.	ECMWF / External users	End of WP3
D5.1.3	Tenderer	Report	Software description	Description of architecture and workings of all software components.	ECMWF	End of WP3
D5.1.4	Tenderer	Report/Other	Deployment documentation	A clear and concise document detailing the steps necessary for the transfer and deployment of the web application. Alongside this, information on maintenance and any update procedures should be provided.	ECMWF	End of WP3
D5.1.5	Tenderer	Report/Other	Maintenance documentation	At the conclusion of the contract, the Successful Tenderer shall provide maintenance guidance enabling ECMWF to perform maintenance tasks independently. This shall include activities such as the incorporation of an ICDR into the web application. Clear and concise instructions are expected, and are to be supported by diagrams, examples and references to code to when appropriate.	ECMWF	Towards end of WP4

Table 8: WP5 deliverables

3.7 Work Package 6: Artificial Intelligence

The purpose of this **optional** Work Package is to enable innovative application(s) of AI that enhance the usability and accessibility of the web application for end users. The Tenderers are expected to propose one or more AI-driven solutions to anticipated user difficulties. The Tenderers are encouraged to propose solutions as they see fit, but the following suggestions provide an example:

- **Intelligent feature control:** AI assistance to help users discover, enable and disable features within the web application. Includes the ability to load different ECV products, toggle layers, and suggest complementary products for multi-parameter analysis.
- **Conversational assistance:** An integrated chatbot that can assist with natural language queries such as questions about the application's functionalities or constituent ECV products, or explaining visualisations, metrics and outputs. The chatbot has seen the ECV documentation and can provide explanations and cite the relevant documentation.
- **Visualisation interpretation guide:** Use of AI to create documentation explaining how to read commonly featured data on the web application (e.g. trend lines, uncertainty representations)

For this optional Work Package, the Tenderers are expected to propose their own list of Deliverables and Milestones and associated due dates. More information about this is provided in section 4.2.

Please note the Milestone corresponding to ECMWF's decision about the activation of this optional WP6, added under the WP0 list of Deliverables and milestones (cf. Milestone ref. M0.5-DEC-WP6).

3.8 Work Package 0: Management and coordination

The WP0 "Management and coordination" shall ensure the correct overall implementation of the Framework Agreement and associated Service Contract(s) during their whole Term and shall be further described and completed, if necessary, by the Tenderer in its technical proposal. The WP0 tasks are the following ones:

Task 0.1: Service management and coordination

Ref.	Requirement
[R01.01]	To appoint a Service Manager with experience of managing projects and contracts of this type and size. This person will be the main point of contact for administrative matters. Amongst others this person shall ensure the implementation of all contractual obligations as described in the ITT Volume V and all necessary **day-to-day service management and coordination** including the planning and monitoring of all Work Packages activities and corresponding resources. This person shall be involved in the activities of this ITT at a minimum level of 10% of their total working time, unless otherwise agreed.
[R01.02]	To appoint a Technical Lead[1] with more than 5 years of experience in technical activities related to this ITT that shall ensure that all technical requirements are met. This person will be the point of contact on technical matters and shall be involved in the activities of this ITT at a minimum level of 10% of their total working time, unless otherwise agreed.
[R01.03]	To ensure **quality assurance and control activities**, including in what concerns the Sub-contractors' activities if any. The final quality check of all deliverables (contents, use of ECMWF's templates for deliverables and reports, format, deliverables/milestones numbering and naming, typing errors, etc.) shall be made by the Successful Tenderer. The Tenderer shall provide a list

[1] The role of Service Manager and Technical Lead can be performed by the same person (in this case to be considered as the Service Manager only) if duly justified. In that case a second contact person needs to be appointed as alternative contact.

	of its quality assurance processes and management systems and if applicable, any quality related accreditations or certifications it holds.
[R01.04]	To enforce a proactive **risk management**, including in what concerns the Sub-contractors' activities if any. The technical proposal shall therefore include a risk register which shall be updated regularly by the Successful Tenderer. Any update (related to new risks, likelihood or impact) shall be reported during the PRM as well as be part of the QIR and AIR.
[R01.05]	To ensure proactive and dynamic **internal and external communication**, towards and between all parties involved in the contract.
[R01.06]	To **manage the personal data** in accordance with the ITT Volume V Clause 2.8 and its Annex 6 "Personal Data Protection".
[R01.07]	To **manage the Sub-contractor(s)**, if any, in accordance with the ITT and annexes, including dispute resolution (the Successful Tenderer will be responsible for settling disagreements, although advice/approval from ECMWF may be sought on the subject). The Tenderer shall also describe in its Tender how the ITT Volume V, in particular Clause 2.9 "Sub-contracting", has been flowed down to all its Sub-contractors.
[R01.08]	The Successful Tenderer shall **support ECMWF in its general communication activities** for the C3S services, where they are related to the activities described in this ITT.

⇨ The Tenderer shall outline and justify the proposed overall management methodology for this contract in its technical proposal.

Task 0.2: Reporting activities for the benefit of the European Commission

Ref.	Requirement
[R02.01]	To ensure the timely and quality delivery of the Deliverables as stated in ITT Volume IIIA and in accordance with ITT Volume V, especially in its Clause 2.3 "Reporting and Planning", necessary to ECMWF's **reporting towards the European Commission**.

Task 0.3: Meeting management and coordination

Ref.	Requirement		
[R03.01]	To organise and/or attend the following meetings:		
Meeting	**Objective**	**Date/Frequency, format and location, duration**	**Expected attendance (<u>as a minimum</u>)**
Kick-Off Meeting (KOM)	(All) To introduce all involved parties, remind the requirements, report on the first efforts performed and next steps to implement.	• Once (max. T0+1) • Hybrid (teleconference and/or on site attendance) • 2 to 3 hours	• ECMWF • Prime contractor's Service Manager and Technical Lead • Sub-contractors' representatives
Progress Review Meeting (PRM)	(Contractor) To report on the progress accomplished. (All) To take actions and/or make decisions for the sake of the contract implementation.	• Quarterly • Teleconference • 1 hour	• ECMWF • Prime contractor
C3S General Assembly (GA)	(All) To present C3S activities and service provision and perform side-meetings if need be.	• Annually • On site attendance • Europe • Ca. 2-3 days	• ECMWF • Prime contractor
Ad-hoc meetings	(All) To solve any issue faced during implementation and/or take actions and/or make decisions for the sake of the contract implementation.	• On ECMWF and contractor's request • Teleconference	• ECMWF • Prime contractor • On-request attendants
<u>Note</u>: If considered necessary, the Tenderer can propose additional project meetings, whose added value must nevertheless be precisely substantiated.			

The Tenderer shall therefore incorporate the following Deliverables and Milestones in the relevant spreadsheet part of the ITT Volume IIIA. All Deliverables and Milestones shall be numbered as indicated below.

Deliverable / Milestone ID	***Deliverable / Milestone title***	***Due date***	***Main contributor***	***Nature***
D0.1-QIR-YYYYQQ	Quarterly Implementation Report YYYY QQ *YYYY QQ being the previous quarter (i.e. either Q1, Q2 or Q3)*	Quarterly on 15/04, 15/07 and 15/10	Tenderer	Report
D0.2-AIR1-YYYY	Annual Implementation Report Part 1 YYYY *including both:* • *the Quarterly Implementation Report YYYY Q4 and* • *the requested preliminary financial information YYYY* *YYYY being the Year n-1*	Annually on 15/01	Tenderer	Report / Other
D0.3-AIR2-YYYY	Annual Implementation Report Part 2 YYYY *YYYY being the Year n-1*	Annually on 28/02	Tenderer	Report
D0.4-AIP-YYYY	Annual Implementation Plan YYYY *YYYY being the Year n+1*	Annually on 30/09	Tenderer	Report
D0.5-FS-YYYY	Copy of Prime Contractor's general financial statements and audit report YYYY *YYYY being the Year n-1*	Annually, not later than on 15/12	Tenderer	Other
D0.6	Final Implementation Report	End date of the contract, only once all other activities have been duly performed	Tenderer	Report
D0.7[2]	Evidence of or a declaration about the Contractor's insurance	Max 30 days after start of contract	Tenderer	Other
M0.1	Kick-Off Meeting	Max 30 days after start of contract	Tenderer	Presentation and MoM
M0.2-PRMxx	Progress Review Meeting No xx *x being the number of the PRM*	~ every 3 months	Tenderer	Presentation and MoM
M0.3-C3S-YYYY	C3S General Assembly YYYY *YYYY being the Year of the GA edition*	Annually, not later than on 15/12	Tenderer	Attendance
M0.5-DEC-WP6	ECMWF's decision concerning the activation of optional WP6	Deadline to be agreed between parties	ECMWF	Other

⚠ Important note ⚠

Given the proposed structure of the Agreement, i.e. two Service Contracts under a Framework Agreement (see also section 4.1 below), some specific aspects must be considered by the Tenderer in its offer regarding the WP0 activities:

- Each Service Contract shall include the WP0 activities and shall include in its respective List of Deliverables and Milestones only the Deliverables and Milestones that are due during the term of the concerned Service Contract.
- Only one KOM (cf. Milestone M0.1) is required and shall take place under the frame of the SC1 only.
- Only one FIR (cf. Deliverable D0.6) is required to be delivered under the Framework Agreement, therefore a FIR shall first be added to the List of Deliverables and Milestones of both Service Contracts

No 1 and No 2. In case the parties agree to sign the Service Contract No 2, then the FIR part of the list of Deliverables and Milestones of SC1 will be cancelled and its price deducted.

- The Milestone M0.3-C3S-YYYY corresponding to the C3S General Assembly shall only be considered under the frame of the SC2.
- The evidence of or a declaration about the Contractor's insurance (cf. Deliverable D0.6) shall be considered under each SC since the Overall Price may evolve depending on the Parties' agreement concerning the SC2 (see also Clause 2.1.9.2 in the ITT Volume V).

4 General Requirements

4.1 Implementation Schedule

ECMWF intends to award a **Framework Agreement** for a total period of twenty-four (24) months, which shall be implemented via **two Service Contracts**:

- The **Service Contract No 1 (SC1)** shall be composed of **WP0 and WP1**. The SC1 is expected to commence in Q2 2026, ideally 01/06/2026, and last five (5) months, therefore until 31/10/2026.
- A period of one (1) month is expected between the end date of SC1 and the start date of SC2 to allow the signature of the SC2 and, if necessary, to perform all necessary amendments of the SC2 as originally agreed (e.g. Pricing Tables and List of Deliverables and Milestones parts of the Framework Agreement Annex 2, see also Clause 2.1.2.1 (i) of the ITT Volume V) and formalise them thanks to an amendment agreement to the Framework Agreement and the Service Contract(s).
- The **Service Contract No 2 (SC2)** shall be composed of **WP0, WP2, WP3, WP4, WP5 and WP6 (optional)**. The SC2 is expected to commence in Q4 2026, ideally on 01/12/2026, and last eighteen (18) months, therefore until 31/05/2028.
- **Important**: For the sake of clarity, the Parties will first sign only the Framework Agreement and its SC1. The signature of the SC2 will be fully depending on the outcomes of the implementation of the SC1 and, if necessary, their formalisation through an amendment agreement of the contractual documents originally agreed between ECMWF and the Successful Tenderer.

The Tenderer shall provide a detailed implementation plan of proposed activities for the total period.

4.2 Deliverables and Milestones

The Tenderer shall use the ITT Volume IIIA "Pricing and deliverables" spreadsheet "Deliverables List" to provide the list of Deliverables and Milestones for each WP while considering the following:

- A **Deliverable** is a substantial, tangible or intangible good or service produced as a result of a project (see also the deliverable definition in this ITT Volume V Clause 1.2 and Clause 3.2). In other words, a Deliverable is a verifiable outcome produced in response to the specific objectives of the contract and is subject to approval by both ECMWF's Technical Officer (TO) and Contract Management Officer (CMO) before being considered as contractually approved.
- A **Milestone** is designed as a marker of demonstrable progress in service development and/or quality of service delivery during the contract implementation (see also the milestone definition in this ITT Volume V Clause 1.2). The Milestones shall not duplicate deliverables.

The objectives of each Work Package are outlined in section 3 above. As part of the Tender, the Tenderer is expected to propose a list of Deliverables and Milestones for each Work Package which shall be consistent with the set objectives. The Deliverables can be in the form of documents or reports, data sets or databases, services, user support, etc.

The following shall apply to the Deliverables and Milestones:

- All Deliverables and Milestones must be consistent with the activities and objectives described in this ITT and shall allow the Successful Tenderer to comply with the technical requirements listed in this ITT Volume II;
- All Deliverables shall be produced in English unless otherwise expressly agreed between ECMWF and the Successful Tenderer;
- The quality of reports shall be equivalent to the standard of peer-reviewed publications and practice;

- Regarding the format of the deliverables, unless otherwise specified in the contract, or requested by ECMWF during the contract implementation:
    - For the WP0, the Deliverables shall be made available to ECMWF in electronic format (PDF/Microsoft Word/Microsoft Excel/HTML or compatible, while all other formats - if any – must be agreed during the contract negotiation), via the Copernicus Deliverables Repository portal – OpenText Core (OTC) – unless otherwise agreed.
    - For the other WPs, the Deliverables shall be made available to ECMWF in electronic format (PDF/Microsoft Word/Microsoft Excel/HTML or compatible, while all other formats - if any – must be agreed during the contract negotiation) via the platform agreed between parties for the other WPs Deliverables and Milestones. Furthermore, when necessary, the Successful Tenderer shall make the outputs of their work available on a server accessible by ECMWF using standard protocols such as FTP or https. The data formats to be used shall be agreed during the contract negotiation. ECMWF will only accept data in formats that follow internationally recognised standards. Such standards must be open (i.e. non-proprietary), managed by a recognised international standardisation body (e.g. ISO, WMO, OGC, etc.), or any de-facto standard. Open-source software should also exist that can read and write files of these standards. Serialisation formats (e.g. NetCDF) should be supported by standard schemas and conventions.

⇨ ECMWF will provide all necessary templates and guidance at the beginning of the contract.

The following shall be considered by the Tenderer when completing the ITT Volume IIIA "Pricing and deliverables" spreadsheet "Deliverables List" to attach to its Tender:

- All Deliverables and Milestones already listed in this ITT Volume II shall keep their ID. Additional Deliverables and Milestones, if any, shall abide by the following referencing system:
    - *Deliverables and Milestones shall respectively be numbered as per the following format Dx.y.z (for Deliverables) and Mx.y.z (for Milestones), where x is the WP number, y is the task number and z is the Deliverable or Milestone number in this task.*
    - *Deliverables delivered annually should be numbered Dx.y.z-yyyy, where yyyy is the year the Deliverable refers to (e.g. Dx.y.z-2024). Deliverables that will be delivered quarterly should be numbered Dx.y.z-yyyyQa, where Qa is the quarter of the year the Deliverable refers to (e.g. Dx.y.z-2024Q1). The same numbering format shall be applied for Milestones. Continuous deliverables at higher frequency can be labelled in the same way as quarterly deliverables.*
- Each Deliverable shall have an associated resource allocation and price (cf. column I "Nb of PM allocated" and column J "Estimated price"), while the only resource types to be considered is "payroll", "travel" and "professional fees" (the total of these allocated resources and prices shall therefore amount to the total price associated with "payroll", "travel" and "professional fees" in ITT Volume IIIA spreadsheet "Costs and Prices").
- Milestones should not have any associated resource allocation and price unless there are Deliverables associated to them such as presentations, MoMs, etc.
- Each Deliverable and Milestone shall have a realistic and therefore achievable due date. To this regard, the Tenderer shall also consider any dependencies and asses the risk accordingly (see "Important note" boxed text below). **The timely delivery of the web application developed under the Framework Agreement and associated Service Contract(s) is essential for enhancing the accessibility and visibility of the C3S ECV portfolio in the near future.**

As part of its Tender, the Tenderer shall complete the relevant table in the ITT Volume IIIA template which shall therefore include the Deliverables and Milestones already indicated in this ITT Volume II, unless otherwise substantiated.

⇨ For the sake of clarity, the Tenderer can add to the list of Deliverables and Milestones any Deliverables and Milestones that are deemed necessary to duly cover the entire scope of activities to be performed and comply with all associated requirements.

[CONCERNING THE OPTIONAL DELIVERABLES, if any] Please note that the optional Deliverable(s) shall neither be delivered by the Successful Tenderer nor subject to payment unless expressly requested and activated by ECMWF in due time. In case of optional Deliverables, please:

- clearly mention "[optional]" next to the reference of each optional Deliverable in the list of Deliverables and Milestones, and
- add for each optional Deliverable or WP/set of optional Deliverables an associated Milestone *"ECMWF's decision concerning the activation of optional [DelivRef]"* with ECMWF as main contributor and with as a due date the deadline for ECMWF to activate the said optional Deliverable or set of optional Deliverables (see also Milestone ref. M0.5-DEC-WP6 in section 3.8).

[CONCERNING THE CONTINUOUS ACTIVITIES, if any] Please add to the list of Deliverables and Milestone all necessary Deliverables concerning the continuous activities (e.g. user support, maintenance) that will allow their formal approval by ECMWF. The period of activities covered and reported within the concerned Deliverable (technical note) must be clearly indicated in the list of Deliverables and Milestones.

Important note:

The Tenderer shall detail in its offer any specific dependency of any of the activities, Deliverables and/or Milestones on the provision of external input/data, by ECMWF or third party, to the Successful Tenderer, including especially the origin of the necessary input. This shall be duly accounted for in the list of Deliverables and Milestones (cf. ITT Volume IIIA "Pricing and deliverables" spreadsheet "Deliverables List" column "Comment/Means of verification") as well as in the risk register where relevant mitigation shall be envisaged (cf. ITT Volume IIIB Section 5.6).

4.3 Communication

Copernicus is a single brand, owned and overseen by the European Commission and entrusted to the entities delivering the six Copernicus services. ECMWF and its third-party suppliers must consequentially adhere to the Copernicus brand guidance set by the European Commission for all communication material. All communication activities considered by the Successful Tenderer and its Sub-contractors must therefore be agreed with the ECMWF Copernicus Communication team in advance. This includes, without being limited, communication planning, branding and visual style, media outreach, website and social media activity, externally facing written and graphic content and events.

If needed, the Successful Tenderer can be requested to support ECMWF in its communication activities for the C3S services, where they are related to the activities described in this ITT. Examples are contributions to the C3S website news items, and C3S brochures and flyers.

4.4 Data and IPR

It is a condition of EU funding for Copernicus and C3S that ownership of any datasets/software developed with Copernicus/C3S funding (such as the pre-calculated metrics produced under this contract, and the web application itself) passes from the suppliers to the European Union via ECMWF. Ownership will pass from the date of creation of the datasets/software. Suppliers will be granted a non-exclusive licence to use the datasets/software which they have provided to C3S for any purpose.

All software and products used by the Successful Tenderer to produce the C3S datasets/software will remain the property of the Successful Tenderer, except for those components which are acquired or created specifically for Copernicus/C3S purposes, with Copernicus/C3S funding, and which are separable and useable in isolation from the rest of the Successful Tenderer's production system. The identity and ownership of such exceptional components will be passed to the European Union via ECMWF annually. The Successful Tenderer will be granted a non- exclusive licence to use them for any purpose.

For more details please refer to ITT Volume V, Clause 3.

4.5 Key Performance Indicators

As part of its Tender, the Tenderer shall specify a proposed set of Key Performance Indicators (KPIs) suitable for monitoring various aspects of performance. There, the KPIs shall be designed to quantify different aspects of quality of service against the requirements described in this document.

The contractor shall report to ECMWF on a set of SMART (Specific, Measurable, Actionable, Realistic and Time bound) KPIs suitable for monitoring various aspects of service performance, including whenever applicable (but not limited to):

- Code quality
- Service delivery
- Contract management
- User support

During the contract implementation, all KPIs will be reported by the contractor in the Quarterly and Annual Implementation Reports (see the concerned WP0 deliverables in section 3.8).

The table below provides the template to be used by the Tenderer to describe the KPIs relevant for this ITT, together with performance targets, delivery schedules and explanations (if needed). Note that the table also contains KPI.C1, which must be part of the proposal and therefore the contract as well.

WP	KPI #	KPI Title	Performance Target and Unit of Measure	Frequency of Delivery	Explanations / Comments
all	KPI.C1	Timely delivery for review of Deliverables and completion of Milestones	100% of Deliverables submitted for review and Milestones passed on time during previous quarter	Quarterly (via WP0 QIR and PRM)	The due dates associated to each Deliverable and Milestone in the contractual list of Deliverables and Milestones shall be considered the deadlines (inclusive) for the Deliverables to be submitted for review and Milestones to be passed.
WPx	KPI.XX	xxx	…	xxx	xxx
WPx	KPI.XX	xxx	…	xxx	xxx

Table 10: KPI table example, and mandatory KPI.C1

For the sake of clarity:

- All KPIs shall be labelled and numbered as indicated above or follow similar referencing.
- The Tenderer shall limit those additional KPIs to the sole KPIs whose reporting and analysis by both Parties may help to optimize the performance of the contract in case of deviation observed per comparison with the performance targets.

4.6 Price and Payment Plan

4.6.1 Type of price

It is envisaged to use pre-agreed (fixed) price under the frame of the Framework Agreement and its two Service Contract(s). This might be subject to discussion during the negotiation phase, if need be.

4.6.2 Substantiation of the price

The Tenderer is invited to provide a short explanation about the allocation of the resources between the different WPs/activities/Deliverables (e.g. bottom-up approach), focusing on the items that require the most significant efforts. In case of pre-agreed (fixed) price, any indication about difficulty in quoting precisely some activities shall be shared as soon as possible with ECMWF.

Additional exchanges and requests for explanations concerning the efforts and corresponding prices will take place during the negotiation phase if the Tenderer is selected accordingly.

Additional guidance about the prices: WP0 management and coordination is expected to amount to approx. 7-10% of the total effort (person months) allocated to the entire Framework Agreement.

4.6.3 Travel costs

The travel costs shall be presented in accordance with the following provisions:

Travel costs should, in principle, be based on the European Commission's calculator [Table 3: Unit cost per distance band for air or combined air/rail travel, Commission Decision C(2024)5405], and consider a daily subsistence allowance not to exceed €300.

Travel costs must reflect **estimated actual costs and must not include any profit margin**.

If the proposed travel costs deviate from these reference values, the deviation shall be clearly indicated and duly justified.

Tenderers are requested to provide a summary table as shown below as part of their Tender.

Type of cost	Route/Destination	Estimated number of missions	Estimated unit price [€]
Travel/Subsistence			
Travel/Subsistence			

ECMWF will reserve the right to re-claim any declared unspent or unaccounted budget for “Travel”, as it will be described in the Annex 2 Pricing Tables of the Framework Agreement.

4.6.4 Payment Plan

The Tenderer shall propose a Payment Plan in its Tender thanks to the ITT Volume IIIA “Pricing and deliverables” (cf. Excel spreadsheet “Payment Plan preparation”):

- It is foreseen to assess the Services and Deliverables on a (Payment) Milestone basis in accordance with Clause 4.5.3.4 of the ITT Volume V. Therefore, the Payment Milestones should relate to the

Deliverables and Milestones delivered during the period subject of the corresponding Payment Milestone (e.g. the payment covering the period January-June must relate to the Deliverables and Milestones whose due dates are part of the same period).

- It is recommended to have Payment Milestones, and therefore payments, with an anticipated date of completion ca. every 6 months. Any other frequency can be proposed by the Tenderer but shall be duly substantiated.
- The due dates of the Progress Review Meetings shall be adjusted to ensure that each Payment Milestone has an associated Progress Review Meeting.
- In case of request for a payment at contract signature, please note that this should be duly substantiated (e.g. in terms of necessary investment prior to implementation or during first weeks/months for ensuring the initial set up of the project). It is necessary to relate this payment to activities and prices subject to other Payment Milestones.

5 Tender Format and Content

General guidelines for the Tender are described in the ITT Volume IIIB. This section describes specific requirements to prepare the proposal for this particular Tender, along with guidelines for minimum content expected to be included in the proposal, additional to the content described in the general guidelines of the ITT Volume IIIB. This is not an exhaustive description and additional information may be necessary depending on the Tenderer's response.

5.1 Page Limits

As a guideline, it is expected that individual sections of the Tenderer's response do not exceed the page limits listed below. These are advisory limits and should be followed wherever possible, to avoid excessive or wordy responses.

Section	*Page Limit*
Executive Summary	2
Track Record	2 (for general) and 2 per entity (if applicable)
Quality of Resources Applied	2 (excl. Table 1 in the ITT Volume IIIB and CVs with a maximum length of 2 pages each)
Technical Solution Proposed	20 for the technical solution and Work Packages (Table 2 in the ITT Volume IIIB, the section on reference, publications, patents and any pre-existing IPR are excluded from the page limit and have no page limit)
Management and Implementation	6 (excl. Table 4 and Table 5 in the ITT Volume IIIB) + 2 per each Work Package template (Table 3 in the ITT Volume IIIB)

Table 11: Page limits

5.2 Specific additional instruction for the Tenderer's response

The following is a guide to the minimum content expected to be included in each section, additional to the content described in the general guidelines of Volume IIIB. This is not an exhaustive description and additional information may be necessary depending on the Tenderer's response.

5.2.1 Executive Summary

The Tenderer shall provide an executive summary of the proposal, describing the objectives, team and service level.

5.2.2 Track Record

The Tenderer shall demonstrate the availability of expertise as required for the implementation of the web application in line with the requirements and work package descriptions.

The Tenderer shall demonstrate for itself and for any proposed sub-contractors that they have experience with relevant projects in the public or private sector at national or international level. ECMWF may ask for evidence of performance in the form of certificates issued or countersigned by the competent authority.

The Tenderer shall in particular demonstrate its experience in:

- Kubernetes, Helm, Docker
- Front-end development (React), UX
- Python
- Open source
- Agile development methodologies (or similar)

5.2.3 Quality of Resources to be deployed

The Tenderer shall propose a team that includes a Service Manager and Technical Lead (potentially the same person) with more than 5 years of experience in managing activities related to this ITT, with experience in the appropriate delivery methodology proposed in section 3 above.

The technical project team shall have the skills required to meet the technical requirements set out in section 2.

The Tenderer shall describe the experience of the Service Manager, Technical Lead and technical project team in performing activities related to the various aspects of this Tender.

Also required are the CV, proven track records and certifications of all key individuals, including a brief description of the role these individuals will play in the contract.

5.2.4 Technical Solution Proposed

The Tenderer shall give a short background to the proposed solution to demonstrate understanding of the state-of-the-art in the C3S context and hence justify their proposed solution. In addition to the detailed description of the technical solution proposed, this section shall also include information on any other third-party suppliers that are used as part of the technical solution, and a statement of compliance for each requirement formulated throughout this document, describing how the proposed solution maps to the requirements.

5.2.5 Management and Implementation Plan

As part of the general project management description, and in addition to the guidance provided in Volume IIIB, the Tenderer shall consider the elements described in section 3.8 above.

Important note:

Should any sub-contractor be proposed in the Tender, it is a mandatory requirement for the Tenderer to actively involve the said sub-contractor in the development of the proposal to ensure a comprehensive and realistic Tender. This involvement should include, but is not limited to, collaborative planning, clear communication of project timelines, and agreement on the proposed Deliverables and Milestones as well as on their respective due dates. The Tenderer must provide documented evidence of this collaboration, demonstrating that each sub-contractor has been consulted and has agreed to their respective roles, responsibilities, and deadlines as outlined in the proposal. **This requirement is instituted to promote a cohesive and feasible project plan, reflecting a true and committed partnership among all participating entities.**

6 References

Bojinski, S., Verstraete, M., Peterson, T. C., Richter, C., Simmons, A., & Zemp, M. (2014). The Concept of Essential Climate Variables in Support of Climate Research, Applications, and Policy . *Bulletin of the American Meteorological Society*, 1431-1443.

GCOS. (2021). *The Status of the Global Climate Observing System 2021: The GCOS Status Report.* GCOS.

GCOS. (2022). *The 2022 GCOS ECVs Requirements, GCOS-245.*

Appendix A – List of ECV Products available on the CDS

Please note, those ECV Products marked with an Asterix (*) are not yet currently available on the CDS but are expected to be made available within the timeframe of the Framework Agreement and Service Contract(s) that may result from this ITT. Therefore, the Tenderers must plan to include these in the application alongside currently available products.

Additionally, the Tenderers shall be aware that some CDS entries for ECV products contain multiple datasets. This can be due to several reasons, such as data being available from multiple satellite sensors or originating from different sources (e.g. C3S, EUMETSAT, ESA). The exact data from each CDS entry that will be chosen to represent each ECV product on the web application is to be discussed and agreed with ECMWF. The Tenderers are welcome to suggest the data they feel would best represent the ECV products.

Lastly, the Tenderers may note that some of the datasets in the second column are not named identically to the ECV products as described by GCOS (GCOS, 2022), and are instead the variables listed on the associated CDS entry. Again, the specific data from each CDS entry that will be chosen to represent each ECV will be discussed and agreed with ECMWF.

ECV	ECV Product / CDS Variable	Format	CRS	Currently published on CDS	Access (https://cds.climate.copernicus.eu/datasets/ + slug)
Atmospheric Composition					
Carbon Dioxide, Methane & other GHGs	CO2 column-average dry air mole fraction, Mid-tropospheric column CO2	NetCDF-4	Regular lat-lon grid	Y	satellite-carbon-dioxide
	CH4 column-average dry air mole fraction, Mid-tropospheric column CH4	NetCDF-4	Regular lat-lon grid	Y	satellite-methane
Aerosols	Aerosol Optical Depth Fine-mode aerosol optical depth Dust aerosol optical depth Single scattering albedo Aerosol layer height Dust aerosol layer height Aerosol Extinction Coefficient	NetCDF-4	Regular lat-lon grid	Y	satellite-aerosol-properties
Ozone	Total Column Ozone from UV measurements	NetCDF-4	Regular lat-pressure grid	Y	satellite-ozone-v1

	Total and Tropospheric column (0-6 km) Ozone from IT measurements Vertical Ozone Profiles				
Atmospheric Surface & Upper Atmosphere					
Clouds	Cloud cover, Cloud optical depth Cloud top height, Cloud top temperature, Cloud ice water path, Cloud liquid water path, Cloud drop effective radius Cloud phase	NetCDF-4	Regular lat-lon grid	Y	satellite-cloud-properties
Upper-Air Temperature	Atmospheric temperature in the Upper Troposphere and Lower Stratosphere*	NetCDF-4	Regular lat-lon-pressure grid	N	N/A
Upper-Air Water Vapour	Upper tropospheric humidity	NetCDF-4	Regular lat-lon grid	Y	satellite-upper-troposphere-humidity
	Tropospheric humidity profiles	NetCDF-4	Regular lat-pressure grid	Y	satellite-humidity-profiles
Surface Radiation Budget	Upward long-wave irradiance at Earth surface, Downward long-wave irradiance at Earth surface (long-wave, short-wave)	NetCDF-4	Regular lat-lon grid	Y	satellite-surface-radiation-budget
Earth Radiation Budget	Solar spectral irradiance, Upward short-wave irradiance at top of the atmosphere, Upward long-wave irradiance at top of the atmosphere, Downward short-wave irradiance at top of the atmosphere	NetCDF-4, ASCII	Regular lat-lon grid	Y	satellite-earth-radiation-budget
Precipitation	Accumulated precipitation	NetCDF-4	Regular lat-lon grid	Y	satellite-precipitation
Land Hydrology					
Soil Moisture	Surface soil moisture	NetCDF-4	Regular lat-lon grid	Y	satellite-soil-moisture
	Root-zone soil moisture*	NetCDF-4	Regular lat-lon grid	N	satellite-soil-moisture
	Freeze/thaw*	NetCDF-4	Regular lat-lon grid	N	satellite-soil-moisture

Terrestrial Water Storage	Terrestrial water storage anomaly*	NetCDF-4	Regular lat-lon grid	N	N/A
Groundwater	Groundwater storage change*	NetCDF-4	Regular lat-lon grid	N	N/A
Lakes	Lake water levels	NetCDF-4	Regular lat-lon grid	Y	satellite-lake-water-level
	Lake surface water temperature	NetCDF-4	Regular lat-lon grid	Y	satellite-lake-water-temperature
	Lake ice cover*	N/A	N/A	N	N/A
	Lake water leaving reflectance*	N/A	N/A	N	N /A
Land Cryosphere					
Ice sheets and Ice Shelves	Ice Velocity (Greenland and Antarctic)	NetCDF-4	Polar-stereographic (Greenland - EPSG:3413; Antarctica - EPSG:3031)	Y	satellite-greenland-ice-sheet-velocity
	Surface elevation change (Greenland and Antarctic ice sheet)	NetCDF-4	Polar-stereographic (Greenland - EPSG:3413; Antarctica - EPSG:3031)	Y	satellite-ice-sheet-elevation-change
	Ice sheet mass change	NetCDF-4	Polar-stereographic, WGS84	Y	satellite-ice-sheet-mass-balance
Glaciers	Glacier mass change	NetCDF-4	Regular lat-lon grid	Y	derived-gridded-glacier-mass-change
	Glacier area	Shapefile	WGS84	Y	insitu-glaciers-extent
Permafrost	N/A *	N/A	N/A	N	N/A
Snow	Snow water equivalent*	N/A	N/A	N	N/A
	Area covered by snow *	N/A	N/A	N	N/A
Land Biosphere					
Leaf Area Index (LAI),	LAI	NetCDF-4	Plate Carrée	Y	satellite-lai-fapar
Fraction of Absorbed Photosynthetically Active Radiation (fAPAR)	fAPAR	NetCDF-4	Plate Carrée	Y	satellite-lai-fapar

Albedo	Surface Albedo	NetCDF-4	Plate Carrée	Y	satellite-albedo
Land Cover	Land Cover	NetCDF-4	Plate Carrée	Y	satellite-land-cover
Land Surface Temperature	Land Surface Temperature*	NetCDF-4	Regular lat-lon grid	N	N/A
Fire	Active Fire and Fire Radiative Power	NetCDF-4, CSV	Regular lat-lon grid	Y	satellite-fire-radiative-power
	Fire Burned area	NetCDF-4, GeoTIFF	Regular lat-lon grid	Y	satellite-fire-burned-area
Ocean					
Ocean Colour	Water leaving radiance, chlorophyll-a concentration	NetCDF-4	WGS84 and Sinusoidal grid	Y	satellite-ocean-colour
Sea Ice	Sea ice thickness	NetCDF-4	LAEA centered over North Pole	Y	satellite-sea-ice-thickness
	Sea ice drift*	N/A	N/A	N	N/A
	Sea ice temperature*	N/A	N/A	N	N/A
	Sea ice age	NetCDF-4	LAEA	Y	satellite-sea-ice-edge-type
	Sea ice concentration	NetCDF-4	LAEA	Y	satellite-sea-ice-concentration and satellite-sea-ice-edge-type (for the latter edge relates to concentration)
Sea Level	Global and regional mean sea level	NetCDF-4	Cartesian grid	Y	satellite-sea-level-global
Sea Surface Salinity	Sea surface salinity*	N/A	N/A	N	N/A
Sea Surface Temperature	Sea surface temperature	NetCDF-4	Regular lat-lon grid	Y	satellite-sea-surface-temperature
Sea State	Wave height*	N/A	N/A	N	N/A