ECMWF Copernicus Procurement

Invitation to Tender

Copernicus Atmosphere Monitoring Service

Volume II

Development of global reactive gases aspects

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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-live green-house 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.

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.

The Service consolidates many years of preparatory research and development and delivers the following operational services:

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 surface flux inversions for CO_2, CH_4 and N_2O, 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 for the global and European domains and global emissions from wildfires and biomass burning

This Invitation to Tender (ITT) is mainly targeting the CAMS service elements described under items (a) and (b) and shall assist (h) and (i)

1.1 Definitions

Definitions specific for this ITT are defined below.

Global Service Provider: ECMWF is the provider of global products

Real-Time Global Products: the operational real-time analyses and forecasts from the global CAMS data assimilation and forecasting system, which is run by the Global Service Provider. These analyses and forecasts are produced twice- daily and include 3-dimensional fields of aerosols, chemical species, and greenhouse gases with a temporal resolution of at least 6 hours.

Forecast-only Global Products: the outputs of a global CAMS forecasting system that is based on the system used to produce the Real-Time Global Products but without the assimilation of observations of atmospheric composition. The forecasts are produced at least daily and include 3-dimensional fields of aerosols, chemical species, and greenhouse gases with a temporal resolution of at least 6 hours.

Global Reanalysis Products: the outputs of a reanalysis from the global CAMS data assimilation and forecasting system, which is being been run by the Global Service Provider. The reanalysis covers the period from 2003 to 2018 and provides analyses and forecasts of 3-dimensional fields of aerosols, chemical species, and greenhouse gases with a temporal resolution of at least 6 hours. New years will be added on an annual basis.

Chemistry scheme: a computer code that allows the simulation of the concentration changes because of chemical conversion of a set of chemical species and their respective chemical reactions (i.e. a chemical scheme) in the Integrated forecasting System (IFS) of ECMWF. The chemical scheme comprises the (i) calculation of reaction rate constants and photolysis rates based on meteorological input data (ii) the numerical solver for the chemical mechanism (iii) the specification of boundary conditions of the chemical species and (iv) the interfaces to routines calculating wet and dry deposition.

2 Contract Summary

This ITT, entitled “Development of global reactive gases aspects”, is for providing support for and further development of the global production system of CAMS operated at ECMWF, which delivers 3D distributions of reactive gases in the troposphere and stratosphere through data assimilation and numerical modelling. The Successful Tenderer will be expected to deliver improvements to the chemistry schemes and the related parameterisations of source and sink processes in the CAMS global production system. Further, the Successful Tenderer will be expected to provide comprehensive documentation and to contribute to the development of chemistry-specific CAMS products to attract a wider range of users for CAMS. The Successful Tenderer will also advise the team working on the global production system at ECMWF. The ITT targets organisations with considerable experience in the field modelling of reactive gases in the atmosphere.

3 Technical Specification

3.1 General Requirements

Modules for atmospheric chemistry and related physical processes have been integrated on-line 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. This integration 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, weather, as well the land surface, and the ocean.

The IFS can be run with several Chemistry Schemes covering both the troposphere and stratosphere. The chemistry schemes currently integrated in the IFS are: (i) the tropospheric chemistry mechanism CB05 as implemented in the TM5 Chemical Transport Model (CTM), (ii) the stratospheric mechanism from the BASCOE model, which can also be run in conjunction with CB05, and the chemical schemes of the (iii) MOCAGE and (iv) the MOZART-3 CTMs, which cover both the troposphere and the stratosphere. Each chemistry scheme applies its own parameterisations of the photolysis rates. The implementation of (i) and the overall structure of the IFS for the simulation of atmospheric composition is document in Flemming et al. 2015. The chemistry schemes (i) to (iv) are documented in more detail in Huijnen et al., 2019.

The core of this ITT is the further development of the chemical schemes and the related parameterisations for removal processes and surface fluxes in the IFS. The current operational scheme, CB05, shall be maintained throughout the duration of the contract. The sustainable long-term support and maintenance of all chemical schemes in the IFS will be ensured (a) by maintaining a link between the implementation in the IFS and the external development efforts of the original schemes and (b) by aiming at a more unified implementation of the different schemes as an integrated part of the composition modules in in the IFS.

All developments shall be carefully evaluated with a wide range of observations. The Successful Tenderer is encouraged to liaise with the CAMS_84 contract (Evaluation and Quality Control) on evaluation aspects, but also to make efforts beyond the scope of the operational evaluation carried out in CAMS_84. A wide range of observations shall be obtained for the process-oriented evaluation required in CAMS_42. The Successful Tenderer shall share these observations with the Global Service Provider, where possible.

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 the IFS, including its existing formulation of atmospheric transport and other meteorological processes. The implemented chemical schemes have to be made compliant with the IFS coding norms before they can be used operationally.

Flemming, J., Huijnen, V., Arteta, J., Bechtold, P., Beljaars, A., Blechschmidt, A.-M., Diamantakis, M., Engelen, R. J., Gaudel, A., Inness, A., Jones, L., Josse, B., Katragkou, E., Marecal, V., Peuch, V.-H., Richter, A., Schultz, M. G., Stein, O., and Tsikerdekis, A.: Tropospheric chemistry in the Integrated Forecasting System of ECMWF, Geosci. Model Dev., 8, 975-1003, https://doi.org/10.5194/gmd-8-975-2015, 2015.

Huijnen, V., Pozzer, A., Arteta, J., Brasseur, G., Bouarar, I., Chabrillat, S., Christophe, Y., Doumbia, T., Flemming, J., Guth, J., Josse, B., Karydis, V. A., Marécal, V., and Pelletier, S.: Quantifying uncertainties due to chemistry modeling – evaluation of tropospheric composition simulations in the CAMS model, Geosci. Model Dev. Discuss., https://doi.org/10.5194/gmd-2018-331, in review, 2019.

3.2 Work package 4210 – Modelling aspects

Reactive chemistry is simulated in atmospheric models with chemical schemes that represent the gas-phase, aqueous-phase and heterogeneous chemical reactions active in the troposphere and stratosphere. The IFS includes several chemical schemes for either only the troposphere, the stratosphere or both (see section 3.1).

The current operational scheme CB05 shall be maintained throughout the duration of the contract. In addition, the Successful Tenderer shall provide support and shall further develop the chemical schemes currently implemented in the IFS. The implementation of new schemes is welcomed if their implementation fulfils the criteria for the sustainable development outlined in section 3.1. If a new scheme is proposed the continuation of one of the existing schemes, apart from the CB05 scheme, can be negotiated with ECMWF.

The Successful Tenderer is expected to maintain all proposed chemical schemes in order to stay in-line with fast- paced developments, occurring as a result of international research activities, scientific field campaigns, and new laboratory measurements of reaction kinetics.

The Successful Tenderer is expected to substantially advance the simulation of gas-phase precursors for organic and inorganic secondary aerosol, and to improve dynamic gas-aerosol partitioning. This work shall be carried out in close collaboration with CAMS_43 ("Development of global aerosol modelling aspects"). All chemistry schemes shall be interfaced with the implemented aerosol schemes for the simulation of secondary aerosols.

The Successful Tenderer shall also interact with the IFS greenhouse gases modelling aspects in particular for CH_4 and N_2O (CAMS_41 Development of global greenhouse gas aspects). A special focus shall be the common usage of surface fluxes and a more unified approach to the simulation of the chemical loss rates of greenhouse gases.

The Successful Tenderer is encouraged to propose flexible extension of species of the chemical schemes or to significantly improve the realism of species already included in the existing chemical schemes to attract specific users. Chemical species that can be retrieved from satellites and are therefore potential future candidates for the assimilation by the IFS should be considered. Examples of such species are Hydrogen Cyanide (HCN), Glyoxal (OCHCHO) and Ammonia (NH3).

Each chemistry scheme shall correctly interface with the CAMS global emission data sets, initially based on the MACCity data set developed as part of the pre-operational CAMS services (http://eccad.sedoo.fr) and later new emission data sets to be delivered under another CAMS ITT (CAMS_81, Global and regional emissions). The successful Tenderer is expected to assist with the preparation and testing of the specific emissions for each chemical scheme for operational applications and scientific testing, and to provide feedback to CAMS_81, who will provide global anthropogenic, biogenic and natural emissions. Emissions from wildfires and biomass burning are being produced by the Global Service Provider through the Global Fire Assimilation System (GFAS) and shall be used as input for the chemical schemes.

The Successful Tenderer shall interact with the Global Service Provider to optimize the implementation of the chemical schemes in the IFS. This could entail proposing cost effective solutions by proposing reduced chemical schemes, and optimising routines that contribute to the significant load imbalances during the parallel execution of the IFS for CAMS productions runs. In particular, the Successful Tenderer shall provide and test solutions for the chemistry schemes when the IFS is run in single precision mode. The IFS running with single precision is planned to be fully operational in forecast mode by the end of 2020.

The implementation in the IFS and further on-line testing by the Successful Tenderer, in collaboration with the Global Service provider, shall be achieved through remote access to the IFS and on-site visits at the ECMWF premises in Reading, United Kingdom. These on-site visits shall be arranged at least once per year and coordinated between the Successful Tenderer and ECMWF (cost to be included within the Tender to this ITT).

For each one of the proposed developments of the chemistry modelling capabilities of the IFS a multi-year development plan shall be maintained by the Successful Tenderer and this will form input to the CAMS Service Evolution Strategy document (see Section3.4) after approval by ECMWF. The Successful Tenderer shall report on continual development activities for each chemical scheme on a quarterly basis.

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

WP4210 Deliverables			
#	*Type*	*Title*	*Due*
D1.y.z[1]	Code Report	Improvement and evaluation of organic aerosol precursor modelling	
D1.y.z	Code Report	Improvement and evaluation of inorganic aerosol precursor modelling	
D1.y.z	Code Report	Extension of chemistry scheme in preparation of retrievals or additional satellite retrievals	
D1.y.z	Code Report	Single precision execution of the IFS with chemistry scheme	Q3 2020
D1.y.z	Code Report	Improvements to computational efficiency of chemistry aspects in the global CAMS system	
D1.y.z	Other	Article submission to peer-reviewed journal documenting model improvements with respect to chemistry	

WP4210 Milestones			
#	*Title*	*Means of verification*	*Due*
M1.y.z			
M1.y.z			

3.3 Work package 4220 – Support for operational system upgrades

In the operational CAMS IFS configuration that is used to provide the Real-Time Global Products, the Forecast-only Global Products, and the Global Reanalysis Products, only one chemical scheme in conjunction with one aerosol scheme is used. In addition, pre-operational forecast runs using the other chemical schemes shall be envisaged during the duration of this contract.

The scope of this work package is to ensure that the operational chemical scheme(s) and, if applicable, the pre-operational forecast runs, are updated and maintained in line with the cycle update procedure

[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.

of the global CAMS system (https://atmosphere.copernicus.eu/node/326). Operational readiness as well as improvements of the scientific performance of the global CAMS system are the key objectives of this work package.

The implementation in the operational production system of model developments (whether incremental or entirely new elements) follows a model cycle approach. The Global Service Provider will upgrade its global production system once or twice per year. These upgrades include improvements to the model and data assimilation system as well as changes in the assimilated data sets. Because the CAMS global assimilation and forecasting system is based on the ECMWF numerical weather prediction system, new model cycles will also include meteorological developments and input data changes. These can also affect the assimilation and modelling of atmospheric composition. Before upgrading the operational system, the Global Service Provider will set up new experimental production suites that run several months in catch-up mode (producing several days of analyses and forecasts per day) before running in parallel with the operational suite. The contractor for another CAMS contract, CAMS_84 (Global and regional a posteriori evaluation and quality assurance (EQA)) will provide validation of these experimental production runs to support the decision making as well as the documentation of service quality. The evaluation effort in CAMS 42 shall focus on the development work leading to the configuration of the experimental production suites.

The Successful Tenderer shall support the Global Service Provider with the preparation and testing of new model cycles for any changes related to the chemical schemes. Although only mature model components and developments will be part of the experimental suite configuration, the large degree of interdependence of model and data assimilation components can cause inconsistencies. The Successful Tenderer shall provide its expertise and technical knowledge to respond to issues raised by the Global Service Provider during the experimental suite runs, and also assist with analysing the performance of candidate configurations with respect to chemical species.

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

WP4220 Deliverables			
#	*Type*	*Title*	*Due*
D2.y.z-CycleX	Other	Assistance to the Global Service provider in setting up and evaluating operational model cycles (recurring task)	Each IFS operational cycle
D2.y.z	other	Processing of new chemistry emissions data sets for each new year	On request 2 month before the end of the previous year.

WP4220 Milestones			
#	*Title*	*Means of verification*	*Due*
M2.y.z	New model cycle	Improvement of chemical forecast scores against observations	Each IFS operational cycle

3.4 Work package 4230 – Service evolution

Service evolution is a critical aspect of CAMS, that relies on active engagement of the CAMS contractors. The Tenderer shall therefore provide a research and development plan for the full duration of the contractual agreement, which should cover most or all of the following topics:

1) Improvements of the dry deposition simulation of gases to the state-of -the-art. This effort shall entail a literature survey of new developments and alternatives to the currently applied scheme based on Wesely (1989). Any improved approaches for dry deposition modelling should be integrated in the land surface component of the IFS. The land surface model simulates the physical and vegetation processes at the surface, which are required to simulate the surface fluxes of energy and water vapor into and from the atmospheric component of the IFS. Many of these processes as well as the characterisations of the surface also control the dry deposition of reactive gases and aerosols. The Global Service provider will provide documentation and a standalone version of the IFS surface model to enable an efficient testing and development process. The Successful Tenderer is encouraged to obtain a wide range of observations of deposition velocities and fluxes to evaluate the developments. This work shall be carried out in close collaboration with CAMS_43 (global aerosol modelling aspects) ,CAMS_50 (regional modelling) and CAMS_41 (Greenhouse gas modelling). The preparation of specific deposition products in response to user requirements is encouraged.

2) Development of chemistry-specific diagnostics. An advantage of the global CAMS system is the availability of multiple chemical schemes in an otherwise identical model setup. The Successful Tenderer shall implement process diagnostics, e.g. of chemical budget terms, in all chemical schemes. These diagnostics shall be used to provide specific information on the uncertainties of the chemical component in the CAMS simulations, for example in response to varying emission data. The Successful Tenderer shall also develop specific metrics, which convey to users the uncertainty information derived from the planned pre-operational application of multiple chemical schemes.

3) Improvements of the performance for global air quality applications. The products of the CAMS global system are widely used to provide information about air quality (AQ) outside Europe. The Successful Tenderer shall evaluate and make suggestions to improve the forecast performance for surface NO2, SO2 and O3 globally. The successful tender shall obtain access to a wide range of air quality observations (e.q. openAQ.org). These observations shall be used for the evaluation of the global system at the development stage. The data and processing tools shall be made available to ECWMF. The evaluation shall take into account the difference in the represented spatial scales between the model and the observations. Targeted research to improve the surface AQ forecasts at the grid box scale, for example by introducing temporally varying emissions, shall be carried out. This work shall be pursued in collaboration with CAMS_81 and CAMS_43.

4) Support for composition-climate/weather applications of the IFS with focus on the stratosphere. Deriving climate forcing products from the operational CAMS products is the focus of the CAMS_74 contract (Radiative forcing products). In liaison with the Global Service Provider and CAMS_74, the Successful Tenderer is expected to actively support the development and production of the required present-day and preindustrial scenario runs. This work shall also include the preparation of the relevant emission data sets. Multi-year runs for pre-industrial conditions with focus on the stratosphere should be carried out and compared with CMIP modelling results. Furthermore, efforts by the Global Service Provider to improve the simulation of the radiative impact of ozone and other trace gases in the stratosphere and mesosphere for medium range applications shall be supported with evaluation and targeted research.

5) Support to the Global Service Provider to implement the adjoint and tangent linear representation of composition source and sink processes in the IFS. The focus should be on cost-effective solution with simplified versions of the chemical mechanism.

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

WP4230 Deliverables			
#	*Type*	*Title*	*Due*
D3.y.z	Code Report	Improvements on dry deposition modelling and product development	
D3.y.z	Code Report	Chemistry diagnostics for multi-scheme system	
D3.y.z	Code Report	Improvements on air quality performance of global CAMS system	
D3.y.z	Report	Support for composition climate/weather applications	
D3.y.z	Code Report	Cost effective tangent linear and adjoint formulations of chemistry simulation in the IFS	

WP4230 Milestones			
#	*Title*	*Means of verification*	*Due*
M3.y.z			
M3.y.z			

3.5 Work package 4240 – User support and documentation of service

The objective of this work package is to provide specialised 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 is used for ticketing user requests and distributing these requests to specialists as needed. Dedicated staff at ECMWF provide basic support in the form of self-help facilities (FAQs, knowledge bases, 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, user guides and knowledge bases.

As part of the bid, Tenderers shall describe the level of user support service on Service Desk tickets, they can provide.

Tenderers shall also address development of user guides. Documentation of the CAMS services is an integral part of the service provision. The technical and scientific specification of each service shall be documented in reports that will be available to users through the CAMS web site. The successful Tenderer shall therefore produce documentation reports describing in detail the methodologies and products they deliver for this ITT.

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

WP4240 Deliverables			
#	*Type*	*Title*	*Due*
D4.y.z	Other	Specialised user support via the CAMS Service Desk (Respond to user support queries requiring expertise specific to the global reactive gases aspects developed)	within one week of raising the issue
D4.y.z-P1	Other	Specialised User Support - Period 1	At Payment milestone 1
D4.y.z-P2	Other	Specialised User Support - Period 2	At Payment milestone 2
D4.y.z-YYYY	Report	Documentation of global reactive gases developments	Annually
…			

WP4240 Milestones			
#	*Title*	*Means of verification*	*Due*
M4.y.z	Link with CAMS User Support team established; service desk set-up completed	Specialised Service Desk up and running	Month 2
…			

3.6 Work package 4200 – 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:
  - ECMWF will organise annual CAMS General Assemblies within EU member states. 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 should 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.
- Personal data management (name, ID and contact details of prime contractor's data controller in line with Clause 2.8).

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

WP4200 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-YYYY	Tenderer	Other	Letter auditor's opinion specific to CAMS most recent Annual Implementation 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

WP4200 Milestones				
#	*Responsible*	*Title*	*Means of verification*	*Due*
M0.y.z-YYYY	Tenderer	CAMS General Assembly	Participation to the meeting	Annually
M0.y.z	Tenderer	Monthly teleconference meetings with ECMWF	Participation to meeting	Monthly
M0.y.z-Px	Tenderer	Progress review meetings with ECMWF / Payment milestones	Minutes of meeting	~ Every 6 months
M0.y.z	Tenderer	Kick-Off meeting	Minutes of meeting	Month 1
M0.y.z-YYYY	Tenderer	Internal face to face project meetings	Minutes of meeting	Annually
M0.y.z	Tenderer	Internal project monthly teleconferences	Meetings happened	Monthly

4 General Requirements

4.1 Implementation schedule

The Framework Agreement will run from 1 October 2019 to 31 December 2021. The Tenderer shall provide a detailed implementation plan of proposed activities for the period until 30 June 2021. However, note that by Q4 2019 the level and duration of activities for the full year of 2021 will be communicated by ECMWF to the successful Tenderer based on the Copernicus programme review by the European Commission.

Adjustments to the proposed implementation plan can be made on an annual basis depending on needs for service evolution, changed user requirements, or other requirements as agreed between the European Commission and ECMWF.

4.2 Deliverables and milestones

Deliverables should be consistent with the technical requirements specified in section 3.

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). The total of these allocated resources shall amount to the entire requested budget.

Milestones should be designed as markers of demonstrable progress in service development and/or quality of service delivery. They should not duplicate deliverables.

4.3 Acquisition of necessary data and observations

The Successful Tenderer shall closely interact with the Global Service Provider and the provider for the CAMS_84 activities (Global and regional a posteriori validation) for the exchange of relevant data

sets related to the implementation, development and testing of numerical code for modelling and data assimilation as covered by this ITT. The Successful Tenderer shall also closely interact with the provider for the CAMS_81 activities (Global and regional emissions), who is responsible for delivering the anthropogenic and natural emissions that form an input to the IFS, to ensure appropriate use of these emissions in the Chemical schemes.

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.

4.5 User requirements

As part of CAMS, the database and three documents described below will be maintained. 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 for CAMS_94 (User Interaction) with the analysis of relevant user requirements in the URDB. Finally, in case the successful Tenderer provides service elements that are listed in the Service Product Portfolio (SPP), the successful Tenderer shall provide input on product lines and their metadata to ECMWF to ensure the SPP is up-to-date.

User Requirements Database (URDB) and Requirement Analysis Document (RAD)

User requirements are collected in this database in a structured and traceable way, and links to entries in the Service Product Portfolio (see below) are provided, when appropriate. The URDB, which tracks all requirements emanating from a wide variety of user fora, surveys, and support panels, is complemented by a Requirements Analysis Document (RAD) which captures the stratification of user requirements per domain, importance and feasibility. The RAD constitutes the basis for distilling, filtering and translating user requirements into technical specifications for the Service. The URDB and RAD are maintained and continually updated by ECMWF and its contractor for CAMS_94 (User Interaction).

Service Product Portfolio (SPP)

Both data and value-added products are presented in this document in a structured way, providing key technical aspects, when appropriate, such as geophysical parameter, temporal resolution and coverage, spatial resolution and coverage, data formats, time availability, expected quality, data format together with a direct link to detailed information on methodology and quality monitoring for each specific product or services.

Service Evolution Strategy (SES)

The appropriateness of the list of emerging and existing user requirements, the routinely updated Requirement Analysis Document and the existing Service Product Portfolio, are continually monitored by ECMWF and feed into a Service Evolution Strategy (SES) document. The SES document is produced on an annual basis and provides, in addition to the annual implementation plan focussing on year n+1 service Deliverables, a proposed longer term (typically 4 years) perspective for forthcoming service upgrades and extensions, the expected benefits and costs, together with recommendations for potential research needs outside Copernicus operations. This document allows informed discussions to be opened on specific proposed service upgrades and extensions with the stakeholders.

The following deliverables are thus to be added to the WP4250 deliverable lists:

WP4240 Deliverables			
#	*Type*	*Title*	*Due*
D4.y.z-YYYY	Other	Input to CAMS URDB - YYYY	Checked by ECMWF annually in December
…			

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, the current state of monitoring and forecasting of global atmospheric composition, and modelling of reactive 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 how they intend to develop the Chemistry Schemes to ensure they continue to meet the international standards required. The Tenderer shall provide a development plan for each Chemistry Scheme but also how the implementation of the schemes can be more harmonised to better exploit communalities. The Tenderer shall also provide a detailed plan for the service evolution aspects. It should out-line the intended measures to organise an efficient interaction within CAMS_42 as well as with other relevant CAMS contracts. Finally, the Tenderer shall outline how a wider range of users could be attracted by the CAMS_42 efforts.