

Invitation to Tender



Copernicus Atmosphere Monitoring Service Section II

Global and regional a posteriori
validation, including focus on the Arctic
and Mediterranean areas

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1 Introduction to the Project

Some of today's most important environmental concerns relate to the composition of the atmosphere. The increasing concentration of the greenhouse gases and the cooling effect of aerosol are prominent drivers of a changing climate, but the extent of their impact is often still uncertain.

At the Earth's surface, 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. Ozone distributions in the stratosphere influence the amount of ultraviolet radiation reaching the surface. Dust, sand, smoke and volcanic aerosols affect the safe operation of transport systems and the availability of power from solar generation, the formation of clouds and rainfall, and the remote sensing by satellite of land, ocean and atmosphere.

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

The Service will consolidate many years of preparatory research and development and deliver the following operational services:

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

This ITT is targeting the validation of CAMS service elements described under items a, b, c, and d.

1.1 Definitions

General definitions can be found in Section I. Definitions specific for this ITT are defined below.

Global Service Provider: ECMWF is the provider of global products

Regional Service Provider: the regional service provider will be selected through another call for tender, CAMS_50, Regional Production

Near-Real-Time Global Products: the operational near-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 at least daily and include 3-dimensional fields of aerosols, chemical species, and greenhouse gases with a temporal resolution of at least 6 hours.

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

Global Reanalysis Products: the outputs of a reanalysis from the global CAMS data assimilation and forecasting system, which will be run by the Global Service Provider. The reanalysis will cover a period of approximately fifteen years and provide analyses and forecasts every 12 hours of 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 near-real-time analyses and forecasts. The regional CAMS data assimilation and forecasting systems will comprise at least five 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 fast-track in-situ observations 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.

2 Project Summary

This ITT, entitled “Global and regional a posteriori validation, including focus on the Arctic and Mediterranean areas”, is for validation activities of the global and to some extent regional production systems. The aim of the validation activities is to provide information on the scientific and operational quality of Near-Real-Time Global Products in the form of validation reports and on-line graphics. Additionally, validation of Regional Products in the free troposphere as well as more detailed analyses of the Arctic and Mediterranean areas are covered by this ITT. And thirdly, validation of system upgrades for the Near-Real-Time Global Products are included in this ITT as well. In summary, the Successful Tenderer shall deliver:

- Validation of CAMS Near-Real-Time Global Products
- Verification of CAMS Near-Real-Time Global Products through provision of routine validation graphics
- Validation and assessment of upgrades of the CAMS global production system
- Specific validation of CAMS Near-Real-Time Global Products for the Arctic and Mediterranean areas
- Validation of CAMS Regional Products in the free troposphere
- Validation of the interface between CAMS global and regional production systems

- Validation of CAMS Global Reanalysis Products
- Improvement of validation methodology

3 Technical Specification

Validation involves the assessment of the closeness of the data to the geophysical reality and of the sources of uncertainty of the data, over the geographic, vertical and temporal domains of relevance. Uncertainty estimates can include, but are not restricted to, estimates of the bias and precision of the data, and identification of the temporal and spatial domains over which those estimates are valid. Reference measurements used in the comparisons are supposed to represent the atmospheric “truth”. A key aspect of any comparison performed for validation purposes is the careful selection of this “truth”. The quality, traceability and suitability of the latter are essential to allow proper, unbiased and independent validation. Those reference data must be well documented and procedures must exist to ensure adequate quality control in the long term. Validation of CAMS atmospheric data products can rely on comparisons with accurate and well-documented independent observations from ground-, aircraft-, balloon- and satellite-based systems.

3.1 General Requirements

The central element of this ITT is the acquisition, interpretation and use of observational data sets that are independent (not used as input to the service production) to validate the global and regional service products as described in the work packages 84.1 to 84.8. The Tenderer is therefore expected to bring together the relevant expertise and access to relevant data sets to fully exploit the existing knowledge base in Europe on validation of atmospheric composition model outputs.

As a minimum requirement, validation in the work packages described hereafter shall be provided for the following species:

Global products	<ul style="list-style-type: none"> • Aerosols • Ozone • Carbon monoxide • Nitrogen dioxide • Sulphur dioxide • Formaldehyde • Carbon dioxide • Methane
Regional products (free troposphere only)	<ul style="list-style-type: none"> • Aerosol • Ozone • Carbon monoxide • Nitrogen oxides

The validation shall target the full 3-dimensional distribution of these species over time unless stated otherwise in the work package descriptions below. Validation of additional species shall be included if/when relevant independent observational data sets exist.

3.2 Work Package 84.1 – Validation of CAMS Near-Real-Time Global Products

The Global Service Provider will provide the CAMS Near-Real-Time Global Products using the Composition-Integrated Forecast System (C-IFS). These products are produced by combining information from the global forecast model, which models aerosols, chemical species and greenhouse gases, with information from observations of both atmospheric composition and meteorology through a process called four-dimensional variational data assimilation (4D-Var). The analyses are used as initial conditions for the model forecast. Only a subset of the atmospheric composition species in these analyses and forecasts are directly constrained by observations, but all species are in principle available to users and therefore will need to be validated. The Near-Real-

Time Global Products cover both the troposphere and stratosphere. In parallel, the Global Service Provider will produce Forecast-Only Global Products that will act as a benchmark for the impact of the data assimilation on the forecast quality. The Successful Tenderer shall routinely (every three months) provide validation reports for the Near-Real-Time Global Products documenting the scientific quality relative to the independent validation data. The report shall also provide information on the impact of the assimilated observations through comparison of the Near-Real-Time Global Products with the Forecast-Only Global Products. Each report shall document the 3-month period in terms of mean and variability of the product quality based on the individual analyses and forecasts and shall be made available within 3 months after the end of each respective validation period. The validation reports will be used by service providers and users and shall therefore comprehensively document the various validation comparisons and include a summary of the main findings.

3.3 Work Package 84.2 – Verification of CAMS Near-Real-Time Global Products through provision of routine validation graphics

To continuously monitor the scientific quality of the Near-Real-Time Global Products, on-line graphics shall be routinely produced on a daily basis comparing these products as well as the Forecast-Only Global Products with independent observations that are available within a few weeks of measurement. The graphics should be produced within one day of the acquisition of each new observation for a specific validation site. The Successful Tenderer will put in place a system to acquire the relevant validation data sets and to produce the comparisons between the Near-Real-Time Global Products and Forecast-Only Global Products and individual validation datasets. The comparisons shall be presented as daily updated time series comprising the last 3 months of data for validation data representing individual geographic locations or daily updated profiles for validation data providing profile information from ground-based or aircraft measurements. This shall either result in daily updated graphics that will be hosted on the CAMS web site or in a single comprehensive web-based system, which can be embedded in the CAMS web site, producing daily verification graphics. Graphics shall be produced daily with technical support on a next-working-day basis.

3.4 Work Package 84.3 – Validation and assessment of upgrades of the CAMS global production system

Validation also plays an important role in the upgrade procedure of the CAMS operational global production system. The implementation of developments follows a model cycle approach. The Global Service Provider will upgrade its global production system approximately twice per year. These upgrades include improvements to the model and data assimilation system as well as changes in the assimilated data sets. Because the CAMS global assimilation and forecasting system is based on the ECMWF numerical weather prediction system, new model cycles will also include meteorological developments and input data changes. These can also affect the assimilation and modelling of atmospheric composition. Before replacing the operational system, the Global Service Provider will set up a new experimental production suite that runs several months in catch-up mode (producing several days of analyses and forecasts per day) before running in parallel with the operational suite. The Successful Tenderer shall validate the output of this experimental suite against independent observations and compare with the output of the then current operational suite. The Successful Tenderer shall present the validation and comparisons in an evaluation report summarizing the results. This report will be used to adjust the experimental suite, if necessary, and to assess if the experimental suite is ready to replace the operational suite. The final decision to implement the experimental suite as the new operational suite will be taken by Global Service

Provider. The Global Service Provider shall give the Successful Tenderer one month's notice of the start and expected schedule of the experimental suite. The validation report shall cover as full a period of the experimental suite as possible and be produced to a time schedule to be agreed by the Successful Tenderer and ECMWF, on a case-by-case basis.

3.5 Work Package 84.4 – Specific validation of CAMS Near-Real-Time Global Products for the Arctic and Mediterranean areas

The Arctic and Mediterranean areas are important environmental focal points for the European Union (e.g., Union for the Mediterranean, Joint Communication from the European Commission on Developing a European Union Policy towards the Arctic Region in 2012). The Arctic is affected by pollution originating from European countries, while the Mediterranean area is affected by intense ozone chemistry as well as desert dust. This task therefore asks for validation activities that focus on these two areas to ensure the CAMS Operational Global Products are providing accurate results supporting European policymaking. Validation graphics and statistics as described in work package 84.1 shall be produced for the relevant geographical domains and be included in the validation reports described in work package 84.1.

3.6 Work Package 84.5 – Validation of CAMS Regional Products in the free troposphere

The CAMS Regional Products will be provided by an ensemble of air quality models (between five and ten members) for the European domain, which is the subject of another call for tender, CAMS_50 (Regional Production). The Regional Service Provider will provide validation of the Regional Products at the surface. The Successful Tenderer for this ITT shall therefore provide supplementary validation of the Regional Products focussing on concentrations of chemical species above the surface. The Successful Tenderer shall routinely (every three months) provide validation reports for the daily produced Regional Products documenting the scientific quality relative to the independent validation data. Each report shall document a 3-month period in terms of mean and variability of the product quality and shall be made available within 3 months after the end of each respective validation period. The validation reports will be used by service providers and users and shall therefore comprehensively document the various validation comparisons and include a summary of the main findings. For the Regional Products from the interim reanalyses and full reanalysis validation reports based on the daily analyses shall be provided on an annual basis within 3 months of the delivery of the full annual data set.

3.7 Work Package 84.6 – Validation of the interface between CAMS global and regional production systems

A central element of CAMS is the link between the global production system and the regional production system. The CAMS regional air quality models will run on a European geographical domain and therefore need boundary conditions of the relevant aerosol and chemical species for this domain as input to their assimilation and forecast runs. The CAMS global production system will provide these boundary conditions. The Successful Tenderer shall monitor and evaluate the boundary conditions for the CAMS regional geographical domain from the CAMS global model as well as the response of the regional models to these boundary conditions. Inconsistencies between the global and regional systems shall be flagged and communicated directly to the Global Service Provider and Regional Service Provider for further investigation. Focus shall be on longer-lived species, such as carbon monoxide, ozone and aerosols. The results of the monitoring and evaluation shall also be documented in a report that shall be provided on an annual basis.

3.8 Work Package 84.7 – Validation of CAMS Global Reanalysis Products

The Global Service Provider will produce an approximately 15-year global reanalysis within the time frame of this ITT. A reanalysis involves reprocessing observational data spanning an extended historical period using a consistent modern analysis system, to produce a dataset that can be used for various atmospheric composition studies. The same validation principles apply as for the Near-Real-Time Global Products but with a stronger focus on temporal stability of the output. The Successful Tenderer will therefore use a range of relevant validation data sets and homogeneity tests to document quality of the Global Reanalysis Products. The Successful Tenderer shall present the validation results in a series of validation reports based on the daily analyses. The first two reports shall include the validation results for the first and second year of the reanalysis, respectively, and be made available within a period of three months after the Global Reanalysis Products are made available for the respective year. Subsequent reports will describe validation results for five-year periods of the global reanalysis and be made available within three months after the Global Reanalysis Products for the last year of the five-year period have been produced.

3.9 Work Package 84.8 – Improvement of validation methodology

Improvement of the validation methodology involves aspects directly related to the validating observations, such as quality assurance of the validation datasets, identification of outliers, better characterisation of the observation errors, site classification, representativity error estimates, as well as aspects related to validation procedures. The latter includes improved or new definitions of validation scores and development of advanced skill scores documenting the model performance in a more intuitive way and targeting the different application areas of CAMS. The tenderer shall document progress on these aspects in annual reports and implement mature developments in the various validation tasks defined above in consultation with ECMWF.

3.10 Specific Requirements

3.10.1 Acquisition of necessary data and observations

The Global Service Provider will provide the Near-Real-Time Global Products, Forecast-Only Global Products and Global Reanalysis Products needed for carrying out the tasks of this ITT. Similarly, the Regional Service Provider will provide the needed Regional Products. The Tenderer itself shall acquire the relevant observational data sets and make them available for use in all CAMS activities related to assessment of operational and experimental CAMS products.

3.10.2 Documentation

Documentation of the CAMS services is an integral part of the service provision. The technical and scientific specification of each service will be documented in documentation reports that will be available to users through the CAMS web site. The Successful Tenderer shall therefore produce documentation describing in detail the validation methodology used as well as the various independent data sets used for the validation activities.

3.10.3 User interaction

A central responsibility of CAMS will be to continually collect and analyse feedback from the users in order to maintain requirements that meet their evolving needs. ECMWF will provide the first level of user support. This will be implemented by means of a help desk, with a level of service (e.g. available hours, time guaranteed for a response) adjusted taking into consideration the user requirements.

User queries of a more specialised nature will be referred to the relevant CAMS service providers and shall be answered within reasonable¹ time.

As part of CAMS, the four documents described below will be maintained. The Successful Tenderer shall provide input to the RAD, SPP, and SES documents regarding user requirements that are directly related to activities covered by this ITT.

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

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

Service Product Portfolio (SPP)

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

Service Evolution Strategy (SES)

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

3.11 Performance Requirements

3.11.1 Schedule/timetable

The execution of tasks detailed in the work packages will follow an implementation plan, prepared annually by ECMWF. The European Commission will approve annual implementation plans before they enter into force. These implementation plans will take full stock of service reviews, performed thoroughly on an annual basis, as well as of the continuously evolving user requirements and corresponding service specifications. The Successful Tenderer shall therefore provide each year a detailed plan of proposed activities including Deliverables and Milestones, using the work package table template from Section III, which will form part of this implementation plan. Normally a first draft of the input to the annual implementation plan shall be provided to ECMWF by the end of

¹ Reasonable is defined here as within 5 working days excluding holiday periods. The service provider shall at all times provide at least an automatic response indicating receipt of the user query and expected time of response.

February for the year thereafter and a final version shall be submitted to ECMWF by the end of October for the year thereafter. ECMWF shall either accept the provided draft and/or final versions or agree potential alterations with the Successful Tenderer.

This ITT spans a period of 3 years and the Tenderer is expected to provide an indicative implementation plan of the proposed activities for the full duration. Adjustments to the proposed implementation plan will then be made annually following the above-described procedure.

3.11.2 Deliverables

Based on the work package descriptions of this ITT the Tenderer shall define a set of Deliverables and Milestones for each work package. The Deliverables shall cover all the proposed products and services to be delivered by the Successful Tenderer. Each Deliverable shall have an associated resource allocation. The total of these allocated resources shall amount to the entire requested budget.

The Successful Tenderer is also required to provide input to the quarterly and annual reporting to the European Commission. These reports shall be defined as Deliverables as part of an overall management work package. Each quarterly report shall provide information on the performed activities for the previous period, list the achieved Deliverables and Milestones, and provide reasons for deviation from the implementation plan, where relevant.

All reports in this project shall be 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.

ECMWF will organise annual CAMS meetings. The Successful Tenderer is expected to attend these meetings with team members covering the various topics that are part of this ITT.

ECMWF will host monthly teleconference meetings to discuss CAMS service provision, service evolution and other topics. The Prime Investigator appointed by the Successful Tenderer (see 4.2.2) will represent the Successful Tenderer in such meetings.

3.11.3 Data delivery requirements

It is expected that datasets generated as part of this ITT will be delivered to the CAMS Data Store (CDS). While the CDS is under development, CAMS will use the data portal that was developed during the series of MACC (Monitoring Atmospheric Composition and Climate) projects. It is expected that the CDS will be fully operational in 2017. Note that the requirements below will strictly apply when the CDS is fully developed.

3.11.3.1 CAMS Data Store (CDS) requirements

3.11.3.1.1 Provision of data and products

Successful Tenderers will make the output of their services available to CAMS users via the CDS. They can do so by either of the following methods:

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

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

In the case of (b), Successful Tenderers 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 CAMS Data Store 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, WCF, WFS, etc), OpenDAP, etc. Other protocols could be considered as the system evolves. Every dataset and/or service provided will have to be documented using the appropriate metadata standards (e.g. ISO19115).

3.11.3.1.2 Provision of processing capabilities

Successful Tenderers may be asked (if appropriate) to 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 mostly originate from the CAMS Data Store 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. These 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 (a) or (b) options described above.

3.11.3.2 Data and IPR

It is a condition of EU funding for CAMS that ownership of the datasets passes from the Successful Tenderers to the European Commission, via ECMWF. Ownership will pass on delivery of the datasets. In return, the Successful Tenderers will be granted a non-exclusive licence to use the datasets, which they have provided to CAMS, for any purpose except one which conflicts with the aims of CAMS.

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 Tenderer's production system. The identity and ownership of such exceptional components will be passed to the European Commission, via ECMWF annually. In return the Successful Tenderer will be granted a non-exclusive licence to use them for any purpose except one which conflicts with the aims of CAMS.

Detailed contractual terms, including terms to give effect to the arrangements described above are set out in the Terms & Conditions for this ITT.

3.11.4 Key Performance Indicators and Performance Targets

The Tenderer shall provide a set of Key Performance Indicators (KPI) for the validation activities taking the requirements described above into account. KPIs to be developed will address aspects such as timeliness of validation reports, technical performance aspects for the verification graphics, user uptake and user satisfaction. Performance Targets shall be defined for the first year and will be revised annually to reflect service evolution.

4 Tender Format

General guidelines for the Tender are described in Section III. Specific requirements for this particular ITT are described in the next few sub-sections

4.1 Page Limits

It is expected that individual sections of the Tenderer's response do not exceed the page limits listed. Excess pages and wrongly formatted Tenders may be discarded from the evaluation process.

Table 1 Page limits per section

Section	Page Limit
Track Record	1 (for general) and 2 per entity
Quality of Resources Applied	2 (excl. CV's with a maximum length of 2 pages each)
Technical Solution Proposed	2 + 3 per Work Package (the section on reference, publications, patents and any pre-existing IPR is excluded from the page limit and has no page limit)
Management and Implementation	4 + 2 per Work Package table (Implementation plan)
Pricing tables	No limitation for tables

4.2 Specific additional instructions for the Tender

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 Section III. This is not an exhaustive description and additional information may be necessary depending on the Tenderer response.

4.2.1 Track Record

The Tenderer shall demonstrate for itself and for any proposed subcontractors that they have participated in national or international research and private sector projects in the last 5 years for the activities for which this Tender is proposed.

4.2.2 Quality of Resources Applied

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

- A senior team member (Prime Investigator) with more than 5 years' experience in managing activities related to this ITT
- At least two additional senior team members with more than 5 years' 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.

4.2.3 Technical Solution Proposed

The Tenderer is expected to provide a short background to the proposed technical solution to demonstrate understanding of the solution proposed. This should include background of the Tenderer's understanding of the Copernicus Atmosphere Monitoring Service, the global earth observing system, the current state of forecasting of global atmospheric composition and regional air quality, and how validation plays a significant role in the service provision. Emphasis in the description should be given to general validation principles of atmospheric composition products.

An exhaustive and detailed description of the proposed technical solution for all work packages described above shall be given. The Tenderer shall indicate which independent observational data sets it intends to use and how it will acquire the relevant data. The Tenderer shall describe the validation statistics it intends to use and how results shall be presented in the various validation reports. The Tenderer shall also provide a detailed description of how it intends to generate the validation graphics both for the validation reports and for the web-based verification. In case the Tenderer intends to provide a comprehensive web-based system to produce these graphics, it shall describe this system. The description of the proposed technical solution shall be organized in individual tasks following the work package structure indicated above.

4.2.4 Management and Implementation

The Tenderer shall provide a detailed implementation plan of proposed activities for the three-year Tender period using the activity table in Section III as a template. The Tenderer shall provide a table for each work package describing the main objectives, the respective proposed activities and a set of Deliverables and Milestones. The number of Deliverables and Milestones shall be restricted to less than ten per work package. While financial information can be omitted from this table, a specification of the required staff resources is required. As outlined in Section 3.11.1, adjustments to the proposed implementation plan can be made on an annual basis depending on needs for service evolution, changed user requirements, or other requirements subject to approval by ECMWF.