

ECMWF Copernicus Procurement

Invitation to Tender



Copernicus Atmosphere Monitoring Service

Volume II

Developments for reactive gases and
aerosol in the global system

ITT Ref: CAMS2_35_bis
ISSUED BY: ECMWF Administration Department Procurement Section
Date: 28 October 2024
Version: Final



Funded by the European Union

Implemented by



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1 Introduction

Some of today's most important environmental concerns relate to the composition of the atmosphere. 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 changes the oxidation capacity of the atmosphere and controls 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 affect the land- and marine ecosystems. 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.

The increasing concentration of the greenhouse gases and the various aerosol-weather feedback are prominent but often uncertain drivers of climate change. 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) based on inventory data and biogeochemistry models, 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 – 2028, 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 CO₂, CH₄ and N₂O net surface fluxes, allowing the monitoring of the evolution in space and time of these fluxes;
- h) Climate forcing from aerosols and long-lived (CO₂, CH₄) 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 CO₂ and CH₄ for the global domain and emission hotspots.

This Invitation to Tender (ITT) is mainly targeting the CAMS service element described under item a), b), and f) above.

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 “Developments for reactive gases and aerosol in the global system”, is for providing, implementing, and evaluating developments for reactive gases and aerosol in the Global Production System. The Successful Tenderer shall deliver improvements to the aerosol and chemistry schemes and the related parameterisations of source and sink processes in the Global Production System, to develop new products, and to prepare memoranda and reports that support the code development. The Successful Tenderer will also advise the Global Production System team at ECMWF on matters of aerosol and chemistry modelling and contribute to the testing and evaluation of the scheduled upgrades of the Global Production System. The ITT targets organisations with considerable experience in the field of modelling of aerosols and reactive gases in the atmosphere.

Major areas of the required model developments of the Global Production System are:

- Further improvement of the coupling of the aerosol and chemistry schemes with focus on inorganic and organic aerosols in the troposphere as contribution to surface Particulate Matter (PM).
- Testing of a modal aerosol scheme with a special focus on the implementation as part of the 4D-Var data assimilation framework
- Further development of the aerosol and chemistry representation in the stratosphere
- Improved simulation of wet and dry deposition processes
- On-line modelling of natural emissions and the variability of anthropogenic emissions
- Gradual improvements of the computational performance and technical maintenance of the implemented aerosol and chemistry schemes

Besides the progressing improvements of the current Global Production System, the Successful Tenderer shall contribute to CAMS product development efforts as required by the Global Service Provider in response to user requirements. The required contributions are efforts to:

- Advance the global deposition products from the current pre-operational stage to a quality-controlled product ready to be distributed to users
- Develop global diagnostic air quality products that improve the agreement with air quality observations for PM, ozone, NO₂ and SO₂.
- Assessment of the impact of higher spatial resolution on the forecasts scores of the Global Production System
- Support to the development of alternative modelling schemes based on the use of Artificial Intelligence and Machine Learning (AI/ML)

Finally, the successful Tenderer is required to contribute to the process-oriented evaluation of the Global Production System with specific observational data sets and application software.

3 Technical Specification

3.1 Introduction

3.1.1 System Overview

The CAMS Global Production System is ECMWF's Integrated Forecasting System (IFS). It is used to provide global real-time forecasts and analyses of atmospheric composition as well as to provide reanalysis products.

Modules for atmospheric composition and related physical processes have been integrated in the IFS. This integration makes it possible (i) to use the detailed meteorological representation of the IFS for the simulation of the atmospheric transport and sink, source and conversion processes of constituents, (ii) to use the IFS variational data assimilation system to assimilate satellite observations of atmospheric composition, and (iii) to simulate feedback processes between atmospheric composition and meteorological variables.

The IFS can be run with several chemistry schemes covering both the troposphere and the 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 is 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 first two schemes (CB05 and BASCOE) are operational, while the other two schemes are optional. The aerosol scheme in the IFS is referred to in literature as AER¹, and is originally derived from the LOA/LMDZ model. It is essentially a bulk aerosol scheme, while for sea salt aerosol and desert dust, a sectional approach is employed. As such, it is often denoted as a bulk-bin scheme. The chemistry and aerosol schemes are coupled to enable the simulation of secondary aerosols. The implementation of the operational chemistry and aerosols schemes can be found in the official IFS documentation².

¹ Rémy, S., Kipling, Z., Huijnen, V., Flemming, J., Nabat, P., Michou, M., Ades, M., Engelen, R., and Peuch, V.-H.: Description and evaluation of the tropospheric aerosol scheme in the Integrated Forecasting System (IFS-AER, cycle 47R1) of ECMWF, *Geosci. Model Dev.*, 15, 4881–4912, <https://doi.org/10.5194/gmd-15-4881-2022>, 2022

² <https://www.ecmwf.int/en/elibrary/81374-ifs-documentation-cy48r1-part-viii-atmospheric-composition>

The core of this ITT is the further development of the operational chemical and aerosol schemes and the related parameterisations for removal processes and surface fluxes in the IFS. The current operational chemical schemes, CB05, BASCOE, and AER, shall be maintained throughout the duration of the contract. The sustainable long-term support and maintenance of the alternate chemical schemes in the IFS shall be ensured as part of this contract in support of the new AI/ML activities at ECMWF described in Section 3.5. In addition, the (further) development of a modal aerosol scheme, and particularly the use of such a scheme in the 4D-Var data assimilation framework, is included.

The current configuration of the CAMS Global Production System operates at a resolution of about 40x40km for the forecasting system and the upcoming new global reanalysis (EAC5) and at 80x80 km for the current reanalysis system (EAC4). Scientific experimentation can also be carried out at lower resolutions (80km, 160km) but it has to be demonstrated that the findings are valid for the operational resolutions. The Global Service Provider aims to increase the horizontal resolution of the above applications during the duration of the contract. The successful Tenderer shall therefore also contribute to the scientific and computational testing with respect to these resolution upgrades.

3.1.2 Cycle upgrades and code submissions

The development of the operational CAMS Global Production System (o-suite) is organised in version upgrades (cycles) that occur every 12 to 18 months following the overall IFS development schedule. Each cycle upgrade is linked to a fixed timeline for the submission of new code and a testing period with the combined new developments (e-suite). The code submission deadline is usually several months before the planned operational implementation date. ECMWF will communicate the relevant dates as soon as they are known and it will provide guidance on the required testing and evaluation protocol. The successful Tenderer is required to supply the contracted developments intended for o-suite upgrades in packages that allow testing of the candidate options by ECMWF. The submitted code has to be tested by the Successful Tenderer in forecast and data assimilation mode on the ECMWF High Performance Computing (HPC) facility before the code submission deadline. All code developments shall be carried out in accordance with the relevant ECMWF guidelines and procedures regarding coding standards and the use of version-control and issue-tracking systems. ECMWF will also share its guidelines for further improvement of the efficiency of the relevant code. Finally, the Successful Tenderer shall subscribe to the aim to implement developments that improve the forecast skill on all aspects (aerosol, chemical species, and meteorology) unless an exception has been agreed with ECMWF to support longer-term development. The successful Tenderer shall also actively contribute to the evaluation of the e-suite candidate configurations within the implementation time line.

3.1.3 Annual development plan meetings

The development of the Global Production System is a flexible process that requires responding to specific environmental events as well as to a changing scientific and computing environment. The Successful Tenderer shall have annual meetings with ECMWF to discuss the planned developments for each development work package before they are submitted as part of an annual implementation plan. This process shall make it possible to adjust the contracted developments in response to new or modified requirements, results and priorities within CAMS. These meetings shall not be included as Deliverables or Milestones, but be listed as part of the proposal in a separate table summarizing all required meetings.

3.1.4 Scientific publications

Besides the contractually agreed deliverable reports and documentation, the successful Tenderer is required to write peer-reviewed publications on model development and model applications resulting from this contract. At least two scientific publications are required to be submitted before the end of the contract, the content of which shall be agreed with ECMWF at the time of writing.

3.2 Work package 1 (WP1) – Aerosol aspects

This work package comprises of developments of the IFS aerosol code to improve the performance of the CAMS Global Production System. The developments shall be pursued with the main objective to decrease the errors of CAMS products with respect to observations while maintaining operational constraints such as computational cost and stability. The expectation is that developments shall be implemented in the operational system during the extent of this contract. The scientific and computational improvements by the developments of this work package shall be demonstrated in a measurable and robust way against observations as well as against the previous model versions both in forecast-only and data assimilation mode on the HPC facilities at ECMWF (see also Section Cycle upgrades and code submissions 3.1.2). The successful Tenderer shall carry out developments in the following topical areas:

- Maintenance and further improvement of the AER aerosol scheme, both for the troposphere and stratosphere.
- Preparation of the stratospheric AER scheme to be applicable in case of a major volcanic eruption as part of the operational CAMS global forecasts
- Diagnosing and improving the accuracy of the PM_{2.5} and PM₁₀ concentration forecasts worldwide
- Improvement of the specification of aerosol optical properties for the IFS radiation scheme considering both technical and scientific aspects
- Uptake of relevant and mature developments from the CAMS supporting EU-funded research projects CAMEO³ and CAMAERA⁴, such as:
 - Utilise the offline observation operators for aerosol variables developed in CAMEO for diagnostics and potentially data assimilation
 - Utilise the 3MI⁵ proxy data produced in the CAMEO project for diagnostic purposes
 - Integration of mature and available CAMAERA developments for improved aerosol modelling

The Tenderer shall provide as part of its proposal a development plan that includes specific deliverables and milestones for foreseen activities during the first year of the contract in the respective Deliverable and Milestone tables. For the following years, indicative deliverables and milestones shall be defined in the proposal, of which the exact content shall be described in annual development plan deliverables in consultation with ECMWF. These annual development plans shall be annually recurring deliverables.

Tenderers shall complete the relevant table in Volume IIIA as part of their bid, which shall at least 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

³ <https://www.cameo-project.eu/>

⁴ <https://camaera-project.eu/>

⁵ <https://www.eumetsat.int/metop-sg-instruments>

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.

WP1 Deliverables			
#	Type	Title	Due
D1.Y.Z- yyyyQx	Report/c ode	...	Quarterly
D1.Y.Z-yyyy	Report/c ode	...	Annually

WP1 Milestones			
#	Title	Means of verification	Due
M1.Y.Z	M1

3.3 Work package 2 (WP2) – Chemical aspects

This work package comprises of chemistry developments of the IFS code of the CAMS Global Production System. The developments shall be pursued with the main objective to decrease the errors of CAMS products with respect to observations while maintaining operational constraints such as computational cost and stability. The expectation is that developments shall be implemented in the operational system during the extent of this contract. The scientific and computational improvements by the developments of this work package shall be demonstrated in a measurable and robust way against observations as well as against the previous model versions both in forecast-only and data assimilation mode on the HPC facilities at ECMWF (see also Section Cycle upgrades and code submissions 3.1.2). The successful Tenderer shall carry out developments in the following topical areas:

- Maintenance and further improvement of the operational CB05-BASCOE chemistry scheme
- Implementation and testing of online models for natural emissions (ocean and soil) of NO_x, DMS and halogenic compounds
- Improve the computational efficiency of the chemical mechanism and the photolysis solvers.
- Improve the simulation of tropospheric ozone, which is important for air quality applications
- Uptake of relevant and mature developments from the CAMS supporting EU-funded research projects CAMEO⁶ and CAMAERA⁷, such as:
 - Developments in CAMEO for the online biogenic VOC emissions
 - CAMAERA results for improved simulation of precursor gases for secondary aerosol

The Tenderer shall provide as part of its proposal a development plan that includes specific deliverables and milestones for foreseen activities during the first year of the contract in the respective Deliverable and Milestone tables. For the following years, indicative deliverables and milestones shall be defined in the proposal, of which the exact content shall be described in annual

⁶ <https://www.cameo-project.eu/>

⁷ <https://camaera-project.eu/>

development plan deliverables in consultation with ECMWF. These annual development plans shall be annually recurring deliverables.

Tenderers shall complete the relevant table in Volume IIIA as part of their bid, which shall at least 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.

WP2 Deliverables			
#	Type	Title	Due
D2.Y.Z- yyyyQx	Data & Report	...	Quarterly
D2.Y.Z-yyyy	Report	...	Annually

WP2 Milestones			
#	Title	Means of verification	Due
M2.Y.Z	Title		

3.4 Work package 3 (WP3) – Modal Aerosol scheme development

The aerosol module in the IFS is referred to in literature as AER⁸, and is originally derived from the LOA/LMDZ model. It is essentially a bulk aerosol scheme, while for sea salt aerosol and desert dust, a sectional approach is employed. As such, it is often denoted as a bulk-bin scheme. The aerosol species use mass mixing ratios as the prognostic variable of the aerosol tracers. The prognostic species are sea salt, desert dust, organic matter (OM), black carbon (BC), sulfate, nitrate, ammonium, and secondary organic aerosols (SOA).

An alternative approach to the modelling of aerosol are the so-called modal schemes. The IFS already contains an implementation of the GLOMAP-mode two-moment modal scheme⁹. This scheme explicitly represents processes changing the prognostic size distribution such as nucleation, coagulation and condensation. As part of the Horizon Europe funded CAMAERA¹⁰ research project, the introduction of a modal scheme based on the M7 model¹¹ into the IFS is also being carried out.

The Successful Tenderer shall continue the implementation and development of one of these schemes in the IFS to become an operationally-ready alternative to the current operational scheme. A particular focus shall be on implementing the link to the 4D-Var data assimilation scheme in the IFS, which is currently missing for both schemes. The Tenderer shall outline its rationale for choosing either of these schemes as well as describe its plans for further development and linking the model to the 4D-Var data assimilation.

⁸ Rémy, S., Kipling, Z., Huijnen, V., Flemming, J., Nabat, P., Michou, M., Ades, M., Engelen, R., and Peuch, V.-H.: Description and evaluation of the tropospheric aerosol scheme in the Integrated Forecasting System (IFS-AER, cycle 47R1) of ECMWF, *Geosci. Model Dev.*, 15, 4881–4912, <https://doi.org/10.5194/gmd-15-4881-2022>, 2022

⁹ Mann et al., *Geosci. Model Dev.*, 3, 519–551, doi:10.5194/gmd-3-519-2010

¹⁰ <https://camaera-project.eu/>

¹¹ Vignati, E., Wilson, J., and Stier, P.: M7: An efficient size-resolved aerosol microphysics module for large-scale aerosol transport models, *J. Geophys. Res.*, 109, D22202, <https://doi.org/10.1029/2003JD004485>, 2004

The Tenderer shall provide as part of its proposal a development plan that includes specific deliverables and milestones for foreseen activities during the first year of the contract in the respective Deliverable and Milestone tables. For the following years, indicative deliverables and milestones shall be defined in the proposal, of which the exact content shall be described in annual development plan deliverables in consultation with ECMWF. These annual development plans shall be annually recurring deliverables.

Tenderers shall complete the relevant table in Volume IIIA as part of their bid, which shall at least 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.

WP3 Deliverables			
#	Type	Title	Due
D3.Y.Z- yyyyQx	Report/c ode	...	Quarterly
D3.Y.Z-yyyy	Report/c ode	...	Annually

WP3 Milestones			
#	Title	Means of verification	Due
M3.Y.Z	M1

3.5 Work package 4 (WP4) – Crosscutting modelling aspects

This work package comprises of developments of the Global Production System that span across aerosols and reactive gases. The developments shall further improve the coupling between chemistry and aerosol developments of WP1, WP2, and WP3 and improve the modelling of specific aspects that apply to both aerosols and reactive gases. It also includes the evaluation and further improvement of the UV radiation scheme that is used to provide the daily CAMS UV forecasts.

In addition, and based on expressed user requirements, the Global Service Provider intends to increase the horizontal resolution of the daily global forecasts. The successful Tenderer shall systematically investigate the impact of this resolution upgrade on the scientific and computational performance of the Global Production System.

Thirdly, ECMWF is exploring the use of AI/ML for its CAMS global atmospheric composition forecasts. While detailed workplans are still being developed, this will likely include the emulation of the IFS-COMPO chemical and aerosol schemes to assess the potential for improving the speed of the forecasts as well as the investigation of a full AIFS-COMPO system¹². The successful Tenderer shall support this new activity by providing training data sets using the operational CAMS aerosol and chemical schemes as well as the optional schemes that are available in the IFS. A more detailed description of these data sets shall be agreed between ECMWF and the successful Tenderer at the start of this contract to

¹² For information of AIFS, see <https://www.ecmwf.int/en/newsletter/178/news/aifs-new-ecmwf-forecasting-system>.

ensure compatibility with the latest AI/ML developments at ECMWF. The successful Tenderer shall also contribute to discussion meetings with ECMWF staff, ideally with AI/ML specific expertise, as part of the AI/ML developments for the Global Production System. Resources shall be reserved based on at least monthly 2-hour meetings throughout the duration of the contract.

The developments shall be pursued with the main objective to decrease the errors of CAMS products with respect to observations while maintaining operational constraints such as computational cost and stability. The expectation is that developments shall be implemented in the operational system during the extent of this contract. The scientific and computational improvements by the developments of this work package shall be demonstrated in a measurable and robust way against observations as well as against the previous model versions both in forecast-only and data assimilation mode on the HPC facilities at ECMWF (see also Section Cycle upgrades and code submissions 3.1.2). The successful Tenderer shall carry out developments in the following topical areas:

- Improve the representation of the diurnal cycle of surface aerosol and reactive gases concentrations
- Further improve the representation of anthropogenic emissions in the global CAMS system.
- Further advance the harmonisation of the simulation of dry and wet deposition processes of aerosol and reactive gases
- Further improve the aerosol-gas partitioning for both aerosol and gas-phase aspects
- Further development of tangent linear and adjoint formulation of composition scheme components with focus on simplified chemistry schemes and loss processes by deposition.
- Evaluation and possible improvement of the UV radiation scheme that is coupled to the CB05-BASCOE scheme.
- Evaluate the impact of increased horizontal resolution on the forecast scores of the Global Production System.

The Tenderer shall provide as part of its proposal a development plan that includes specific deliverables and milestones for foreseen activities during the first year of the contract in the respective Deliverable and Milestone tables. For the following years, indicative deliverables and milestones shall be defined in the proposal, of which the exact content shall be described in annual development plan deliverables in consultation with ECMWF. These annual development plans shall be annually recurring deliverables.

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.

WP4 Deliverables			
#	Type	Title	Due
D4.Y.Z-yyyy	Other	...	Annually
D4.Y.Z-yyyy	Report	...	Annually
...			

WP4 Milestones			
#	Title	Means of verification	Due

M4.Y.Z
...			

3.6 Work package 5 (WP5) – Development support activities

This work package comprises of development and evaluation of data sets produced from the output of the Global Production System, which has been improved based on the efforts in WP1 to WP4. The development shall be driven by user requirements as communicated by the Global Service Provider and shall support improving the quality of the CAMS products.

The successful Tenderer is required to support the development of additional CAMS products that respond to specific requests from CAMS users. Specifically, the CAMS product portfolio should be extended to application-specific deposition flux products based.

To complement the CAMS near-real-time forecast and re-analysis products, the successful Tenderer is required to carry out, evaluate and post-process model simulations with the IFS on a multi-month to multi-year time scale. The scope and configuration of the model runs will be coordinated together with the Global Service Provider. The aim of these model simulations is (i) to give targeted feedback on emission products and emission modelling developed by the CAMS contract on global emissions, (ii) evaluate the impact of changes in the output of the Global Fire Assimilation System (GFAS) on the global forecasts and analyses, (iii) to provide emission scenario boundary conditions for regional models, (iv) to produce and support required data sets for inter-comparison studies conducted by the scientific community, (v) to estimate the long-term tracer mass conservation properties of the IFS and (vi) to derive IFS cycle-specific mean aerosol and gas model climatologies.

An important further aspect of this work package is to improve the process-oriented evaluation efforts by using a wider range of atmospheric composition observations, developing verification (with observations) and diagnostic (with previous model results) procedures and software tools. The Successful Tenderer shall explore a wide range of observations not yet included in the evaluation efforts in CAMS with focus on scientific development and product evaluation. Examples of these data sets are scientific campaign observations of volatile organic compounds, satellite retrievals of NH₃ and HCHO, aerosol mass spectrometry, air quality networks worldwide and a wide range of dry and wet deposition flux and precipitation chemistry observations. The Successful Tenderer shall make these data sets available for the wider usage by the Global Service Provider and by the contract on global evaluation and quality control, preferably in prescribed data formats that allow a harmonised usage of the observations in CAMS. The evaluation efforts shall be shared and aligned within evaluation efforts by the Global Service Provider and the CAMS contracts on evaluation and quality control.

In summary, the successful Tenderer shall carry out activities in the following topical areas:

- Prepare evaluated global deposition maps for the user-relevant aerosol and chemical species variables and for different surface and biomes from the output of the output of the Global Production System .
- Evaluation of the impact of new versions of the CAMS global emission data sets as well as GFAS, when they become available, on the forecast scores of the Global Production System.
- Contribute to the diagnostic and quality control during the production of the EAC5 re-analysis with focus on the consistency and trends.
- Contribution of model results to international inter-comparison studies
- Access to new evaluation data sets and support development of software tools

The Tenderer shall provide as part of its proposal a development plan that includes specific deliverables and milestones for foreseen activities during the first year of the contract in the respective Deliverable and Milestone tables. For the following years, indicative deliverables and milestones shall be defined in the proposal, of which the exact content shall be described in annual development plan deliverables in consultation with ECMWF. These annual development plans shall be annually recurring deliverables.

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.

WP5 Deliverables			
#	Type	Title	Due
D5.Y.Z-yyyy	Other	...	Annually
D5.Y.Z-yyyy	Report	...	Annually
...			

WP5 Milestones			
#	Title	Means of verification	Due
M5.Y.Z
...			

3.7 Work package 6 (WP6) – 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 contribute to the relevant documentation. 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 is documented in the CAMS Knowledge Base¹³ as linked from the Atmosphere Data Store. More detailed documentation for the IFS is available for each model cycle through the ECMWF website¹⁴. The successful Tenderer shall therefore support the updates of the relevant documentation based on the latest developments. 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.

WP6 Deliverables			
#	Type	Title	Due
D6.Y.Z-yyyy	Other	Overview of contribution to CAMS Knowledge Base to document products and services based on global reactive gases and aerosol aspects developments	Annually
D6.Y.Z-yyyy	Report	Contribution to documentation of products and services based on global reactive gases and aerosol aspects developments	Annually
...			

WP6 Milestones			
#	Title	Means of verification	Due
M6.Y.Z
...			

3.8 Work package 0 (WP0) – Management and coordination

The following management and coordination activities are part of WP0 and shall be briefly described, and completed, if necessary, in the bid:

- Management, planning and coordination of the different Work Packages activities and corresponding resources, including the appropriate tools used to monitor them.
- Contractual obligations as described in the Volume V Framework Agreement Clause 2.3 “Reporting and Planning” and its Annex 5 “Report content”.
- Meetings organisation and/or attendance (classified as tasks and listed in a separate table as part of the proposal):

¹³

<https://confluence.ecmwf.int/display/CKB/CAMS%3A+Global+atmospheric+composition+forecast+data+documentation>

¹⁴ <https://www.ecmwf.int/en/elibrary/81374-ifs-documentation-cy48r1-part-viii-atmospheric-composition>

- ECMWF and the Successful Tenderer will organise a Kick-Off Meeting during the first month of implementation of the contract. Additional interim/ad-hoc progress meetings might be required. All meetings shall be classified as “Milestones” under Volume IIIA “Pricing and deliverables” Excel sheet, tab “Deliverables List”.
 - ECMWF will host monthly teleconference meetings to discuss CAMS service provision, service evolution and other topics (Service Level Board). The Prime Investigator and/or Service Manager appointed by the Successful Tenderer will represent the Successful Tenderer in such meetings.
 - ECMWF and the Successful Tenderer will organise Progress Review Meetings, linked to Payment Milestones, every six months unless otherwise agreed.
 - ECMWF will organise annual CAMS General Assemblies. The Successful Tenderer is required to attend these meetings with team members covering the various topics that are part of this ITT.
 - Successful Tenderer’s internal meetings.
 - Tenderers can propose additional project internal meetings (annual face-to-face meeting and monthly teleconferences) as part of their response.
- Quality assurance and control: the final quality check of the deliverables prior the submission to ECMWF should be made by the prime contractor (contents, use of ECMWF’s templates for deliverables and reports, format, deliverables/milestones numbering and naming, typing errors, etc.).
 - Implementation of checks, controls and risk management tools for both the prime contractor.
 - Communication management (ECMWF, stakeholders, internal communication).
 - Management of personal data and how this meets the requirements of Clause 2.8 and Annex 6 “Personal Data Protection” of the Volume V Framework Agreement.
 - Sub-contractor management, including dispute 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 sub-contractors, if any, describing their contribution and key personnel shall be provided, as well as back-up names for all key positions in the contract. The Tenderers shall describe how the Volume V Framework Agreement, in particular its Clause 2.9 “Sub-contracting”, has been flowed down to all their sub-contractors.

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. All milestones and deliverables shall be numbered as indicated (see also guidelines in Section 4.2). All document deliverables shall be periodically updated and versioned as described in the tables below, and the corresponding due date defined in Volume IIIA for each iteration.

WPO Deliverables				
#	Responsible	Nature	Title	Due
D0.Y.Z-yyyyQx	Tenderer	Report	Quarterly Implementation Report (QIR) yyyyQx yyyyQx being the previous quarter (e.g. 2024Q3 due on 15/10/2024)	Quarterly on 15/04, 15/07 and 15/10

D0.Y.Z-yyyy-Part1	Tenderer	Report / Other	Annual Implementation Report (AIR) for year yyyy - Part 1 including: <ul style="list-style-type: none"> the Quarterly Implementation Report (QIR) yyyyQ4, and the preliminary financial information yyyy being the Year n-1 	Annually on 15/01
D0.Y.Z-yyyy-Part2	Tenderer	Report	Annual Implementation Report (AIR) for year yyyy - Part 2 yyyy being the Year n-1	Annually on 28/02
D0.Y.Z	Tenderer	Report	Final Report	By the end of contract
D0.Y.Z-yyyy	Tenderer	Report	Annual Implementation Plan for year yyyy yyyy being the Year n+1	Annually on 30/09
D0.Y.Z-yyyy	Tenderer	Other	Copy of prime contractor's general financial statements and audit report for year YYYY YYYY being the Year n-1	Annually, not later than on 15/12 ⁽¹⁾
D0.Y.Z	Tenderer	Other	Updated KPIs (list, targets, etc.) after review with ECMWF	1 year after start of contract

WPO Milestones				
#	Responsible	Title	Means of verification	Due
M0.Y.Z-KOM	Tenderer	Kick-Off Meeting	Minutes of Meeting	30 days after start of contract
M0.Y.Z-PMxqqYY	Tenderer	Progress Review Meeting #PMx being the Payment milestone number, #qq - the quarter and #YY - a year during which the Payment Milestone is due xx being the iteration number of the PRM	Minutes of Meeting	~ as a minimum linked to the Payment Milestone.
M0Y.Z-SLB ⁽²⁾	Tenderer	CAMS Service Level Board meeting	Attendance	Every month
M0.y.z-CAMSGA-YYYY	Tenderer	CAMS General Assembly YYYY	Attendance	Annually, not later than on 15/12 ⁽¹⁾

⁽¹⁾ These due dates are indicated to frame the corresponding deliverables and milestones schedule only, consequently the following shall be considered by the Tenderer:

- the general financial statements shall be sent by the contractor as soon as available,
- the schedule of the Progress Review Meetings shall be aligned with the different Payment Milestones during the contract negotiation,
- depending on the year, the CAMS General Assembly may take place at a different period of the year.

⁽²⁾ All iterations for this recurring SLB meeting do not need to be listed by the Tenderer, i.e., only one row shall be added in Volume IIIA "Pricing and deliverables" Excel sheet "Deliverables List".

4 General Requirements

4.1 Implementation schedule

The Framework Agreement will run from 1 April 2025 to 31 March 2028. The Tenderer shall provide a detailed implementation plan of proposed activities for the full period.

4.2 Deliverables and milestones

The Tenderers shall provide the list of deliverables and milestones (cf. ITT Volume IIIA “Pricing and deliverables”, Excel spreadsheet “Deliverables List”) for each Work Package. All deliverables and milestones must be consistent with the activities and objectives described in Section 3 of this ITT Volume II:

- 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 an outcome produced in response to the specific objectives of the contract and is subject to acceptance by both ECMWF’s Technical Officer (TO) and Contract Management Officer (CMO).
- Milestones should be designed as markers of demonstrable progress in service development and/or quality of service delivery (see also the milestone definition in this ITT Volume V Clause 1.2). They should not duplicate deliverables and shall not attract the budget under Volume IIIA “Pricing and deliverables”, Excel sheet “Deliverables List”.

The following shall apply to the deliverables and milestones:

- The deliverables and milestones should be consistent with the technical requirements specified in Section 0.
- When defining deliverables, please assign clear due dates (DD/MM/YYYY) to each of them.
- All contract reports and deliverables 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. See also Section 4.7 in what regards the data provision.

Volume IIIA “Pricing and deliverables” (cf. Excel sheet “Deliverables List”) of this ITT shall be used by the Tenderer to describe the complete list of deliverables, milestones and schedules for each work package (due dates). Please note that:

- All deliverables and milestones shall 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-2016). 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 the 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 type to be considered

is “payroll” (the total of these allocated resources and prices shall therefore amount to the total price associated with payroll in Volume IIIA spreadsheet “Costs and Prices”). Milestones should not have such associated resource allocation, unless otherwise agreed.

- The Tenderers shall provide a due date for each proposed deliverable and milestone (in accordance with those indicated in Section 3):
 - o The Tenderers shall ensure that the proposed due dates of deliverables and milestones are realistic and achievable. **Any dependencies on input data (whose origin must be specified) shall be detailed and also accounted for in the risk table.**
 - o It is advised to schedule the submission/completion of the last deliverables and/or milestones associated to a Payment Milestone not later than 15 days before the expected date of completion of the said Payment Milestone (i.e. when all deliverables have been submitted by the contractor and all milestones have been completed by the concerned parties).

4.3 Acquisition of necessary data and observations

The Successful Tenderer shall closely interact with the Global Service Provider and the provider for the Global and regional a posteriori EQC activities 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(s) for the Global and regional emissions activities, who are 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 and aerosol schemes.

4.4 Access to ECMWF HPC and IFS code base

ECMWF will support the development work of this contract by providing access to the IFS code base, the High Performance Computing Facility (HPCF) and Data Handling System (DHS) to specific individuals for the duration of the contract. This will allow the successful Tenderer to carry out the required experimentation in both modelling and data assimilation mode for the technical testing and scientific evaluation of the results. The use of the HPC resources will be closely monitored by ECMWF to ensure they stay within the allocation for CAMS global development..

4.5 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.

<i>Section</i>	<i>Page Limit</i>
<i>Executive Summary</i>	2
<i>Track Record</i>	2 (for general) and 2 (per entity)
<i>Quality of resources to be Deployed</i>	2 (excluding Table 1 in Volume IIIB and CVs with a maximum length of 2 pages each)
<i>Technical Solution Proposed</i>	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)
<i>Management and Implementation</i>	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)
<i>Pricing Table</i>	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 required 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 and aerosol 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 and aerosol schemes to ensure they continue to meet the international standards required. This shall take into account all the requested development activities.