

ECMWF Copernicus Procurement

Invitation to Tender



Copernicus Atmosphere Monitoring Service

Regional Air Quality Products

Volume II

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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 change the oxidation capacity of the atmosphere and control therewith also the abundance of long-lived greenhouse gases. The composition of the troposphere and the associated deposition fluxes are major components of the biogeochemical cycles of carbon, nitrogen and sulphur and iron, which affect 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.

The increasing concentration of the greenhouse gases and the various aerosol-weather feedbacks 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) and atmospheric transport modelling.

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

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

- a) Daily production of real-time analyses and forecasts of global atmospheric composition;
- b) Reanalyses providing consistent multi-annual global datasets of atmospheric composition with a stable model/assimilation system;
- c) Daily production of real-time European air quality analyses and forecasts with a multi-model ensemble system;
- d) Reanalyses providing consistent annual datasets of European air quality with a frozen model/assimilation system, supporting in particular policy applications;
- e) Products to support policy users, adding value to "raw" data products in order to deliver information products in a form adapted to policy applications and policy-relevant work;
- f) Solar and UV radiation products supporting the planning, monitoring, and efficiency improvements of solar energy production and providing quantitative information on UV irradiance for downstream applications related to health and ecosystems;
- g) Greenhouse gas atmospheric inversions for CO₂, CH₄ and N₂O net surface fluxes, allowing the monitoring of the evolution in 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 elements described under items (c) and (d).

1.1 Definitions

Definitions specific for this ITT are defined below.

Global Service Provider: ECMWF is the provider of global products

Regional Service Provider: the successful Tenderer of the present ITT CAMS_50, Regional Production

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.

Regional Products: the outputs of analyses and forecasts from the regional CAMS data assimilation and forecasting systems, which are run by the Regional Service Provider. The Regional Products consist in the first place of real-time analyses and forecasts. The regional CAMS data assimilation and forecasting systems will comprise eleven individual systems as well as their model ensemble products. These analyses and forecasts will be produced every 24 hours and include 3-dimensional fields of aerosols and chemical species with a temporal resolution of 1 hour. The Regional Products also include the outputs from interim re-analyses based on in-situ observations in an interim stage of validation and re-analyses based on fully validated in-situ observations. Outputs from these reanalyses consist of analyses of chemical species and aerosols with a temporal resolution of 1 hour and will be provided on an annual basis by the Regional Service Provider.

Central Regional Production Unit (CRPU): the organisation in charge of ensemble processing and of delivering the Regional Products to the users on behalf of the Regional Service Provider.

Regional Systems: the ten or more regional air quality modelling and data assimilation systems that contribute to the operational delivery of the Regional Products.

2 Contract Summary

This ITT, entitled “Regional air quality products” is for the operational delivery of the European-scale air quality component of CAMS. It consists of a set of services, which are further detailed in the technical specification below. The production must be based upon a geographically distributed ensemble of more than ten individual models and a central processing function to deliver three numerical data streams:

- on a daily basis, analyses for the previous day and forecasts for key air pollutants up to +96h with a temporal resolution of one hour;
- with a delay of a few weeks (in order to maximise the number of observations), interim reanalyses shall be produced daily with systems frozen in their configuration of January 1st every year;
- with a delay of up to two years (due to the delay in getting fully validated data), reanalyses shall be produced with frozen systems, which are only updated every few years.

All the individual Regional Systems must be mature, well-validated and operated by their main developers. This aspect is essential so that the operators can directly maintain a continuous workflow of changes to the numerical systems, in order to include new research developments, to make corrections reflecting findings from verification and validation activities, as well as to implement changes to better meet user requirements. Acquisition of data, production of analyses, reanalyses and forecasts, data dissemination services and support to the users form the bulk of the operational delivery and development activities that are procured within this ITT.

3 Technical Specification

The successful Tenderer shall bring together a group of organisations which will continuously develop and operate ten or more regional air quality assimilation and forecast systems (Regional Systems), which support the delivery of the Regional Products.

3.1 General Requirements

The successful Tenderer will bring evidence that the following conditions are met for each of the individual Regional Systems that it has selected:

- the domain covered shall be at least (25°W-45°E, 30°N-72°N);
- the system's horizontal resolution shall be finer than or equal to 0.2° by 0.2°, or the equivalent resolution in kilometres;
- transport and physical processes shall be driven by ECMWF's high-resolution operational meteorological forecasts (using the most recent available forecast), either directly in the case of chemistry-transport models or by means of nudging or similar techniques;
- the system shall use the regional emissions dataset (other than fire) provided by the CAMS contract for regional emission inventories and possibly using refinements from observation-based emission estimates provided by ECMWF to the successful Tenderer, if these estimates become available within the duration of this contract;
- the system shall use fire emissions as well as chemical boundary conditions provided by the CAMS Global Service Provider (aerosol, reactive gases and greenhouse gases, if accounted for) using the most recent available products;
- the system shall have the capability to forecast atmospheric pollutants regulated at the European and national levels in Europe, gases and particulate, as well as pollens (if the source term is externally provided);
- the system shall have a documented data assimilation capability for surface Air Quality observations (at the minimum);
- the system shall have an existing track record of providing daily forecasts with evidence of performance (quality, timeliness/completeness of the output...) as documented in peer-reviewed publications, reports or technical notes.

3.2 Work package 4010 – Observational data acquisition

The successful Tenderer shall acquire observational data for data assimilation purposes and shall ensure that identical datasets are made available to and used by all the individual Regional Systems.

Surface observations of air pollutants measured from regulatory networks in Europe will be primarily acquired from the European Environment Agency (EEA). CAMS has a dedicated contract with EEA and its contractors to support the operational data provision. Additional surface air quality data may be obtained directly from European countries, in particular in order to reduce data gaps or mitigate issues with the primary data feed. Finally, the use of advanced chemical surface observations from the ACTRIS and EMEP programmes, the provision of which will be supported by separate CAMS contracts, shall be taken into account.

The successful Tenderer shall acquire directly three streams of observational data:

- Near-Real-Time un-validated data (“NRT data”) shall be acquired daily.
- “Interim data” shall be gathered routinely with a delay of between 2 and 4 weeks. Such data may have undergone certain validation processes but are not officially reported by the European Countries.
- “Validated data” shall be gathered within a month after they have been made available in EEA’s Airbase, following the official reporting process of the European Countries, which currently takes up to two years.

The successful Tenderer shall organise together with ECMWF the liaison with the EEA regarding feedback on NRT data integrity, quality, acquisition and format aspects. ECMWF and EEA have an ongoing contract, which is dedicated to the improvement of the infrastructure as well as to visit individual European countries for the purpose of solving specific issues and of advocating for increasing the amount of data submitted on a routine basis.

Other types of observations (satellite, data from research infrastructures and networks) will be acquired by ECMWF and made available to the successful Tenderer for activities directly related to this ITT. The successful Tenderer shall acquire, process (formatting, black-listing...) and filter observations according to their representativeness and suitability for assimilation and verification purposes at the resolution of the Regional Systems. The successful Tenderer shall interact with the provider for Regional Evaluation and Quality Control (EQC) services to set aside some observations for the purpose of independent verification and quality control of analyses, re-analyses and forecasts.

The successful Tenderer shall report data acquisition activities on a quarterly basis. At the minimum, information will be stratified by country, by parameter and by hour in the day. Indications will be given whether the data flow is steady, improving or deteriorating for the different entries.

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.

WP4010 Deliverables			
<i>#</i>	<i>Type</i>	<i>Title</i>	<i>Due</i>
D1.Y.Z- yyyyQx ¹	Data & Report	Daily data acquisition and quarterly status report of NRT and interim data from the EEA and the ACTRIS and EMEP programmes	Quarterly

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.

D1.Y.Z-yyyy	Report	Annual data acquisition and status report of validated data from the EEA and the ACTRIS and EMEP programmes	Annually (3 months after release of Airbase by the EEA)
...			

WP4010 Milestones			
#	Title	Means of verification	Due
M1.Y.Z		List here the milestones	
...			

3.3 Work package 4020 – Provision of near-real-time (NRT) European analyses and forecasts

For the provision of daily near-real-time European air quality analyses and forecasts, the Regional Systems selected by the successful Tenderer shall deliver numerical outputs to the Central Regional Production Unit (CRPU) that shall process the input from each individual Regional System and prepare ensemble products based on that input. Output data from all individual Regional Systems as well as the ensemble products shall be made available to the users via the Atmosphere Data Store (ADS) and shall have the following characteristics:

- Delivery done in GRIB format;
- model outputs are made available over the area defined in section 3.1;
- ensemble products shall have a horizontal resolution of 0.1°;
- model outputs are provided for at least eight vertical levels: surface, 50m, 250m, 500m, 1000m, 2000m, 3000m and 5000m above ground; during the contract period the number of levels shall be increased to at least ten, increasing the resolution in the planetary boundary layer;
- at the start of the contract, the model variables will include at least O₃, NO, NO₂, CO, SO₂, PM_{2.5}, PM₁₀, NH₃, total Non-Methane Volatile Organic Compounds (NMVOC), total Peroxy-Acetyl Nitrates (PANs) and, during the relevant part of the year, birch, olive, grass, alder and ragweed pollens; in addition, the following aerosol parameters should be included: PM₁₀ from wildfires, PM₁₀ from dust, PM_{2.5} secondary inorganic aerosols, and PM_{2.5} from anthropogenic combustion (including separation between residential and other sources).
- Within 12 months from the start of the contract: formaldehyde (HCHO), glyoxal (OCHCHO), and mugwort pollen shall be added
- Within 36 months from the start of the contract: models variables accounting for the PM_{2.5} fraction of secondary organic production, sea salt, and ammonium nitrate and shall be added progressively as well as PM_{2.5} from ship emissions.

The methodology employed for the centralised regional production shall initially be based on the median value of the ensemble of the individual systems for each geographical location, vertical level and parameter. The outputs from the different ensemble members shall be used to estimate uncertainties, which are required by the users. Particular attention shall be paid to adequate routine

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.

quality control for any significant outliers in the model ensemble. The successful Tenderer shall also take into account any feedback provided by the CAMS contract on regional Evaluation and Quality Control on the quality of the provided services. The ensemble methodology shall be changed during the contract based on the development activities in Workpackage 4030.

3.3.1 Task 4021: Daily Near-Real-Time (NRT) European air quality analyses

The successful Tenderer shall provide daily analyses with a temporal resolution of one hour for the previous day (0h to 24h) for each of the individual Regional Systems using the NRT observations compiled under Work package 4010 (see section 3.2). The successful Tenderer shall also provide the equivalent ensemble products. All the variables mentioned in section 3.3 shall be provided, even if no observations are assimilated for a certain variable or if the impact of the assimilation of other chemically related species on that variable is marginal.

The analyses shall be made available daily to the users by the CRPU via the ADS not later than 12 UTC. The successful Tenderer has to make the necessary arrangements so that individual production of the analyses, dissemination to the CRPU and ensemble processing allows for meeting this target.

For each of the individual regional systems, a detailed record will be kept of the data effectively assimilated each day as well as the time of delivery of the analyses. This will be used to produce a short note with the time of delivery of the daily analyses two weeks after the end of each quarter.

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.

WP4020 Deliverables			
<i>#</i>	<i>Type</i>	<i>Title</i>	<i>Due</i>
D2.Y.Z- YYYYQx	Data & report	Provision of daily individual NRT analyses from each of the operational systems plus the ENSEMBLE and quarterly report providing the uptime statistics of data servers, explanations for issues, volume and number of files served.	Quarterly

WP4020 Milestones			
<i>#</i>	<i>Title</i>	<i>Means of verification</i>	<i>Due</i>
M2.Y.Z		List here the milestones	
...			

3.3.2 Task 4022: Daily European air quality forecasts

The successful Tenderer shall provide daily 96-hour air quality forecasts with a temporal resolution of one hour based from 00 UTC for each of the individual Regional Systems. The successful Tenderer shall

also provide the equivalent ensemble products. The forecasts for chemical variables will be initialised by the 24-hour forecast of the previous day for the same system.

Forecasts will be made available daily to the users by the CRPU via the ADS not later than 08 UTC (0-48h) and 10 UTC (49-96h). The successful Tenderer has to make the necessary arrangements so that individual production of the forecasts, dissemination to the CRPU and ensemble processing allows for meeting this target.

For each of the individual regional systems, a detailed record will be kept of the data effectively delivered each day and the timeliness of the delivery for the four forecast days. It will be used to produce a short note with the time of delivery of the daily forecasts two weeks after the end of each quarter.

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.

WP4020 Deliverables			
#	Type	Title	Due
D2.Y.Z- yyyyQx	Data & report	Provision of daily individual forecasts (up to 96h) from each of the operational systems plus the ENSEMBLE and quarterly report providing the uptime statistics of data servers, explanations for issues, volume and number of files served.	Quarterly

WP4020 Milestones			
#	Title	Means of verification	Due
M2.Y.Z		List here the milestones	
...			

3.4 Work package 4030 – Maintenance and system upgrades of the operational forecasting systems

The Regional Systems shall be operated by organisations that have demonstrated capability of bringing changes to the corresponding numerical codes. For each one of the Regional Systems a multi-year development plan will be maintained and will form part of the CAMS Service Evolution Strategy document. The implementation development plans of the Regional Systems will especially focus on implementing items that will be finalized and validated by the long-term development work package (4040) comprising modelling, data assimilation and post-processing aspects. Two specific short-term developments shall be included:

- Implement and test novel methodologies to provide an improved range of ensemble products based on the outcomes of the CAMS-63 contract from the first Copernicus phase, which will become available in the form of reports from the CAMS website by 30 June 2021.
- Implement and test the production of observation-adjusted (Model Output Statistics) point forecasts for all stations in Europe that report regularly to the Up-To-Date (UTD) system of the European Environment Agency (EEA), including urban stations. The production shall use the methodology that will be recommended by the CAMS-63 contract from the first Copernicus phase, which will become available in the form of reports from the CAMS website by 30 June 2021, and shall only be applied to the ENSEMBLE forecasts.

The successful Tenderer shall report on continual development activities for all Regional Systems as well as the ENSEMBLE processing on a yearly basis. The operational configuration of each of the Regional Systems shall be changed only once a year and simultaneously, in principle during the month of November each year. The successful Tenderer shall inform the users at least two months in advance of the main changes; in case the contents or format of the outputs is changed, sample files shall be made available also at least two months in advance. In the case that another change is proposed by the successful Tenderer (either for fixing an issue in one or the Regional Systems or for making a general change to all the Regional Systems), it will have to be formally approved by ECMWF before implementation and information of the users. Each change shall be described by updating the documentation of the relevant Regional Systems in the centralized CAMS Knowledge Base (see also WP4060).

In principle, most developments will be phased in with the planned upgrades of the systems. However, the successful Tenderer shall keep the possibility for interim ad hoc upgrades to correct issues that affect the quality of the operational data provision, subject to discussion with and approval from ECMWF. This shall take into account the feedback provided by the CAMS contract on regional Evaluation and Quality Control. The successful Tenderer shall inform the users at least two months in advance of the main changes; in case the contents or format of the outputs is changed, sample files will be made available also at least two months in advance. Each change will be described by updating the documentation of the relevant Regional System(s): the main body of the text should describe the current version, while annexes should describe the changes compared to previous operational versions (indicating periods when these were in operations).

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.

WP4030 Deliverables Template			
<i>#</i>	<i>Type</i>	<i>Title</i>	<i>Due</i>
D3.Y.Z-yyyy	Report	Annual plan for short-term maintenance and development activities for all Regional Systems and the ENSEMBLE processing	End of November
D3.Y.Z-yyyy	Report	Annual report on the short-term maintenance and development activities for all the Regional Systems and the ENSEMBLE processing	End of November

D3.Y.Z- yyyyQx	Note	Note confirming the status of the short-term development milestones planned for the current year for all Regional Systems and the ENSEMBLE processing	February, May, September
...			

WP4030 Milestones Template			
#	Title	Means of verification	Due
M3.Y.Z	Operational upgrade of the Regional Systems and ENSEMBLE processing	Email sent via the CAMS Service Desk to the users informing of completion of the operational upgrade	At each operational upgrade*
...			

* The Tenderer shall indicate in the proposal the planned approximate implementation dates of the main system upgrades.

3.5 Work package 4040 – Forecasting system development

The successful Tenderer shall further develop the methods and tools used to deliver the products from the model and data assimilation systems and the ensemble products. A multi-year development plan for longer-term developments shall be maintained and will form part of the CAMS Service Evolution Strategy document. Additionally, the plans may cover other aspects to address specific shortcomings that have not necessarily been identified in the context of CAMS operations. The successful Tenderer shall report on continual development activities for the regional central processing system on a half-yearly basis.

The developments shall include:

- A dedicated study to evaluate deposition fluxes for key pollutants from the Regional Systems. Outputs from the Regional Systems shall be compared with each other, but also with equivalent outputs from the global CAMS data assimilation and forecasting system. Where possible, observations of the deposition fluxes shall be used to provide a further evaluation.
- Activities on satellite data assimilation to prepare for the launch of the Sentinel-4 satellite that will provide up to hourly measurements at 4km resolution over the entire European domain. Preliminary data assimilation tests shall be conducted using the Sentinel-5p satellite with a selection of models. This work shall take the outcomes of the CAMS-61 contract from the first Copernicus phase (Cop1) into account, which will become available in the form of reports from the CAMS website by 30 June 2021. Activities shall also be coordinated with similar activities as part of the Horizon Europe work programme, specifically the Calls for proposal related to CAMS service development.
- Further develop the capability to produce timely forecasts initialized by the analyses. This will require benchmarking and showing the added value of including the analyses as initial conditions (potentially delayed) for the ensemble forecast scores.

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.

WP4040 Deliverables Template			
#	Type	Title	Due
D4.Y.Z-yyyy	Report	Annual plan for long-term development activities for all Regional Systems and the ENSEMBLE processing	End of November
D4.Y.Z-yyyy	Report	Annual report on the long-term development activities for all the Regional Systems and the ENSEMBLE processing	End of November
D4.Y.Z-yyyyQx	Note	Note confirming the status of the development milestones planned for the current year for all Regional Systems and the ENSEMBLE processing	February, May, September
...			

WP4040 Milestones Template			
#	Title	Means of verification	Due
M4.Y.Z			
...			

3.6 Work package 4050 – Provision of European reanalyses

For the provision of annual European air quality reanalyses, the Regional Systems selected by the successful Tenderer shall deliver numerical outputs to the Central Regional Production Unit (CRPU) that shall process the input from each individual Regional System and prepare ensemble products based on that input. Output data from all individual Regional Systems as well as the ensemble products shall be made available to the users via the Atmosphere Data Store (ADS) and shall have the following characteristics:

- Delivery done in GRIB format;
- model outputs are made available over the area defined in section 3.1;
- ensemble products shall have a horizontal resolution of 0.1°;
- model outputs are provided for at least eight vertical levels: surface, 50m, 250m, 500m, 1000m, 2000m, 3000m and 5000m above ground; during the contract period the number of levels shall be increased to at least ten, increasing the resolution in the planetary boundary layer;
- at the start of the contract, the model variables will include at least O₃, NO, NO₂, CO, SO₂, PM_{2.5}, PM₁₀, NH₃, total Non-Methane Volatile Organic Compounds (NMVOC), total Peroxy-Acetyl Nitrates (PANs) and, during the relevant part of the year, birch, olive, grass, alder and ragweed pollens; in addition, the following aerosol parameters should be included: PM₁₀ from wildfires, PM₁₀ from dust, PM_{2.5} secondary inorganic aerosols, and PM_{2.5} from anthropogenic combustion (including separation between residential and other sources).
- Within 12 months from the start of the contract: formaldehyde (HCHO), glyoxal (OCHCHO), and mugwort pollen shall be added
- Within 36 months from the start of the contract: models variables accounting for the PM_{2.5} fraction of secondary organic production, sea salt, and ammonium nitrate and shall be added progressively as well as PM_{2.5} from ship emissions.

The methodology employed for the centralised regional production shall initially be based on the median value of the ensemble of the individual systems for each geographical location, vertical level and parameter. The outputs from the different ensemble members shall be used to estimate uncertainties, which are required by the users. This methodology shall be changed during the contract based on the development activities in Workpackage 4030.

3.6.1 Task 4051: European air quality interim re-analyses

The successful Tenderer shall provide annual interim reanalyses with a temporal resolution of one hour for the past year and for each of the individual Regional Systems, using the “Interim data” compiled under Workpackage 4010. The successful Tenderer shall also provide the equivalent ensemble products. All the above-mentioned parameters shall be provided, even if no observation is assimilated for a certain parameter or if the impact of the assimilation of other chemically-related species on that parameter is marginal. The first year to be provided shall be 2021.

Interim reanalyses based on “Interim data” shall be made available to the users by the CRPU not later than at the end of February each year for the entire previous year. The successful Tenderer has to make the necessary arrangements so that individual production of the analyses, dissemination to the CRPU and ensemble processing allows for meeting this target.

For each of the individual Regional Systems, a record shall be kept of the data effectively assimilated for each day of the year.

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

WP4050 Deliverables Template			
<i>#</i>	<i>Type</i>	<i>Title</i>	<i>Due</i>
D5.Y.Z-yyyy	Data	Provision of the annual interim reanalysis for Year N from each of the operational systems plus ENSEMBLE	End of February of Year N+1

3.6.2 Task 4052: European air quality validated re-analyses

The successful Tenderer shall provide annual reanalyses with a temporal resolution of one hour for each past year and for each of the individual regional systems, using the “Validated data” compiled under Work package 5010. The successful Tenderer shall also provide the equivalent ensemble products. All the above-mentioned parameters shall be provided, even if no observation is assimilated for a certain parameter or if the impact of the assimilation of other chemically-related species on that parameter is marginal. The first year to be provided shall be 2019.

Reanalyses based on “Validated data” shall be made available to the users by the CRPU not later than four months after data has been made available by the EEA in Airbase for a given past year. The

successful Tenderer has to make the necessary arrangements so that individual production of the analyses, dissemination to the CRPU and ensemble processing allows for meeting this target.

For each of the individual Regional Systems, a record shall be kept of the data effectively assimilated for each day of the year.

The successful Tenderer shall also provide annual validated reanalyses for the years 2011, 2012 and 2013 to extend the current CAMS record backwards in time. The Tenderer shall indicate in the proposal the expected timeline for providing these additional years.

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

WP4050 Deliverables Template			
<i>#</i>	<i>Type</i>	<i>Title</i>	<i>Due</i>
D5.Y.Z-yyyy	Data	Provision of the annual reanalysis for Year N-1 from each of the operational systems plus ENSEMBLE	During Year N+1, no later than 4 months after 'validated' observations for Year N-1 have been released by the EEA
D5.Y.Z	Data	Provision of annual reanalyses for 2011, 2012 and 2013 from each of the operational systems plus ENSEMBLE	

3.7 Work package 4060 - 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 required to contribute to the delivery of multi-tiered technical support for the data and/or services they provide. Such specialised user support shall take the form of direct response to individual user queries via the Service Desk facility, as well as contributions to FAQs, Knowledge Base, and user guides. Contractors may also be requested by the CAMS Service Desk to contribute to support questions in the online Forum.

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

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

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

WP4060 Deliverables			
<i>#</i>	<i>Type</i>	<i>Title</i>	<i>Due</i>
D6.Y.Z-yyyy	Other	Contribution to CAMS Knowledge Base to ensure up-to-date information about products and services covered under this contract	Annually
D6.Y.Z-yyyy	Other	Contribution to CAMS Knowledge Base about system upgrades of Regional Production	At each system upgrade
D6.Y.Z-yyyy	Other	Contribution to CAMS Knowledge Base about new release of (interim) reanalysis products	At each annual release of Regional (interim) reanalysis
...			

WP4060 Milestones Template			
<i>#</i>	<i>Title</i>	<i>Means of verification</i>	<i>Due</i>
M6.Y.Z
...			

3.8 Work package 4000 - Management and coordination

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

- Contractual obligations as described in the Framework Agreement Clause 2.3 on reporting and planning.
- Meetings (classified as tasks and listed in a separate table as part of the proposal):
 - ECMWF will organise annual CAMS General Assemblies. The successful Tenderer is required to attend these meetings with team members covering the various topics that are part of this ITT.

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

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

WP4000 Deliverables				
<i>#</i>	<i>Responsible</i>	<i>Nature</i>	<i>Title</i>	<i>Due</i>
D0.Y.Z-yyyyQx	Tenderer	Report	Quarterly Implementation Report QQ YYYY <i>QQ YYYY being the previous quarter</i>	Quarterly on 15/04, 15/07 and 15/10
D0.Y.Z-yyyy	Tenderer	Report	Annual Implementation Report YYYY <i>YYYY being the Year n-1</i>	Annually on 28/02
D0.Y.Z-yyyy	Tenderer	Other	Preliminary financial form YYYY <i>YYYY being the Year n-1</i>	Annually on 15/01
D0.Y.Z	Tenderer	Report	Final report	60 days after end of contract
D0.Y.Z-yyyy	Tenderer	Report	Finalised Implementation plan YYYY <i>YYYY being the Year n+1</i>	Annually on 30/09
D0.Y.Z-yyyy	Tenderer	Other	Copy of prime contractor's general financial statements and audit report YYYY <i>YYYY being the Year n-1</i>	Annually

D0.Y.Z	Tenderer	Other	Updated KPIs (list, targets...) after review with ECMWF	One year after start of contract
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WP4000 Milestones				
#	Responsible	Title	Means of verification	Due
M0.Y.Z-Px	Tenderer	Progress review meetings with ECMWF / Payment milestones	Minutes of meeting	~ Every 6 months

4 General Requirements

4.1 Implementation schedule

The Framework Agreement will run from 1 November 2021 to 30 April 2025. The Tenderer shall provide a detailed implementation plan of proposed activities for the full period.

4.2 Deliverables and milestones

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

Each Deliverable shall have an associated resource allocation (person-months and financial budget, resource type: payroll only). The total of these allocated resources shall amount to the requested budget associated with payroll. Milestones should not have the associated budget.

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

CAMS Copernicus services have now entered an operational phase and timely delivery of services is essential. Tenderer shall therefore ensure that the proposed due dates of deliverables and milestones are realistic and achievable i.e. Tenderer shall consider dependencies i.e. source of original data and assess the risk accordingly.

4.3 Acquisition of necessary data and observations

The Successful Tenderer shall closely interact with the Global Service Provider and the providers of the relevant in situ support contracts for the exchange of relevant data sets related to 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 emission data sets that form an input to the Regional Systems, to ensure appropriate use of these emissions.

4.4 Communication

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

4.5 Support for user engagement and training activities

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

Requests to support activities may be raised on for example:

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

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

As part of the CAMS user interaction, user requirements are continually collected in a User Requirements Database (URDB) in a structured and traceable way. This URDB tracks all requirements emanating from a wide variety of user fora, surveys, user support and direct interactions between service providers and their users. The entries of the URDB are analysed on a regular basis in terms of user requirements per domain, importance and feasibility. This analysis constitutes the basis for distilling, filtering and translating user requirements into technical specifications for the Service and its evolution.

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

The following deliverables are thus to be added to the WP4060 deliverable lists:

WP4060 Deliverables Template			
#	Type	Title	Due
D6.y.z- YYYY	Other	Input to CAMS URDB - YYYY	Checked by ECMWF annually in November
...			

4.6 Data provision and IPR

It is expected that data sets (including databases) generated or acquired by the successful Tenderer will be delivered to the users via the Atmosphere Data Store (ADS). The section below indicates generic requirements for these datasets in terms of standards and conformity.

Provision of data and products:

Suppliers will make the output of their work available to CAMS users via the ADS, by one of two methods:

- a) uploading their data and products to a designated server,
- b) providing them via web services.

In the case of (a), suppliers will have to agree with ECMWF on the data formats to be used. ECMWF will only accept data in formats that follow internationally recognised standards. Such standards must be open (i.e. non-proprietary), managed by a recognised international standardisation body (e.g. ISO, WMO, OGC, etc.), or any de-facto standard. Open source software should also exist that can read and write files of these standards. Serialisation formats (e.g. NetCDF, XML, JSON) should be supported by standard schemas and conventions. All text-based formats should be encoded in UTF-8. ECMWF will implement tools to check the compliance of the provided data and products to the agreed standards before they are added to the ADS.

Examples of case (a) are data uploaded to the ADS in WMO GRIB edition 1 and 2, NetCDF files conforming to CF-1.6, or greater.

In the case of (b), suppliers will have to agree with ECMWF on the protocols to be used to invoke the web services. ECMWF will only accept protocols that follow internationally recognised standards. Such standards must be open (i.e. non-proprietary), managed by a recognised international standardisation process (e.g. ISO, WMO, OGC, etc), or be a de-facto standard such as OpenDAP. ECMWF will consider using bespoke web-based APIs to access the data and products if they implement very simple protocols (e.g. REST), as long as the results returned by these APIs are compatible with (a). It should be noted that requests for these web services will mostly originate from the ADS itself, as part of a workflow run on behalf of an end-user; ECMWF will therefore need to have the necessary credentials to invoke these services. ECMWF will not provide information on the end user's identity when invoking the web services. ECMWF will nevertheless collect usage statistics for all aspects of CAMS.

Examples of case (b) are OGC standards (WMS, WCS, WFS, etc), OpenDAP, etc. Other protocols could be considered as the system evolves.

Every dataset and/or service provided shall be documented using the appropriate metadata standards (e.g. ISO 19115, INSPIRE Directive 2007/2/EC).

Provision of processing capabilities:

Successful tenderer will (when appropriate) implement specific web-service-based data manipulation facilities. These will make it possible to run some agreed reduction and/or analysis algorithms directly on the data and products located on the suppliers' systems, and to return the results of said algorithms.

As for data retrievals, invocation of these web services will originate from the ADS itself as part of a workflow run on behalf of an end user, and ECMWF will need to have the necessary end-user credentials to invoke these services. ECMWF will not provide information on the end user's identity when invoking the web services. ECMWF will nevertheless collect usage statistics.

ECMWF will ensure that these services are invoked in a controlled fashion, to prevent any misuse of the system. This web services will be implemented with OGC's WPS standards or will be based on simple web-based REST API or equivalent. The results returned by these services will have to be in formats compatible with options (a) or (b) described above.

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 from the suppliers to the European Union via ECMWF. The successful Tenderer will be granted a non-exclusive licence to use them for any purpose

4.7 Key performance indicators

Contractors shall report to ECMWF on a set of Key Performance Indicators (KPIs) suitable for monitoring various aspect of service performance. These will be used in the overall monitoring of the CAMS programme.

The table below provides the template to be used by the Tenderer to describe the KPIs, relevant for this ITT, together with performance targets, delivery schedules and explanations if needed. Please note that the listed KPIs form part of the overall set of KPIs comprising the full CAMS service portfolio; the successful Tenderer therefore might have to provide KPI values for a KPI in support of services outside this ITT.

All KPIs shall be labelled and numbered as indicated. All KPIs shall be periodically updated as described in the tables. Tenderers shall provide preliminary versions of the completed tables as part of their bid.

The list of KPIs shall be reviewed with ECMWF in the second year of the contract and updated if necessary.

KPI #	KPI Title	Performance Target and Unit of Measure	Frequency of Delivery	Explanations / Comments
KPI_40.1	Data server uptime in latest Quarter	95%	Quarterly	

KPI_40.2	Production on time of NRT analyses and forecasts with all N operational models / with N-2 models in latest Quarter	90% / 98%	Quarterly	
KPI_40.3	User Support ticket acknowledgement in latest Quarter	100% within 3 working days	Quarterly	
KPI_40.4	User Support ticket response in latest Quarter	80% within 15 days	Quarterly	

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 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 CAMS and more specifically of the CAMS Regional Products, their applications areas and the different categories of users to be served. This part should also identify the main areas of development that will help meet better the users' requirements and expectations.

An exhaustive and detailed description of the proposed technical solution for all work packages described above shall be given. The Tenderer shall describe how service provision will be organised in order to meet the stringent timeliness and completeness requirements. Some emphasis shall be put on the quality assurance and quality control strategy and, in particular, on the measures taken to ensure detection of issues in order to avoid that erroneous or uncomplete products make their way to the users and damage the Service's reputation. The description of the proposed technical solution shall be organized in individual tasks following the work package structure indicated above.