ECMWF Copernicus Procurement

Invitation to Tender

Copernicus Atmosphere Monitoring Service

Volume II

Development of greenhouse gas aspects in the global CAMS system

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1 Introduction

Some of today's most important environmental concerns relate to the composition of the atmosphere. The increasing concentration of the greenhouse gases and the various aerosol-weather feedbacks are prominent but often uncertain drivers of climate change. Ozone distributions in the stratosphere influence the amount of ultraviolet radiation reaching the surface.

In the troposphere, aerosols, ozone and other reactive gases such as nitrogen dioxide determine the quality of the air around us, affecting human health and life expectancy, the health of ecosystems and the fabric of the built environment. The variable abundance of the reactive gases change the oxidation capacity of the atmosphere and control therewith also the abundance of long-lived greenhouse gases. The composition of the troposphere and the associated deposition fluxes are major components of the biogeochemical cycles of carbon, nitrogen and sulphur and iron, which effect the land- and marine eco systems. Dust, smoke and volcanic aerosols affect the safe operation of transport systems and the availability of power from solar generation, the formation of clouds and rainfall, and the remote sensing by satellite of land, ocean and atmosphere.

In the wake of the agreement signed in Paris at the UNFCCC's 21st Conference of the Parties (COP-21) in December 2015, the need to monitor and to inform about the effectiveness of mitigation efforts for anthropogenic emissions of key greenhouse gases has become more acute and prominent. With its global coverage (or regional in the case of geostationary platforms), Earth Observation has a decisive role to play within such a monitoring system, complementing ground-based observations, "bottom-up" estimates of the emissions (included in official reporting) and atmospheric transport modelling.

To address these environmental concerns there is a need for data and processed information. The Copernicus Atmosphere Monitoring Service (CAMS) has been developed to meet these needs, aiming at supporting policymakers, business and citizens with enhanced atmospheric environmental information.

Within its first phase (2015 – 2020), Cop1, the Service consolidated many years of preparatory research and development to deliver a range of operational services. In its second phase (2021 – 2027), Cop2, these services are further consolidated, improved and expanded to address all the existing and emerging societal needs related to the atmospheric environment. The CAMS service portfolio consists of the following service elements:

a) Daily production of real-time analyses and forecasts of global atmospheric composition;
b) Reanalyses providing consistent multi-annual global datasets of atmospheric composition with a stable model/assimilation system;
c) Daily production of real-time European air quality analyses and forecasts with a multi-model ensemble system;
d) Reanalyses providing consistent annual datasets of European air quality with a frozen model/assimilation system, supporting in particular policy applications;
e) Products to support policy users, adding value to "raw" data products in order to deliver information products in a form adapted to policy applications and policy-relevant work;
f) Solar and UV radiation products supporting the planning, monitoring, and efficiency improvements of solar energy production and providing quantitative information on UV irradiance for downstream applications related to health and ecosystems;
g) Greenhouse gas atmospheric inversions for CO_2, CH_4 and N_2O net surface fluxes, allowing the monitoring of the evolution in time of these fluxes;

h) Climate forcing from aerosols and long-lived (CO_2, CH_4) and shorter-lived (stratospheric and tropospheric ozone) agents;
i) Anthropogenic and natural emissions, based on inventory data and modelling, for the global and European domains;
j) Observation-based emission estimates of atmospheric pollutants for the global and European domains;
k) Observation-based anthropogenic emission estimates of CO_2 and CH_4 for the global domain and emission hotspots.

This Invitation to Tender (ITT) is mainly targeting the CAMS service elements described under items (a), (b) and (k).

1.1 Definitions

Definitions specific for this ITT are defined below.

Global Service Provider: ECMWF is the provider of global products

Global Production System: the modelling and data assimilation infrastructure used to provide the CAMS global analyses and forecasts of atmospheric composition.

2 Contract Summary

This ITT, entitled "Development of greenhouse gas aspects in the global CAMS system", is for providing support for and further development of the Global Production System of CAMS operated at ECMWF, which delivers 3D distributions of greenhouse gases (CO_2 and CH_4) in the troposphere and stratosphere through data assimilation and numerical modelling. The Successful Tenderer shall deliver an improved representation of methane fluxes from natural wetlands for use in the CAMS Global Production System with a focus on wetland extent and wetland type. The successful Tenderer shall also adapt, implement, and evaluate a radiative transfer model for solar-induced chlorophyll fluorescence (SIF) for future use of satellite observations of SIF to evaluate and optimize the land surface model used in the CAMS Global Production System. In addition, the successful Tenderer shall deliver memoranda and reports to document the requested developments and provide expertise to the team working on the global production system at ECMWF regarding greenhouse-gas aspects. The ITT targets organisations with considerable experience in the field of CH_4 emissions from wetlands including the use of near-real time remote sensing observations to estimate wetland extent, the classification of wetland types, and more generally the representation of wetland emissions of CH_4 in global models. Experience with the modelling of SIF radiative transfer to exploit satellite observations is also required.

3 Technical Specification

3.1 General Requirements

Modules for atmospheric greenhouse gases and related physical processes have been integrated in ECMWF's Integrated Forecasting System (IFS), which forms the basis for the CAMS global data assimilation and forecasting system. The CAMS global data assimilation system is used to provide the Real-Time Global Products, the Forecast-only Global Products, and the Global Reanalysis Products. The extension of the IFS makes it possible (i) to use the detailed meteorological simulation of the IFS for the simulation of the atmospheric transport and removal processes of constituents, (ii) to use the IFS data assimilation system to assimilate observations of atmospheric composition, and (iii) to

simulate feedback processes between atmospheric composition and weather. The IFS currently includes CO_2 and CH_4 as separate tracers. Although most surface fluxes for these two species are currently prescribed, the IFS is directly coupled to the CHTESSEL land surface model for the natural biosphere fluxes of CO_2 (see also: Agustí-Panareda et al., 2014, doi:10.5194/acp-14-11959-2014; Boussetta et al., 2013, doi: 10.1002/jgrd.50488). A simple parameterisation for the oxidation of CH_4 based on Bloom et al. (2017, doi:10.5194/gmd-10-2141-2017) is also part of the IFS.

The central elements of this ITT are the further development of the Bloom et al. (2017) parameterisation of wetland emissions for CHTESSEL and the implementation of a proven Solar-Induced Chlorophyll Fluorescence (SIF) radiative transfer model for future use of satellite observations. Due to the operational, product-driven nature of CAMS, the Successful Tenderer shall ensure that the provided numerical code and developments are suitable for the time-critical, operational data assimilation and forecasting environment based on IFS, including its existing formulation of atmospheric transport and other meteorological processes.

3.2 Work package 52a10 – Development of CH4 wetland model

The IFS uses the Carbon-Hydrology Tiled ECMWF Scheme for Surface Exchanges over Land (CHTESSEL) land surface model. CHTESSEL includes a representation of soil, vegetation, snow, mountains, and water bodies and the associated energy, water and carbon exchanges with the atmosphere. This includes a multi-layer soil scheme and a single- layer snow scheme representing thermodynamics and water transfer processes. A mixed-layer scheme for resolved and sub-grid water bodies has been recently added. Satellite-based land-use maps and monthly varying vegetation-soil descriptions (for Leaf Area Index and Albedo) specify ancillary conditions, while processes like evapotranspiration, snow and ice melting/sublimation, percolation and runoff are explicitly taken into account. The natural land carbon cycle is represented in its soil respiration, parameterised with a so-called Q10 scheme and modulated by a land-use dependent basal respiration, and a photosynthesis scheme that simulates the CO_2 assimilation by plants or gross primary production. The CO_2 residuals of assimilation and respiration processes compose the Net Ecosystem Exchange. The land surface model benefits from continuous benchmarking of its main prognostic variables and fluxes against in-situ and satellite remote sensing products and is used across all ECMWF forecasting applications (more information can be found in Chapter 8 of the IFS documentation at https://www.ecmwf.int/file/267309/download?token=RV- BAg4d).

CHTESSEL is already providing the hydrological and CO_2-specific carbon cycle exchanges with the atmosphere, and it also includes a model component for natural CH_4 fluxes. A simple CH_4 wetland scheme has previously been introduced in CHTESSEL through a precursor contract of the current ITT. This scheme uses forecasted soil temperature and respiration to simulate flux variability; however, the wetland extent is not derived by CHTESSEL. Therefore, suitable ancillary data, either based on model output (external) or observations, is required to provide wetland characteristics. Currently, the wetland extent is based on a climatology from the ORCHIDEE land surface model (Ringeval *et al.*, 2012, doi:10.5194/gmd-5-941-2012).

The successful Tenderer will further develop the parameterisation of the wetland emissions in CHTESSEL to a stage where it can be operationally implemented within the CAMS Global Production System as outlined in the subsections below. ECMWF will provide an off-line version of CHTESSEL that can be used for this model development together with support/training on performing the model simulations. The development of the CH_4 wetland flux parameterisation shall be performed in coordination with ECMWF staff to assure consistency with other CHTESSEL developments.

The parameterisation shall be evaluated with observations from a selection of in situ FLUXNET sites and further benchmarked against other independent products from established model intercomparison projects and information on the global budget provided by the Global Carbon Project. The expected model developments have been grouped into three tasks listed below.

3.2.1 Task 52a11 – Wetland extent

The main cause of model disagreement in bottom-up global wetland CH4 flux inter-comparison studies is the disagreement in both space and time of the wetland areal extent (e.g., Parker et al., 2020, doi: 10.5194/bg-17-5669-2020, and references therein). This is not surprising given that the wetland location is a prerequisite for accurate emissions.

A comprehensive overview of existing wetland products is available in Tootchi et al. (2019; doi: 10.5194/essd-11-189-2019). The disagreement in products comes from both the definition of wetland extent and the methods of obtaining the data to estimate the wetland extent. Wetland extent is typically modelled or observed from both the ground and space. Of importance to the CHTESSEL development is evaluating which method and product yield the most accurate representation of wetland extent relevant to CH_4 fluxes. To achieve this the successful Tenderer shall provide an inter-comparison of existing wetland extent products and methodologies within the context of the CHTESSEL model. Results shall identify a suitable candidate for use in the CAMS operational global modelling system.

In addition, products provided as an annual or monthly wetland climatology fail to capture the required interannual variability in wetland extent. This limits the accuracy of modelling spatiotemporal variability in methane fluxes. Products based on multi-sensor satellite observations can provide the variability required and as such should be utilised to derive wetland extent variability (e.g. Bloom *et al.*, 2017). The successful Tenderer shall provide an investigation into the use of NRT remote sensing observations, which can be used to constrain the wetland extent within an operational context. These methods need not be restricted to direct microwave observations of wetland extent but can include novel applications of other observations, such as precipitation.

3.2.2 Task 52a12 – Classification and Model Development/Optimisation

Wetland CH_4 model optimisation for CHTESSEL has previously been performed using the inverse modelling estimates from the Global Carbon Project – Methane (Saunois *et al.*, 2020, doi: 10.5194/essd-12-1561-2020) to provide a global or latitudinally dependent scaling factor or base Q_{10} value. To further disaggregate the scaling factor and Q_{10} function in a more physically-based hypothesis, the successful Tenderer shall provide an investigation into scaling factors and Q_{10} values which are wetland type dependent. This shall involve three steps:

1. Identifying a suitable wetland and lake classification dataset, which can be merged with the wetland extent (Task 52a11) and used within the CHTESSEL wetland CH_4 model.
2. Optimise the model parameters for such a classification set.
3. Define uncertainty values per wetland type and suitable correlation length scales.

Several wetland classification datasets exist (e.g. Lehner and Döll, 2004, doi:10.1016/j.jhydrol.2004.03.028), which shall be evaluated for suitability. These are typically dependent on wetland seasonality, carbon substrate composition (short/long lived), climate zones and more. The flux response to the three controls in the CH_4 model (wetland extent, soil temperature

and substrate carbon) is expected to vary between regions, therefore each region should be optimised separately.

Inverse optimisation will be performed using the global and site-specific offline, surface-only, version of the IFS and can be further validated using FLUXNET observations. The defined regions are expected to be an appropriate size for use as part of a control vector in potential atmospheric inversions. Optimised values should also be accompanied by uncertainty estimates and correlation length scales suitable for use in such an inverse system. Additional work can include adjustments to the respiration/anaerobic decompositions rates of specific regions.

3.2.3 Task 52a13 – Evaluation and Service Evolution

The current CH_4 wetland model used in CHTESSEL generates an instantaneous CH_4 flux based on wetland extent, soil temperature and heterotrophic respiration (which is used as a proxy for carbon substrate). Developments and investigations will be required into:

1. Improved representation of physical processes within the CH_4 flux model.
2. A representation of so-called lag effects to improve flux representation.

The representation of wetland extent is dealt with in Task 52a11, soil temperature is relatively well modelled by CHTESSEL and the representation of carbon substrate availability is currently limited to model heterotrophic respiration until a more dynamic version of the model becomes available with the possible addition of soil carbon. Several other elements shall therefore be investigated to improve model representation of CH_4 wetland fluxes, but model complexity should only be increased if it leads to improved model performance. Specific processes relevant to different wetland-types should also be considered, for example pulse events during permafrost thawing in boreal wetlands. These also include, but are not limited to, exploring transport pathways (ebullition, diffusion, plant-mediated transport), as done in previous studies (e.g., McNorton *et al*., 2016, doi: 10.1002/2016GL070649), oxidation mechanisms of CH_4 before being emitted, suppression of methanogenesis by other chemical species, e.g. sulphates (e.g., Laanbroek, 2010, doi: 10.1093/aob/mcp201), soil pH (Singh *et al.*, 2000, doi: 10.1016/S1465-9972(99)00046-X) and organic decomposition rates (Miyajima *et al*., 1997, doi: 10.1016/S0016-7037(97)00189-0).

A second area of model development shall focus on potential cross-correlation or lag processes between the three key parameters (wetland extent, temperature and respiration) and the CH_4 flux. Previous studies have shown that CH_4 concentrations over wetlands can lead in time the peak wetland extent by several months due to the rapid depletion of carbon stocks during the onset of the wet season (Bloom *et al*., 2012, doi: 10.5194/bg-9-2821-2012). Conversely, wetland extent may lead CH_4 flux due to the required accumulation of either a microbial methanogen population (Chadburn *et al*., 2020, doi: 10.1029/2020GB006678) or a sufficient large methane pool for transport mechanisms to release the methane into the atmosphere (McNorton *et al*., 2016). These processes shall at the very least be explored, and if found to improve performance, be incorporated within the CHTESSEL CH_4 framework.

Tenderers shall complete the relevant table in Volume IIIA as part of their bid, which shall include the deliverables and milestones for this work package already indicated in the tables below. Volume IIIA will be used by the Tenderer to describe the complete list of deliverables, milestones and schedules

for each work package. All milestones and deliverables shall be numbered as indicated. All document deliverables shall be periodically updated and versioned as described in the tables.

WP52a10 Deliverables			
#	*Type*	*Title*	*Due*
D1.1.1[1]	Report	Evaluation of existing wetland extend products with options for use in near-real time	M6
D.1.1.2	Data set	Provision of selected wetland extend dataset	M9
D.1.2.1	Report and data set	Provision of wetland type classification and maps	M12
D1.2.2	Report and code	Wetland model parameter optimization including code	M18
D1.3.1	Report	Test additional physical processes of wetland model including use of ancillary data in near-real time	M24
D1.3.2	Report	Documentation and evaluation of wetland model developments	M24

WP52a10 Milestones			
#	*Title*	*Means of verification*	*Due*
M1.3.1	Transfer of wetland model code and relevant ancillary data		M24

3.3 Work package 52a20 – Development and implementation of Solar Induced Fluorescence radiative transfer model

The IFS currently uses satellite observations to constrain the atmospheric concentrations of CO_2 and CH_4 using its 4D-Var formulation. For this to work accurately a realistic short-term model forecast is needed. For CO_2, the synoptic variability of the forecast is dominated by the natural biosphere fluxes and it is therefore necessary to constrain the output of CHTESSEL as much as possible with observations. Some of the hydrology-related variables (soil moisture, soil temperature and snow depth) can be constrained either through on-line assimilation of in-situ and satellite observations or through an off-line benchmarking. The CO_2 fluxes are currently benchmarked against FLUXNET (http://fluxnet.ornl.gov) observations. Because this does not sufficiently constrain the total CO_2 budget, a bias correction is applied as part of the IFS model simulations (Agusti-Panareda et al., 2016, doi:10.5194/acp-16-10399-2016). The use of satellite observations directly related to the CO_2 fluxes associated with the photosynthetic uptake like Solar-Induced Fluorescence (SIF) would help to

[1] Deliverables (and Milestones) shall be numbered as per the following format DX.Y.Z (MX.Y.Z), where X is the WP number, Y is the task number and Z is the Deliverable (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-2016, DX.Y.Z-2017). Deliverables delivered quarterly should be numbered DX.Y.Z-yyyyQx, where yyyyQx is the quarter of the year the Deliverable refers to (e.g. DX.Y.Z-2016Q1, DX.Y.Z-2016Q2). The same numbering format shall be applied for Milestones. Continuous deliverables at higher frequency can be labelled in the same way as quarterly deliverables.

evaluate and potentially constrain the biogenic fluxes, and in particular the disaggregation between the Gross Primary Production (GPP) and ecosystem respiration.

This ITT asks for the adaptation and implementation of an existing SIF radiative transfer model in CHTESSEL. The accurate simulation of SIF satellite observations requires the implementation of complex radiative transfer models that generally rely on the well-established Farquhar photosynthesis model (Farquhar et al. 1980). The Farquhar model has been recently implemented in CHTESSEL based on Yin and Struik (2009, doi:10.1016/j.njas.2009.07.001). Forward modelling of SIF in CHTESSEL will enable the evaluation of the modelled GPP by providing direct predictions of canopy SIF, which can be compared to satellite observations. The radiative transfer model of canopy SIF involves the computation of SIF at leaf scale linked with photosynthesis and the explicit representation of scattering and reabsorption effects within the canopy with a vegetation canopy radiative transfer model.

The Successful Tenderer shall implement the SIF observation radiative transfer operator in the CHTESSEL model. For this model development, ECMWF will provide an off-line version of CHTESSEL which includes the Farquhar photosynthesis model. The modelled SIF shall be evaluated with SIF observations from satellites (e.g., TROPOMI, OCO-2, GOME-2, GOSAT) and in situ observations, if possible. The SIF observation operator shall allow the matching of the SIF wavelength, footprint and overpass time of the above satellites. Priority shall be given to the satellites with the best global coverage that provide data in near-real time.

The implementation work in CHTESSEL shall be performed in collaboration with ECMWF to assure consistency with other CHTESSEL modelling work at ECMWF.

Tenderers shall complete the relevant table in Volume IIIA as part of their bid, which shall include the deliverables and milestones for this work package already indicated in the tables below. Volume IIIA will be used by the Tenderer to describe the complete list of deliverables, milestones and schedules for each work package. All milestones and deliverables shall be numbered as indicated. All document deliverables shall be periodically updated and versioned as described in the tables.

WP52a20 Deliverables			
#	*Type*	*Title*	*Due*
D2.1.1.YYYY	Report Dataset	Description of the selected SIF radiative transfer model	M6
D2.1.2.YYYY	Report	Progress report on implementation of SIF radiative transfer model with preliminary results of modelled SIF	M12
D2.1.3.YYYY	Report	Evaluation of modelled SIF with observations	M24
D2.1.4.YYYY	Report	Final report to document the SIF radiative transfer model	M24

WP52a20 Milestones			
#	*Title*	*Means of verification*	*Due*
M2.1.1	Transfer of preliminary SIF radiative transfer model code to ECMWF		M18

M2.1.2	Transfer of final SIF radiative transfer model code to ECMWF		M24

3.4 Work package 52a30 – User support and documentation of service

The objective of this work package is to provide support to users of the delivered products and services.

ECMWF has established a centralised Copernicus Service Desk to provide multi-tiered technical support to all users of CAMS data, products, tools and services. The Service Desk handles user queries through a ticketing system and distributes these queries to specialists when needed. Dedicated staff at ECMWF provide basic support in the form of self-help facilities (FAQs, Knowledge Base, online Forum, tutorials etc.) as well as individualised support on technical queries related to the Atmosphere Data Store (ADS), data formats, data access etc. In addition, ECMWF staff provide specialised scientific support to address questions related to its industrial contributions to CAMS, e.g. in the areas of global forecasting of atmospheric composition.

All CAMS contractors are expected to contribute to the delivery of multi-tiered technical support for the data and/or services they provide. Such specialised user support shall take the form of direct response to individual user queries via the Service Desk facility, as well as contributions to FAQs, Knowledge Base, and user guides. Contractors may also be requested by the CAMS Service Desk to contribute to support questions in the online Forum.

Tenderers shall describe the level of user support service on Service Desk tickets as a specific Key Performance Indicator (KPI) with a target value of 80% of the assigned specialised user queries being resolved within 15 days after being informed by the CAMS Service Desk.

Tenderers shall also address development of user guides. Documentation of the CAMS services is an integral part of the service provision and is directly linked to the Atmosphere Data Store. The technical and scientific specification of each service shall be documented in the CAMS Knowledge Base as linked from the Atmosphere Data Store (see example for the CAMS global reanalysis at https://ads.atmosphere.copernicus.eu/cdsapp#!/dataset/cams-global-reanalysis-eac4?tab=doc), and, if more detail is required, in reports that will be available to users through the CAMS web site. The successful Tenderer shall therefore produce documentation describing in detail the methodologies and products they deliver for this ITT. The documentation in the Knowledge Base shall be targeted at the general external user community, while the additional detailed reports shall address the needs of expert users.

Tenderers shall complete the relevant table in Volume IIIA as part of their bid, which shall include the deliverables and milestones for this work package already indicated in the tables below. Volume IIIA will be used by the Tenderer to describe the complete list of deliverables, milestones and schedules for each work package. All milestones and deliverables shall be numbered as indicated. All document deliverables shall be periodically updated and versioned as described in the tables.

WP52a30 Deliverables			
#	*Type*	*Title*	*Due*
D3.y.z-YYYY	Other	Overview of contribution to CAMS Knowledge Base to document products and services requiring expertise specific to global greenhouse gas aspects developments	Annually
D3.y.z-YYYY	Report	Contribution to documentation of products and services based on global greenhouse gas aspects developments	Annually

…			

WP52a30 Milestones			
#	*Title*	*Means of verification*	*Due*
M3.y.z	…	…	…
…			

3.5 Work package 52a00 – Management and coordination

The following management aspects shall be briefly described in the bid:

- Contractual obligations as described in the Framework Agreement Clause 2.3 on reporting and planning.
- Meetings (classified as tasks and listed in a separate table as part of the proposal):
  - ECMWF will organise annual CAMS General Assemblies. The successful Tenderer is expected to attend these meetings with team members covering the various topics that are part of this ITT.
  - ECMWF will host monthly teleconference meetings to discuss CAMS service provision, service evolution and other topics. The Prime Investigator appointed by the successful Tenderer will represent the successful Tenderer in such meetings.
  - ECMWF will organise six-monthly project review meetings (linked to Payment milestones).
  - Tenderers can propose additional project internal meetings (kick-off meeting, annual face-to-face meeting and monthly teleconferences) as part of their response.
- Quality assurance and control: the quality of reports and Deliverables shall be equivalent to the standard of peer-reviewed publications. The final quality check of the deliverables should be made by the prime contractor (contents, use of ECMWF reporting templates for deliverables and reports (Microsoft Word), format, deliverable numbering and naming, typos…); all reports in this project shall be in English. Unless otherwise specified the specific contract Deliverables shall be made available to ECMWF in electronic format.
- Communication management (ECMWF, stakeholders, internal communication).
- Resources planning and tracking using the appropriate tools.
- Implementation of checks, controls and risk management tools for both the prime contractor and subcontractors.
- Subcontractor management, including conflict resolution, e.g. the prime contractor is responsible for settling disagreements, although advice/approval from ECMWF may be sought on the subject.
- A list of subcontractors describing their contribution and key personnel shall be provided, as well as back-up names for all key positions in the contract. The Tenderer shall describe how the Framework Agreement, in particular Clause 2.9 has been flowed down to all their subcontractors.
- Management of personal data and how this meets the requirements of Clause 2.8 and Annex 6 of the Volume V Framework Agreement.

Tenderers shall complete the relevant table in Volume IIIA as part of their bid, which shall include the deliverables and milestones for this work package already indicated in the tables below. Volume IIIA will be used by the Tenderer to describe the complete list of deliverables, milestones and schedules for each work package. All milestones and deliverables shall be numbered as indicated. All document deliverables shall be periodically updated and versioned as described in the tables.

WP52a00 Deliverables

#	Responsible	Nature	Title	Due
D0.y.z-YYYYQQ	Tenderer	Report	Quarterly Implementation Report QQ YYYY *QQ YYYY being the previous quarter*	Quarterly on 15/01, 15/04, 15/07 and 15/10
D0.y.z-YYYY	Tenderer	Report	Annual Implementation Report YYYY *YYYY being the Year n-1*	Annually on 28/02
D0.y.z-YYYY	Tenderer	Other	Preliminary financial form YYYY *YYYY being the Year n-1*	Annually on 15/01
D0.y.z	Tenderer	Report	Final report, including letter from auditor specific to CAMS contract YYYY *YYYY being the last year of the contract*	60 days after end of contract
D0.y.z-YYYY	Tenderer	Report	Draft Implementation plan YYYY *YYYY being the Year n+1*	Annually on 28/02
D0.y.z-YYYY	Tenderer	Report	Finalised Implementation plan YYYY *YYYY being the Year n+1*	Annually on 31/10
D0.y.z-YYYY	Tenderer	Other	Copy of prime contractor's general financial statements and audit report YYYY *YYYY being the Year n-1*	Annually
D0.y.z	Tenderer	Other	Updated KPIs (list, targets…) after review with ECMWF	One year after start of contract

WP52a00 Milestones				
#	Responsible	Title	Means of verification	Due
M0.y.z-Px	Tenderer	Progress review meetings with ECMWF / Payment milestones	Minutes of meeting	~ Every 6 months

4 General Requirements

4.1 Implementation schedule

The Framework Agreement will run from 1 September 2021 to 31 August 2023. The Tenderer shall provide a detailed implementation plan of proposed activities for the full period.

4.2 Deliverables and milestones

Deliverables should be consistent with the technical requirements specified in section 3. A deliverable is a substantial, tangible or intangible good or service produced as a result of a project. In other words, a deliverable is an outcome produced in response to the specific objectives of the contract and is subject to acceptance by the technical contract officers at ECMWF. When defining deliverable please **consolidate their numbers** against a specific deadline, where possible. All contract reports shall be produced in English. The quality of reports and deliverables shall be equivalent to the standard of peer-reviewed publications and practice. Unless otherwise specified in the specific contract, deliverables shall be made available to ECMWF in electronic format (PDF/Microsoft Word/Microsoft Excel or compatible) via the Copernicus Deliverables Repository portal.

Each Deliverable shall have an associated resource allocation (person-months and financial budget, resource type: payroll only). The total of these allocated resources shall amount to the requested budget associated with payroll.

Milestones should be designed as markers of demonstrable progress in service development and/or quality of service delivery. They should not duplicate deliverables. Apart from the payment milestone review meetings, all foreseen meetings shall not be classified as milestones but listed in a separate overview table for each work package.

4.3 Acquisition of necessary data and observations

The Successful Tenderer shall acquire the relevant observational data sets needed for the optimisation and evaluation of the developments of this ITT.

4.4 Communication

The successful Tenderer shall support ECMWF in its communication activities for the CAMS services, where they are related to the activities described in this ITT. Examples are contributions to the Copernicus State of the Climate report, CAMS web site news items, and CAMS brochures and flyers. All communication activity must be agreed with the ECMWF Copernicus Communication team in advance. This includes, but not exhaustively, communication planning, branding and visual style, media outreach, website and social media activity, externally facing written and graphic content and events. Agreed activity would also need to be evaluated and reported on, once complete, so that success measures and KPIs can be provided to the European Commission.

4.5 Support for user engagement and training activities

While user engagement and training activities are not part of the scope of this ITT, the Tenderer shall accommodate for eventual needs in providing technical and scientific expertise in support of these activities. The bidder shall specify in the bid the experts intended to be allocated to provide this support.

Requests to support activities may be raised on for example:

- Contribute with content specific input to training, education and capacity building material: development and/or review of learning resources in the domain of the contract, participation in train-the-trainer events and MOOCs;
- Contribute with content specific input to user-oriented communication material such as slides, story maps and user testimonials;
- Contribute and attend User Uptake workshops and stakeholder meetings. Presentations in your mother tongue may be asked to be provided;
- Input to the URDB with user requirements (cf. template as provided during the negotiation process) as well sharing needs and aspirations as raised by potential new user communities;

An indicative maximum budget of 5,000.- EUR shall be allocated in the pricing table to accommodate for these needs. This shall be paid as a cost-reimbursement against a fixed fee rate/day]. Details on the expected activities and the budget shall be refined during the negotiation/contract preparation phase.

As part of the CAMS user interaction, user requirements are continually collected in a User Requirements Database (URDB) in a structured and traceable way. This URDB tracks all requirements emanating from a wide variety of user fora, surveys, user support and direct interactions between

service providers and their users. The entries of the URDB are analysed on a regular basis in terms of user requirements per domain, importance and feasibility. This analysis constitutes the basis for distilling, filtering and translating user requirements into technical specifications for the Service and its evolution.

The successful Tenderer shall provide input to the User Requirements Database (URDB) regarding user requirements that are directly related to activities covered by this ITT. The successful Tenderer shall also support ECMWF and the contractor of User Interaction activities with the analysis of relevant user requirements in the URDB.

The following deliverables are thus to be added to the WP52a30 deliverable lists:

WP52a30 Deliverables			
#	*Type*	*Title*	*Due*
D3.y.z-YYYY	Other	Input to CAMS URDB - YYYY	Checked by ECMWF annually in November
…			

4.6 Data and IPR

It is a condition of EU funding for CAMS that ownership of any datasets developed with CAMS funding passes from the suppliers to the European Union via ECMWF. Ownership will pass from the date of creation of the datasets. Suppliers will be granted a non-exclusive licence to use the datasets which they have provided to CAMS for any purpose.

All software and products used by the successful Tenderer to produce the CAMS datasets will remain the property of the successful Tenderer, except for those components which are acquired or created specifically for CAMS purposes, with CAMS funding, and which are separable and useable in isolation from the rest of the successful Tenderers' 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.

5 Tender Format and Content

General guidelines for the tender are described in Volume IIIB. Specific requirements to prepare the proposal for this particular tender are described in the next sub-sections.

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)
Quality of resources to be Deployed	2 (excluding Table 1 in Volume IIIB and CVs with a maximum length of 2 pages each)

Technical Solution Proposed	2 + 3 per Work package (Table 2 in Volume IIIB, the section on references, publications, patents and any pre-existing IPR is excluded from the page limit and has no page limit)
Management and Implementation	6 (excluding Table 3, Table 5, Table 6 and Table 7 in Volume IIIB) + 2 per each Work package description (Table 4 in Volume IIIB)
Pricing Table	No limitation

Table 1: *Page limits*

5.2 Specific additional instructions 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 for itself and for any proposed subcontractors 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.

5.2.3 Quality of Resources to be Deployed

The Tenderer shall propose a team that meets at least the following requirements:

- A senior team member (Prime Investigator) with more than 5 years of experience in managing activities related to this ITT;
- At least two additional senior team members with more than 5 years of experience on performing activities related to the various aspects of this ITT.

These team members shall be involved in the activities of this ITT at a minimum level of 10% of their total working time. The successful Tenderer shall also appoint a Service Manager, which will be its primary contact for contractual delivery and performance aspects.

5.2.4 Technical Solution Proposed

The Tenderer is expected to provide a short background to the proposed technical solution to demonstrate understanding of the solution proposed. This should include background of the Tenderer's understanding of the Copernicus Atmosphere Monitoring Service, and the current state of monitoring and forecasting of global greenhouse gases in the atmosphere.

An exhaustive and detailed description of the proposed technical solution for all work packages described above, including any ramp-up or mobilization phase, shall be given. The Tenderer shall indicate in detail its development plan for the proposed CH4 wetland flux developments, and the adaptation, implementation, and testing of a SIF operator in CHTESSEL. Finally, for the model development aspects, the Tenderer shall indicate its proposal for required input data sets and observations/products to be used in the optimization of model parameters and final evaluation of the model performance.