ECMWF
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Procurement

CAMS_81 Global and regional emissions

COPERNICUS PROJECT
VOLUME III B: Proposal

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1 Executive Summary

Air quality and climate change are some of today's most important environmental concerns. Poor air quality and climate change are closely linked and directly relate to the changing composition of the atmosphere. The dominant driver of the changing atmospheric composition over the past decades are human activities like industrial production, agriculture and energy production. All these activities are associated with emissions of air pollutants and greenhouse gases. Therefore, understanding emissions, including where and when they occur, is essential to predict air quality and climate change as well as design effective mitigation options. The CAMS_81 Global and regional emissions project is designed to provide state of the art information on natural and anthropogenic emissions at the global and European regional scale. The emissions information will be direct input for the Copernicus Atmosphere Monitoring Service (CAMS) Regional and Global Production Systems. Next to the direct use in the CAMS production systems, the CAMS_81 products will be part of the CAMS services and be freely available to CAMS users.

1.1 Objectives

The proposed project, entitled "CAMS_81 Global and regional emissions" (hereafter CAMS_81) will provide gridded distributions of anthropogenic (global and European domains) and natural and biogenic emissions (global only) in direct support of CAMS production chains and for CAMS data users. More specifically objectives are:

A. To provide annual (2000-2018) total gridded emissions data for the European regional scale a target resolution of 5 to 10 km (0.1° x 0.05° (longitude - latitude) (CAMS-REG dataset).
B. To provide annual (2000-2021) total gridded emissions data for the global scale with target resolutions of 10 to 50 km aiming at a resolution of 0.1° x 0.1° (longitude - latitude) for anthropogenic emissions (CAMS-GLOB-ANT dataset)
C. To provide international shipping emissions (CAMS-GLOB-SHIP dataset)
D. To provide annual (2000-2021) total gridded emissions data for the global scale with target resolutions of 10 to 50 km aiming at a resolution of 0.1° x 0.1° (longitude - latitude) for biogenic emissions (CAMS-GLOB-BIO dataset)
E. To support AQ modellers with temporal profiles (monthly, weekly and diurnal where appropriate), so that timing of emissions can be accounted for in the CAMS systems (CAMS-TEMPO dataset).

1.2 Team

The proposed CAMS_81 project, coordinated by TNO, brings together complementary expertise and long-term experience in the quantification of anthropogenic and natural emissions. The CAMS_81 consortium consists of nine partners:

The Netherlands Organisation for Applied Scientific Research (TNO, Netherlands)	The Charles University (CUNI, Czech Republic)
The National Centre for Scientific Research (CNRS, France)	The Finnish Meteorological Institute (FMI, Finland)
• CNRS – LA: Laboratoire d'Aérologie	The Barcelona Supercomputing Centre (BSC, Spain)
• CNRS – OMP: Midi-Pyrénées Observatory	The Environment Agency Austria (EAA, Austria)
The Norwegian Meteorological Institute (MET Norway, Norway)	The Chalmers University of Technology (Chalmers, Sweden)

All partners have long-term experience in the delivery of datasets and their associated documentation in a timely manner. The partners have worked together previously in different national and

international projects, including the H2020 MACC project and previous CAMS_81 project (For more details on the individual partners we refer to Chapter 2: Track record).

The following specifications will be apply to all the objectives (A-E) and CAMS_81 team ambitions:

- The emissions will include all the main species for air quality (AQ) and climate change research as well as predicting air quality stratified into headline activity sectors;
- The team will further work on improving the representation of the temporal variations of emissions and investigating modelling methodologies to calculate certain emissions as a function of e.g. meteorological parameters and continue development of further improved spatial distribution of emissions;
- The team will provide alternative emission datasets for specific source sectors which can be used next to the official CAMS emission datasets to reflect new scientific understanding.

The CAMS_81 team will continue to ensure active links with several strategic international initiatives, such as GEIA/IGAC (Global Emission Initiative) with several CAMS_81 partners represented in the Scientific steering committee, the Task Force on Hemispheric Transport of Air Pollution (http://www.htap.org/) and the AMIGO/IGAC (Analysis of eMIssions usinG Observations) project. Regular discussions with other CAMS service elements will be important to the success of the CAMS_81 project: the interested CAMS partners (based on experience during the previous CAMS_81 project) will be invited to provide input for the CAMS_81 kick-off meeting and where needed a telecom will be organized for discussion or clarifications.

1.3 Service level by work package

CAMS_81 is organised around five work packages plus one work package dedicated to management (WP8100). Figure 1 shows the different work packages, as well as their interactions.

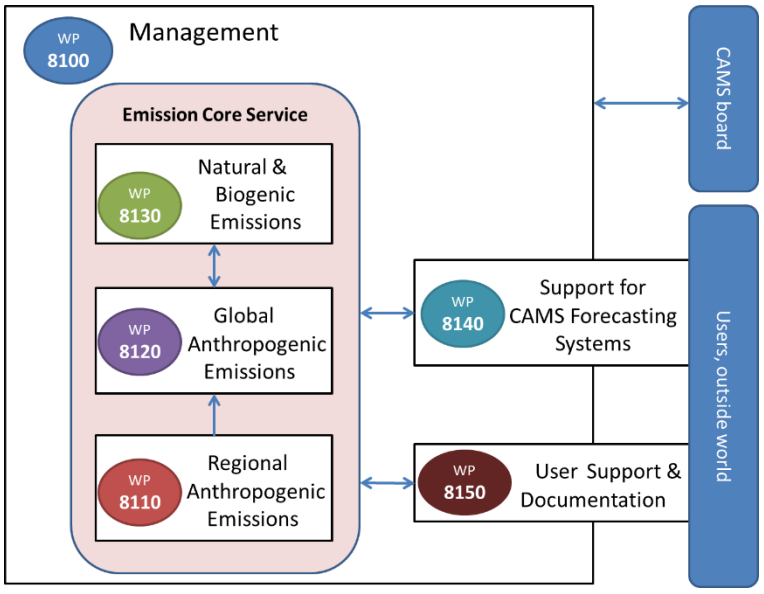

Figure 1 The CAMS_81 work packages and their interactions

The WPs located in the Emission core service address the objectives A - D. These are led by partners TNO (WP8110), CNRS-LA (WP8120) and CUNI (WP8130).

The CAMS regional emissions dataset will contain the following species: CO, NOx, SO_2, NMVOC, NH_3, PM_{10}, $PM_{2.5}$ (air pollutants), and the greenhouse gases CH_4 and CO_2. Next to temporal profiles, WP8110 will also provide chemical speciation profiles for NMVOC and aerosols. The CAMS-GLOB-ANT emission dataset provides the emissions of NOx, NH_3, SO_2, NMVOCs, CO, CH_4, CO_2, BC and OC and 25 hydrocarbons, it also includes monthly temporal profiles provided by version 2.1 of the CAMS-TEMPO data set prepared by partner BSC (WP8120). A series of actions will be performed to improve the current dataset, including: extension of the time series to 2000-2020, review of the data gap-filling methods used for those countries with no information available and investigation of current state-of-the-art methods and sources of information for specific pollutants/sources that are currently not covered. A separate global dataset providing the emissions

of international shipping (CAMS-GLOB-SHIP) will be prepared by partner FMI. Together these datasets support the CAMS regional / global production chains. The WP8130 on natural and biogenic emissions for the global domain will address Vegetation emissions of biogenic VOCs (BVOC) and natural emissions from soils, oceans and volcanoes. It is complementary to the CAMS-GLOB-ANT dataset.

Two WPs are dedicated to provide direct support to CAMS forecasting systems (WP8140, objective E) and users in general (WP8150), there are led by BSC and MET Norway, respectively. WP8140 provides direct support but also initiates discussion and interaction with CAMS forecasting systems to identify potential issues with the global and regional emission datasets through a sequence of physical and tele meetings. The User support and documentation of service (WP8150) is the interface between users and providers of CAMS_81 products. It includes providing specialised user support in a timely manner, multi-tiered documentation of the products, and ensuring the conformity of the data sets with ADS standards.

Finally a separate work package (WP8100, led by TNO) is dedicated to the management and coordination of the CAMS_81 project. It will set-up the sub-contracts for the different partners in the project, follow-up timely delivery of milestones and deliverables and submission of invoices to ECMWF timely and that the budget is delivered to all partners. The management WP will organise teleconferences at various intervals with the other partners as well as review meetings with ECMWF.

2 Track Record

The coordinating institute (TNO) and the institutes who are partners of this project bring together substantial and complementary expertise, facilities, and strong experience in the fields included in the call, i.e. the quantification of anthropogenic and natural emissions, their evaluation and consistency, and in providing access to different types of emissions through user-friendly databases. All partners have a large experience in the delivery of datasets and their associated documentation in a timely manner. Many of the partners have also worked together previously in different national and international projects, which will ensure excellent collaboration between the members of the group. Through their involvements in several international bodies, the partners will furthermore ensure a strong synergy between the work done as part of CAMS_81 and other international programs.

Each of the eight consortium members were involved in the previous CAMS_81 project, and most were also involved in previous projects which prepared the Copernicus Atmospheric Service, i.e. the GEMS, MACC, MACC-II and MACC-III projects. The emissions datasets that have been developed as part of these projects, such as MACCity, TNO-MACC, MEGAN-MACC and CAMS-REG have become a reference for many international projects and have a very large number of users.

Many of the consortium partners are also providers in different CAMS service elements, which will ensure good communications between the CAMS_81 work (Development and delivery of emissions data, evaluation of their consistency) and the users of the datasets in the other service elements: CNRS-Laboratoire d'Aérologie, MET Norway and BSC are providers in CAMS_84 (Validation activities), TNO is a provider in CAMS_73 (Greenhouse gases fluxes), TNO, MET Norway, BSC and FMI are providers in CAMS_61 (Regional AQ modelling and data assimilation), TNO, MET Norway and FMI are providers in CAMS_50 (Regional Production), MET Norway is a provider in CAMS_43 (Aerosol developments), TNO and MET Norway are providers in CAMS_71 (Products in support of policy users) and FMI is a provider in CAMS_72 (Solar radiation). All these involvements of the CAMS_81 partners in other CAMS service elements will provide links and synergies and improve the use of the data developed in CAMS_81 for the entire CAMS system. BSC is furthermore involved in the Copernicus Climate Change Services (i.e. C3S 34a Lot 2, C3S 52 Lot 2, C3S 441 Lot 2).

The CAMS_81 partnership consists of the following institutes, which all have a proven experience in developing emission datasets, in their analysis and delivery, as shown in Sections 2.1 to 2.8:

1 The Netherlands Organisation for Applied Scientific Research (TNO)
2 The National Centre for Scientific Research (CNRS)
  - CNRS – LA: Laboratoire d'Aérologie
  - CNRS – OMP: Midi-Pyrénées Observatory
3 The Norwegian Meteorological Institute (MET Norway)
4 The Charles University (CUNI)
5 The Finnish Meteorological Institute (FMI)
6 The Barcelona Supercomputing Centre (BSC)
7 The Environment Agency Austria (EAA)
8 The Chalmers University of Technology (Chalmers)

As described in more detail in the following sections, all the members of the consortium have been involved for a long time in the determination of surface emissions of different types. The partners have been carefully selected, based on their experience in the determination of anthropogenic and natural emissions, and on their access and contacts with the users of the datasets. They all have complementary experience in the different themes of the project, which ensures the success of the project and the delivery of all deliverables in a timely manner.

TNO has a long experience in quantifying emissions from different anthropogenic sources, the development of inventories, quantification of the impact of legislation on emissions and air quality modelling. TNO has developed the TNO-MACC, TNO-MACCII, TNO-MACCIII and CAMS-REG European inventories which are now used in the CAMS_50 and CAMS_71 regional simulations and in many other European and (inter)national projects. TNO also has a long track record in the coordination of large international projects.

CNRS has a large experience in the quantification of surface emissions in different parts of the world, and in the use of emissions datasets in atmospheric chemistry modelling. **CNRS-LA** has also coordinated international projects dealing with surface emissions, the analysis of atmospheric composition, and the interactions with users. **CNRS-LA** has developed the CAMS global anthropogenic emissions, and has worked on the evaluation of anthropogenic emissions inventories in different parts of the world.

CNRS-OMP is the group responsible for the development of the ECCAD database, which is the official emission database of the Global Emissions Initiative (GEIA). ECCAD has now more than 1200 regular users and it provides access to the datasets developed as part of the CAMS emission project, as well as to reference datasets developed and used in several international projects.

The strengths and experience of **MET Norway** lie mainly within the parameterization of natural emissions and air quality modelling. They have several decades of experience under the LRTAP convention and the science-policy interface and operational services.

The Department of Atmospheric Physics of **CUNI** has a strong experience in the quantification of natural emissions at the global scale, and in the impact of regional emissions on air quality and climate using chemistry-transport modelling.

FMI is one of the most experienced groups in Europe in the quantification of ship emission inventories based on actual ship movements. This work allows the determination of full geographical and temporal variation of ship emissions on a global level.

BSC has a wide experience in the development of emission modelling tools and of temporal profiles for the preparation of emission data for air quality modelling, as well as in the evaluation of emission inventories through air quality modelling. BSC has developed the CAMS-GLOB-TEMPO and CAMS-REG-TEMPO emission temporal profiles. The first dataset is now integrated in the CAMS-GLOB-ANT inventory and the second one will be tested in the framework of the CAMS_50 development activities.

Umweltbundesamt (EAA) can call upon over a decade of experience in management, review and processing (gap-filling and gridding) of reported GHG and air pollutant emission inventories. Through hosting EMEP/CEIP and being a key partner in the European Topic Centres on Air Pollution, Transport, Noise and Industrial Pollution (ETC-ATNI) and Climate Change Mitigation and Energy (ETC-CME), EAA is an important organisation acting at the interface between science and policy on emissions. It can thus utilise a unique network of contacts that can be leveraged to further the various project objectives as well as facilitate the outreach to important user- and stakeholder groups.

Chalmers is expert in the development of instruments and measurement strategies for volcanic gas measurements, and in the determination of emissions from volcanoes. It has coordinated NOVAC (Network for Observation of Volcanic and Atmospheric Change) since 2005 and developed a database of global emission from volcanoes.

2.1 Track record of the Netherlands Organisation for Applied Scientific Research (TNO)

TNO is the Netherlands Organisation for Applied Scientific Research. TNO is the largest fully independent Research, Development and Consultancy organisation in the Netherlands with a staff of about 3,000 and a total annual turnover of more than 500 million Euros. It derives a significant portion of its contract R&D from foreign private sector, governments and international organisations. TNO's primary tasks are to support and assist trade and industry including SME's, governments and others in technological innovation and in solving problems by rendering services and transferring knowledge and expertise. TNO participates in many EU programmes aiming at technological development. TNO has conducted co-operation agreements with many foreign research institutes and companies in Western, Central and Eastern Europe, USA, Canada, Japan and India.

The expertise group Climate, Air and Sustainability (CAS) is an expert centre and contract research unit for industry and government in the field of sustainable development and environmentally oriented process innovation. The expertise group investigates the processing of anthropogenic pollutants in the atmosphere and their influence on the environment and climate change. TNO has multiple decades of experience in quantifying emissions from various technologies and their characteristics, constructing emission inventories using all this input, and the impacts of legislation on the emission characteristics. TNO also has decades experience in translating emissions into air pollution concentrations at local, national and European scale as well as impact assessments using various modelling tools, including local and regional scale air quality models at European level. TNO has ample experience with the use of observed air pollutant concentrations in ambient air, amongst others in comparison to modelled values.

The emission expertise of the expertise group CAS is built up in research projects (many funded by FP7/H2020 e.g. ENERGEO, MEGAPOLI, EUCAARI, MACC, CHE, VERIFY) where a.o. high resolution gridded emission data on the European scale were prepared as input for air quality modellers. Furthermore, since 1974 TNO has been strongly involved in the annual compilation of the Dutch emission inventory. TNO is commissioned by the National Institute for Public Health and heavily involved in development of new methodologies and the international reporting of emission figures to the EU, UNECE and UNFCCC. Translating emissions into air pollution concentrations at local, national and European scale as well as impact assessments using various modelling tools (a.o. Lotos-Euros, CAR) is another key strength of TNO.

This expertise is applied in research and policy evaluation assessment studies for national and European wide organisations (a.o. EU DG Environment/DG Climate Action, DG RTD, various national governments in Europe, local and regional governments).

The professional staff is active in the following fields related to air pollution, i.e. emission inventories and reporting, policy development and evaluation, air quality modelling, impact assessment, cost benefit analysis, protection technologies.

The four members of TNO who will work on the CAMS_81 project, H. Denier van der Gon, J. Kuenen, A. Visschedijk and S. Dellaert have a long experience in the development of inventories, in the analysis of emissions from a large variety of sources and in the interactions of users. They have developed the TNO-MACC, TNO-MACCII, TNO-MACCIII and CAMS-REG inventories, which are now used as a reference in the CAMS regional models and in other European projects.

2.2 Track record of the National Centre for Scientific Research (CNRS) CNRS-Laboratoire d'Aérologie (CNRS-LA) and CNRS-Observatoire Midi-Pyrénées (CNRS-OMP)

The National Centre for Scientific Research (in French: Centre National de la Recherche Scientifique) is a public organisation for scientific and technological research and is under the authority of the French Ministry for Research. CNRS is the largest fundamental research organisation in Europe. Measured by the amount of human and material resources it commits to a great range of disciplines, CNRS is clearly the hub of research activity in France. It is also an important breeding ground for scientific and technological innovation. The main tasks of CNRS are: the development of knowledge, its transfer to and its application in enterprises and all domains contributing to the progress of society, the dissemination of information and of scientific and technical culture to the public, and especially towards young people, the participation in early training and life-long training, training by research, and quality in the research management.

The scientists working in the CAMS_81 project are part of two different laboratories, the "Laboratoire d'Aérologie", and the "Observatoire Midi-Pyrénées:

- CNRS-LA: the Laboratoire d'Aérologie (LA), is a Joint Research Unit of University between CNRS and the University of Toulouse. The laboratory has a long and well-known experience in the field of atmospheric sciences. The scientific objectives of LA concern the observation, the understanding and the numerical modelling of dynamic, physical and chemical processes controlling the evolution of the atmosphere. The LA is well recognized internationally for its long experience in the development of emission inventories from regional to global scales and for the analysis of atmospheric modelling studies. The reputation of LA lies in the innovation and maintenance of observing networks, such as the observation of tropospheric gases aboard commercial aircrafts (IAGOS) and the INDAAF African network.

CNRS-LA scientists have been involved in the preparation, management and exploitation of international scientific programs such as DACCIWA (EU-FP7, completed in 2018) projects in West Africa or MISTRALS (2011-2015) in the Mediterranean region. CNRS-LA has also been part of the management teams of the European ACCENT and ACCENT-Plus networks (2005-2014), and in the CityZEN, PEGASOS, and PANDA FP-7 projects, where they were in charge of the coordination of the work concerning surface emissions. CNRS-LA is also involved in the PAPILA project between Europe and Latin America, and in the AQ-WATCH project which started in 2020 (Air Quality: Worldwide Analysis and Forecasting of Atmospheric Composition for Health.

The Laboratoire d'Aerologie, has been involved in the series of CAMS precursors projects, i.e. GEMS, MACC, MACC-II, and MACC-III. Claire Granier has been the coordinator of the emissions sub-project in all these projects. She was also the deputy-coordinator of MACC, MACC-II and MACC-III. She is the coordinator of the CAMS_81 current project. Nellie Elguindi has joined the CAMS_81 project in 2018, where she has gained a lot of experience in the development of global emissions of greenhouse gases and pollutants at the global scale.

- CNRS-OMP (Midi-Pyrénées Observatory) is a group of CNRS laboratories dedicated to research on the Universe, the Earth, and the environment. These missions cover a large panel from research, observation, education, diffusion of scientific knowledge, to international cooperation. CNRS-OMP is a unit under the umbrella of CNRS and its National Institute for Earth Sciences and Astronomy (INSU), of the French National Centre for Space Studies (CNES), of the French National Research Institute for Sustainable Development (IRD), and the French Meteorological Centre (Meteo-France). One of the

height units of OMP is SEDOO (Observatoire Midi-Pyrénées Data Service, SEDOO): this service data centre is dedicated to environmental data management and data distribution for international and multidisciplinary projects. It was for example involved in European FP6 and FP7 projects such as AMMA (African Monsoon Multidisciplinary Analyses) and the ACCENT and ACCENT-Plus networks. SEDOO has also developed the website and database for the MISTRALS (Mediterranean Integrated Studies at Regional and Local Scales) multidisciplinary project. The CNRS-OMP team is specialized in the development of web applications and generic databases that enable to store and distribute datasets (field campaign observations, long term monitoring networks) through data portals. CNRS-OMP is in charge of the IAGOS (In-Service Aircraft for a Global Observing System) international portal and database. IAGOS is a research program conducting long-term observations of atmospheric composition, aerosol and cloud particles on a global scale from commercial aircraft of internationally operating airlines. The near-real time IAGOS observations are used in the CAMS_84 (Validation) service element.

CNRS-OMP have been in charge of the development of the ECCAD (Emissions of Atmospheric Compounds & Compilation of Ancillary Data) portal for the past years. ECCAD is the data base of the international GEIA program (Global Emission InitiAtive) and allows an easy access to global and regional emission inventories and tools for on-line data analysis and comparison. Sabine Darras and Hung Le Vu are responsible for the technical development of ECCAD. The ECCAD database has been developed during the past ten years. ECCAD is currently distributing the CAMS_81 global and regional emissions to the CAMS users and many other institutions worldwide.

2.3 Track record of the Norwegian Meteorological Institute (MET Norway)

The Norwegian Meteorological Institute is the national meteorological service of Norway and represents Norway e.g. in ECMWF, EUMETSAT, EUMETNET, and WMO. The institute employs about 450 persons, among them 140 scientists doing research within numerical weather prediction, ocean modelling, remote sensing, air pollution, product development, instrumentation, climatology and climate research. For several decades, MET Norway has been hosting the Meteorological Synthesizing Centre – West (MSC-W), which is one of the scientific centres within the European Monitoring and Evaluation Programme (EMEP) under the UN Convention on Long-range Transboundary Air Pollution (CLRTAP). EMEP provides the technical underpinning for air pollution policies within CLRTAP and also for the EU. Until 2006 MET Norway was the main responsible for collecting officially reported emission data from the Parties to CLRTAP and for gap filling emission data. Since then MET Norway has continued its work on biogenic emission modelling and estimations of other emissions e.g. from volcanoes, nuclear accident emissions, sea salt, and wind-blown dust. It participated in the emission sub-projects of the MACC projects and in the first phase of CAMS_81 (2017-2020). MET Norway hosts the AeroCom project, which is a platform of model and observational data but also collects emission data for multi-model experiments. Through its involvement in numerous CAMS contracts over several years (CAMS_43, _50, _61, _71, _81, and _84) MET Norway has a good overview of CAMS products and the relation between users and providers of CAMS services, both within the scientific and the policy sector.

At least two employees will contribute to CAMS_81 in the proposed project. D. Simpson has a long track record in air quality modelling and biogenic emissions. M. Gauss has substantial experience with MACC (former member of management board) and CAMS (leader of MET Norway's contribution to CAMS_50 and involved in other CAMS contracts as well).

2.4 Track record of the Charles University (CUNI)

Charles University (CUNI) is the largest university institution in Czech Republic covering education in the full spectrum of fields including medicine, law, theology, art, natural sciences, mathematics and physics. CUNI is a platform for broad research activities as it supports research teams at individual faculties, enhances collaboration with international research institutions, supports participation in national and international research projects and promotes incorporation of research results into teaching.

The Department of Atmospheric Physics is part of the Faculty of Mathematics and Physics and provides education and training in meteorology, climatology, atmospheric chemistry and physics. Its research activities focus on studying climate variability in the past and in the future by analysing observational data and simulating climate with regional and global models. The department has a strong base in modelling atmospheric transport and chemistry, linking atmospheric chemistry to climate, studying impacts of emissions on regional air quality, forcing of urban land-surfaces and long-term impact of urban emissions. Other research activities focus on numerical modelling of turbulent flow including modelling of air-pollution transport in complex terrain and direct eddy simulations in street canyons.

The department played an active role in several international European research projects of the 6th and 7th European Framework Programmes. These projects focused on regional climate modelling, impact of climate change on regional scale (CECILIA), development of an ensemble prediction system for climate change based on regional and global models (ENSEMBLES), quantifying the impact of transportation on climate in Europe (QUANTIFY), assessment of the impact of transport emissions on climate change and ozone depletion (ATTICA), studying interactions between megacities, air quality and climate (MEGAPOLI). Recently, the department was involved in project sponsored by the Central Europe Program of EU, which monitored and evaluated the interactions of urban heat islands of metropolitan areas in Central Europe with global climate change (UHI).

Katerina Sindelarova has participated on the MACC-II and MACC-III projects. She worked on the development of the long-term global inventory of biogenic VOC emissions (MEGAN-MACC), studied sensitivity of BVOCs on environmental factors and impact of these species on atmospheric chemical composition. She also participated on evaluation of global and regional anthropogenic and biomass burning emissions datasets. Jana Doubalova is an expert on modelling of biogenic VOC emissions, regional air quality modelling and evaluation of air quality with satellite observations.

2.5 Track record of the Finnish Meteorological Institute (FMI)

FMI conducts research of a high international standard in the fields of meteorology, marine sciences, air quality, space physics and earth observation ad also carries out competitive business specialised in expert services, both in Finland and abroad, and contributes actively to national and international cooperation in its field. It also works to keep decision-makers, industry and the general public constantly informed of issues associated with the atmosphere, seas and near space.

Atmospheric composition research unit studies and observes the physical and chemical properties of aerosol particles and trace gases effecting climate and air quality. The main research themes of the unit include also the development of air quality models and their validation; the modelling of urban air quality and exposure, the regional and long-range transport of pollutants, accidents involving hazardous and radioactive materials and the integration of meteorological models and measurements with air quality modelling systems (data fusion).

Current projects of the Atmospheric Composition Unit involve monitoring of air quality and atmospheric composition (e.g., EMEP, HELCOM/EGAP, WMO/GAW, AMAP), research and development in air chemistry and aerosol physics (including a National and two Nordic Centres of Excellence), and assessment and modelling of airborne pollutants (including also pollen, volcanic ash, smoke from forest fires) from the local to the continental scale. FMI/Dispersion Modelling Group has a very strong expertise in recent and ongoing research projects dealing with environmental impacts of shipping, including projects like: EU/BSR InnoShip, ESA/Samba, EU/Interreg/SNOOP, BSR/BONUS SHEBA, EU/Interreg/EnviSum, EU/Interreg/CSHIPP, IMO/GHG3, Acad. Finland/KAMON, Acad. Finland/GLORIA, NCM/EPITOME, H2020/AIRCOAT, H2020/SCIPPER, H2020/EMERGE, Traficom/ShipNOEm, EU/Interreg/ShipNODep and Copernicus/CAMS81.

Dispersion modelling team has participated in the development of European Air Quality Monitoring and Forecasting Service (CAMS_50) from the very beginning (GEMS-> MACC I-II-III) and is now one of the teams providing operatively model results (SILAM-FMI) for the European-scale air quality forecast based on the model ensemble. In these projects FMI has had a very important role especially in modelling the global scale shipping emissions, forest fire emissions, sea salt emissions and regional scale pollen emissions.

Dr. Jukka-Pekka Jalkanen has worked as the leader of ship emission modelling team within the dispersion modelling group of the FMI since 2006, developing the Ship Traffic Emission Assessment Model (STEAM). Dr Jalkanen and Ms Elisa Majamäki represent the state-of-the-art development in ship emission research with strong contribution to maritime environmental policy support. The annual emission reporting of Baltic Sea shipping for Helcom member states, background studies for Emission Control Areas applications for the Baltic Sea, North Sea, Mediterranean Sea and the 3rd IMO GHG study had significant contribution from FMI ship emission research. Dr Jalkanen is the invited expert to the Commission of Transport and Economy of the Finnish Parliament and he frequently supports the Finnish delegation to the International Maritime Organization on issues concerning shipping pollution and GHG emissions.

2.6 Track record of the Barcelona Supercomputing Centre (BSC)

The Barcelona Supercomputing Centre (BSC), formed in 2005, is the Spanish national supercomputing facility and has the mission to research, develop and manage information technology in order to facilitate scientific progress. At the BSC, more than 600 people from 40 different countries perform and facilitate research into Computer Sciences, Life Sciences, Earth Sciences and Computational Applications in Science and Engineering. The BSC is one of the four hosting members of the European PRACE Research Infrastructure as well as one of the first eight Spanish "Severo Ochoa Centre of Excellence" awarded by the Spanish Government. The Earth Sciences Department of the BSC (ES-BSC) was established with the objective of carrying out research in Earth system modelling, and focuses its activity on emissions, air quality, mineral dust and global and regional climate modelling and prediction. The department has a wide experience in running operational atmospheric forecasting systems and delivering timely and quality forecasts, observations, information and knowledge to users. The ES-BSC currently hosts the CALIOPE air quality forecast system (http://www.bsc.es/caliope), the Barcelona Dust Forecast Centre (http://dust.aemet.es/) and the WMO Regional Center Northern Africa-Middle East-Europe for the Sand and Dust Storm Warning Advisory and Assessment System (http://sds-was.aemet.es/). Another major activity in the ES-BSC is the development of the online multi-scale MONARCH Chemical Transport Model, which has participated in the AQMEII-Phase2 intercomparison exercise, provides routine products of global aerosols to the ICAP multi-model ensemble (https://www.nrlmry.navy.mil/aerosol/icap.1135.php) and is currently participating as a candidate model in the Copernicus CAMS_50 regional production service. The ES-BSC has also developed the HERMES system, a stand-alone multiscale emission modelling framework that processes and computes emission data for air quality modelling, and that is capable of processing the CAMS emission inventories for modelling purposes. Finally, the ES_BSC is currently working on the GHOST system, a tool dedicated to the harmonisation of global surface observations and metadata for facilitating observational/model comparisons in the atmospheric chemistry community, and which is currently being applied in the framework of the Copernicus CAMS_61 service.

The group has a strong experience in the compilation of high-resolution emission inventories, as well as in the development of spatial, temporal and speciation profiles for creating air quality model-ready emissions. Regarding this last aspect, the ES-BSC has developed the CAMS-TEMPO emission temporal profiles in the framework of the current CAMS_81 service. The benchmarking of emission inventories and evaluation of emission datasets through air quality modelling is another strength of the group, which has been proved through several projects and initiatives such as the EURODELTA III exercise or the FAIRMODE community. The expertise of the ES-BSC in atmospheric chemistry modelling is the result of the group's participation in several European and international projects, including: APPRAISAL (FP7-ENV-2012-one-stage), IS-ENES2 (FP7-INFRASTRUCTURES-2012-1), ACTRIS-2 (H2020-INFRAIA-2014-2015) and AQ-WATCH (H2020- GA 870301), among others. BSC is currently involved in several Copernicus Atmospheric Monitoring Services (i.e. CAMS_43, CAMS_50, CAMS_61 and CAMS_84 (2)) as well as in several Copernicus Climate Change Services (i.e. C3S_512, C3S_429g and C3S_34c).

Dr. Marc Guevara is the coordinator of the emission modelling research line at ES-BSC, he is leading the Service Evolution work package of the current CAMS_81 contract and he is also the co-chair of the Urban Emission Working Group under FAIRMODE. Dr. Oriol Jorba has a long track-record in meteorology and air quality modelling. Dr. Carlos Pérez is the leader of the Atmospheric Composition group at ES-BSC, he holds and ERC Consolidator grant, and he is also an ICREA Professor, AXA Professor on Sand and Dust Storms and a Ramón y Cajal Fellow.

2.7 Track record of the Environment Agency Austria (EAA)

The Environment Agency Austria (EAA; Umweltbundesamt) deals with all environmental issues. Beside developing environmental strategic perspectives in order to provide support to environmental policy in Austria, EAA with its roughly 480 employees acts as partner and adviser of international organisations such as the EU Commission, the European Environment Agency, UNEP, OECD and ECE.

In the area of air emissions EAA has many years of experience in air emission inventory data (air pollutants and GHGs) collection, management and review through being partner in the ETC/ATNI (European Topic Centre for Air Pollution, Transport, Noise and Industrial Pollution) and through hosting the European Monitoring and Evaluation Programme (EMEP) Centre on Emission Inventories and Projections (CEIP). The EMEP is a scientifically based and policy driven programme under the CLRTAP (Convention on Long-range Transboundary Air Pollution) for international co-operation to solve transboundary air pollution problems.

The EAA staff involved in the CAMS_81 proposal all work for CEIP. The main tasks of CEIP are (1) collecting emissions and projections of acidifying air pollutants, heavy metals, particulate matter and photochemical oxidants from Parties to the LRTAP Convention, (2) reviewing submitted inventories in order to improve the quality of reported data (and keeping a long term record of review findings from the detailed checks), (3) preparing gridded data sets as input for long-range transport models, (4) providing support to the Parties, the UNECE secretariat and EMEP Implementation Committee. CEIP also operates the UNECE/EMEP emission database (WebDab) which contains information on emissions and projections from all Parties to the LRTAP Convention. The new EMEP domain covers the geographic area between 30°N-82°N latitude and 30°W-90°E longitude. CEIP closely cooperates on the improvement of gridded data sets from international modellers as well as with organisations like IIASA, JRC, TFEIP and AMAP. In addition, EAA has experience with the review of E-PRTR data (since 2007) and its use in spatial distribution of emissions.

The data EAA/CEIP is processing for the EMEP domain are:

- official sectoral emissions of 21 air pollutants as submitted by Parties,
- emissions as used in EMEP models (reported data gap-filled with expert estimates),
- reported gridded emissions in 50x50km² and 0.1° x 0.1° (long-lat) resolution on GNFR sector level,
- gap-filled gridded emissions as used in EMEP models for SO_x, NO_x, NMVOC, NH_3, CO, $PM_{2.5}$, PM_{10} and PM_{coarse} in 0.1° x 0.1° (long-lat) geographical coordinates on GNFR sector level and in 50x50km² on SNAP sector level (1990 onwards),
- information on black carbon (BC) emissions from the reporting European countries,
- data set of large point sources (LPS),
- officially reported activity data and emission factors

Sabine Schindlbacher co-leads the EMEP centre CEIP and has plenty of experience in the compilation and management of international air emission inventory datasets, as a lead author of the European Union LRTAP Convention Inventory Report and the European Union NEC Directive Status Report for several years and through writing papers and preparing data sets for the EMEP Centre CEIP. She will make an in-kind contribution to the project, while other CEIP team members, Robert Wankmüller and Bradley Matthews will contribute directly. Robert Wankmüller is the data manager, software-developer and system-administrator of the EMEP Centre of CEIP since 2008. He is responsible for the emission database, the preparation of datasets for long- range transport models, communication to the parties and the development of the EMEP gridding system for sectoral emissions. Bradley Matthews has been support CEIP for the last two years providing expertise on black carbon and technical know-how on gap-filling of air pollutant emissions inventories.

2.8 Track record of the Chalmers University of Technology (Chalmers)

Chalmers University of Technology is one of Sweden's leading technical universities and conducts research and offers education in technology, science, shipping and architecture with a sustainable future as its global vision. Chalmers is well-known for providing an effective environment for innovation and has 13 departments. Graphene Flagship, an FET Flagship initiative by the European Commission, is coordinated by Chalmers. Situated in Gothenburg, Sweden, Chalmers has 10,300 full-time students and 3,100 employees.

The Division of Microwave and Optical Remote Sensing (MOF) of the Department of Space, Earth and Environment (SEE) conducts basic and applied research related to remote sensing of Earth and space using spectroscopic methods throughout the electromagnetic spectrum. Research activities of this Division include radar remote sensing of boreal biomass and sea ice and global environmental observations and modelling using passive microwave and optical sensors.

Our division is also working with development and application of ground-based optical remote sensing methods for atmospheric research. The work is very international and field oriented, and spans a large variety of disciplines, including research related to stratospheric ozone depletion, urban air chemistry, biogenic climate gas emissions, and emissions from industry and shipping. During the last 15 years an important activity has been the development of instruments and measurement strategies for volcanic gas measurements. This includes coordinating the EU projects DORSIVA (*Development of Optical Remote Sensing Instruments for Volcanic Applications, 2002-2005*) and NOVAC (*Network for Observation of Volcanic and Atmospheric Change, 2005-2010*). Through NOVAC, Chalmers instruments are used in routine operation at more than 50 volcanoes worldwide. Data from this network is collected in an archive at Chalmers that today comprises nearly 40 daily measurements of the flux of SO_2 at each volcano since 2005. Our group has also been involved in the US-funded DCO/DECADE (*Deep Carbon Observatory*/*Volcanic Deep Earth Carbon Degassing*) project, aimed at significantly improving our knowledge about emission of CO_2 from volcanoes.

Dr. Santiago Arellano is a Researcher at SEE/MOF and will lead Chalmers activities in this project. He is an expert on evaluation of volcanic gas emissions from optical remote sensing instruments, with more than 10 years' experience in the field. He has developed a database for re-analysis emission data from NOVAC, which has been linked to ECCAD during the CAMS_81 project. He is a member of the Validation Team for the Copernicus Sentinel 5-Precursor/TROPOMI mission and serves as Secretary of NOVAC and Co-Leader of the IAVCEI Commission on the Chemistry of Volcanic Gases.

2.9 Letters of Commitment

Letters of commitment have been received from all partners.

3 Quality of Resources to be Deployed

3.1 Description of Resources

As shown in the previous section, and in the CVs of the partners involved in the project (given in Annex 1), the consortium has a long-term and internationally recognized experience in all the components of the project. Several groups have been working together for many years as part of European collaborative research projects such GEMS, MACC, MACC-II, MACC-III and the previous CAMS_81 project. In order to fulfil the requirements for this project, the same groups have been included in this follow-up, based on their expertise and successful cooperation, in order to deliver the best products possible to the other CAMS providers.

The team is composed of eight European institutions that have a long experience in the quantification of emissions, their analysis, and in the interactions with groups from different backgrounds who are using these emission data for their work. The datasets and databases developed by several partners have over the years become the reference emission datasets for MACC and CAMS, as well as for many other international projects. For example:

- The European anthropogenic inventories TNO-MACC, TNO-MACC-II and TNO-MACC-III have been developed and used in the MACC, MACCII and MACCIII regional forecasts and reanalysis by all groups involved in these projects. This inventory is also used in projects dealing with changes in the air quality in Europe, such as EuroDelta or FAIRMODE.
- The CAMS-REG inventory of European anthropogenic emissions has been developed in the previous CAMS_81 project for the years 2000 – 2017. This inventory is an updated and improved version of the TNO-MACC inventories with a large number of (European) users.
- The MACCity global anthropogenic emissions inventory has been developed as part of GEMS, MACC and MACC-II. It has been used in the global forecasts and reanalysis of MACC, MACCII and MACCIII. This inventory is now considered as a reference and is used in different international projects such as the CCMI (Chemistry-Climate Model Initiative) project of the International Global Atmospheric Project (IGAC) and of the Stratosphere-Troposphere Processes and Their Role in Climate (SPARC).
- The CAMS-GLOB-ANT inventory of global anthropogenic emissions has been developed in the previous CAMS_81 project and has been updated from the MACCity global anthropogenic emissions inventory with a large number of users including the CAMS IFS model and many users from the international community.
- The MEGAN-MACC inventory of biogenic volatile organic compounds has been developed as part of MACC, MACC-II and MACC-III. This dataset is also used as a reference for CCMI and other international and European projects.
- The CAMS-GLOB-BIO inventory of global emissions of biogenic volatile organic compounds has been developed in the previous CAMS_81 project for the period of 2000-2018. It is currently used in the CAMS IFS model and by many international users.
- The global and regional CAMS-TEMPO emission gridded temporal profiles have been developed in the previous CAMS_81 project for years 2010-2017. The monthly global profiles are currently integrated in the CAMS-GLOB-ANT inventory and the regional profiles are planned to be tested within the CAMS_50 validation plan.
- The NOVAC database of daily volcanic emissions of SO_2 from 32 volcanoes during 2005-2017 has been developed and linked to ECCAD through the previous CAMS_81 project.

All these datasets have been made available to partners and users through the ECCAD (Emissions of Chemical Compounds and Compilation of Ancillary Data) database (http://eccad.aeris-data.fr). This

database was developed by the CNRS-OMP and CNRS-LA groups: ECCAD has now more than 2,500 users, and has contributed greatly to promote the TNO-MACC, MACCity, MEGAN-MACC and CAMS-REG datasets and to their very large number of users.

The persons involved in this project are:

1 TNO: Hugo Denier van der Gon, Peter Coenen, Jeroen Kuenen, Antoon Visschedijk, Stijn Dellaert
2 CNRS: Claire Granier, Nellie Elguindi, Sabine Darras, Hung Le Vu
3 MET Norway: David Simpson, Michael Gauss
4 CUNI: Katerina Sindelarova, Jana Doubalova
5 FMI: Jukka-Pekka Jalkanen, Elisa Majamäki
6 BSC: Marc Guevara, Carlos Pérez, Oriol Jorba
7 EAA: Sabine Schindlbacher, Bradley Matthews, Robert Wankmüller
8 Chalmers University: Santiago Arellano

A summary of the role of each of these contributors and their qualifications are detailed in Table 1.

Table 1: HR Profiles

Title	Broad description of work in relation to Service	List of personnel who fit the profile and whose CVs are submitted with tender	Qualifications	Effort / engage-ment in months[1]
Contract manager and Senior Scientist	Prime Investigator CAMS_81; Co-Leader of WP8110, contributor to WP8140, WP8150	Dr. Hugo Denier van der Gon, TNO	Leader of the development of the TNO-MACC & CAMS-REG European inventories. Expert in interactions with agencies and users.	1.1
Senior project manager	Service manager, Leader of WP8100	MSc. P. Coenen, TNO	30 years of project management experience a.o. CAMS_61	0.8
Co-Investigator	Coordination of European anthropogenic emissions; Co-Leader of WP8110; Contributor to WP8140, WP8150	MSc. Jeroen Kuenen, TNO	Expert in the development of regional inventories of greenhouse gases and pollutants, and emissions scenarios. Expert in data formatting.	1.3
Co-Investigator	Development of European anthropogenic emissions; Contributor to WP8110	MSc. Antoon Visschedijk, TNO	Expert in the development of regional inventories of greenhouse gases and pollutants, and in emissions scenarios. Expert in emissions reporting.	0.9
Co-Investigator	Development of European anthropogenic emissions; Contributor to WP8110	MSc. Stijn Dellaert, TNO	Expert in the development of regional inventories of greenhouse gases and pollutants.	1.3

[1] Figures are rounded to 1 decimal

Project Administrator	Project management support	To be decided	Efficient project management	0.3
Co-Investigator	Coordinator of previous CAMS_81 project, representative in various global international research initiatives, Leader of WP8120; Contributor to WP8140, WP8150	Dr. Claire Granier, CNRS-LA	Coordinator of the emissions sub—project in GEMS, MACC, MACC-II and MACC-III Expert in the development of inventories, their analysis, databases and relations with users. Links with international projects.	0.4
Co-Investigator	Development and evaluation of the global emissions; Contributor to WP8120, WP8140	Dr. Nellie Elguindi, CNRS-LA	Expert in emissions inventories and their analysis, and writing documentation on datasets.	8.0
Co-Investigator	Contributor to WP8120, WP8140, WP8150	Ing. Sabine Darras, CNRS-OMP	Expert in databases and in data formatting. Service manager for the previous CAMS_81 project. She had led the technical development of the ECCAD database and has a large experience in managing services to users.	0.7
Technical support	Data distribution; Contributor to WP8120	Hung Le Vu, CNRS-OMP	Expert in the development of databases and in data distribution	4.2
Co-Investigator	Biogenic and soil-N emissions; Contributor to WP8130, WP8140	Dr David Simpson, MET Norway	Expert in biosphere-atmosphere exchanges, in biogenic volatile organic compounds.	2.0
Co-Investigator	Oceanic emissions and interactions with users; Leader of WP8150; Contributor to WP8130	Dr. Michael Gauss, MET Norway	Expert in surface emissions and their impact on the atmospheric composition. Expert in interactions with EMEP and users.	1.8
Co-Investigator	Natural emissions; Leader of WP8130; Contributor to WP WP8140	Dr. Katerina Sindelarova, CUNI	Leader of the development of the MEGAN-MACC emissions dataset. Expert in the emissions of biogenic volatile organic compounds, and in exchange between the surface and the atmosphere.	7.2
Co-Investigator	Natural emissions; Contributor to WP WP8130	Ing. Jana Doubalova, CUNI	Expert in BVOC emission modelling, use of satellite data in air quality and data formatting.	4.1
Co-Investigator	Ship emissions; Contributor to WP WP8110, WP8120	Dr. Jukka-Pekka Jalkanen, FMI	Leader of the ship emission modelling team at FMI. Expert in maritime environmental policy.	1.1
Co-Investigator	Ship emissions; Contributor to WP WP8110, WP8120	Elisa Majamäki, FMI	Expert in the development of ship emission models,	1.3

			and in policy support for national emission reporting.	
Co-Investigator	Development of temporal profiles and benchmarking of emission inventories; Leader of WP8140; Contributor to WP8110, WP8120, WP8150	Dr. Marc Guevara, BSC	Leader of the BSC emissions modelling research line. Expert in emission inventories and spatial, temporal and speciation profiles for creating air quality model-ready emissions.	4.2
Co-Investigator	Evaluation of emission inventories through air quality modelling; Contributor to WP8140	Dr. Carlos Pérez, BSC	Leader of the BSC atmospheric composition group. Expert in the emissions of particles and temporal profiles.	0.2
Co-Investigator	Evaluation of emission inventories through air quality modelling; Contributor to WP8140	Dr. Oriol Jorba, BSC	Group manager of the BSC atmospheric modelling group. Atmospheric chemistry model developer.	0.3
Co-Investigator	Availability of regional emission inventories and interactions with users; Contributor to WP WP8110, WP8150	Dr. Sabine Schindlbacher, EAA	Co-Lead of the CEIP emissions centre for EMEP. Expert in the compilation and management of emission inventory datasets. Lead author of international reports.	0.5
Co-Investigator	Regional emission inventories, interaction with users and EMEP; Contributor to WP8110	Dr. Bradley Matthews, EAA	Team member of CEIP emissions centre for EMEP. Expert in emissions inventories of air quality and greenhouse gases.	0.3
Co-Investigator	Spatial distribution of emission data, interaction with users; Contributor to WP8110	Ing. Robert Wankmuller, EAA	Expert in data management and software development for the CEIP centre of EMEP.	0.1
Co-Investigator	Volcanic emissions; Contributor to WP8130	Dr. Santiago Arellano, Chalmers	Expert in the analysis of data for the NOVAC volcanoes network. Expert in volcanic emission databases.	0.7

3.2 CV's of Key Personnel

The CVs of the key personnel can be found in Annex 1.

4 Technical Solution Proposed

4.1 Introduction

The goal of this project is to provide gridded distributions of European and global anthropogenic emissions, as well as global natural emissions for the CAMS regional and global production chains. The emissions for a large set of atmospheric species will be developed from 2000 to the present. These developments will be achieved through a close collaboration among the partners, and with the CAMS Global Service Provider and Regional Service Provider. Interactions with different types of users will also be developed.

During the past few years, several emissions inventories were developed as part of the GEMS, MACC, MACCII, MACCIII and CAMS_81 projects, i.e.:

- The TNO-MACC, TNO-MACCII and TNO-MACCIII regional inventories for Europe, which cover the 2000-2011 period at a ~7x7 km^2 spatial resolution
- The MACCity global anthropogenic inventory, which was developed during the MACC projects, and is based on inventories developed more than ten years ago, as well as on IPCC AR5 scenarios which are based on emissions for the year 2000.
- The MEGAN-MACC global emissions of biogenic volatile organic compounds (BVOCs) inventory. It is however not fully consistent with the CAMS global model since it is based on different meteorology. Furthermore, the dataset needs to be improved with updated emission factor maps corresponding to detailed land cover and recent measurements.
- The CAMS-REG inventory of European anthropogenic emissions has been developed in the previous CAMS_81 project for the years 2000 – 2017. This inventory is an updated and improved version of the TNO-MACC inventories at 6x6 km^2 spatial resolution.
- The CAMS-GLOB-ANT inventory of global anthropogenic emissions has been developed in the previous CAMS_81 project for the years 2000-2020. The inventory has a monthly temporal resolution and a spatial resolution of 0.1x0.1 degree.
- The CAMS-GLOB-BIO inventory of global emissions of biogenic volatile organic compounds has been developed in the previous CAMS_81 project for the years 2000-2018 with spatial resolution of 0.25x0.25 degree. The emissions are based on ECMWF meteorology and are available as monthly means as well as monthly averaged daily profiles.
- The CAMS-TEMPO (global and regional) emission gridded temporal profiles have been developed in the previous CAMS_81 project for years 2010-2017. The monthly global profiles are currently integrated in the CAMS-GLOB-ANT inventory and the regional profiles are planned to be tested within the CAMS_50 validation plan.
- The CAMS-GLOB-VOLC dataset of volcanic SO_2 emissions for the years 2005 – 2017. This inventory is being updated and include daily observations on more than 30 volcanoes.

The work proposed in CAMS_81 will improve the emissions datasets and temporal profiles used as input in the CAMS regional and global models. Both at the regional and global scale, the datasets will cover more recent years and will account for the changes in emissions during the past years. The datasets will be extended through a.o. the addition of species and disaggregation of emission sources to further increase the value of the datasets for the partners and user groups. Furthermore, a range of methodological improvements will be implemented to improve the accuracy and representation of the datasets. The development of user guides will stimulate the successful uptake of the datasets by partners and user groups.

The work done in CAMS will also ensure a good consistency between the emissions of greenhouse gases, reactive gases and particles and their precursors. The natural emissions will consider not only the emissions of BVOCs, but also the emissions from soils, oceans and volcanoes. Analysis of these different datasets will be performed, together with consistency analysis between regional, global anthropogenic and natural emissions. For consistency and avoidance of double counting, attention will be given to clarifying the contribution from agricultural waste burning in cooperation with the developers of the GFAS system (CAMS_44).

CAMS_81 has been organised around five work packages plus one work package dedicated to management. Figure 2 shows the different work packages, as well as their interactions. The details of the work to be done in each work package is detailed in the following paragraphs. Section 5 details the implementation plan and gives details on the tasks defined in each of the work packages to achieve the goals of the project.

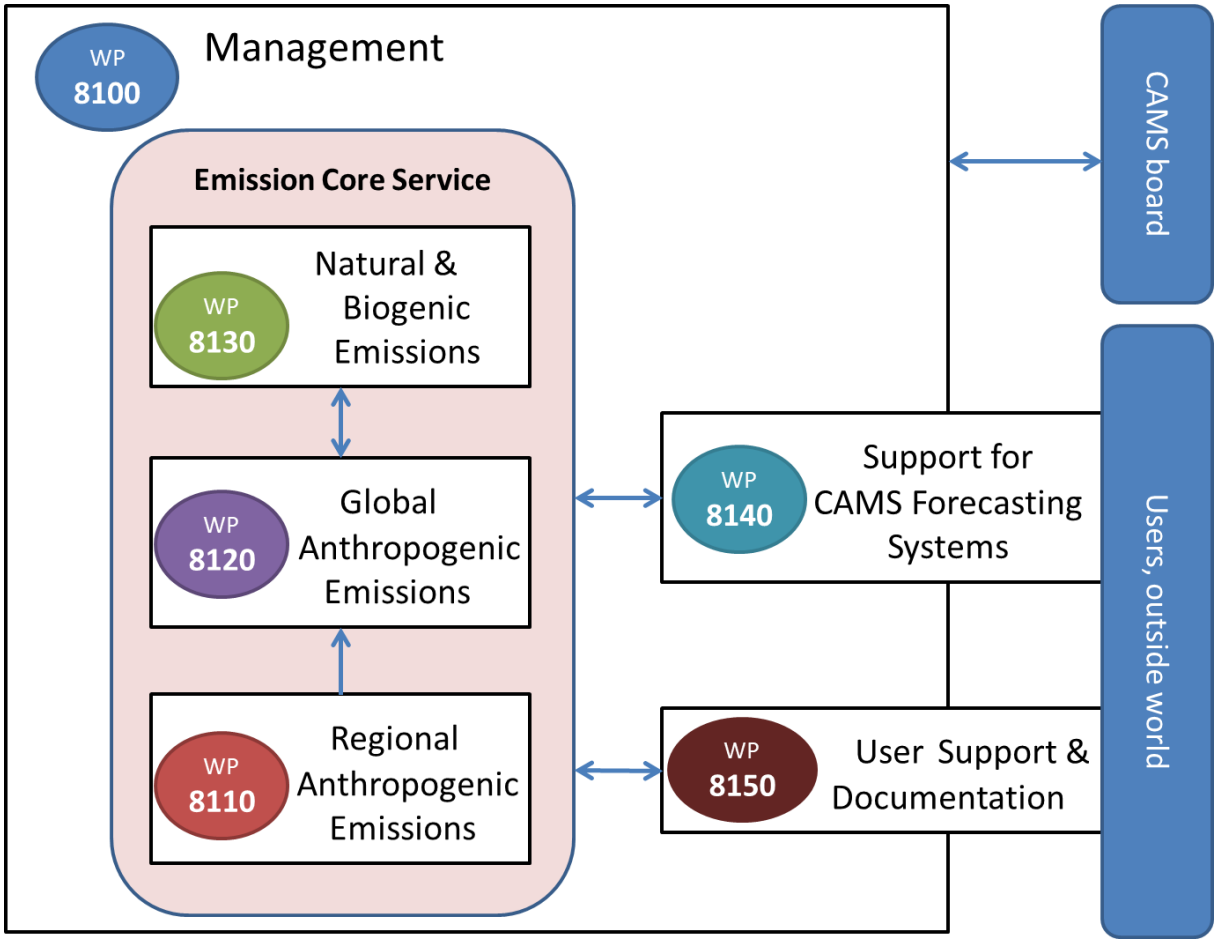

Figure 2: Work package overview

4.2 Work packages

4.2.1 WP8100 – Management and coordination

Coordination of the project

The first activity of the service manager (in close cooperation with the prime investigator) will be to set-up the sub-contracts for the different partners in the project: this will be done with the assistance of the TNO administration. TNO is also lead partner of CAMS_61: therefore, the TNO administration has already a good knowledge of the details of the establishment of sub-contracts. The service manager will work with the TNO administration to make sure that the invoices are submitted to ECMWF timely and that the budget is delivered to all partners.

Several mailing lists will be established: one will include all the partners involved in the project. The project manager will send an email to all partners every month, to inform them of all the information that could be interested to CAMS_81 partners. A second mailing list will be established, which will also include the names of the administrative representative of each partner: this email list will be used to send administrative and financial information to all partners. The third email list will contain the names of relevant users of CAMS_81 which will be used to send annual update emails on state of play regarding CAMS_81 activities/products: its members will be established after discussions with ECMWF and the different CAMS providers. These lists will be available from the web-based collaboration tool (CAMS_81 dedicated SharePoint site at TNO) by the service manager at the beginning of the project.

Teleconferences will be organised on a monthly basis by the prime investigator during the first three months of the contract; in the following months, teleconferences will be organized every three months, about two weeks before each quarterly report is due to ECMWF. During these teleconferences, each partner will present the work they have done since the last teleconference, and the status of the planned deliverables will be reviewed. In cases where the work is delayed, teleconferences will be organised twice a month with the partners involved in the work, in order to find efficient solutions to the problems encountered. At the end of each teleconference, the prime investigator and the service manager will write a summary of the discussions and the decisions taken. These summaries will be made available to all partners.

Regular review meetings, about every three months, will be organized together with ECMWF.

Organisation of yearly meetings

A telecom-based kick-off meeting will be organised[2] during the first month of CAMS_81. During this meeting, we will review the work plan, discuss in details the work to be done during the first year, and review all the deliverables. The developers of the EDGAR inventory (Joint Research Centre) will also be invited to this meeting. All CAMS service providers will be informed of this kick-off meeting and will be asked for any specific requests or concerns. If some providers propose to attend the CAMS_81 kick-off meeting, an extra time slot can be added when deemed necessary where discussions can take place on specific requests of the service provider. TNO will take minutes of the kick-off meeting and these will be send by email to the participants and ECMWF. The current CAMS_81 project has a relatively short duration, we therefore propose to organize a physical CAMS_81 meeting in May-June 2021 to evaluate progress, review the project and prepare for any future activities.

The CAMS_81 partners will also attend the CAMS general assembly: the service manager will inform all partners about these meetings, and make sure that all the CAMS_81 work is well represented during these meetings.

[2] due to the COVID-19 situation this will be a tele conference.

Monitoring and reporting

The service manager will ensure a timely production and delivery of deliverables, as indicated in the work plan. If needed, the prime investigator will discuss with the CAMS management about possible changes in the work plan: this could happen when new datasets become available, new studies show the very high or very low importance of a specific source, or if specific events occur in a specific country, etc. The requested changes in the work plan (including consequences for the allocated budget and timing) will be agreed upon with ECMWF.

The service manager will gather the necessary material for the quarterly and annual reports: he will contact all partners in advance to get a written report on the work done during the period, and collect the deliverables that have been completed during the reporting period. Each quarterly report will provide information on the work done, the achieved deliverables and milestones, and possible deviations from the implementation plan.

A preliminary list of key performance indicators is provided in Section 5.8, and will be developed further by the service manager after discussions with the ECMWF management. This list will be made available to all CAMS_81 partners and will be monitored during the project. A web-based collaboration tool will be developed by the contract manager and the project manager, which will allow an efficient monitoring of the project.

Both TNO and ECMWF will take care of storage of all deliverables. The datasets will be stored both on ECMWF and ECCAD websites. The latest versions of final and draft reports will be uploaded to the Copernicus document repository and TNO will also keep copies of the latest draft and final version.

Interactions with other CAMS projects

Regular discussions with other CAMS service elements will be important to the success of the CAMS_81 project: the interested CAMS partners (based on experience during the previous CAMS_81 project) will be invited to provide input for the CAMS_81 kick-off meeting and where needed a telecom will be organized for discussion or clarifications. Discussions will also take place during the CAMS general assemblies. These discussions will help better define the details of the datasets needed for each subproject and issues found by users of each dataset. Feedbacks from the users of the CAMS_81 products will be beneficial, and will help define newer versions of the regional anthropogenic, global anthropogenic and natural emissions.

At the beginning of CAMS_81, the prime investigator together with the service manager will contact each of the subprojects and make a list of the subprojects interested in a collaboration. This list will give some details on the different products each CAMS subproject is interested in. The coordinators of these projects will be invited to provide input for the CAMS_81 evaluation meeting in May/June 2021. As indicated above, a mailing list with all users from the different CAMS projects will be established, in order to keep our CAMS colleagues informed about the CAMS_81 work.

Meetings with other CAMS providers could be organised when necessary, in order to discuss specific issues or requests. We refer especially to WP8140 and WP8150 which are designed to provide support to other CAMS providers and users.

Third-party tights and pre-existing datasets/software

CAMS_81 does not have deliverables subject to third party rights: EMEP, MACCity, MEGAN-MACC and TNO-MACC datasets are public. The ECCAD database, the MEGAN model and the STEAM ship emissions model are pre-existing technologies. CAMS_81 will not transfer any pre-existing datasets to ECMWF. The IPR of all deliverables will be transferred to ECMWF and the EC.

4.2.2 WP8110 – Anthropogenic emissions for the CAMS regional domain

The documentation will describe the characteristics of the dataset, a short overview of how it will be compiled and improved. The major tasks within WP8110 are:

- Regional emission inventory dataset covering 2000-2018 (M8) including documentation;
- Guidance on estimating current year emissions from latest year emissions;
- Alternative, science based, bottom-up emission dataset for activity sectors where shortcomings exist in official emission reporting including brief documentation.

4.2.2.1 Task 81.1.1 CAMS regional emission inventory dataset (2000 – 2018)

The main task in this work package is to deliver high resolution anthropogenic emissions data for the years 2000 to 2018 to be used in regional CAMS projects (e.g., CAMS_50 and CAMS_71) and as a stand-alone CAMS product to support the wider atmospheric composition modelling, emission inventory and policy support communities.

The key elements and the work flow for generating regional emissions are shown in Figure 3.

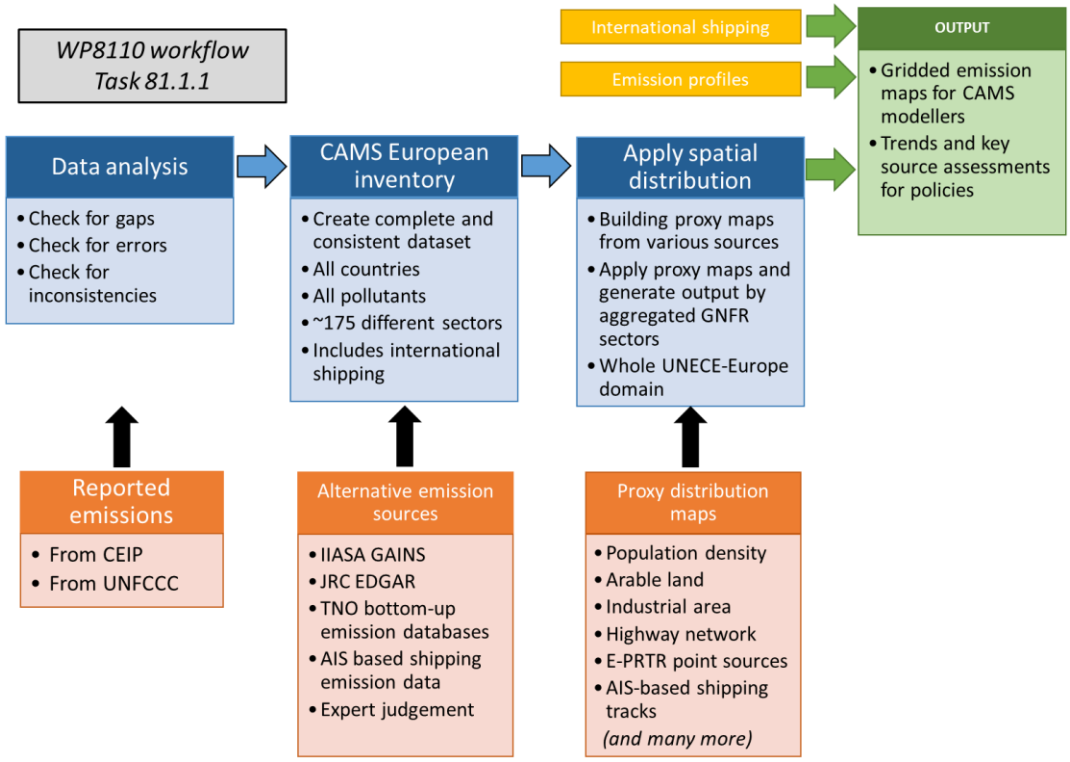

Figure 3: Technical workflow for WP 8110 for historic emissions up to current year -2

Data analysis and preparation of CAMS_81 regional emissions inventory

The proposed CAMS regional emissions inventory (CAMS-REG) will be largely based on the reported emissions by countries to the Convention for Long-Range Transboundary Air Pollution (http://www.unece.org/env/lrtap/). The official submitted emissions data are collected by the Centre for Emission Inventories and Projections (CEIP) maintained by the EAA partner. The reported emissions often provide the most accurate estimate for a country but may also contain gaps and errors and lag about 2 years behind present as they need to wait for annual statistical data to be released. Data will be process and cross-checked at the most detailed level to identify errors and data gaps, which will be subsequently corrected following a procedure developed by TNO which involves both programmed and manual detailed checking for gaps, errors and inconsistencies in the dataset. Where needed, alternative emission data from various sources are used to complete the dataset for all pollutants and countries.

In order to combine emission data from different sources, TNO has set up an own source sector definition comprising of ~175 different sectors which are consistently used for all years, ensuring consistency in the time series. International emissions that are not reported by countries will be added from other sources or constructed by CAMS_81 partners e.g., FMI (shipping), TNO (agricultural waste burning). This procedure is described in more detail in the literature by Kuenen et al. (2014) and Pouliot et al. (2012, 2015) and the CAMS-REG deliverable reports of CAMS_81 (https://atmosphere.copernicus.eu/anthropogenic-and-natural-emissions).

The following air pollutant species will be included in the CAMS regional emissions dataset: CH_4, CO, NOx, SO_2, NMVOC, NH_3, PM_{10}, $PM_{2.5}$ (air pollutants), starting from the country reporting to EMEP/CLRTAP (except for CH_4). For the greenhouse gases (GHGs), CH_4 and CO_2, the CAMS_81 emission dataset will start from the emissions reported in the National Inventory Reports (NIR) to UNFCCC and reporting of GHGs to the EU under the Monitoring Mechanism Regulation (No 525/2013). DMS emissions for the regional domain will be covered in WP 8130 and provided as an add-on to the CAMS-REG dataset in consultation with the users. Since the CAMS-REG dataset will be an updated, improved and expanded version of the dataset delivered in the previous CAMS_81 project, the changes for these time series compared to the earlier CAMS-REG inventory will be documented.

Source sector categories

The emissions of air pollutants and GHGs will be stratified into main source categories with a breakdown into sub-source categories for selected categories (see Table 2).

Table 2: Description of proposed new CAMS_81 Regional source categories and connection to the Gridding Nomenclature for reporting (GNFR) code system used in reporting of air pollutant emissions to EMEP/CEIP

CAMS_81 source sector	Source description	GNFR14 Category
A	Public electricity and heat production	A_PublicPower
B	Industrial combustion and processes	B_Industry
C	Residential, commercial, institutional, agricultural and other small stationary combustion plants	C_OtherStationaryComb
D	Fugitive and flaring emissions from fossil fuel production and distribution	D_Fugitive
E	Emissions from solvent use	E_Solvents
F	Road Transport	F_RoadTransport
F1	*Exhaust (gasoline fuelled vehicles)*	
F2	*Exhaust (diesel fuelled vehicles)*	
F3	*Exhaust (LPG/ natural gas fuelled vehicles)*	
F4	*Evaporation of gasoline*	
F5	*Tyre, brake and road wear*	
G	International shipping, Inland shipping and Coastal shipping	G_Shipping (only national part)
H	Aviation (airport and LTO emissions up to 1000 m)	H_Aviation
I	Other mobile machinery, including rail transport	I_OffRoad
J	Waste disposal (except agriculture, see L)	J_Waste
K	Agriculture (livestock emissions)	K_AgriLivestock
L	Agriculture (non-livestock emissions including agricultural waste burning)	L_AgriOther

Notes:

- GNFR category M_Other is included with E_Solvents, as generally these emissions are small.
- A separate GNFR category exists for international shipping, but for simplicity it is included in source sector G with other shipping. International shipping is always recognizable in the dataset since it is represented by sea codes instead of country codes.
- GNFR categories N – Z are representing sources not considered to be part of the national emissions in the inventories (aviation cruise emissions, natural emissions, etc.), these are also excluded in CAMS (with the exception of international shipping, which is included in source sector G).

The source sector system is different from the TNO-MACC dataset (Kuenen et al., 2014) and in line with the current official gridding nomenclature for reporting (GNFR) used in country reporting. In addition, emissions from road transport emissions will be broken down by fuel type to understand the contribution of different fuels, especially for PM and NOx emissions and evaporation from road transport fuels for NMVOC. Finally, the wear emissions (GNFR F5) are health relevant and become increasingly important for urban PM exposure (Denier van der Gon et al., 2013).

The emission data sets constructed in WP8110 will have a transparent versioning system (detailed in WP 8150) and will be accompanied by documentation including emissions totals by country. WP8110 will closely cooperate with WP8150 for the delivery of regional datasets for the production systems, correct formats and data interoperability (including adding to CDS and ECCAD). WP8110 will also contribute to future UNECE HTAP emissions activities upon request, as was done for the HTAPv2.2 data set (Janssens-Maenhout et al., 2015).

Fugitive emissions of reactive gases and methane from shale gas extraction as well as leaks

Recently, attention was drawn to the leakage of CH_4 and NMVOCs from oil and gas production (O&G), especially since the start of the large scale shale gas exploitation in the US (source sector D in Table 2). As of today (2020) there is no commercial shale gas exploitation in the EU. The most advanced case in Europe (non-EU) is the UK. Even in the UK it is still in the explorative phase; the UK Cabinet Office expected in 2016 to have up to 20 fracked wells by mid-2020, but only three wells have been fracked to date[3]. However, if this changes in the coming years a distinction between emissions from shale gas and conventional O&G exploitation in source sector D in the gridded regional emissions data can be made upon request. This will not affect the budget and planning of the task but adding the sub-source sector without significant emissions connected to it would not improve the overall quality of the CAMS-REG inventory. Next to shale gas production related emissions, we will closely follow the data coming available for conventional oil and gas exploitation and will improve the quality of these data where possible, both in terms of spatial distribution as in absolute emissions. International shipping emissions for the European seas will be developed by the partner FMI. The approach and estimates will be consistent with the global dataset developed in WP8120 (CAMS-GLOB-SHIP_v2.1.) but more detail on individual seas and temporal profiles will be available (See M81.1.1.3).

Spatial distribution

The final step in the inventory is the distribution of the complete emission dataset across the European emission domain at 0.1° x 0.05° longitude-latitude resolution. Gridding proxies are identified for each of the ~175 source categories, and in specific cases also fuel specific: an illustrative overview per sector is given in the supplementary material of Kuenen et al. (2014). Where necessary, proxies will be updated, notably residential combustion, road transport, large point sources, agricultural waste burning and international shipping. The E-PRTR database[4] and the LCP database which provide annual information on the emissions of the major industrial facilities in Europe will be used to make a dynamic emission map for multiple years for point sources. A similar dynamic approach will be applied for airport emissions, taking into account rapid developments in this sector. For remaining point sources TNO's own point source database (Denier van der Gon et al., 2010) and/or JRC/EDGAR data will be used as default. Where possible new information e.g., from satellites will be taken up as it becomes available. An example of the latter is the implementation of agricultural waste burning (AWB) emissions as detected by the Global Fire Assimilation System (GFAS) in cooperation with CAMS_44.

Official gridded emission data for individual countries and sectors are submitted to EMEP (and to the EU) and processed by CEIP (https://www.ceip.at/) operated by the partner EAA. The gridded data

[3] National Audit Office, https://www.nao.org.uk/wp-content/uploads/2019/07/Fracking-for-shale-gas-in-England.pdf

[4] From emission year 2018 onwards, LCP and EPRTR reporting and datasets are integrated in 'E-PRTR and LCP Integrated Data Reporting' (https://cdr.eionet.europa.eu/help/eprtr_lcp)

available from CEIP[5] have not been used for the CAMS inventories to date, since reporting of gridded data has seen serious completeness and consistency issues in earlier years. However, in view of the new NEC Directive (2016/2284/EU) there is a stronger requirement for EU countries to submit gridded emission inventories. As part of this task the partners TNO and EAA will prepare a note with an overview of the completeness of reporting and possible inconsistencies of gridded reporting for selected countries (EU27+UK) (M81.1.1.1), taking into account findings from a currently ongoing EU funded project (ENV.C.3/SER/2019/0015) to review country submissions of gridded data. Currently, there are various advantages of the gridded data processing as done by TNO for CAMS-REG such as the consistent and transparent approach for all countries. Moreover, the resolution of the CAMS-REG grid maps (0.1 x 0.05 degree) is a factor 2 higher than official gridded data (0.1 x 0.1 degree). Hence it is important to have a dialogue with the users of the CAMS-REG inventory such as CAMS_50 and CAMS_71 to discuss whether the decrease in resolution when switching to official reported grids is a disadvantage. Based on the analysis in the aforementioned note, the team shall investigate how to absorb official gridded data should the quality appear equal or superior e.g. due to local knowledge.

The CAMS_81 regional product will be extended with emissions for North Africa and Middle East to cover the entire CAMS regional domain, starting from the EDGAR emissions and proxies available to the project. To this end we have a confirmed collaboration and data exchange with the JRC – EDGAR team[6] including the option for the JRC team to attend CAMS_81 annual meetings as observer.

European emissions from shipping
Emission inventories for shipping using the Automatic Identification System (AIS) data from both terrestrial and satellite networks will be provided by FMI. Data from AIS allows for tracking of ships as well as emission and energy consumption modelling of the global fleet based on actual vessel movements using the Ship Traffic Emission Assessment Model (STEAM; Jalkanen et al, 2009, 2012, Johansson et al., 2013). This approach builds on the design principles of naval architecture, and takes technical features of individual ships and relevant legislative changes (sulphur content restrictions in Emission Control Areas, EU sulphur directive) into account.

Profiles for PM, NOx, NMVOC, CO_2, vertical emission profiles and temporal emission profiles
The following profiles will be constructed or updated

- **Aerosols** (coarse and fine fraction) will be subdivided into EC, OC, SO4, Na and other minerals by providing a speciation split profile in line with the approach described in Kuenen et al. (2014) segregated by country, activity sector and reporting year into EC, OC, SO4, Na, Other Minerals for both the fine and coarse fractions and total PM fraction. A separate split will be made to derive the share of biofuel in coarse and fine PM by country and activity sector, of if that proves easier both PM splits will be integrated into 1 profile
- A chemical **NMVOC** speciation profile, specific for each source sector and country, based on earlier TNO profiles and updated with new NMVOC profiles where possible. The first improvement foreseen will be the addition of a separate profile for the Agriculture sectors GNFR K and L.
- Anthropogenic **CO_2** emission will be split into fossil CO_2 (fossil fuel combustion and cement) and biofuel CO_2 (biofuel, agricultural waste burning).
- **Nitrogen oxide** emissions are reported as total NOx. A profile by country and sector will be provide to split the emissions at the point of emission in NO and NO_2.
- For the **vertical emission distribution** of point sources, the vertical profiles developed by Bieser et al. (2011) are proposed. Where data become available we will selectively update these profiles where necessary, starting with the vertical profile for airport emissions (sector H).

[5] https://www.ceip.at/ms/ceip_home1/ceip_home/new_emep-grid/01_grid_data/

[6] Confirmed by E-mail communication 27/03/2020 with Dr Monica Grippa, European Commission, Joint Research Centre, Directorate C -Energy, Transport and Climate, Air and Climate Unit. Available upon request.

- **Temporal profiles** by sector will be provided at least at the monthly scale (e.g. for AWB, shipping) up to hourly (e.g. road transport and residential combustion) in collaboration with the BSC partner (see section 4.2.3 for details on the CAMS-TEMPO dataset). The time profiles for the agriculture sector will differentiate between livestock (GNFR K) and other (GNFR L; crops, land management, manure and fertilizer application, AWB). For GNFR L, a temporal profile by pollutant will be proposed as the timing of emissions from activities like e.g. manure spreading and AWB have no correlation and are relevant for very different pollutants like NH_3 and CO, respectively.

4.2.2.2 Task 81.1.2 Guidance to estimate current year (t) and year t-1 emissions

A major improvement of regional emissions data by CAMS_81 is the development of preliminary regional emission data sets for the current (t) and previous year (t-1) while the official country emissions are not yet available. Preliminary approximation of the year t-1 (2019) emissions will be made using the 2000-2018 time series and trends and relations of the emissions to other proxies like climate variables (temperature). However the "current year" in the life time of the project will be 2020. Due to the outbreak of Covid-19, air pollutant emissions have drastically changed and a separate assessment of how to estimate year 2020 emissions needs to be made. A proposal on how to approach this, within time and budget, will be made and discussed with ECMWF (See also section 4.2.3)

4.2.2.3 Task 81.1.3 Alternative dataset for selected sectors/sources

As described in section 4.2.2.1 the CAMS-REG inventory for 2015 builds on and is in line with the emissions reported by the European countries in compliance with the Gothenburg protocol of the Convention on Long Range Transboundary Air Pollution (CLRTAP)[7] and for the countries belonging to the European Union, in compliance with the NEC Directive. The national emission inventories result from the combination of a certain amount of activity and emissions factors for a given pollutant and unit of activity. The methodology, emission factors, and data to be used are described in guidebooks edited by the European Environment Agency and the EMEP program of the CLRTAP[8]. However, countries have the freedom to derive and/or develop country specific methodologies.

In recent years it has been shown that methodological differences between countries can lead to substantial differences in the estimated emissions. It is important to stress that these are mostly not a matter of right or wrong but that different protocols or definitions are used that may lead to incompatible data sets. A striking example are emissions from the residential heating sector where countries may report emissions including, partly including or excluding a condensable PM fraction (see e.g. Denier van der Gon et al., 2015; Simpson et al., chapter 5 in EMEP status report 1/2019). It has been shown that the understanding and prediction of AQ episodes by AQ models benefits substantially from using a consistent dataset for all countries. In this light we will provide alternative datasets to support AQ modellers which can be used next to the official CAMS-REG emission dataset for a selected number of sources. We propose to elaborate an alternative emission inventory corresponding to the current situation, but with revised emissions factors and activity data for the residential heating sector (PM10, PM2.5) to reflect new scientific understanding of emissions in this sector. Next to the residential heating sector we will investigate what other sectors would benefit from such an approach. As time and budget are limited, the priority will be with residential heating emissions.

[7] http://www.unece.org/env/lrtap/lrtap_h1.html)

[8] http://www.eea.europa.eu/themes/air/emep-eea-air-pollutant-emission-inventory-guidebook

4.2.3 WP8120 – Anthropogenic emissions for the global domain

The CAMS global simulations use the CAMS-GLOB-ANT emissions, which provide anthropogenic emissions for a large set of compounds. CAMS-GLOB-ANT provide the emissions of NOx, NH3, SO2, NMVOCs, CO, CH4, CO2, BC and OC and 25 hydrocarbons. The latest version of CAMS-GLOB-ANT is version 4.2. It also includes the monthly temporal profiles provided by version 2.1 of CAMS-GLOB-TEMPO. A global dataset providing the emissions of several compounds from shipping has also been developed during the previous months: the latest version is called CAMS-GLOB-SHIP_v2.1.

During the April-August 2020 period, a new version of CAMS-GLOB-ANT will be developed, which will be called 4.3: this version will represent a merge of the CAMS-GLOB-ANT_v4.2 and the CAMS-GLOB-SHIP. The CAMS-GLOB-ANT emissions is based on two global emissions datasets, EDGAR4.3.2 which was developed by the European Joint Research Centre (Crippa et al., 2018) and the CEDS emissions (Hoesly et al., 2018) which provide emissions for the next IPCC report, AR6. From 2000 to 2012, EDGAR4.3.2 annual emissions are used, with temporal monthly variations from CAMS-GLOB-TEMPO. The current CAMS_81 ship emission data deliveries cover the period 2000-2018, of which 2000-2013 are based on back casting the global ship activity of year 2016. The period 2014-2018 is based on actual traffic activity of those years. The CAMS_81 global ship emissions for 2019 will be reported for CAMS_81 towards the end of 2020. Necessary data acquisitions have already been made.

The current CAMS_81 global emission temporal profile dataset (CAMS-GLOB-TEMPOv2.1) reports a collection of global gridded and fixed monthly, weekly, daily and diurnal temporal factors for several pollutants and anthropogenic source categories. For those profiles that are based on meteorological-dependent parametrizations, the current dataset covers the period 2010-2017. A series of actions will be performed to improve the current dataset, including: extension of the time series to 2000-2020, review of the data gap-filling methods used for those countries with no information available and investigation of current state-of-the-art methods and sources of information for specific pollutants/sources that are currently not covered.

During the September 2020-June 2021 period, updated versions of the CAMS-GLOB-ANT, CAMS-GLOB-SHIP and CAMS-GLOB-TEMPO datasets will be developed. At the end of the project, i.e. around May-June 2021, the most recent versions of CAMS-GLOB-ANT, CAMS-GLOB-SHIP and monthly CAMS-GLOB-TEMPO will be merged. Two options are proposed for the developments planned in the project, as shown in Figure 4, and described in the following sections.

Development of new version of CAMS-GLOB-ANT

The two different options shown in Figure 4 depend on the availability of new emissions datasets in September 2020.

Option 1: if no new global datasets are available in September 2020, the CAMS-GLOB-ANT emissions will be further developed using the same methodology as the one used for version 4.2. Trends from CEDS for the 2011-2014 period will be used to extrapolate the emissions up to 2021.

It should however be noted that a new dataset will be available for Asia: this dataset, called REASv3, provides emissions for all countries in Asia, at a 0.25x0.25 degree resolution on a monthly basis. The peer-reviewed paper discussing this dataset in under review in ACP (Kurokawa et al., 2019), and the corresponding emissions will be available after the paper is published, i.e. at the beginning of the summer of 2020. The REASv3 dataset provides emissions up to 2015, for all countries in Asia, i.e. in the region where the emissions have changed the most in the recent years. The trends from the REAS emissions between 2011 and 2015 will be used to extrapolate the data up to 2021. Since the methodology used to develop these emissions within option 1 will be rather similar to the one used

for versions 4.2 and 4.3, the newest versions of the emission will be called version 4.4 (updated CAMS-GLOB-ANT) and 4.5 (merge of the updated CAMS-GLOB-ANT-v4.4, and the newest CAMS-GLOB-SHIP and CAMS-GLOB-TEMPO, as described in the next sections). Since the methodology to derive the emissions will not change from what is used in version 4.2 and 4.3, the updated version will also be a version "4".

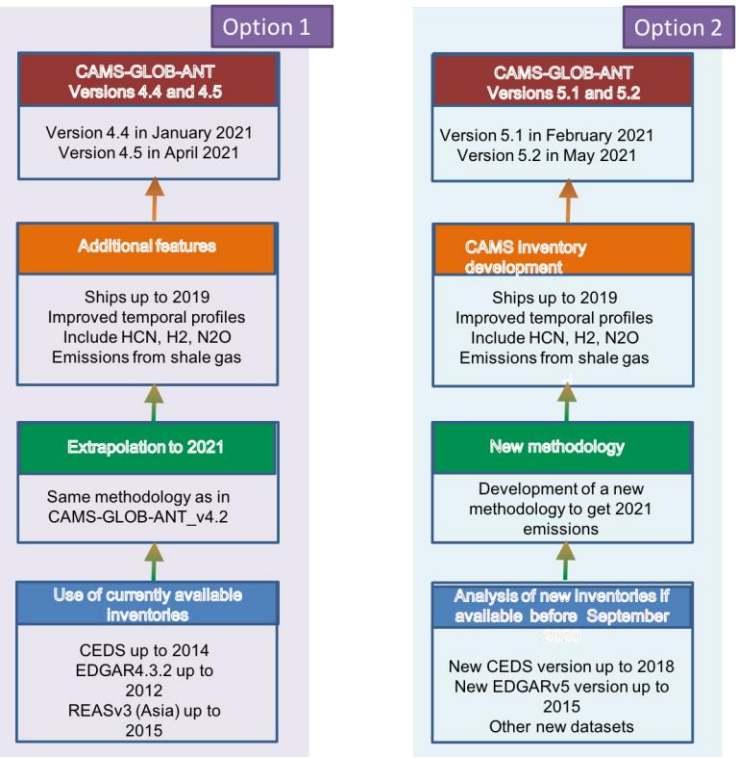

Figure 4: Methodology for developing the anthropogenic global emissions, depending on the datasets available in September 2020

Option 2: The groups who have developed the EDGAR4.3.2 emissions (the Joint Research Centre in Italy) and the CEDS emissions (the Pacific Northwest National Laboratory in the USA) have indicated that they are planning to release a new version of their datasets in the coming months. The EDGAR group is planning to release a new version of the EDGAR emissions of air pollutants covering the 1970-2015 period. Version 5 of the emissions is already available for greenhouse gases, CO_2, CH_4 and N_2O. The PNNL group is planning to release a new version of the CEDS dataset, which will provide emissions up to 2018. If the EDGAR5 and CEDS new versions are released before September 2020, they will be used, together with the REASv3 dataset, to develop a new version of CAMS-GLOB-ANT, which will be called version 5.1 (and 5.2, when merged with CAMS-GLOB-SHIP and CAMS-GLOB-TEMPO).

New species will be added to the CAMS-GLOB-ANT dataset, if possible. The N_2O emissions which are not currently provided in CAMS-GLOB-ANT-v4.2 will be added to the dataset, using the methodologies described in options 1 and 2. Emissions for H_2, HCN and CH_3CN will be added as well if possible. Emission factors for HCN released by diesel vehicles are available from the literature, and could be used to infer HCN global emissions. Concerning molecular hydrogen and acetonitrile, rather old publications providing limited information are available, which will be reviewed in detail.

Fugitive emissions will also be improved in the CAMS-GLOB-ANT dataset, by improving the quantification of emissions from shale gas. Emissions from shale gas in North America are available from several publications and publicly available datasets, developed in support of several observations campaigns. Data for methane, as well as for other compounds (NOx, CO and several VOCs) are

available. We will also consider the most recent emissions of greenhouse gases from shale gas in China, which became recently larger than the emissions from shale gas in the USA (Li et al., 2020).

Comprehensive emissions from point sources at the global scale are difficult to obtain. Average release heights will be determined for all countries, based on the data available for all countries for the energy sector. These release heights will be provided as separate files for an easy testing.

As a result of Covid-19, many industrial activities were partially or totally stopped, and transportation was strongly affected by the confinement of a large part of the world population during a few months in late 2019/early 2020 (in China) and in other countries (Spring 2020). Information on the decrease in the NO_2 columns as seen from satellite was published in several newspapers, but no peer-reviewed paper has been published on the quantification of these decreases and on the changes in surface emissions of atmospheric compounds before mid-April 2020. It is likely that modelling studies will be conducted as part of CAMS to study the impact of these lockdowns in different countries. We propose therefore to conduct a literature review of the changes in tropospheric columns of compounds such as NO_2, CO and HCHO, and on the changes in surface emissions. We will then write a short report and propose for example scaling factors that could be used for modelling studies.

Development of new version of CAMS-GLOB-SHIP

It is very likely that emissions from ships have experienced disruptive changes both in geospatial distribution of emissions as well as in their temporal variation. On Jan 1st 2020, the global sulphur cap of 0.5% became effective in areas outside the SOx ECAs (Emission Control Areas). This should be reflected by significant reductions in ship emitted Sulphur and PM. Further, both 2019 and 2020 emission data will fully reflect the traffic pattern changes of the looming economic crisis because of the global pandemic. Neither of these features can be extrapolated from existing ship emission datasets but can be evaluated using traffic activity data from those periods.

For the ship emissions work, we will continue the approach introduced in the current CAMS_81 work. The application of the Ship Traffic Emission Model will include the relevant regulatory changes to environmental rules of the maritime sector. Within CAMS_81, we will use vessel activity data from years 2019 and 2020. These datasets will be acquired within other existing projects, because the cost of these acquisitions cannot be covered by CAMS_81. The 2019 ship emission data will be made available Q3-Q4/2020 and 2020 ship emission data will be ready in Q2/2021.

Development of new version of CAMS-TEMPO

The work related to the development of a new version of the global and regional CAMS-TEMPO datasets (referred to as v3.1) will focus on three main aspects.

Firstly, we will extend the time series of the current gridded temporal profiles (i.e. 2010-2017) to 2000-2020. This extension will be applied to all the current meteorological-dependent weight factors, which include the sectors of residential combustion, agricultural fertilizers and agricultural livestock. For that, we will combine the parametrizations already introduced in current CAMS_81 work with the ERA5 meteorological dataset. Within this action, we will also assess the feasibility of including the temperature influence on the seasonality of CO gasoline exhaust road traffic emissions. This feature is currently only included in the regional CAMS-TEMPO dataset as in the CAMS-REG-AP inventory road transport emissions are split by type of fuel (i.e. gasoline, diesel, gas GLP and non-exhaust), whereas in CAMS-GLOB-ANT they are reported under one single category.

Secondly, we will review the data gap-filling methods implemented in current CAMS_81 work to report temporal profiles in those countries with little or no information available (mainly Africa and South America). Profiles constructed for countries with geographical and/or behavioural similarities

will be proposed as an alternative. In parallel, the synergies with other international emission activities (described in the detail in the next section) will be used to identify potential existing profiles for these developing regions.

Thirdly, we will investigate the development of new temporal profiles for sources/pollutants currently not considered in the CAMS-TEMPO dataset. The key category-pollutant that is envisaged to be selected for this work includes CH_4 emissions from waste management (landfills). The relationship between landfill CH_4 emissions and changes in barometric pressure reported by the literature (Czepiel et al., 2003; Xu et al., 2014) will be explored with the aim of providing a meteorological-parametrization to derive monthly and, if possible, daily temporal profiles.

Finally, and following with the discussions already started in the current CAMS_81 work, we will closely interact with CAMS_30 and CAMS_50 services to propose a simplification of the current CAMS-TEMPO profiles in such a way that they can be easily implemented both in the global IFS model and the different operational models of the CAMS_50 service.

Link with international initiatives

We will continue to ensure active links with several international initiatives, such as the GEIA/IGAC (Global Emission Initiative) international project: starting in 2020, one of the co-chairs of the GEIA project will be Cathy Liousse (from CNRS-LA), Claire Granier from CNRS-LA is a member of the GEIA executive committee and Hugo Denier van der Gon (TNO), Katerina Sindelarova (CUNI) and Marc Guevara (BSC) are or will become later in 2020 members of the GEIA steering committee. We will also develop strong links with the AMIGO/IGAC (Analysis of eMIssions usinG Observations) co-chaired by Claire Granier. We have also been invited to participate in the development of the new HTAP-version 3 inventory: the first discussions on this inventory, which were planned to start at the end of 2019, have been postponed to 2020. Where possible, links with other groups working on the development of emission data in different European and international projects will be established.

4.2.4 WP8130 – Natural and biogenic emissions for the global domain

Emissions of biogenic VOCs

During the first phase of CAMS_81 an algorithm for inclusion of the calculation of BVOC emissions directly in the IFS model (namely in the CHTESSEL) was suggested. This set of equations is based on formulations defined in Guenther et al. (1995) and in the MEGANv2.1 model (Guenther et al., 2012). This is an algorithm to calculate hourly emissions of the main BVOC species (isoprene, monoterpenes, sesquiterpenes, methanol, acetone, etc.) depending on ambient meteorological conditions (temperature and solar radiation), considering effects of the forest canopy, leaf ageing and emission inhibition due to CO_2 concentration. The algorithm also uses light dependence factor for individual modelled species to decide which part of the emission is both light and temperature dependent and which is temperature dependent only.

In the phase-II of the project we will provide support to ECMWF on either implementation of this proposed algorithm, or development of a simpler algorithm to capture diurnal cycle and day-to-day variability of the emissions. Alternative to the algorithm proposed above (and in Phase I. of the CAMS_81) is a simpler approach defined in Guenther et al. (1995). Such algorithm is also implemented in various air quality models, e.g. the EMEP model.

Part of the work will be dedicated to comparison of the CAMS-GLOB-Bio emissions, calculated off-line by the state-of-the art emission model MEGANv2.1, to other available emission estimates. It is planned to include results of the EMEP and CLM models in the comparison. As already mentioned, the EMEP model uses a simpler approach of Guenther et al. (1995) to calculate BVOC emissions. CLM (Community Land Model) is the land model for the Community Earth System Model, both developed by NCAR. The algorithm for BVOC calculation in the latest CLM is similar to MEGANv2.1 and is considered to be on-line as it is connected to the land surface model which includes land biogeophysics, hydrologic cycle, biogeochemistry, etc., similar to the CHTESSEL. It should be noted that results of such dataset comparison should be interpreted carefully as the emission estimates rely strongly on input data, mainly meteorology, land cover description and emission potentials. As shown in the current CAMS_81 and in the literature (e.g. Arneth et al., 2011; Guenther et al., 2012; Messina et al., 2016) different input data can lead to significant differences in emission estimates.

Special focus will be given to creation of consistent global emission potential maps for isoprene and monoterpenes. For Europe, we will keep the emission potential maps delivered in the current CAMS_81 by MET Norway based on the knowledge from the EMEP model. For the rest of the world, we will make use of the vegetation and emission factor data recently released for the MEGANv3 model (https://bai.ess.uci.edu/megan/data-and-code).

Emissions from soils

In phase-I of CAMS_81 WP3 (up to 2019), a number of methodologies and data-sets for the emissions of NO, N_2O, NH_3 and OCS were explored, with widely varying levels of time-resolution, sophistication, and data-requirements. All such soil-N emission estimates were shown to be highly uncertain, especially at high time-resolution, since the factors which influence e.g. microbial activity, production and loss are many and complex (e.g. Butterbach-Bahl et al., 2013, Fowler et al., 2015, Hertel et al., 2012, Simpson et al., 1999), and the underlying data (e.g. agricultural practices, soil textures, moisture) are difficult to assess. Therefore, an important component of this work was to examine and elucidate the uncertainties in these emissions, and to seek a pragmatic merge of existing methodologies suitable for use in regional and chemical transport models. It was concluded that NH_3 emissions from natural soils were rather insignificant compared to emissions from agricultural (especially fertilised) sources, and these emissions were dealt with in the anthropogenic databases. Time-disaggregated emissions

of agricultural NH_3 can be estimated using meteorological and other factors, and these variations were provided by BSC in phase I.

Emissions of NO from soils were identified as the most important source needing attention, and a first data-set of monthly soil-NO emissions covering 2000-2015 were calculated as the basis for future work. Emissions were provided as total values and also with separate data for soil NO emissions induced by fertilizers/manure and atmospheric deposition, so that users can provide their own modifications if wanted. These estimates relied on land-cover maps, estimates of nitrogen inputs (fertilizer, deposition) to the soils, combined with meteorological modifying factors such as temperature, soil water and/or precipitation.

It was stressed that this initial data-set was a first attempt at estimating emissions from a notoriously difficult source. As noted above, emissions are very sensitive to many parameters that are impossible to know (except at a few heavily instrumented sites), and as such the data require comparison against other data-sets, and, to-the-extent possible, evaluation and calibration against measurements. The process of comparison with NO_2 column data from the TROPOMI satellite instrument was begun in 2020 (in cooperation with KNMI), but much work is still needed. Initial efforts will focus on the Sahel region in Africa since soil-NO emission episodes seem to be visible in the data and the area has fewer complicating anthropogenic NOx sources than over Europe or other regions. Efforts will be made to tune the soil-water-thresholds and other functions and values of the soil-NO algorithms. Comparison with other soil-NO algorithms and results (e.g. Rasool et al., 2019) will also be made in order to improve the CAMS algorithms, and to evaluate the possibility of extending the algorithms to account for NH_3 and HONO.

Emissions from oceans

In phase-I of CAMS_81, a number of methodologies and data sets for the emissions of halogenated substances, dimethyl sulphide (DMS), carbonyl sulphide (OCS), and nitrous oxide (N_2O) were explored. The overall strategy for all these species was to find reliable climatological data in the literature for concentrations in ocean water, and then to apply Henry's law and meteorological data from ECWMF IFS to calculate fluxes across the sea-air interface with (at least) daily temporal resolution and (at least) 1° x 1° spatial resolution for the entire world ocean. Henry's law, and in particular the calculation of the kinematic viscosity and the diffusion coefficient, requires the determination of various constants for which empirical values had to be found either in the literature or through expert consultation.

In phase-II, this strategy will be pursued only for the two species required in the ITT, i.e. DMS and OCS. For DMS we consider climatologies from Lana et al. (2011) but also the newer data set described in Galí et al. (2018) for concentrations in ocean water, while for OCS we will propose the use of Lennartz et al. (2017). For the other properties of ocean water, which are needed for calculation of the kinematic viscosity, we will evaluate continued use of data from the World Ocean Atlas (2013, 2018) versus data available in the IFS model. This concerns mainly sea surface temperature, ocean skin temperature, water salinity and density.

The methods of calculation (including Fortran code and empirical constants) used in phase-I of CAMS_81 for DMS and OCS will be shared with ECWMF, and support will be offered to test these methods in the IFS and to compare with results from phase-I or with new results obtained by MET Norway.

It has to be noted that in the case of OCS uncertainties are very large, as reflected by the greatly varying estimates found in the literature. Furthermore, a biogeochemical model to calculate ocean concentrations of OCS may be required to calculate OCS uptake and emissions correctly based on IFS

meteorology. This is because biogenic production of OCS in the ocean strongly depends on UV radiation and thus exhibits strong diurnal variation, which is not included in publicly available climatologies that we are aware of. A biogeochemical model for OCS is not in the possession of MET Norway, but we will point to relevant literature describing the calculation of OCS concentrations in sea water.

Emissions from volcanoes

This product is not explicitly mentioned in the Invitation to Tender for the phase-II of CAMS_81. However, we propose to update the database of daily emission rates of SO_2 from volcanoes in the NOVAC network until December 2019 and to compare this with the annual (or sub-annual, if available) emission inventory derived from observations of the space-based sensors OMI (NASA) and TROPOMI (ESA). NOVAC is a network of ground-based remote sensing instruments operating in more than 50 volcanoes around the world (https://novac-community.org). Measurements of the SO_2 flux are produced with a typical cadence of 10 minutes. Short-time variability is large due to atmospheric transport and measurement uncertainty, but daily estimates of emission are more reliable. Data belongs to each volcano observatory running the instruments, but it is accessible after a typical grace period of two years. To obtain emission rate, the remote sensing signals are evaluated using the DOAS technique and combined with meteorological information from the ECMWF ERA5 re-analysis database. Processing is done by Linux-based NOVAC Post Processing Programme running on the Chalmers Computer Cluster. Data from selected volcanoes, representing a range of geographical, volcanological and meteorological conditions, will be compared with corresponding emission estimates derived from observations of the OMI (NASA/Aura) and TROPOMI (ESA/Sentinel 5-Precursor) satellite sensors. Daily estimates of observed mass are reported by the NASA group (https://so2.gsfc.nasa.gov/measures.html), but to get emission rate it is necessary to account for wind and lifetime of the emissions. This is usually done off-line and published in the literature (e.g., Fioletov et al., submitted). We will present at the end of this project a report comparing the bottom-up and top-down approaches to assess the reliability of global emission inventories obtained solely from space-based observations. NOVAC data will be made available through the NOVAC database (https://novac.chalmers.se), and linked to ECCAD, upon previous agreement from the volcano observatories.

4.2.5 WP8140 – Support for CAMS forecasting systems

The main objective of this WP is to support the CAMS global and regional productions in discussing the trial run results obtained when using the emissions datasets delivered as part of the work in this ITT.

The aim of these discussions will be to help both production groups identify potential issues with the global and regional emission datasets provided under WP8110 and WP8120, as well as the formulations provided in WP8130 (in case they are considered in the trial runs). The aforementioned datasets will be made available to the global and regional production systems following the procedures and standard formats that were already discussed and defined in the current CAMS_81 contract.

The discussions will include at least one face-to-face meeting with the CAMS global (ECMWF) and regional (Météo-France and representatives of subcontractors) productions as well as a series of teleconferences that will take place before and after the face-to-face meetings.

The teleconferences organised prior to the face-to-face meetings will serve to address several topics such as making sure that the datasets provided by WP8110 and WP8120 to the production groups are in the right format and cover the right period, and that all the compounds necessary for the trial simulations are available. The timing of these teleconferences will be aligned with the delivery dates of the corresponding emission datasets, which are described in WP8110 and WP8120.

The face-to-face meetings will take place after the execution of the trial runs. The final dates will be defined in coordination with ECMWF and Météo-France, respectively. It is expected that both CAMS productions provide the results of the trial runs some days before the meeting, to ensure a two-way dialogue as well as the appropriate time to analyse the results in detail. It is also expected that the CAMS global and regional productions provide information on how the emission inventories are being used in the specific model configurations and also combined with other emission datasets (e.g. vertical and temporal profiles). As a result of the face-to-face meetings, potential errors and/or issues with the emission datasets or their integration into the atmospheric chemistry models will be identified. In case an error is identified, the provider of the corresponding dataset will be informed so that the emission file can be corrected and redelivered to the production system. Other issues identified during the discussions will be addressed as far as reasonably possible. The adjustment of the original emission datasets or the proposal of adjustment factors to address issues such as, e.g., potential uncertainties or lack of representativeness in the emission datasets will be considered to the extent possible, taking into account the amount of time and resources of the current ITT. All those identified issues that cannot be addressed in the current ITT will be described in a list of recommendations, which will serve to guide future developments of the CAMS_81 services.

The teleconferences organised after the face-to-face meeting will serve to track the progress of all the agreed actions and to follow on how the potential errors/issues identified are being addressed.

The outcomes of this WP will include two reports summarising the discussions and the decisions taken during the meetings, as well as a description of all the issues identified and a list of recommendations to resolve them. All in all, the results developed under this WP will be used to give input, suggestions and feedback to the WP in charge of developing anthropogenic and natural emissions (WP8110, 8120 and 8130).

4.2.6 WP8150 – User support and documentation of service

This work package is about the interface between users and providers of CAMS_81 products. It includes providing specialised user support in a timely manner, multi-tiered documentation of the products, and ensuring the conformity of the data sets with ADS standards.

User feedback system

As indicated in the ITT, ECMWF has established a centralised Copernicus Service Desk to provide multi-tiered technical support to all users of CAMS data, products, tools and services. All CAMS_81 providers will contribute to the delivery of multi-tiered technical support for the data and/or services they provide. Such specialised user support will take the form of direct response to individual user queries via the Service Desk facility, as well as contributions to FAQs. Users will be able to ask questions concerning CAMS_81 products: these questions will be forwarded to and handled via the Copernicus Service Desk. Answers will be provided by relevant CAMS_81 partners within 5 working days.

The procedures of how to respond to user queries and the level of user support service on Service Desk tickets we can provide will be described in a report early on in the project. The queries we receive during the project period will be summarized twice, half-way through and at the end of the project. The summaries will serve as input to the User Requirement Data Base (URDB), which tracks all requirements emanating from a wide variety of user fora, surveys, and support panels. The input will also be useful for the Requirement Analysis Document (RAD) and the Service Evolution Strategy (SES) and will be shared and discussed with ECMWF and CAMS_94.

Documentation and User guides

Documentation of the CAMS_81 products is an integral part of the service provision. The technical and scientific specification of each product will be documented in reports that will be available to users through the CAMS web site. CAMS_81 providers will produce reports describing in detail the methodologies and products they deliver as part of this project. The documentation will be targeted at an informed external user community. Access to scientific papers discussing the evaluation and quality of the data will also be detailed.

An internal document with concise descriptions of all CAMS_81 products (including a versioning system) will be updated regularly, corresponding to the release of the different versions of the regional and global anthropogenic and natural emissions. This document will include information on the atmospheric species as well as key technical aspects such as geophysical parameters, temporal resolution and coverage, spatial resolution and coverage, time availability, expected quality, data format, and a direct link to detailed information on methodology and quality monitoring for each specific product or services. Twice during the project period, basic information will be extracted as input to the CAMS Service Product Portfolio (SPP).

The versioning system will include the documentation of each version of the data sets provided in CAMS_81. It will ensure a good traceability of the changes applied to each dataset. All data sets, including obsolete versions, will be listed and briefly described in a document kept up-to-date continuously. Each data set will be uniquely labelled by a version number for the ease of identification. We also aim to assign a DOI to the data sets.

Data provision

The data sets generated or acquired in CAMS_81 will be delivered via ECCAD and the Atmosphere Data Store (ADS), by one of two methods:

a) uploading their data and products to a designated server,

b) providing them via web services.

In case (a), suppliers will agree with ECMWF on the data formats to be used. Standards will be open and managed by a recognised international standardisation body, or any de-facto standard. All text-based formats will be encoded in UTF-8.

In case (b), suppliers will agree with ECMWF on the protocols to be used to invoke the web services. Such standards will be open and managed by a recognised international standardisation process (e.g. ISO, WMO, OGC, etc.), or be a de-facto standard such as OpenDAP. ECMWF will be given the necessary credentials to invoke these services.

Every dataset and/or service provided will be documented using the appropriate metadata standards (e.g. ISO 19115).

Specific web-service-based data manipulation facilities will be implemented. 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. The 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 be in formats compatible with options (a) or (b) described above.

While supporting development of ECMWF's ADS, the ECCAD server, which is currently used by a large user community, will be maintained, too: The pre-processing system will, in addition to the already existing one with file standardisation CF Convention 6.1, add a better system for data quality checks, e.g. quick look galleries. The interactive data visualization tools will add time series within a polygon, and the on-line data analysis will include comparison tools between data sets, versions, and species. Regarding the ECCAD Thredds data service we will discuss with ECMWF which protocols should be used to invoke the web services. Based on already existing algorithms, we will develop processing capabilities and implement specific web-service-based user-friendly tools for manipulation of the data.

4.3 Summary of equipment

The equipment (including hardware and software) used by the subcontractors for the provision of the Service is summarised in Table 3 below.

Table 3: Equipment (including hardware and software) to be used for provision of the Service

Equipment	Describe Relevant Function	List each work package for which equipment will be used	Owned / To be Purchased / To be Leased
TNO			
TNO regional emission model	The model uses spatial proxy maps to perform a spatial disaggregation of emissions and create gridded emission maps	WP8110	Owned
Software: various Python scripts	Pre-processing and post-processing of emissions	WP8110	Owned
CNRS			
ECCAD database	The ECCAD database is currently hosting all the CAMS_81 emission data, and will continue to host all the new emission data	WP8110, WP8120, WP8130, WP8140, WP8150	Owned
Software: Python scripts	Generation and evaluation of the global anthropogenic emissions.	WP8120	Owned
MET Norway			
Hardware: HPC nebula.nsc.liu.se (only those nodes owned by MET Norway)	Calculation and testing of emissions, pre-processing and post-processing of data	WP8130	Owned
Hardware: PPI Linux cluster at MET Norway	Calculation and testing of emissions, pre-processing and post-processing of data	WP8130	Owned
Hardware: PPI cluster storage system at MET Norway	Temporary and permanent storage of input data and results	WP8130	Owned
Software: emission modules of EMEP MSC-W air quality model	Calculation of emissions	WP8130	Owned
Software: various Python scripts	Pre-processing and post-processing of emissions	WP8130	Owned
CUNI			
Hardware: Linux cluster at CUNI	Calculation and testing emissions, pre-processing and post-processing of data	WP8130	Owned
Hardware: cluster storage system at CUNI	Storage of input data and results	WP8130	Owned
Software: emission model MEGANv2.1	Calculation of BVOC emissions	WP8130	Owned
FMI			
FMI ship emission model STEAM	Calculation of ship emission inventories	WP8110, WP8120	Owned
BSC			

BSC temporal profile scripts	The scripts use compiled activity statistics and meteorological data to create gridded emission temporal profiles	WP8110 and WP8120	Owned
BSC HERMESv3 system	The model combines the CAMS inventories with the CAMS temporal profiles to derive hourly emission data	WP8110 and WP8120	Owned
EAA			
Database	CEIP database (WebDab) with emissions reported by Parties to the LRTAP Convention	WP8110	Owned
Chalmers			
Hardware:	Computer cluster at Chalmers: Linux platform	WP8130	Owned
Software:	NOVACPostProcessingProgram: Home-made software for evaluation of data from NOVAC network	WP1830	Owned
Database:	ECMWF ERA5 Re-Analysis: Wind speed information at volcanic plume level used for derivation of SO2 fluxes	WP1830	Free access as EU member
Database:	Copernicus Data Hub: SO2 column density maps from S5P/TROPOMI for derivation of gas emission from volcanoes	WP1830	Free access to data and to tools as part of Validation Team

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5 Management and implementation plan

5.1 Introduction

TNO, as ECMWF's contractor, will be responsible for all management aspects of the CAMS_81 project (see WP8100 description). This includes the establishment of the physical and organisational structure to carry out the activities requested in this ITT.

Applicable documents will be:

- This document and the CAMS_81 contract.
- The quality standards for research and service of TNO will be applied.

The main management structure is described in the following sections and is defined as Work package WP8100 Management and coordination.

5.2 Organigram

The proposed management structure for CAMS_81 is outlined in Figure 5.

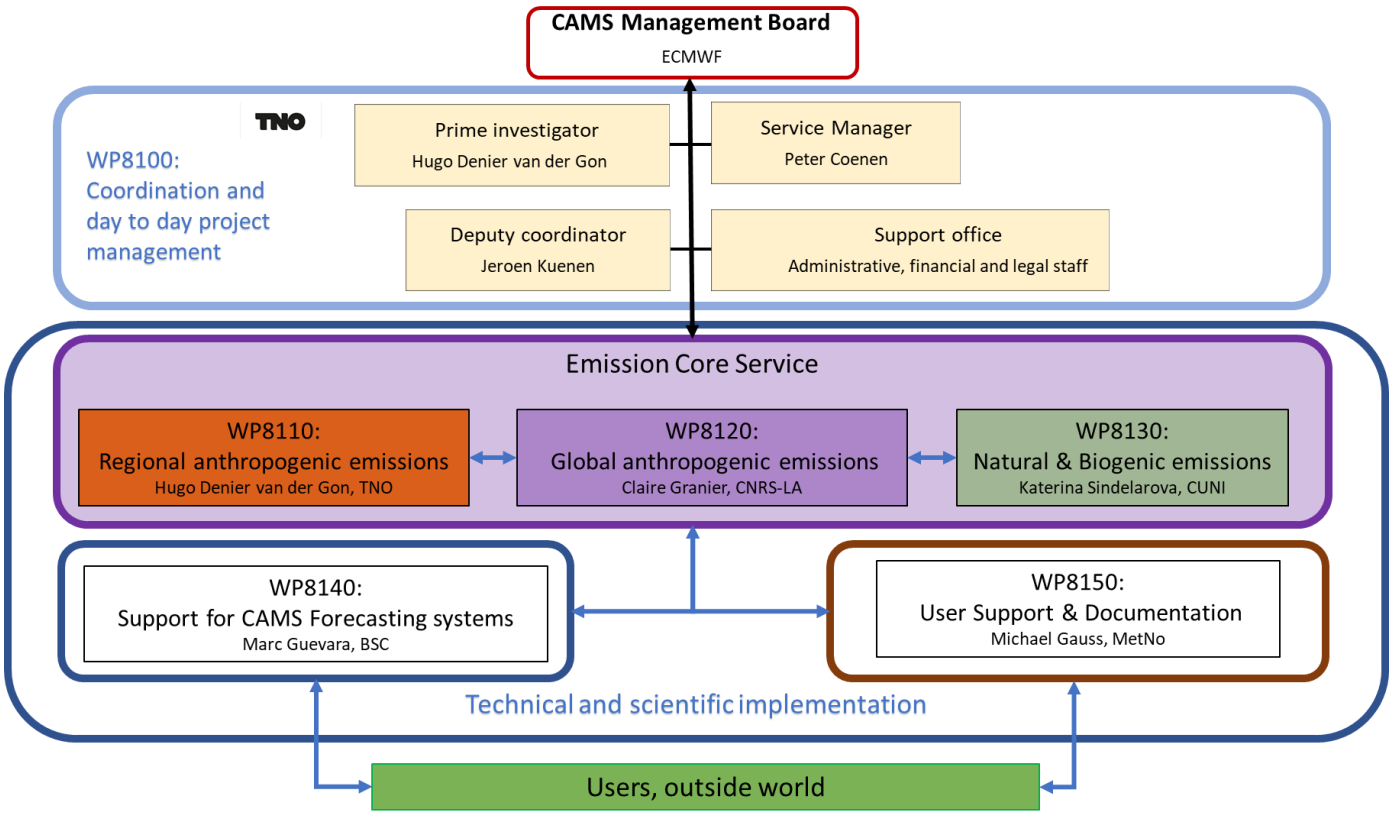


Figure 5: Proposed management structure CAMS_81

The work packages shown in Figure 5 and their tasks will be managed by different groups of the consortium: the responsibility for each task and all its associated deliverables has been assigned to different partners. The interactions between the partners of the project will follow the Framework Agreement.

TNO agrees to use ECMWF templates for deliverables and reports. To ensure efficient reporting on progress (content wise and financial) TNO will demand the work package leaders to report to TNO in ECMWF templates. It is expected that the frequency of changes to templates will be low (not more than once a year).

5.3 Management team

The overall coordination and project management of CAMS_81 is the responsibility of TNO.

The CAMS_81 management team will be composed of 9 members, reflecting the different work packages (leads), the different institutes (subcontractors) and from TNO the prime investigator and service manager (chair).

The management team is responsible for maintaining an effective and efficient working relationship and coordination between subcontractors within all WPs during the project.

Peter Coenen will be the service manager (and lead of WP 8100) and Hugo Denier van der Gon is the envisaged prime investigator. They will be assisted by Jeroen Kuenen, senior scientist and deputy coordinator. The service manager and prime investigator work on the different management tasks; overall day to day project management and scientific management (scientific alignment of WP and subcontractors and quality assurance of deliverables).

The CAMS_81 Management team will maintain strong interactions with other relevant CAMS projects, such as CAMS_50 (regional services), CAMS_61 (regional AQ and data assimilation services), CAMS_84 (validation services), CAMS_42 (developments for the global reactive gases) and CAMS_43 (developments for the global aerosols).

5.3.1 The Service manager

The service manager will be the primary contact for contractual delivery and performance aspects. His responsibilities include the following tasks:

- organise coordination between the subcontractors and the WPs (incl. internal meetings);
- establish together with the prime investigator efficient management and reporting systems;
- assist WP leaders in coordinating their WPs
- organise the CAMS_81 milestone meetings;
- follow and maintain the CAMS_81 Annual implementation plans (with prime investigator);
- coordinate and control the overall Service activities (incl. reporting activities across the WPs);
- coordinate and control the drafting of commitments and contracts with partner organisations and their execution;
- report to CAMS Management (Service-Level Boards);
- resource planning and tracking
- manage risks issues;
- manage WP 8100 (Management and coordination) and associated deliverables.

Although the number of partners and work packages is limited, we know from experience that the managerial and administrative burden for such a project is considerable. The project manager will therefore be assisted by Jeroen Kuenen and experienced TNO administrative, financial and legal staff. This staff worked on earlier CAMS projects and is familiar with the CAMS requirements. This support staff will assist the service manager in :

- internal and external planning;
- handling administrative and budgetary issues;
- handling contract and subcontract monitoring and the financial reporting to ECMWF;
- personal data management (contact details for the responsible person can be supplied if necessary).

For scientific issues the service manager will liaise with the prime investigator.

5.3.2 The Prime investigator

The prime investigator will be coordinating and leading the scientific activities in CAMS_81. This includes the following tasks:

- represent the consortium during monthly teleconference meetings and 6-monthly review meetings with ECMWF to discuss the service provision and other topics;
- validate the scientific choices of the Service, in line with recommendations from ECMWF, from user needs and from the other CAMS services related to model development and validation;
- coordinate and monitor progress of the development activities among the partners;
- follow and maintain the CAMS_81 Annual implementation plans (with service manager);
- will establish together with the service manager efficient management and reporting systems;
- report to CAMS Management (Service-Level Boards);
- monitor the KPIs regarding the quality of the deliverables and propose actions to improve results, should this be necessary, or new KPIs;
- quality assurance and control (QA/QC) of the final (non-TNO) reports and deliverables; for the TNO reports the final QA/QC will be delegated to one of the other WP managers.

Besides these activities directly related to the services the prime investigator, with his extensive network in and outside the CAMS and air quality community, will also contribute and be responsible for external relations of the project. He will support ECMWF with their communication activities related to the CAMS_81 activities (e.g. website news items).

The prime investigator will liaise closely with the service manager and the administrative staff who will assist him in his day to day work.

5.3.3 The work package managers

The work packages will be led by individual work package managers. Each work package will have its own specific day to-day management and will report on a monthly basis via web conferencing or email, focusing on important issues and changes. The work package manager will have the following tasks:

- responsible for the coordination of their own WP and for the associated deliverables (including QA/QC);
- participate in the management team;
- responsible for the planning and (financial) reporting to the CAMS_81 management team;
- validate the technical choices of the project, in line with recommendations and constraints from ECMWF;
- propose and follow the KPIs related to their WP.

Within each work package the various tasks are allocated to task leaders. Distributing task management will allow to share management activities and to motivate all the contributors as well, giving them responsibilities in the achievement of the project goals. Each task leader will be responsible for the products and deliverables associated with their task, and for the milestone completion.

5.4 Management procedures

5.4.1 Project management tools

The anticipated tools to facilitate information sharing are as follow:

- a secured SharePoint site supplied by TNO and to be used by all partners; it will be the reference for all meetings reports, implementation plans and other documentation and will allow interactive work on documents;
- monthly CAMS_81 meetings, mainly through web conferencing (Blue Jeans sessions) allowing presentations to be shown and discussed;
- easy to use project management tooling to be used by TNO (and its partners) to keep track of all CAMS_81 activities and prepare reports and other related matters for communication towards ECMWF.

5.4.2 Reporting and meetings

Formal quarterly and annual reports will be prepared and submitted by TNO to ECMWF in conformity with Clause 2.3 of the Framework Agreement. They will amongst others provide information on the performed activities during the previous periods, review progress in deliverables, compliance with the milestones and solutions to fix potential deviations from the implementation plan.

Progress and results will also be formally reported to ECMWF through the following meetings organized by ECMWF:

- Monthly/quarterly teleconference (or videoconference) meetings hosted by ECMWF to discuss CAMS service provision, service evolution and other topics;
- six-monthly project review meetings organized by ECMWF (linked to Payment milestones);
- annual CAMS General Assemblies within EU member states; these will be attended by team members representing the different activities in the project.

In addition to the meetings organised by ECMWF, the following meetings will be organised by the consortium:

- consortium kick off meeting;
- annual internal face to face meetings, preferably linked to the annual CAMS general assemblies;
- monthly internal videoconferences to discuss and follow progress of the project;
- three meetings with ECMWF

5.4.3 Subcontractors Management

TNO will apply a carefully-devised subcontractor management strategy, which already was implemented in the acquisition phase for this contract. The subcontractors have signed teaming agreements with TNO outlining their responsibilities in the project (as stated in this contract) and safeguarding capacity to perform the CAMS_81 project. After approval of the contract the subcontractors will sign subcontracts with TNO in which ECMWF terms and conditions also will be included. This safeguards that the different organisations are bound to the required ECMWF service level.

The key features of the subcontract management are specified below:

- Legally-binding subcontracts with clear provisions concerning deliverables, milestones, performance obligations and budgetary constraints (including annual accountancy reports).
- A cohesive work environment conducive to open discussion between TNO and the subcontractors.
- Easy communication channels.

- Appropriate information allowing subcontractors to have an overview of the overall CAMS_81 activities and interactions with other CAMS services, and where their contributions fit.
- Smooth payment flows and assistance to subcontractors concerning invoicing and payment matters. This matter should not be overlooked since finances are one of the key considerations for the subcontractor.
- Subcontractor performance regularly monitored through regular meetings and reports (as much as possible tuned to the ECMWF templates) to ensure activities are being completed according to plan.
- Back-up contact person assigned by each subcontractor for all relevant domains.

This will ensure that TNO (and the management team) stays up-to-date on progress made and any potential roadblock.

5.4.4 Conflict resolution

The management team will facilitate a cooperative working environment where the specific teams will be able to discuss healthy conflicts in depth and express different points of view. Additionally, the teams have long worked together in the former CAMS_81 and other CAMS, which should mitigate the risk of a critical conflict situation occurring and adversely affecting the success of CAMS_81.

Should such situation arise, it should be stressed that dispute provisions will be included in all subcontracts, both in terms of formal dispute settlement and in terms of performance continuity during pendency of dispute. However, TNO stands firm on the need to firstly explore all possible avenues and help the teams concerned find win-win solutions before escalating a conflict this way.

Concerning potential conflicts with other CAMS services connected to CAMS_81, we will seek to work together on good terms provided the activities fall within the scope of the ITT and within budgetary constraints.

5.5 Other aspects

5.5.1 Geographical and gender balance

The consortium includes different teams covering the different regions from North to South across the European Union.

The consortium exhibits a good female to-male ratio at the various work levels. Gender-biased practices or language will not be permitted in the Service day-to-day operations. Lastly, all partner institutes strive to maintain a supportive environment for a gender-balanced workforce.

5.5.2 Outreach towards users

As outreach towards users lies at the heart of the ITT, communication actions will be performed by CAMS_81 Management team, by means of direct interaction with other CAMS teams, presentations during the CAMS General assemblies, press articles and news releases through the TNO websites for instance. Proper acknowledgement of EU Copernicus funding will be displayed on these occasions and in scientific publications resulting from CAMS_81.

5.5.3 Pre-existing technologies

The services and products developed by TNO and its sub-contractors are based on pre-existing tools they develop for a long time, generally for other purposes, and that are adapted or completed by new functionalities to achieve CAMS_81 goals. Pre-existing technologies and assets generally refer, in our cases to the emission models we develop and use in this framework.

5.5.4 Custody of the deliverables

TNO will take care of the custody of the deliverables in the form of a secured electronic archive during the project. This repository and archive will hold all deliverables not archived by ECMWF during and after (at least 6 years) the contract. Upon request of ECMWF and/or the European Commission, TNO will be able to retrieve these data.

Master copies of the Deliverables are stored and archived in places where the Copernicus Regulation and related delegation legislation such as the Copernicus Data Policy can be enforced (EU Member States and Norway) during the full duration of the Framework Agreement.

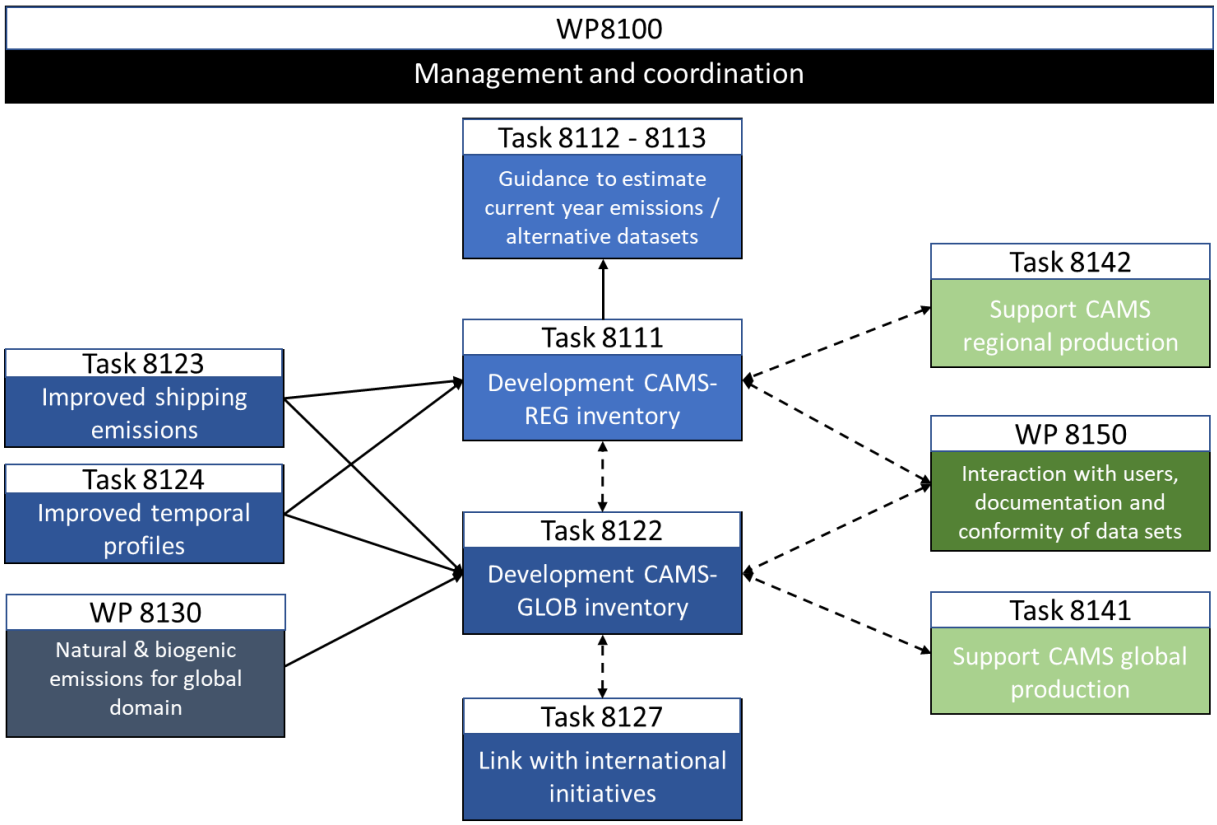
5.6 Gantt chart and PERT chart

The Gantt chart below illustrates the CAMS_81 time line of each work package and tasks and the milestone and deliverable dates, D= Deliverable, M=Milestone, ♦= milestone meeting:

	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10
WP_8100										
Task 8101	M	D/ M	M	D/ M	D/ M	D/ M	M	D/ M	M	D/ M
Task 8102		♦							♦	
Task 8103	M	M	M	M	M	M	M	M	M	M
Task 8104		M								
Task 8105										
Task 8106					M					
WP_8110										
Task 8111							M	D	M	D/M
Task 8112										
Task 8113										
WP_8120										
Task 8121		M								
Task 8122							D			D
Task 8123							D			D
Task 8124										D
Task 8125										
Task 8126										
Task 8127										
WP_8130										
Task 8131			D							
Task 8132										D
Task 8133										D
Task 8134										D
Task 8135										D
WP_8140 [9]										
Task 8141										
Task 8142										
WP_8150										
Task 8151		M		D	D					D
Task 8152				M	D					D
Task 8153					M					D

[9] Timing of deliverables and milestones is dependent on meetings with CAMS regional and global production

The Pert Chart below illustrates the interdependencies and linkages between the different tasks in the CAMS_81 work packages. Strong relationships exist between all the work packages, as these have joined objectives.



5.7 Work package description

The following pages give the main objectives of each work package, the different task in each work package and the deliverables. For each task, we have indicated the group that will lead the task.

5.7.1 WP8100

Work-package #	**WP8100**	**Start/End date**	**M1/M10**
Work-package title	**Management and coordination** **Lead: TNO**		
Budget (k€)	50.23		
Participants (person months)	TNO (1,69), CNRS-LA (0,79), CUNI (0,35)		
Other main direct cost elements	Travel, Auditor report		

Main objectives

- Coordinate the CAMS_81 project, organize the annual meeting of the project, as well as regular teleconference for all partners
- Develop a web-based collaboration tool, which will make easier the monitoring of the project and its deliverables and interaction with partners
- Gather the material needed for the quarterly and yearly reports
- Establishment of links with other CAMS subprojects

Description of activities

Task 8101: Monitoring of the deliverables and delivery of the quarterly and yearly reports and interaction with ECMWF (TNO)

Task 8102: Organisation of the kick-off and annual meeting (TNO)

Task 8103: Organisation of regular teleconferences to monitor the project: these teleconferences will take place every month during the first 6 months, and every three month afterwards, two to three weeks before the quarterly reports (TNO)

Task 8104: Implementation of a web-based collaboration tool, visible and editable by all partners (TNO)

Task 8105: Set-up of the CAMS sub-contracts for all partners (TNO)

Task 8106: Development of interactions with other CAMS projects (TNO)

Deliverables

#	Responsible	Nature	Title	Due
D0.1.1-2020 Q4	TNO	Report	Quarterly Report Q4 2020	1/20/2021
D0.1.1-2021 Q1	TNO	Report	Quarterly Report Q1 2021	4/20/2021
D0.1.1-2021 Q2	TNO	Report	Quarterly Report Q2 2021	6/30/2021

D0.1.2	TNO	Report	Annual implementation report 2020	2/28/2021
D0.1.3	TNO	Report	Final report (incl. letter from auditor specific to CAMS81 contract for 2020)	8/30/2021 60 days after end of contract
D0.1.4-2021	TNO	Report	Draft Implementation plan 2021	10/30/2020
D0.1.5-2021	TNO	Report	Finalised Implementation plan 2021	12/31/2020
D0.1.5-2022	TNO	Report	Potential plans for 2022	6/30/2021
D0.1.6-2020	TNO	Other	Preliminary financial information 2020	1/15/2021
D0.1.7-2020	TNO	Other	Copy of prime contractor's general financial statements and audit report 2020	6/30/2021
D0.1.8-2020	TNO	Other	Letter from auditor specific to CAMS/C3S contract 2020	6/30/2021

Milestones

#	Responsible	Nature	Means of verification	Due
M0.1.1	TNO	Monthly teleconferences with ECMWF	Minutes	Monthly
M0.1.2-2020Q4	TNO	Progress Review Meeting / Payment Milestone 1 - Minutes of meeting	Minutes	12/31/2020
M0.1.2-2021Q2	TNO	Progress Review Meeting / Payment Milestone 2 - Minutes of meeting	Minutes	6/30/2021
M0.2.1	TNO	Kick-off meeting	Minutes of meeting	10/15/2020
M0.2.2	TNO	Internal face-to-face project meeting	Minutes	5/30/2021
M0.3.1	TNO	Project internal monthly teleconferences	Minutes	Monthly
M0.4.1	TNO	Web tool	Implementation of the web-based collaboration tool and establishment of different mailing lists	10/30/2020
M0.6.1	TNO	Participation in CAMS general assembly	Participation (minutes)	1/15/2021

5.7.2 WP8110

Work-package #	WP8110	Start/End Date	M1/M10
Work-package title	Anthropogenic emissions for the CAMS regional domain (Lead: TNO)		
Budget (k€)	89.95		
Participants (person-months)	TNO (3.6), FMI (1.1), BSC (1.0), EAA (0.46)		
Other main direct cost elements	Travel		

Main objectives

- Construction of a consistent European high resolution (~6x6 km) dataset of anthropogenic emissions with full time series (2000 to 2018) for use by other CAMS Regional Service Providers and as stand-alone CAMS product.
- Stratification of emissions data in policy relevant (sub)source sectors, disaggregation in spatial (including vertical) and temporal domains, consistency between global and regional products
- Development of a methodology for predicting current year emissions from latest year emissions in the absence of the official emission data from the countries

Description of activities

Task 81.1.1: Development of CAMS_81 regional emission inventory data set for 2000-2018 (TNO)
Task 81.1.2: Development of guidance to estimate current year emissions from latest year emissions (TNO)
Task 81.1.3: Provide alternative datasets for those sector/sources where official country data have shortcomings (particularly relevant for wood burning)

Deliverables

#	Responsible	Nature	Title	Due
D81.1.1.1	TNO	Dataset with accompanying report	CAMS_81 regional emission inventory data set for 2000-2018	M8
D81.1.2.1	TNO	Report	Guidance on estimating current year -1 (2020) emissions including Covid-19 impact	M10
D81.1.3.1	TNO	Dataset with accompanying report	Alternative datasets for selected sector/sources where official country data have shortcomings	M10

Milestones

#	Responsible	Nature	Means of verification	Due
M81.1.1.1	EAA	Report	Overview of the completeness of reporting and possible inconsistencies of gridded	M7

			reporting for selected countries (EU27+UK)	
M81.1.1.2	TNO	Dataset	Delivery of produced Regional Emission Inventory data files to ECMWF to be included in the currently existing CAMS data portal	M9
M81.1.1.3	TNO	Report with example profiles	European shipping emissions: Opportunities for more detailed temporal profiles and shipping categories (cargo vs passenger)	M10

5.7.3 WP8120

Work-package #	WP8120	Start/End date	M1/M10
Work-package title	Anthropogenic emissions for the global domain Lead: CNRS-LA		
Budget (k€)	77.73		
Participants (person months)	CNRS-LA (6.8), CNRS-OMP (2.4), BSC (1.0), FMI (1.1)		
Other main direct cost elements			

Main objectives

- Provide anthropogenic emissions datasets to be used by the CAMS Global Service Provider, for the 2000-2021 period
- Provide gridded global emissions for different source categories for the following species: BC and OC, NOx, NH3, SO2, NMVOCs, CO, CH4, N2O, CO2
- Evaluate the possibility of defining global anthropogenic emissions for H2, HCN and CH3CN
- Provide global emissions from shipping
- Improve the diurnal/weekly/monthly temporal profiles of the emissions
- Provide the datasets in the CAMS data store and in the ECCAD database
- Organize synergies with international initiatives

Description of activities

Task 8121: Review the most recent global emission datasets available in September 2020 for improving the global emissions (CNRS-LA)

Task 8122: Create new version of the CAMS-GLOB-ANT emissions, for the 2000-2021 period (CNRS-LA)

Task 8123: Improve the ship emissions applying the FMI approach to emission modelling (FMI)

Task 8124: Improve the temporal (monthly/weekly/diurnal) profiles of the anthropogenic emissions (BSC)

Task 8125: Emissions of N2O, H2, HCN, CH3CN, evaluation of shale gas emissions, and point sources (CNRS-LA)

Task 8126: Evaluation of changes in emissions during the 2019-2020 lockdown of several countries (CNRS-LA)

Task 8127: Link with international initiatives (CNRS-LA)

Deliverables				
#	**Responsible**	**Nature**	**Title**	**Due**
D81.2.2.1	CNRS-LA	Dataset	2000-2021 emissions	M6
D81.2.2.2	CNRS-LA	Dataset and report	2000-2021 emissions, after merge with CAMS-TEMPO and CAMS-GLOB-SHIP	M10
D81.2.3.1-M6, M10	FMI	Dataset and report	Improved ship emissions for 2019 (M6) and 2020 (M12) available	M6, M10
D81.2.4.1	BSC	Dataset and report	Improved temporal profiles	M10

Milestones				
#	**Responsible**	**Title**	**Means of verification**	**Due**
M81.2.1.1	CNRS-LA	Option retained for the development of CAMS-GLOB-ANT	Short report on the options	M2

5.7.4 WP8130

Work-package #	WP8130	Start/End date	M1/M10
Work-package title	Natural and biogenic emissions for the global domain Lead: CUNI		
Budget (k€)	71.89		
Participants (person months)	CUNI (8.7), MET Norway (2.6), Chalmers (0.7)		
Other main direct cost elements			

Main objectives

- Provide support to model biogenic emissions and natural emissions from soils and oceans including formulations to be used by the Global Service Provider
- Evaluate volcanic SO_2 emission estimates with satellite-based observations

Description of activities

Task 8131: Construction of a detailed development plan for inclusion of updates for modelling natural and biogenic emissions in the IFS model (CUNI)

Task 8132: Support for modelling biogenic emissions including update of isoprene and monoterpene emission potential maps (CUNI)

Task 8133: Support for modelling natural NOx/NH3 from soils and non-frozen land systems (MET Norway)

Task 8134: Support for modelling natural DMS and OCS from oceans (MET Norway)

Task 8135: Comparison of space-/ground-based estimates of gas emission from volcanoes (Chalmers)

Deliverables

#	Responsible	Nature	Title	Due
D81.3.1.1	CUNI	Report	Detailed development plan for updates in natural and biogenic emission modelling	M3
D81.3.2.1	CUNI	Report	Report providing support for modelling biogenic emissions with updates in isoprene and monoterpenes emission potential maps	M10
D81.3.3.1	MET Norway	Report	Report providing support for modelling natural NOx and NH3 from soils and non-frozen land systems	M10
D81.3.4.1	MET Norway	Report	Report providing support for modelling DMS and OCS from oceans	M10
D81.3.5.1	Chalmers	Report	Report comparing emission estimates of SO2 from volcanoes obtained from	M10

			ground-based (NOVAC) and space-based (OMI/TROPOMI) observations on volcanoes representing different geographical, geological and meteorological conditions (2005-2018)	

5.7.5 WP8140

Work-package #	WP8140	Start/End date	M1/M10
Work-package title	Support for CAMS forecasting systems Lead: BSC		
Budget (k€)	43.59		
Participants (person months)	BSC (2.5), TNO (0.3), CUNI (1.1), CNRS-OMP / CNRS-LA (0.35 / 0.3), MET.no (0.2)		
Other main direct cost elements			

Main objectives

Support the Global and Regional Service Providers in the discussions of the trial run results, with the aim of identifying issues with the emission datasets developed in WP8110, WP8120 and WP8130 and of proposing reasonable corrections and/or adjustments.

Description of activities

Task 8141: Support CAMS global production in discussing trial run results (BSC)

Task 8142: Support CAMS regional production in discussing trial run results (TNO)

Deliverables

#	Responsible	Nature	Title	Due
D81.4.1.1	BSC	Report	Report of the minutes of the discussions with the CAMS global production, description of agreed actions and list of recommendations	1 month after the face-to-face meeting with CAMS global production
D81.4.2.1	TNO	Report	Report of the minutes of the discussions with the CAMS regional production, description of agreed actions and list of recommendations	1 month after the face-to-face meeting with CAMS regional production

Milestones

#	Responsible	Title	Means of verification	Due
M81.4.1.1	BSC	Discussions with CAMS global production on trial run results	Minutes	1 week after the face-to-face meeting with CAMS global production

M81.4.2.1	TNO	Discussions with CAMS regional production on trial run results	Minutes	1 week after the face-to-face meeting with CAMS regional production

5.7.6 WP8150

Work-package #	WP8150	Start/End date	M1/M10
Work-package title	Interactions with users Lead: MET Norway		
Budget (k€)	38.4		
Participants (person months)	MET Norway (1.0), CNRS-OMP (2.2), CNRS-LA (0.35), CUNI (1.2), FMI (0.11), BSC (0.1), TNO (0.19)		
Other main direct cost elements	Travel		

Main objectives

- Optimise the user-provider interface and respond to user support queries concerning CAMS_81 products in a timely manner
- Provide ECMWF with information relevant to the URDB, RAD, SPP, and SES documents.
- Establish and regularly update documentation of all CAMS_81 products (including version numbers).
- Ensure that all the CAMS_81 products are fit for purpose (conformity of data sets with ADS standards and conventions)

Description of activities

- Task 8151: Interaction with users (MET Norway)

  We will answer user queries about CAMS_81 products (reactive gases and particles, temporal profiles) received through the CAMS Service Desk and the ECCAD Helpdesk. The procedures on how to handle user requests will be described in a report. User queries will be summarized and structured for input to the URDB, RAD, and SES documents maintained by ECMWF.

- Task 8152: Multi-tiered documentation of CAMS_81 products (CNRS-OMP)

  A document listing all CAMS_81 data sets (including a versioning system) with brief descriptions, metadata and references, will be maintained and kept up-to-date during the project period. Information will be extracted regularly for input to the SPP document maintained at ECMWF. Comprehensive data documentation and user guides will be provided in addition.

- Task 8153: Conformity of data sets with ADS conventions as described in the ITT (CNRS-OMP)

  Conformity with the formats and standards set by the Atmospheric Data Store will be ensured. The metadata will be further developed and exported in xml using standards scheme definition, following the ISO 19115 standards and using GCMD science keywords. This task also includes further development of the ECCAD server with better visualization and quick analysis capabilities.

Deliverables				
#	**Responsible**	**Nature**	**Title**	**Due**
D81.5.1.1	MET Norway	Other	Specialised user support via the CAMS Service Desk	within one week of raising the issue
D81.5.1.2	MET Norway	Report	Specialised User Support - Description of procedures for responding to user support queries	M4
D81.5.1.3-P1	MET Norway	Report	Summary of user requests / input to CAMS URDB, RAD and SES – Period 1	M5
D81.5.1.3-P2	MET Norway	Report	Summary of user requests / input to CAMS URDB, RAD and SES – Period 2	M10
D81.5.2.1	CNRS-OMP	Report	Documentation of products (as available by December 2020)	M5
D81.5.2.2	CNRS-OMP	Report	Documentation of products (as available at the end of the project)	M10
D81.5.2.3-P1	MET Norway	Report	CAMS_81 product portfolio / input to CAMS SPP	M5
D81.5.2.3-P2	MET Norway	Report	CAMS_81 product portfolio / input to CAMS SPP	M10
D81.5.3.1	CNRS-OMP	Report	Summary of data formats and protocols	M10

Milestones				
#	**Responsible**	**Title**	**Means of verification**	**Due**
M81.5.1.1	TNO	Link with CAMS User Support team established; service desk set-up completed	Specialised Service Desk up and running	M2
M81.5.2.1	MET Norway	Document with description of products (including version numbering) established	Online document accessible	M4
M81.5.2.2	CNRS-OMP	Document with user guides for each product available for update	Online document accessible	M4
M81.5.3.1	CNRS-OMP	First version of protocols and set of data conventions established.	Ongoing communication between ECCAD and ADS teams	M5

5.8 Key Performance Indicators

Several performance indicators (KPI) have been defined. These indicators will be reviewed each quarter by the CAMS_81 partners and the CAMS providers. They will be mentioned explicitly when needed in the deliverables. Over the past years these KPIs proved essential information for the CAMs_94 (User interaction activities) project.

Table 4: Key Performance Indicators

KPI #	KPI Title	Performance Target and Unit of Measure	Frequency of Delivery	Explanations / Comments
1	Timely delivery	90% of deliverables delivered on time or with short delay (< 2 weeks)	According to WP tables	
2	ECCAD database	ECCAD uptime larger than 90% on working days	Reported to ECMWF every 3 months	
3	Number and size of files downloaded	Number and size of files downloaded	Reported to ECMWF every 3 months	
4	Number of users	Number of users (i.e. users downloading files, working on the website, looking at metadata) Target for the number of users : "increase"	Reported to ECMWF every 3 months	
5	Number of new users	Number of new users	Reported to ECMWF every 3 months	

5.9 Risk management

As a general rule, the partners will attempt to minimize all risks through frequent and regular communication among project partners and with the different CAMS providers using the data generated as part of CAMS_81.

Table 5: Risk Register for each Work package

Work package:					
Risk Name	**Description**	**Likelihood**	**Impact**	**Response Strategy**	**Period**
Unexpected unavailability of key personnel	One of the key personnel is not available to perform the proposed tasks	3	3	Reduce: Involvement of more than one person on each task. In several groups, the work will be done by permanent staff. Backup staff members will be identified for each WP.	M1-M10
Input data access	Unavailability of critical input data	1	3	Reduce: Use of multiple data sources	M1-M10
Equipment	Critical equipment failure (Storage, IT infrastructure)	1	3	Reduce: Regular data backup procedures, physical transfer of data	M1-M10
Late delivery	Risk of not being able to deliver datasets, documentation or reports	3	3	Accept: Most groups have been part of predecessor projects or are part of other CAMS projects. They all are used to delivering datasets and report in a timely manner. The prime investigator and the service manager will make sure that all planned deliveries are on time.	M1-M10
Poor quality of input data	The project will collect, analyse and use different types of data	3	3	Accept: Most of the necessary input data to be used in the project have already been carefully checked by the groups who have developed them. If some issues are found, these groups will be contacted and corrections will be applied.	M1-M10
Quality of regional and global datasets	Emissions datasets have issues or flaws and cannot be used	1	4	Reduce: Include traceability from input data. Check against other existing datasets	M1-M10
Recruitment of junior staff	While most senior staff are identified, the more junior staff are yet to be recruited (with some degree of risk on delays and skills)	2	3	Accept: Recruitment of junior staff is needed to achieve the work	M1-M10
Contract	Contract Management risk due to the large number of subcontractors	1	3	Reduce: Establish good contacts between the different partners	M1-M10
UK leaving the European Union	The UK leaving the EU may have financial consequences on availability of funds.	3	3	Accept: In case the budget will be reduced: Together with ECMWF the consortium will negotiate on the most favourable closing of the project within the available budget	M1-M10

Annex I: CV's of key personnel

See separately uploaded file "Annex 1_CVs_CAMS_81.pdf ".