ECMWF

Copernicus

Procurement

COPERNICUS PROJECT

CAMS2_83
Regional evaluation & quality control (EQC)

- Annex 2 to the Framework Agreement -

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Table of Contents

1 Executive Summary

CAMS offers information services based on satellite Earth observation, in situ data and modelling. Regional air quality modelling is an integral part in several CAMS projects. Continuous evaluation of the air quality models used in CAMS allows users of CAMS products to judge the accuracy of the data, and product providers to detect any shortcomings early on. Evaluation also provides a valuable input to strategies for further model development and service evolution.

Until recently, the evaluation of regional model data from CAMS has been part of different projects, namely CAMS_50 (Regional production) including regular evaluation against *surface* measurements, CAMS_61 (Regional model development aspects) including a comprehensive evaluation of hindcast data and dedicated model sensitivity experiments, and CAMS_84 (Global and regional model evaluation) including comparisons against *above-surface* measurements and the CAMS global model to study the effect of *boundary conditions*.

The CAMS2_83 project gathers experts in model evaluation both from the scientific and the technological side and builds to a large extent on existing tools which were developed in the above-mentioned projects but will be further developed during CAMS2_83. Special emphasis is put on merging and harmonizing the evaluation tools developed in these different projects into one web interface, a 'one-stop shop', where both users and providers can find information relevant to their work easily and in a timely manner.

The main objectives of CAMS2_83 are to:

- ensure a seamless transition of evaluation services from previous CAMS projects;
- continuously evaluate the regional models of CAMS in near-real time against large volumes of surface and above-surface measurement data;
- convey the results of the evaluation to both users and providers timely and in a convenient format, through comprehensive reports, a harmonized web interface, and different sorts of user engagement.

The team members selected for this contract - MET Norway, Meteo France, INERIS, KNMI (with CNRS-LAERO as its sub-contractor), and FMI - have an excellent track record in providing this kind of services for CAMS, with many pieces of software already in their possession, to be applied and further developed during the CAMS2_83 project based on feedback from ECMWF, product providers and users.

Model evaluation in CAMS2_83 will comprise the chemical species O_3, NO_2, SO_2, CO, PM_{10}, $PM_{2.5}$ and pollen, as provided by the Regional Service Provider. Bias, Normalized Modified Mean Bias, Root Mean Square Error, Correlation and Fractional Gross Error will be reported as a function of forecast hour, season, averaged over the CAMS regional domain, individual countries, and at site-level. Metrics suggested by FAIRMODE will be included during the project. In addition, the response of the regional system to boundary conditions from the CAMS global model will be monitored regularly, including a comparison of performances between the regional and the global models of CAMS.

All results from this project will be made publicly available in reports and on a web interface to be embedded in the CAMS web site. Emphasis will be placed on user friendliness, and documentation and interaction with users will be ensured.

2 Track Record

2.1 Introduction

This project team led by MET Norway includes the following sub-contractors: Meteo France, KNMI (with CNRS-LAERO as its sub-contractor), INERIS, and FMI. All contractors of this project team have many years of experience within CAMS and are leading (or have led in the past) CAMS contracts and/or sub-projects in the MACC precursor projects.

Meteo France (as leader of CAMS_50) has been responsible for the NRT evaluation of the regional models in CAMS_50, while INERIS has been responsible for the evaluation of the interim and validated reanalyses so far. KNMI has been leading CAMS_84 and worked on the evaluation of regional models against above-surface measurements and comparisons between the regional and global models of CAMS, with CNRS-LAERO responsible for the evaluation against IAGOS data in particular. FMI, as the leader of CAMS_23 and developer of the pollen modules used in the CAMS_50 regional systems, will cover the aspect of evaluation of pollen results in CAMS2_83. MET Norway has recently led Work Package 6110 of CAMS_61 where a new powerful tool for evaluation of CAMS regional and global models was developed and recommendations on model development were made. All contractors are actively involved in a number of other CAMS projects.

In CAMS2_83 we will build on this vast experience within CAMS and exploit software and IT infrastructure that is already in place and develop these tools further, towards an enhanced and harmonized service product. The contractors of CAMS2_83 are presented in more detail below.

2.2 MET Norway (prime contractor)

The Norwegian Meteorological Institute (MET Norway) [https://www.met.no/en] is the national meteorological service of Norway and represents Norway in ECMWF, EUMETSAT, EUMETNET, WMO and other international forums. It takes part in international projects on marine and atmospheric research, including climate change and air pollution research. The institute employs about 460 persons, among them 125 scientists doing research within numerical weather prediction, ocean modelling, remote sensing, air pollution, product development, instrumentation, climatology and climate research. MET Norway has extensive experience in developing methods and operational applications, which have led to innovation and added value for both the private and public sectors.

Air pollution research is performed within the Division of Climate Modelling and Air Pollution, which is part of the Research and Development Department at MET Norway. The division has a strong operational component turning research findings into products to meet the needs of policy makers, public authorities nationally or internationally, as well as the research community and the general public. These products include not only daily operational air pollution forecasts and analyses, but also emergency modelling in the case of volcanic eruptions or nuclear accidents.

MET Norway hosts MSC-W (Meteorological Synthesizing Centre - West), which is one of the scientific centres within the European Monitoring and Evaluation Programme (EMEP) under the UN ECE Convention on Long-range Transboundary Air Pollution (LRTAP Convention). EMEP provides the

technical underpinning for air pollution policies within the LRTAP Convention and also for the EU. Through its long-term involvement in EMEP and its support of the EU Thematic Strategy on air pollution, MET Norway has the capability and mission to provide services in air pollution abatement and understanding beyond the duration of single projects.

The provisional budget share of MET Norway in CAMS2_83 is 275k€ (≈45.8% of the total budget).

Key team members

Dr. Hilde Fagerli has 20 years of experience in air pollution modelling and has co-authored more than 50 peer-reviewed publications. Since 2009, she has been head of the Division of Climate Modelling and Air Pollution, managing 30 scientists working in the field of air pollution from local to global scale, climate modelling, evaluation systems for air quality and climate models based on in situ observations, lidars, satellite data etc., emergency modelling of radioactivity and volcanic ash. She is also head of the EMEP MSC-W. She has managed MET Norway's contribution to numerous other policy-relevant projects, e.g. the more recent AAQD (to support the impact assessment for a revision of the EU Ambient Air Quality Directives), and 'Ambient Air Quality and Public Health in South Asia' (financed by the World bank). She is leading the operational Norwegian ash forecasting system and coordinates MET Norway's contribution to the inter-agency cooperation to improve Norwegian local air pollution forecasts. She has participated in many national and international research projects, including CAMS projects, such as CAMS_61 (as WP leader), CAMS_71, and CAMS_50.
Dr. Augustin Mortier received his PhD in atmospheric physics in 2013 at the University of Lille. He has been employed at MET Norway since 2014. He was developing and is responsible for the CAMS71 policy portal with innovative visualisations of source receptor relationships for policy users. He will be part of the technical team in CAMS2_83.
Mr. Daniel Heinesen received his Master of Science degree at the University of Oslo in 2021 in the field of Astronomy at the Institute of Theoretical Astrophysics. He has substantial experience in programming and has been employed at MET Norway since summer 2021, mainly involved in the development of Pyaercom (which will be used in CAMS2_83 for model evaluation).
Prof. Dr. Michael Schulz received his PhD at the University of Hamburg in 1993, continued as postdoc 1994-1999 and joined the Laboratoire des Sciences du Climate et de l'Environnement (LSCE) as post-doc in 1993/4 and then as senior 1999-2010, as leader of the "Biogeochemical cycle modelling" research team. He joined MET Norway in 2010, co-leading EMEP and NorESM model development and applications, became an adjunct professor for meteorology at the University of Oslo in 2017. His research focuses on the understanding of the role of aerosols for climate change and air quality (h index 65, >18800 citations). He worked as PI in numerous national and international projects, contributing to policy relevant assessment reports such as being a lead/contributing author of the 4th&5th IPCC assessment report. He has coordinated MET Norway's contributions to CAMS_71.
Dr. Michael Gauss received his PhD in atmospheric chemistry in 2003 at the University of Oslo. He has been employed at MET Norway since 2006 and has been involved in a large number of research projects and operational services. He has co-authored more than 50 peer-reviewed publications and contributed to two IPCC assessments. He has gained international experience through his participation in more than twenty EU-funded projects focusing on atmospheric chemistry and climate change, and the EMEP programme funded by the UN ECE. He coordinated the EU FP7 project CityZen and the Policy support sub-projects of MACC-I/II/III. In CAMS_50.I and CAMS_50.II, his main role has been to coordinate MET Norway' contribution (scientific developments, operational work and reporting). In CAMS_81 he has been leading the User Support work package. HE coordinates CAMS2_83 with support from Dr. Hilde Fagerli and Prof. Dr. Michael Schulz.

Key facilities, infrastructure and equipment

As the national meteorological service of Norway, and as a governmental body, MET Norway has extensive and stable access to High Performance Computing resources. For data storage, analysis and evaluation in CAMS2_83, Met Norway will be using a Post-Processing Infrastructure (PPI), which has been established in house, and which is divided into four parts: a) storage b) post-processing section composed of Login Nodes, c) visualization nodes d) data gateways, i.e. servers that will make the storage available to other servers or directly on a computer through the CIFS or NFS protocols. Currently we have 155 Tbytes of disk space, and this volume is increasing. All work will be done at MET Norway's premises in Oslo, where also the PPI is located.

Involvement in projects relevant to CAMS2_83

Of most relevance for this call is Work Package 6110 of CAMS_61, which MET Norway has led, and where we developed tools to evaluate output from the CAMS regional and global models in great detail and to visualize the results via a new web interface. MET Norway has also been involved in CAMS_84, and has, for many years, led the AeroCom project (aerocom.met.no) for model evaluation. MET Norway is also involved in other CAMS contracts (CAMS_43, CAMS_71, and CAMS_81). In CAMS_81, MET Norway is leading the user support work package, providing multi-tier documentation of CAMS_81 products and user support.

2.3 Meteo France

Meteo-France [http://www.meteofrance.com] is the French national meteorology and climate service, and its core mandate is to ensure the meteorological safety of people and goods. Its primary activities range from developing and maintaining a network of observation stations, collecting and processing climate data, delivering weather forecasts, to developing climate projections and conducting research in the fields of meteorology and climatology.

From the outset, Meteo-France has been delivering operational weather and climate products at a national level and overseas. It covers all fields of operational research at all scales of time and space, thereby steadily improving the quality of its operational products. Cross-fertilisation between the work of engineers and that of scientists is a major asset, as is the user-oriented spirit underlying its daily operations. Users of Meteo-France productions are the public sector including policy-makers, armed forces, aviation and academics, large businesses and SMEs, and citizens.

Meteo-France enjoys a solid reputation across the world and is a strong player in major international and European organisations: WMO, ECMWF, EUMETSAT and EUMETNET.

Regarding air quality, Meteo-France coordinates the current CAMS Regional production service and provides the outputs of its chemistry-transport model MOCAGE. Additionally, Meteo-France actively contributes to PREV'AIR, the French ministry-driven service delivering operational air quality forecasts and maps concerning the world, Europe and France.

Air quality modelling and pollutant dispersion research has been conducted for more than 20 years. The National Centre for Meteorological Research (CNRM), a joint Meteo-France-CNRS laboratory, performs the research activities in the fields of chemistry, aerosols and air quality, mostly with MOCAGE.

The provisional budget share of Meteo France in CAMS2_83 is 100k€ (≈16.7% of the total budget).

Key team members

Dr. Mathieu Joly joined CNRM in 2005. He obtained a PhD in meteorology in 2007, with a strong expertise in statistical analysis of numerical simulations. Since then, he has been working on air quality modelling and verification. He was involved in the MACC, MACC-II and MACC-III projects and currently takes part in the current CAMS_50. In CAMS2_83, he will be responsible for the supervision of Meteo France's contribution.
Valentin Petiot received his Masters degree in Applied Mathematics in 2017. He then joined CNRM as a contractor for the CAMS_50 project to work on regional models evaluation and on the development of MOCAGE. In CAMS2_83 he will be the main developer for Meteo France's contribution to the project.
Etienne Blot was Project Manager for the severe forecasting of floods at the French National Hydrological Centre (SCHAPI) for four years and joined Meteo-France as a forecaster specialised in emergency forecasts. He is the Deputy Head of the Atmospheric Environment and Health Team of the Meteorological Services Direction and currently acts as the Production manager in CAMS_50. In CAMS2_83 he will be in charge of coordination between CAMS2_40 and CAMS2_83.

Key facilities, infrastructure and equipment

Meteo-France is equipped with high-performance computing and storage facilities.

- **Hardware**: Bull supercomputer and operational production chain ("Soprano"). The deployment of 2 supercomputers has multiplied by 3 the actual power calculating system in comparison to the previous configuration installed in 2014. Total peak power: above 5 Petaflops.
- **Software**: MOCAGE model in different configurations and "Openwis" software.

Location where services will be delivered: Meteo France, Toulouse, France.

Involvement in projects relevant to CAMS2_83

Meteo-France Meteo-France is the Prime contractor for CAMS_50 and takes part in 16 other Copernicus projects including C3S and CMEMS. It has been involved in CAMS_42 (inclusion of MOCAGE chemistry scheme in IFS) and CAMS_43 (aerosol development in IFS). It took part in the FP7 IMPACT2C project dedicated to the assessment of future air quality over Europe, and in some research projects for the preparation of future satellite missions such as ESA ISOTROP for the Sentinel-4 and Sentinel-5 missions. In addition to CAMS_50 Meteo-France manages the operational programmes EUMETNET E-SURFMAR and the EUMETSAT Satellite Application Facility on Ocean and Sea Ice. Meteo-France also participates in the H2020 SEEDS project led by NILU.

2.4 KNMI

The Royal Netherlands Meteorological Institute (KNMI) [https://www.knmi.nl/over-het-knmi/about] is the national meteorological service of the Netherlands and an integral part of the Ministry of Infrastructure and Environment. The institute combines in house operational as well as strategic research tasks. The KNMI provides, on a day-to-day to multi-annual basis, advice on weather, climate, air quality and seismological risks to national, regional, and local authorities. For this, it maintains national geophysical observational networks and it develops models.

The division R&D Satellite Observations is strongly involved in satellite observations of atmospheric composition, formerly as co-PI of GOME and SCIAMACHY and presently as PI institute of the OMI (PI Pieternel Levelt) and TROPOMI (PI Pepijn Veefkind) instruments and responsible for the development of several products, such as NO_2. TROPOMI has been launched in 2017 as single payload of the Sentinel 5-Precursor mission. The division is also strongly involved in the CAMS activity.

The division R&D Modelling develops regional weather forecast (Hirlam/Harmonie), climate (Racmo, Harmonie) and air quality (Lotos-Euros) models and it is involved in the further development of the global climate model EC-Earth and the global chemistry models TM5 and C-IFS.

The division Information and Chain Management is responsible for keeping the KNMI infrastructure (supercomputer, network, etc.) at De Bilt operational on a 24/7 basis. The Dutch national air quality model LOTOS-EUROS is run operationally there by them to produce the daily air quality forecasts for the Netherlands that are presented on the website of the Environmental Institute (RIVM, lml.rivm.nl) and the European air quality forecasts that are presently part of the CAMS_50 Regional ENSEMBLE.

The provisional budget share of KNMI in CAMS2_83 is 125k€ (≈20.8% of the total budget). This includes 30k€ for their sub-contractor CNRS-LAERO (see Section 2.4.1).

Key team members

Dr. Henk Eskes is a senior scientist with extensive expertise on chemical data assimilation and retrieval of satellite observations e.g., of ozone and NO_2. He has set up the operational air quality forecasting system for the Netherlands and has been involved in the series of precursor projects that have developed the models and data assimilation capabilities for CAMS, namely the EU projects SODA, GEMS, MACC, MACC-II and MACC-III. He has been a member of the management team in these projects and is co-ordinating the validation sub-project in MACC-II-III and more recently CAMS_84. He has also participated in many other EU projects (DARE, GODIVA, ASSET, EVERGREEN, PASODOBLE and GOA). Furthermore, Henk Eskes is product lead for the TROPOMI NO_2 retrieval, and was involved in the production of the European QA4ECV project NO_2 long-term data record based on observations of GOME, SCIAMACHY, OMI and GOME-2. He will contribute to the evaluation of the comparisons of the CAMS regional model products against satellite and vertical profile observations.
Dr. John Douros is a scientist specializing in meteorological and photochemical dispersion modelling. He has been actively involved in several EU funded projects in the past, including the FP7 projects MEGAPOLI, TRANSPHORM and APPRAISAL. He has performed most of the CAMS_50 activities at KNMI until now, providing daily forecasts and reanalyses datasets using the LOTOS-EUROS model. He is also involved in CAMS_84, as editor of the validation reports for the regional models. In CAMS2-83 he will be responsible for the comparisons of the regional models versus satellite (TROPOMI) observations and ozone sondes.

Key facilities, infrastructure and equipment

Hardware: Supercomputer (Bull), storage (disk/tape archive), network and internet facilities available (monitored) 24 hrs/7 days.

Software: LOTOS-EUROS Air Quality Model including Data Assimilation and required software libraries (NetCDF, hdf, etc.) and Software shell for running KNMI's operational applications.

Operational services are run on KNMI facilities, see E-capability KNMI.

Involvement in projects relevant to CAMS2_83

Apart from CAMS, the KNMI team has since the late 90's been involved in many EU projects related to CAMS, including SODA, GOA, ASSET, PROMOTE, GEMS, PASODOBLE, and MACC I-II-III.

KNMI participated in MACC (Monitoring Atmospheric Composition and Climate) and the Copernicus Atmosphere Monitoring Service (CAMS) and was involved in several CAMS subprojects: CAMS-50, CAMS-42, and CAMS-84. KNMI has provided OMI and TROPOMI satellite observations, crucial inputs for the CAMS-global assimilation, and contributed to the development of C-IFS based on the code of the global TM5 CTM.

Henk Eskes and Nikos Benas coordinate the CAMS-84 contract responsible for the validation of the CAMS-global (NRT, reanalysis) and CAMS-regional (above-surface only) service products. John Douros is editor of the CAMS-84 validation reports, comparing the CAMS-regional ensemble and individual models with remote-sensing and in-situ aircraft and balloon-borne observations. Vincent Huijnen of KNMI is coordinating the CAMS-42 contract, devoted to the development of the chemistry in IFS-COMPO. In CAMS-50, John Douros is responsible for the delivery of air quality forecasts for the European regional ENSEMBLE with the Dutch LOTOS-EUROS model.

2.4.1 CNRS-LAERO

CNRS-LAERO [http://www.aero.obs-mip.fr] (legal name: Centre National de la Recherche Scientifique, Laboratoire d'Aerologie (UMR 5560)) will be involved in CAMS2_83 as sub-contractor to KNMI, dealing with the above-surface evaluation against IAGOS measurements.

Key facilities, infrastructure and equipment

CNRS-LAERO is under the joined supervision of Université Paul Sabatier Toulouse III (UT3) and Centre National de la Recherche Scientifique (CNRS). With 6 other laboratories devoted to studies on oceanography, continental surfaces, ecology, solid earth, astronomy and astrophysics, it is part of Observatoire Midi-Pyrénées (OMP), the second most important center for environmental, planetary and space research in France (about 800 people). CNRS-LAERO is directed by Pr. Sylvain COQUILLAT and CNRS-OMP is directed by Dr. Michael TOPLIS. CNRS-LAERO focuses its research on the fields of atmospheric dynamics and composition (from the surface to the lower stratosphere) as well as coastal oceanography. The institute is a research center with about 50 junior and senior scientists, 30 engineers, technicians and administrative staff, 10 to 15 PhD students, 5 to 10 PostDocs.

CNRS-LAERO is an academic research laboratory with all the needed facilities linked to research and communication (i.e. efficient internet network, efficient database servers and computers for modeling activities and/or data storage), etc.

KNMI is taking responsibility for the full *above-surface evaluation* activity, with CNRS-LAERO as its sub-contractor. In the CAMS_84 contract, CNRS-LAERO has been a sub-contractor of KNMI, so that KNMI already has experience in setting up contracts with them. A similar type of contract will be set up for CAMS2_83. We assume there is a fair chance that the project team led by KNMI for CAMS2_82 (global evaluation) will be successful. In this case the same CNRS-LAERO team (same persons) will be involved in CAMS2_82 and CAMS2_83. KNMI will then set up one contract with CNRS-LAERO for both activities, which will be efficient from an administrative point of view. With these two contracts, CNRS-LAERO will finance one full Post-doc position (Dr Yasmine Bennouna).

Location where services will be delivered from: 14 Avenue Edouard Belin, 31400 Toulouse, France.

Key team members

Dr. Valérie Thouret received her PhD in 1998 at the University Paul Sabatier, Toulouse, France, with subject "Study of spatial and temporal variations of ozone in the troposphere and lower stratosphere based on the first results of the MOZAIC airborne program". Since 2011 she has been working as a physicist (equivalent to Professor) at the Laboratoire d'Aérologie (CNRS and Université Paul Sabatier). Among other roles, she is the Chair of the IAGOS-AISBL Executive Board (since Feb. 2014) and the Coordinator of IAGOS-France (since mid-2012). She has also been involved in the MACC precursor projects to CAMS.
Dr. Yasmine Bennouna received her PhD in 2009 at the Université du sud Toulon Var (USTV) and Eindhoven University of Technology (TU/e), with subject "Aerosol remote sensing from Geostationary Observations with MSG-SEVIRI". She is currently also employed at KNMI, working for CAMS_84 and the validation of CAMS products using in-situ observations from the IAGOS European infrastructure.

Previous and current involvement in projects related to the sectoral application of this contract

- CNRS-LAERO used to be and/or still is PI in the European projects dedicated to routine aircraft observations: MOZAIC, IAGOS, IGAS.
- CNRS is one of the founding member of IAGOS-AISBL (presidency between 2014 and 2018, vice-presidency from 2018 on).
- CNRS-LAERO used to be and/or still is PI in European projects dedicated to the preparatory phase of CAMS: GEMS, MACC, MACC-II, and MACC-III.
- CNRS-LAERO is also PI in European projects dedicated to the harmonization and integration of environmental research infrastructures: ENVRI+, its continuation ENVRI-FAIR, and the most recent ones ATMO-ACCESS and RI-URBANS.

2.5 INERIS

The French National Institute for Industrial Environment and Risks (INERIS) [https://www.ineris.fr/fr/presentation] is a public industrial and commercial undertaking founded in 1990. A large part of the activity of the Institute is devoted to air quality: metrological and modelling tools are developed and assessed to contribute to a better understanding and management of atmospheric pollution. The INERIS expertise relies on both local sources (industrial, urban...) and transboundary air pollution. INERIS is involved in a large number of European working groups related to air quality assessment and air pollution impact, and provides technical support to national decision-makers in the field of air quality management.

Within this framework, INERIS brings its expertise to the Ministry for the Ecological Transition during the phases of negotiation and implementation of the Directives and protocols. INERIS develops, in partnership with the National Scientific Research Centre the chemistry transport model CHIMERE (www.lmd.polytechnique.fr/chimere/). INERIS ensures the continuous development of this model and the improvement of its capacities and performances through European research projects. INERIS operates the PREv'AIR system (www.prevair.org), the national air quality forecasting platform, since 2003 in cooperation with Meteo-France and the National Scientific Research Centre. INERIS runs operationally the CHIMERE model for PREV'AIR, which produces on a daily basis up to three days

forecasts of ozone, particles and nitrogen dioxides concentrations at the global, European and French scales.

INERIS is responsible for running CHIMERE for the Copernicus regional service in order to provide daily air quality forecasts for the next few days. Within this service, INERIS is also in charge of the model developments and the management of the reanalyses productions.

INERIS leads a number of technical and scientific projects that help to implementing coordinated actions related to strategic, methodological, technical aspects of air quality measurement and the modelling, including indoor air quality.

The provisional budget share of INERIS in CAMS2_83 is 75k€ (12.5% of the total budget).

Key team members

Dr. Augustin Colette is head of the Atmospheric Modelling and Environmental Mapping Unit of Ineris. He holds a PhD in Atmospheric Sciences from Sorbonne University and worked in the past for UNESCO, Stanford University, Ecole Polytechnique and the private sector for Meteorological Risk Assessment. He has co-authored 75 reviewed articles in the field of atmospheric modelling. Augustin is chair of the Task Force on Measurement and Modelling in support of the UNECE CLRTAP Convention , Member of the Scientific Committee of the French AQACIA Research Programme, Scientific Advisor of the CAMS_50 Regional Production, Lead of the CAMS_63 Service on machine learning for air quality forecasts, Member of the Management Committee of the European Topic Centre on Air pollution, Transport, Noise and Industrial pollution of EEA and editor for the journal Geosciences Model Development.
Dr. Frederik Meleux is a research scientist. He holds a PhD in atmospheric chemistry and physics. At INERIS, he is in charge of the modelling activities in the framework of the PREV'AIR operational system which he coordinates since 2008. He is also responsible for its evolution and quality assurance. To this need, he supervises a number of activities and projects related to model developments, data assimilation and model evaluations. He's managing the reanalyses productions within the CAMS regional air quality service. In CAMS2_83, he will act as work package lead for reanalyses EQC.
Dr. Anthony Ung is R&D engineer who joined INERIS in 2007. His doctoral thesis dealt with air quality mapping using multi-sources data. At INERIS, he is involved in several national and European air quality projects such as PREV'AIR, CITEAIR2 and the Copernicus/GMES projects. His field of expertise is data assimilation, mapping and scripting tools for operational post-processing (including MOS development) and validation of modelled data. Under CAMS2_83, he will contribute to the EQC of analysis products.
Blandine Raux joined INERIS in 2019 with a MSc in Scientific Computing. At INERIS she focuses on model evaluation and visualisation activities. She has been actively involved in several aspects devoted to the development of the Air Control Toolbox in the framework of the CAMS_71 Policy Service.

Key facilities, infrastructure and equipment

For activities related to reanalyses evaluation, INERIS mainly relies on ECMWF facilities with the CCA machine so far.

Other resources can be used that are located in the large computing centre of CEA (French Alternative Energies and Atomic Energy Commission) which is called CCRT made of several computers for a total of more than 500 Tflops with a large storage capacity associated.

Location where services will be delivered: Verneuil en Halatte, France.

Involvement in projects relevant to CAMS2_83

INERIS has been involved in all the projects that prepared the implementation of the operational Copernicus Atmosphere services from GEMS (FP6) and PROMOTE (ESA service Elements) to the MACC suites. In this framework, INERIS led the production of yearly-validated air quality re-analyses concerning Europe. Activities that INERIS has continued to have in charge during the CAM50.I and CAMS_50.II services, besides also a coordinating or contributing role in CAMS_71, CAMS_63 and CAMS_61.

EURODELTA : The scope of several EURODELTA phases were coordinated by INERIS to assess model performances of a range of European Chemistry Transport Models against EMEP field measurement campaigns. It also included a retrospective analysis of air quality over the policy horizon of the Convention on Long Range Transport taking 1990 as a starting point.

RI-URBANS: INERIS is leader of the work package devoted to modelling in this Horizon Europe (Green Deal) starting in 2021 and designed to bring the best of ACTRIS monitoring approaches for urban air quality.

ETC/ACM-ATNI-HE: Since 2011, INERIS is one of the members of the Topic centres (ACM, ATNI and HE) providing expertise to the European Environment Agency in the field of air quality assessment, modelling and mapping, and also contributes to air quality monitoring strategies.

2.6 FMI

The Finnish Meteorological Institute (FMI) [http://en.ilmatieteenlaitos.fi/] is designated by the Finnish government as national air quality expert with a mandate to produce information and forecasts on the state of the atmosphere and its characteristics, with the aim of promoting safety and serving various needs of the public, industry and commerce, as well as contributing to scientific ends. FMI makes observations of the physical state of the atmosphere, its chemical composition, and electromagnetic phenomena. FMI also develops and applies numerical models – from urban to global scales – in order to analyse and forecast various atmospheric physical and chemical processes. FMI employs about 600 people, about 300 of which are involved in research. The modelling teams have extensive experience in developing and implementing various numerical systems, from urban pollution models up to global stratospheric ozone studies.

Scientists from the Atmospheric Composition Research and Production departments of FMI will be involved in CAMS2_83. The Atmospheric Composition research division has as its main task to investigate, monitor, model and report on air quality and its influencing factors. The Finnish government has designated FMI as the national air quality expert.

FMI is involved in numerous international co-operative, research and assessment efforts. Current projects involve the following activities: 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 in particular one National and two Nordic Centres of Excellence, ACCENT, EC/Environment), assessment and modelling of the dispersion, transformation and deposition of airborne pollutants from the local to the continental scale (H2020 AirQast, EMERGE, SCIPPER,

EXHAUSTION, HEATCOST, ESA HAPS, EUMETSAT O3M SAF and others; contributed to the AQ assessments within IPCC, UN/ECE EMEP and IM, HELCOM, WMO/GAW, AMAP, GEOSS, etc.).

FMI is the designated institute in Finland for monitoring air quality. It performs AQ measurements over the country territory, maintains the infrastructure and databases, and reports the data to European Environment Agency and other international bodies.

The provisional budget share of FMI in CAMS2_83 is 25k€ (≈4.2% of the total budget).

Key team members

Prof. Dr. Mikhail Sofiev has over 30 years of experience in atmospheric composition research and model development, coordinator of the SILAM team, deputy leader of the FMI AQR Modelling Group and Adjunct Professor at University of Helsinki. He has an extensive experience in development and application of air pollution models at various scales – from meso- to hemispheric scales – and for various compounds – acidifying, toxic, aerosol, and radioactive accidental releases – and in related fields: model evaluation, statistical methodology, data analysis, computer experiments, etc. He coordinated FMI modelling work in numerous international projects, coordinated Finnish national projects PS4A, POLLEN, IS4FIRES, and ASTREX, etc. M.Sofiev is author of 252 scientific publications (h-index 43), 155 of which in peer-reviewed journals and series. M.Sofiev is a member of WMO Scientific Advisory Group on Applications, WHO GAPH SAG on desert dust and health, European Aerobiological society, European Academy of Allergology and Clinical Immunology, Board member of European Aeroallergen Network, member of Finnish emergency preparedness team, and has contributed to policy advisory boards. His role in CAMS2_83 will be to link to CAMS2_23 and to provide the methodological support for the proper evaluation of regional air quality model output against measurements of pollen.
Dr. Julia Palamarchuk is working in the team of Prof. Dr. Sofiev and has vast experience in pollen modelling. She will assist in the proper evaluation of regional air quality model output against measurements of pollen and participate in user engagement activities.

Key facilities, infrastructure and equipmentement

The FMI operational supercomputer facility consists of two identical Cray XC40 systems with 172 compute nodes of 28 (56 hyperthreading) cores. Each node has 128GB RAM. Peak performance is 1035 GFLOP per node, or 178 TFLOP in total. It is accompanied with 960-TB fast-access storage and a tape archive of essentially unlimited capacity. The system is equipped with all necessary software for large-scale computations, data processing, archiving, visualization and dissemination. The research work is based on a new supercomputer with a total of 682 CPU nodes, with a theoretical peak performance of 1.8 petaflops with 750TB of fast Lustre disk space. For massive research simulation, FMI has access to the Mahti supercomputer of Centre of Scientific Computing of Finland, which has a total of 1404 CPU nodes and 24 GPU nodes. The theoretical peak performance is 7.5 petaflops for the CPU nodes and 2.0 petaflops for the GPU nodes, in total 9.5 PF.

Location where services will be delivered: Finnish Meteorological Institute, Helsinki, Finland.

Involvement in projects relevant to CAMS2_83

FMI has been involved in CAMS_50, running one of the Regional models, responsible for pollen line development.

Other projects:

- GLORIA (2017-2020): Global health risks related to atmospheric composition and weather. Finnish Academy. Long-term re-analysis of global/European AQ and pollen exposure.
- BATMAN (2015-2018) Environmental impact assessment of airborne particulate matter: the effects of abatement and management strategies. Academy of Finland. High-resolution (1km) AQ assessment for Finland.
- NeGI NCOE (2014-2017). Ensemble-based methods for environmental monitoring and prediction. Responsible for atmospheric applications.
- Ragweed (2011-2012): Assessing and controlling the spread and the effects of common ragweed in Europe. Responsible for the modelling part of the project.

FMI is leading the CAMS_23 WP5 sub-contract focusing on real-time pollen data delivery. FMI has also been involved in several other CAMS contracts, e.g. CAMS_61 and CAMS_63, which included extensive model evaluation tasks.

3 Quality of Resources to be Deployed

3.1 Description of Resources

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 contract	Qualifications
MET Norway			
Senior scientist	project manager, reporting	Michael Gauss	PhD in atmospheric chemistry. Team leader MET Norway for CAMS_50, former leader of MACC-POL, leader of user support WP in CAMS_81.
Team leader	supervision, reporting	Hilde Fagerli	Head of Division of Climate modelling and Air pollution at MET Norway Head of EMEP MSC-W
Professor, senior scientist	supervision, advisor, data acquisition, link to Aerocom.met.no	Michael Schulz	Head of Earth System Modelling Team, Team leader CAMS_71, CAMS_43, CAMS_84 Leader of Aerocom.met.no
Analyst and scientist	development and use of AeroVal for CAMS, maintain operational	Augustin Mortier	Main technician in CAMS_71, experience in data processing and visualization
Analyst and scientist	development and use of Pyaerocom for CAMS	Daniel Heinesen	Experience in data processing and visualization
Meteo France			

Senior scientist	Supervision of Meteo-France contribution	Mathieu Joly	PhD Atmospheric Science
Senior Engineer - Research	Main developer for MF contribution to CAMS2_83	Valentin Petiot	Graduated from the University of Bourgogne in Applied Mathematics MSc equivalent.
Operational unit deputy manager	Coordination between CAMS2_40 and CAMS2_83	Etienne Blot	Graduated from the French School of Meteorology – equivalent to MSc
Senior engineer IT	IT developper	Loïc Martin	Graduated from the ENSEEITH Engineering School equivalent to MSc.
INERIS			
Senior scientist	WP lead for analyses EQC	Frederik Meleux	PhD Atmospheric Physics and Chemistry
Scientific team manager	Model development and evaluation expertise	Augustin Colette	PhD Atmospheric Physics and Chemistry
Senior scientist	analyses EQC	Anthony Ung	PhD Atmospheric Physics and Chemistry
Junior scientist	analyses EQC	Blandine Raux	MSc Scientific computing
KNMI			
Senior scientist	Will contribute to the interpretation of the validation results	Henk Eskes	PhD Theoretical Physics
Senior scientist	Will perform most of the above-surface model-observation intercomparison activities	John Douros	PhD Mechanical Engineering Chemistry-transport modeller.
CNRS-LAERO (sub-contractor to KNMI)			
Senior Scientist	Supervision of CNRS-LA contribution and coordination of IAGOS	Valérie Thouret	Coordination of IAGOS and chair of IAGOS AISBL
Analyst and scientist	will produce the comparison results with IAGOS observations and contribute to their interpretation	Yasmine Bennouna	PhD in Atmospheric Physics
FMI			
Research Professor / Senior Scientist	Technology for evaluation of pollen model output against pollen data	Mikhail Sofiev	Coordinator of CAMS2_83, deputy leader of modelling group at FMI
Senior Scientist	Practical work on evaluation of pollen model output against pollen data	Julia Palamarchuk	PhD in Geosciences

3.2 CV's of Key Personnel

The CV's of all key personnel in CAMS2_83 have been provided in a separate file.

4 Technical Solution Proposed

4.1 Introduction

Through their involvement in other relevant CAMS projects (CAMS_50, CAMS_61, CAMS_71, CAMS_84, and CAMS_23) the contractors of this project can guarantee a seamless transition from the data acquisition/processing, evaluation, and reporting activities in these previous projects. CAMS2_83 will build on tools and infrastructure developed in these previous CAMS projects, but develop them further to meet the specifications in the CAMS2_83 ITT.

The evaluation of the CAMS Regional system has been somewhat fragmented up to now, with the following outputs (some links to relevant web pages will be provided here but are not critical to understanding the technical solution proposed):

- Visualization of NRT daily evaluation of regional models at the surface (CAMS_50 regional website, under 'Verification Results');
- Visualization of quarterly evaluation for the whole domain (CAMS_50 'Ensemble and Model evaluation' of forecasts and analyses);
- Visualization of quarterly evaluation at country and station level (CAMS_50, prototype evaluation of forecasts and analyses);
- Visualization of quarterly evaluation of CAMS regional models and global model at country level and station level (CAMS_61, AeroVal);
- Reports on evaluation of hindcast and assessment of the importance of boundary conditions (CAMS_61);
- Annual reports on the evaluation of the interim and validated reanalyses (CAMS_50);
- Quarterly reports of NRT production (including uptime statistics) (CAMS_50 and CAMS_84, Regional services page);
- Reports on the evaluation of CAMS regional and global models against above-surface measurements, and uptake of boundary conditions[4] (CAMS_84).

A seamless continuation of these evaluation products will be ensured *from the beginning* of the project. During a transition period, envisaged to last for about 18 months (until spring 2023) the Pyaerocom and AeroVal tools of MET Norway (Section 4.3) will be developed further to combine the visualizations listed above in a *merged and harmonized* web interface (WP CAMS2_8330), to be embedded into the CAMS website. The exact layout and content of the new web interface is not fully decided yet, but will evolve during the transition period based on feedback from ECMWF and user experience.

In any case, the evaluation tools and visualizations will cover as many spatial and temporal scales as possible, as model performance not only depends on the species in question, but also on the geographic location, the height above surface, and the time (year-to-year variability, seasonal variation, weekday, hour of the day/forecast length). Models that perform well on one aspect may perform less well on another.

The next two sections will explain the selection of measurement data used in CAMS2_83 and the pre-existing software, as this is of relevance for all Work Packages. A summary of the data flow (model data, measurement data from external sources, and results from CAMS2_83) is given in Section 4.4, followed by detailed descriptions of the 5 Work Packages in Sections 4.5 to 4.9.

4.2 Acquisition of measurement data

In the evaluation activities of CAMS2_83 we will use *in situ* data from various sources (e.g. EEA, EMEP, and EAN), but also satellite data. When evaluating the analyses (both daily, interim and validated) we will ensure that the data used for evaluation will not be those that have been assimilated in the models. The different sources of measurement data are briefly described in the following paragraphs.

Surface measurements used at Meteo France, INERIS and MET Norway

The main source of observational data for the surface evaluation will be the European Environment Agency (EEA) databases which contain regulatory observations reported by the Member States according to Air quality Directive 2008/50/CE and the Air Quality Directive Implementation provisions or IPR (2011/850/EU), defining the so-called 'AQ e-reporting' process. The EIONET network (European Environment and Information Network) is a partnership network of EEA that supports environmental data collection and organisation. It supports the implementation of such reporting regulations and a large part of the observational in-situ data used by CAMS2_40 (led by Meteo France) will come from this network. Regulatory databases are available on the AQ-portal of the Agency designated as 'AQ e-reporting DB'. Meteo France will continue their evaluation with these data in CAMS2_83. Other more specific sources of surface observations will be processed in other CAMS services, such as for ACTRIS observations and observations from the EMEP network.

MET Norway has access to data from the EMEP network and has also established its own flow of data from EEA, but will receive separate lists of measurement sites from Meteo France and Ineris to be used for evaluation - one that includes assimilated data (against which all forecasts can be evaluated) and one that does not contain data assimilated in models and will be used to evaluate the analyses/reanalyses.

The bulk of surface data used for Regional production and obtained from EEA are the hourly concentrations of the pollutants O_3, NO_2, SO_2, CO and hourly or daily concentrations PM_{10} and $PM_{2.5}$ (depending on the adopted measurement device). For evaluation purposes, the set of selected measurement data should be representative at the spatial scale of the model simulation. At a typical resolution of 10 km in the CAMS regional models, this is especially important for sites that are influenced by local emission sources or are located in high-mountain areas. We will use an approach to qualify classification of monitoring stations, which was developed in the MACC projects (Joly and Peuch, 2012) and updated in 2017 during CAMS_50.I. This objective classification allows accounting for historical concentration records and is more appropriate to data assimilation purposes, with a classification index ranging from 1 (remote sites) to 10 (sites close to emissions sources). For the evaluation of the regional models we will use classifications 1-5 and 1-7, while for evaluation of the CAMS global model lower values will be used.

Above-surface data (vertical profiles and column observations) used at KNMI

The CAMS2_83 ITT explicitly mentions that "free-tropospheric" observations shall be considered. The comparison of the CAMS regional air quality models was an activity which was developed over the past 6 years during CAMS_84 (Global and regional model evaluation). The results were reported in a series of quarterly validation reports[4]. The proposed validation work will be a continuation of parts of this activity. The project team will collaborate with providers of the relevant *in situ* support contracts and make use of the real-time datasets provided by these contracts. In particular, we propose to use the following validation datasets for CAMS2_83:

- Take-off and landing profiles of ozone and CO using real-time data from IAGOS;
- Tropospheric ozone profiles from balloon-borne ozone sondes;
- Tropospheric NO_2 columns from Sentinel-5P. During 2022 we will extend this with other species like CO, and HCHO and CHOCHO depending on availability of model results from CAMS2_40.

The motivation for these choices is the following: Detailed profile information is very valuable to test the concentration gradients inside the boundary layer and concentration drops from the PBL to the free troposphere. Such unique information is brought by the IAGOS programme and by the ozone sondes. Ozone is a key target for the regional modelling systems, with direct health implications. Inclusion of the sonde and IAGOS datasets is linking to contracts with the IAGOS European Research Infrastructure, with WMO/GAW and with NDACC.

Nitrogen dioxide is a compound which is also regulated, is a key product of the regional CAMS service and plays an important role in tropospheric chemistry. TROPOMI provides very detailed high-quality daily maps of NO_2, with 5km resolution at nadir, showing plumes originating from local sources like cities, highways, power plants, industry and shipping. During the project we plan to extend the comparisons to other species including CO and also HCHO and CHOCHO when this output becomes available from the models as planned. Sentinel-5P is part of the fleet of Copernicus Sentinel satellites, and CAMS is the prime user of the S5P mission. In our view, the wealth of information in the TROPOMI datasets has not been exploited to its full potential, and through daily, monthly and seasonal comparisons against the individual models and ensemble we plan to contribute to this. We note that a few models have plans to assimilate the TROPOMI NO2 data, but not all. Furthermore, we expect that the forecasts will not be significantly affected by the assimilation (this may depend on details of the assimilation approach), and it will still be valuable to check the impact of TROPOMI, in combination with NO2 surface observations, on the analyses for individual models.

We have allocated about 20% of the budget of CAMS2_83 to the above-surface activity and boundary conditions checks. This, however, implies a substantial budget reduction compared to the activity in CAMS_84 (to only about 30% of the funding that was available for these tasks in CAMS_84). In CAMS_84 we involved 7 partners in the activity, which we propose to reduce to only two partners. Several activities started in CAMS_84 will have to be discontinued: comparisons against EARLINET and AERONET, MAXDOAS, high-altitude EEA data, GAW in-situ ozone and CO at mountain tops, as well as Infrared CO satellite observations (MOPITT).

The main missing component is the vertical aerosol or PM information. In particular, no operational use is made of the available AERONET (and satellite) AOD and European lidar/ceilometer information, part of the ACTRIS contract. The main reason for this choice is the incomplete information available in the CAMS regional service products, which currently still offer only limited PM speciation information. In the CAMS_84 validation report[4] we mention that "Missing information on composition, size and humidity growth of the aerosol in the models introduces considerable uncertainty to the PM derived extinction, which conservatively spans up to a factor 10 for absolute extinction values." We consider this a too large uncertainty range for meaningful quantitative comparison. Nevertheless, we plan to investigate this further during the CAMS2_83 project, and to check if the newly added PM speciation information may reduce these uncertainties. Also, we will closely follow the developments in the ACTRIS-lidar contract and provide advice on how the CAMS regional activity can make best use of real-time lidar profile measurements.

Pollen data

Pollen data will be provided by the European Aeroallergen Network EAN through the CAMS2_23 project. FMI will not only provide the link between the CAMS2_23 and the CAMS2_83 projects, but also give advice on proper evaluation of model results against pollen measurements. This is not straightforward as pollen dispersal is confined to pollen seasons and specific geographical areas, depending on the pollen species in question, and pollen measurements are relatively sparse and majority of the data is not available in near real time. However, a noticeable set of data is expected to become available from the Autopollen framework and CAMS_23 WP5 (led by FMI). Utilization of these data opens, for the first time, possibility of NRT evaluation of pollen predictions.

Another pollen-specific issue is that the standard metrics, such as RMSE or bias, are of low value for the users. More important quantities are shift of the season start and end, probability of the medical threshold exceedance, etc.

4.3 Evaluation software and web pages

Currently, two advanced evaluation tools exist for the evaluation of CAMS regional models, one developed and maintained at Meteo France ('Evaltools') and one at MET Norway ('Pyaerocom'), which will generate the graphs and scores to be visualized in the new AeroVal web interface, to be fully operational from 2023. In addition, KNMI and CAMS_84 partners have developed tools for above-surface evaluation and visualization. These tools are briefly described in the next paragraphs.

Evaltools (Meteo France)

The Python package *evaltools* is designed to assess comparisons between surface atmosphere composition prediction models and in-situ observations. The package provides different tools to compute model scores and to plot them. It is especially used for evaluation of regional air quality models of CAMS_50.

The concept of evaltools is to compare observations (measured over time in fixed lat/lon locations) to simulations (that can have a forecast horizon of several days), computed over a period of several days. Therefore, it can be suited for other data types like AERONET data, but will not manage data with a vertical component.

This *evaltools* software is governed by the CeCILL-C license under French law and abides by the rules of distribution of free software. One can use, modify and/or redistribute the software under the terms of the CeCILL-C license as circulated by CEA, CNRS and INRIA at http://www.cecill.info. The link to the official web page of evaltools is https://opensource.umr-cnrm.fr/projects/evaltools/.

Pyaerocom (MET Norway)

Pyaerocom (https://github.com/metno/pyaerocom) is an open source python software for model evaluation and intercomparison with observations. It features reading routines for commonly used ground-based observational datasets such as EEA, EBAS, AERONET, EARLINET. In addition, Pyaerocom supports reading L3 satellite datasets such as MODIS, AATSR, CALIOP, etc.

Pyaerocom provides powerful and flexible spatiotemporal colocation routines for intercomparison of models and validation against observations. This includes routines for computing standard statistical evaluation scores such as biases (NMB, MNMB), correlation coefficients, RMSE, etc. Colocated data can be output in lightweight standardized netcdf output which can be easily shared. These data files are the basis for the computation of a set of json files containing time series and statistical evaluation

scores both on a global scale and down to the station level. These files serve as input for the AeroVal web interface which is described hereafter.

Pyaerocom has been successfully used in relevant projects such as CAMS_61, CAMS_84, as well as in several peer-reviewed studies focusing on model evaluation and trends[1,2].

AeroVal (MET Norway)

AeroVal is a versatile and interactive web interface that provides flexible visualization of model and observation data. It features a multitude of charts highlighting model performances at all scales including:

- Heatmaps (colored tables) of statistical scores visualizing performances across a suite of models as compared to multiple observation datasets (e.g. EEA-rural, EEA-urban, Joly&Peuch classifications 1 to 5 or 1 to 7) and for multiple variables;
- Statistical scores at the station-level as well as regional averages;
- Temporal evolution of model performance;
- Taylor diagrams;
- Global maps highlighting the spatial distribution of evaluation scores at the observation sites;
- Model fields (maps) with superimposed measurements, and more.

All of these visualizations rely on the json files precomputed by *Pyaerocom* introduced in the paragraph above.

Tools to compare with ozone and CO profiles measured with IAGOS (CNRS-AERO) and sondes (KNMI)

CNRS-LAERO will make use of tools developed during CAMS_84 with which regional CAMS models have been compared with IAGOS aircraft observations. Because of the high spatial resolution of the regional models the 3-dimensional fields are sampled along the flight path during take-off and landing. The comparison methods and datasets are described in the "Observation characterisation" document[3] and the validation results can be found in the regional "above-surface" validation reports available on the CAMS website[4].

At KNMI, the daily CAMS-regional forecast and analysis fields are downloaded operationally on a daily basis for all regional models and CAMS-global. These 3D fields are co-located with the locations of the ozone sonde launch sites. These co-located datasets are available for the CAMS 1.0 period and will be used for the ozone sonde validation.

Tools to compare CAMS models with TROPOMI (KNMI)

The KNMI team has recently developed a Python-based toolset to compare the CAMS regional models and CAMS global model against satellite data from TROPOMI, with a first focus on NO_2. The tool starts from the operational CAMS_50 3-dimensional forecast and analysis products provided on fixed altitude levels. The regional CAMS models, including the ensemble model, are combined with CAMS-global NO_2 profiles above 3 km. The tool interpolates based on overlaps, converts from height to pressure and convolutes the profiles with the averaging kernels. Comparisons are available on a daily, monthly, seasonal, or yearly basis. Model and satellite can be compared at the CAMS-regional regular grid, or on the TROPOMI footprints. As a side product, the toolset provides an alternative European TROPOMI L2 NO_2 data product (available from 30 April 2018 to real time) by replacing the global a-priori profiles with the CAMS-regional profiles. The resulting netcdf files have been used to create maps, time series for regions and cities, and statistical results.

A paper on these CAMS-TROPOMI NO_2 comparisons is ready to be submitted (July 2021). As part of this publication the Python tools will be made available.

Tools to compare model results and regional boundary conditions (KNMI)

This activity will build on tools that have been developed during CAMS_84 by the Aristotle University of Thessaloniki, which will ensure continuity of this activity and are available to KNMI. More details on the comparisons may be found in the latest validation report[4] (their Section 3).

Tools to compare pollen model predictions (FMI)

This activity will build on tools that have been developed during CAMS_50 by FMI for retrospective evaluation of pollen predictions. The specificity of the task is in the special needs of the user community - allergy sufferers and medical practitioners. Their primary interest is not in the RMSE or bias but rather in the error in the start and the end of the active pollen season, various hit rates for the medical thresholds exceedances, etc. These will be combined with the more classical metrics used in other evaluation tools - based on the NRT Autopollen data.

4.4 Summary of data flow, input and output

To provide a first overview, and for later reference, we summarize the data flows and interlinkages in CAMS2_83 already in Figure 1 below. The text boxes at the bottom of the figure contain only brief summaries about the various outputs from CAMS2_83, while the descriptions of Work packages CAMS2_8310, CAMS2_8320, and CAMS2_8330 in sections 4.6, 4.7, and 4.8, respectively, will provide more details about these outputs.

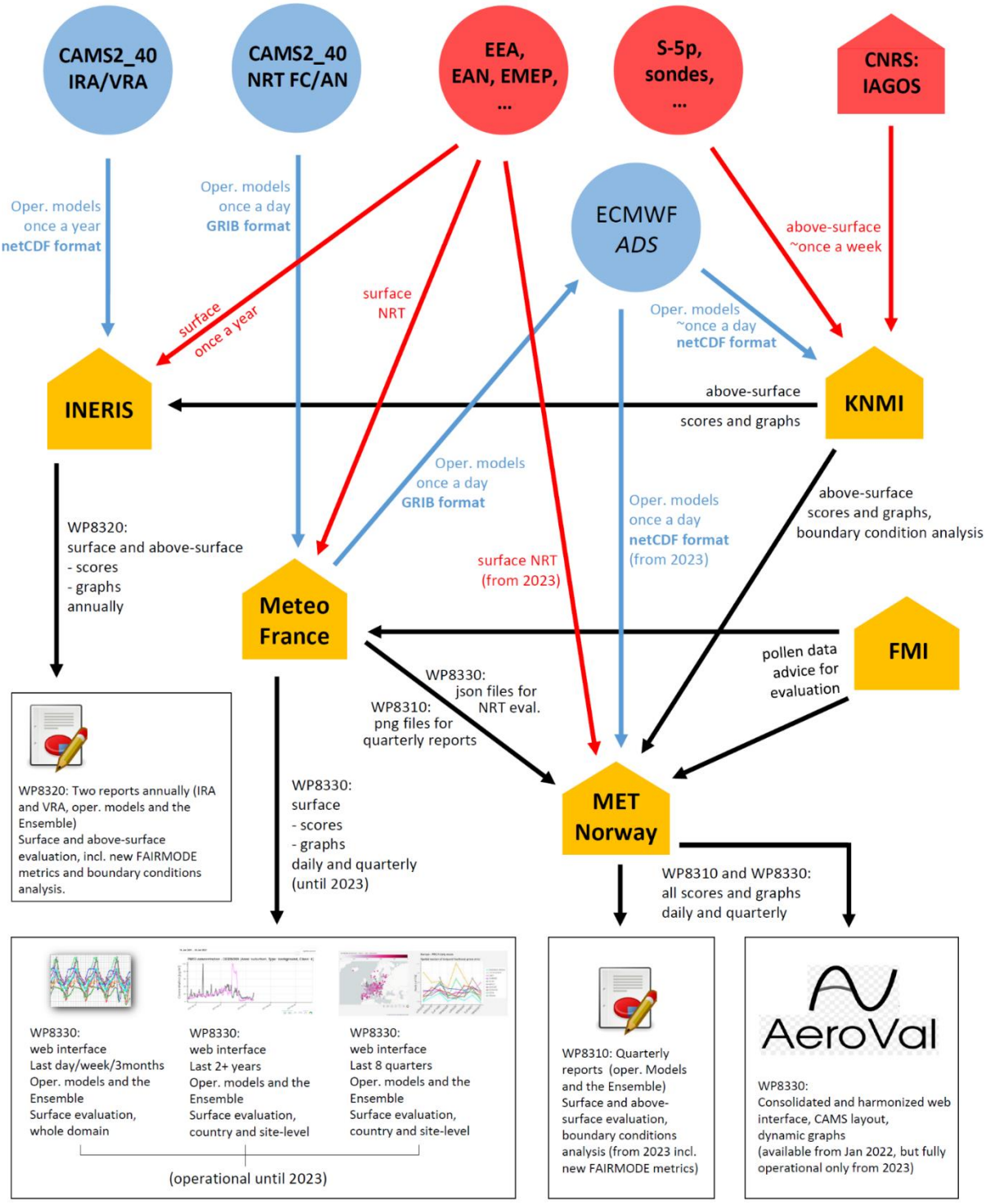

Figure 1: Flow of data in CAMS2_83. Red arrows: Measurement data, Blue arrows: model data, Black arrows: Plotting and editing. Circles: databases, Houses: CAMS2_83 contractors, Text boxes: CAMS2_83 output. More details will be given in the Work package descriptions below.

4.5 Work Package CAMS2_8300

This WP will fulfil our contractual obligations as described in the Framework Agreement Clause 2.3 on reporting and planning. Tangible output will consist of quarterly implementation reports (progress

reports for the previous quarter), annual implementation reports and preliminary financial forms (for the previous year), and annual implementation plans (for the next year). In addition, the key performance indicators (KPIs) will be updated with ECMWF after the first year of the project, and a final report will be written and be made available 2 months after the end of the project. To ensure that the progress of the project is in line with ECMWF's expectations, review meetings will be held with ECMWF about every 6 months during the whole project period.

As prime contractor, MET Norway will take responsibility for all reports and meetings in this Work Package, but input from all sub-contractors will be requested regularly for the reports and before and after the review meetings.

Coordination among contractors will mainly proceed via e-mail, but regular phone conferences are envisaged about every quarter. In addition, a face-to-face meeting with all contractors is planned for 2022, and at least one (but possibly two) visits of MET Norway staff to Meteo France (and possibly KNMI) will occur early in the project to implement scripts needed for operational evaluation and visualization in Work Packages CAMS2_8310 and CAMS2_8330.

4.6 Work Package CAMS2_8310

Quarterly EQC reports for daily regional production

In this WP we will provide quarterly EQC reports for the regional NRT analyses and forecasts covering the periods September-October-November (SON), December-January-February (DJF), March-April-May (MAM), and June-July-August (JJA), to be made available no later than two months after the end of each period, i.e. the first report will be available in January 2022 and cover the SON2021 period. In total, 14 quarterly EQC reports will be provided during CAMS2_83: SON2021, DJF2021/22, MAM2022, JJA2022, SON2022, DJF2022/23, MAM2023, JJA2023, SON2023, DJF2023/24, MAM2024, JJA2024, SON2024, and DJF2024/25.

The EQC reports are intended for both service providers and users and will thus comprehensively and clearly document the various EQC comparisons and include a summary of the main findings. The reports *will continue the series of quarterly CAMS_50 NRT production reports seamlessly* (daily forecasts and analysis), but with the following modifications: Uptime statistics and explanations of delivery issues will *not* be included (as they will be provided in CAMS2_40), while an evaluation against above-surface data *will* be included (previously this was part of the quarterly CAMS_84 validation reports). The evaluation of pollen forecasts will be added when measurement data become available and cover the periods of pollen dispersal.

Another new aspect to be included in the quarterly EQC reports is the uptake of boundary conditions in the CAMS regional air quality models. These are run on a European geographical domain and therefore need boundary conditions of the relevant aerosol and chemical species for this domain as input to their assimilation and forecast runs. We will monitor and evaluate the boundary conditions for the CAMS regional geographical domain from the CAMS global production as well as the response of the regional models to these boundary conditions. This will include comparisons between the global and regional forecasts over the European domain taking into account the different representativeness of the observations in regard to the regional systems and the global system. Inconsistencies between the global and regional systems will be flagged and communicated to the Global Service Provider and

Regional Service Provider for further investigation. Focus will be on longer-lived species, such as carbon monoxide, ozone and aerosols.

In the quarterly CAMS_50.II NRT production reports, the main findings for each model were discussed by the individual model teams, but since not all teams can be included in the CAMS2_83 contract these texts will be shorter and will not attempt to explain in detail (or speculate on) the reasons for suboptimal model performance. The discussions will rather point out the main findings, such as any failures to meet the target performance, deterioration or improvement compared to previous periods, discrepancies between the regional domain and the boundary conditions, and other major issues that model teams should be made aware of.

The reports will be made available on the AeroVal web interface, but we suggest to put them also on the CAMS regional services QA/QC web page: https://atmosphere.copernicus.eu/regional-services.

Monitoring of boundary conditions

The monitoring of boundary conditions and direct comparison between the models is a task which was developed during CAMS_84 (Global and regional model evaluation).

In CAMS2_83, the daily regional CAMS forecasts will be retrieved on a daily basis by KNMI. This includes the 3-hourly *regional* forecast data (ensemble members and regional ENSEMBLE) for all provided species at all vertical layers for the 5 forecast days and the 3-hourly *global* forecast data for 5 forecast days. Species from the CAMS-global product are converted from mass mixing ratio (kg/kg) to concentration (µg/m3) and the concentration are extracted from those vertical levels that lie closest to the CAMS-regional height levels.

The following parameters are used from the CAMS-global model: hybrid layer coefficients, temperature, surface pressure, "GEMS" ozone; carbon monoxide; nitrogen dioxide, "aermr01-11" and "aermr16-18" (aermr* are aerosol species in the CAMS-global model, given in kg/kg). Data from the first 78 vertical layers (from the surface) are used.

PM_{10} and $PM_{2.5}$ species are converted to concentrations ρ (given in µg/m3) in the following way:

ρ_PM10=[aermr01/4.3+aermr02/4.3+aermr04+aermr05+0.4*aermr06+aermr07+aemr08+aermr11+aerm09+aermr10+aermr16+aemr17+aermr18]*(p_m/(Rspec*T))

ρ_PM2.5=[aermr01/4.3+(aermr02*0.5)/4.3+aermr04+aermr05+0.7*aermr07+0.7*aermr08+0.7*aermr11+aermr09+aermr10+0.7*aermr16+0.25*aermr17+0.7*aermr18]*(p_m/(Rspec*T))

where the aermr species are given in mass mixing ratio, T is the air temperature in K, and Rspec=287.058 J/(kg·K) is the specific gas constant for dry air.

The consistency between the global and regional forecasts is then assessed by comparing global and regional (Ensemble and individual models) output at the four boundaries of the regional domain (vertical cross sections, height vs. lon/lat) and on different vertical levels (horizontal maps covering the regional domain, lon-lat). In addition, we will compare time series and diurnal cycles between the global and regional models for different European regions.

The activities in CAMS_84 included:

- Comparisons of the CAMS-regional ensemble forecast/analysis with the CAMS global model at the altitude levels from the surface to 5 km;

- comparisons of the individual CAMS-regional ensemble forecasts with the ensemble and the CAMS global model at the altitude levels;
- evaluation of the individual CAMS-regional ensemble forecasts/analyses against CAMS-global at the four boundaries of the domain;
- comparisons between the analysis and forecasts for the different models at the altitude levels;
- comparison of time series and diurnal cycles.

It is proposed to continue and improve these comparisons in CAMS2_83. The species considered are O3, CO, NO_2, $PM_{2.5}$ and PM_{10} at the start of the project. During the first year and depending on availability from CAMS2_40 we will develop the extension to other species like NH_3, HCHO, and PM speciation such as dust and sea salt. Any notable deviations of individual models against the Ensemble or the CAMS global model at the boundaries will be reported to the CAMS service providers and to the modelling teams involved. In any case, the results of the monitoring will be included in the quarterly reports.

Contents of the quarterly EQC reports

All scores and graphs that up to now have been included in the quarterly CAMS_50 NRT production reports will be included in the EQC reports of CAMS2_83 as well. In addition, plots for the above-surface evaluation and boundary conditions analysis (provided by KNMI) will be included.

More specifically, for NRT *forecasts* from all operational models and the Ensemble we will show:

- Median of RMSE as a function of season (e.g. JJA Y-2, SON Y-2, DJF Y-1, MAM Y-1, JJA Y-1, … until and including the season the report refers to), with target value indicated as horizontal bar in the plot;
- Median of RMSE as a function of forecast hour (0 to 96, starting from day D0 00UTC to day D+4 00UTC), averaged over the season the report refers to;
- Median of modified mean bias as a function of forecast hour (0 to 96), averaged over the season the report refers to;
- Median of correlation as a function of forecast hour (0 to 96), averaged over the season the report refers to;
- Time series of daily RMSE covering the season the report refers to;
- Cross sections for the regional models and the CAMS global model at the four lateral boundaries (south, west, north, east) showing the influence of the boundary conditions;
- vertical profiles of model data vs. sonde data and satellite column data (as described in Section 4.2).

For NRT *analyses*, the report will contain the same type of plots, but, where applicable, as a function of *analysis* hour, i.e. 0 to 24 of day D-1, averaged over the season the report refers to. For ease of comparison, the curves for forecasts will be included with dotted lines in these plots.

There will be one graph for each operational model and each chemical species (O_3, NO_2, SO_2, CO, PM_{10}, $PM_{2.5}$), which shows the performance of the model compared to the Ensemble. In the case of the above surface evaluation and the boundary conditions analysis, all models will be shown in a multi-panel figure to enable easy comparison between all regional models and the global model. Of course, this option (i.e. all models in one plot) can also be chosen for the surface evaluation, to allow for easy inter-model comparisons.

Additions to be implemented during the first 18 months of the project

The following additions will be implemented during the first 18 months of the project and be fully operational by 2023:

- The evaluation of all modelled pollen species (NRT forecasts only) will be added when measurement data become readily available to CAMS2_83 and the methodology for evaluation has been fully developed with Pyaerocom/AeroVal (but no later than 2023). The inclusion of FMI as a sub-contractor in this project team will provide the link between the pollen contract CAMS2_23 and CAMS2_83 and ensure proper evaluation of model data against pollen data, which is less straightforward than for the chemical species due to the transient nature of pollen dispersal and specific needs of the pollen data users. Among those, the most-important one is the error in identification of the season start and end. It is of utmost importance for the users, both professionals and the general public. The formal definition of the pollen season for some of the CAMS species is provided in the Position paper of the European Academy of Allergology and Clinical Immunology[6]. For species not included in this paper, similar formulations will be suggested based on characteristic levels of pollen of each kind during the pollen season. The evaluation will consist of both a real-time component based on CAMS_23 WP5 Autopollen online monitoring data and the retrospective (delay of a few weeks) analysis with the EAN data supplied via CAMS_23 WPs1-4 and analogous WPs in the foreseen CAMS2_23 contract;
- FAIRMODE metrics (further explained in Section 4.7) will be implemented during the first 18 months of the project and be included in the quarterly reports no later than 2023;
- comparisons of the regional and global model performance at the surface will be added early during the project and most likely in early 2022;
- the new Model Output Statistics (MOS) recommended by CAMS_63 will be included in 2023 when they have been implemented in CAMS2_40.

Workflow

In CAMS_50 (surface evaluation) and CAMS_84 (above-surface and boundary conditions evaluation), the provision of scores and graphs was the responsibility of Meteo France and KNMI, respectively. Both sub-contractors are included in CAMS2_83 and will continue to provide these results. However, the reports will be generated at MET Norway from the beginning (first report due in January 2022) using scores and graphs from Meteo France and KNMI. However, above-surface evaluation plots may not be available in time for the first EQC reports (due in early 2022), but will be implemented as soon as possible and certainly during the transition period described above.

During the first 18 months of the project the Pyaerocom tool of MET Norway (Section 4.3) will be further developed to gradually replace the surface evaluation of Meteo France and will by 2023 create scores and graphs by itself. For this purpose, we will also establish streams of model and measurement data to MET Norway (from ECMWF's ADS and measurement providers such as EEA). KNMI will remain responsible for the above-surface evaluation and boundary condition analysis throughout the project and send plots to MET Norway for inclusion in the quarterly EQC reports.

The quarterly EQC reports will be sent out to the modelling teams of the regional service provider for commenting within a 2-week period (as has been common in the CAMS_50 NRT production and CAMS_84 validation reports), and all comments will be included in the final versions of the reports within one additional week at most. The resulting reports will then be submitted as deliverables.

4.7 Work Package CAMS2_8320

Annual EQC reports for regional reanalyses

In this WP we will provide EQC reports for the interim reanalysis (IRA) and the validated reanalysis (VRA) no later than two months after the numerical products have been delivered by the Regional Service Provider (CAMS2_40). In total, 7 EQC reports will be issued - 3 for the IRA (referring to 2021, 2022, and 2023), and 4 for the VRA (referring to 2019, 2020, 2021, and 2022). The EQC reports are intended for both service providers and users and will thus comprehensively and clearly document the various EQC comparisons and include a summary of the main findings.

We suggest that these reports be made available on AeroVal but also on the CAMS regional services QA/QC website: https://atmosphere.copernicus.eu/regional-services.

Contents of the EQC reports for IRA and VRA

All scores and graphs that until now have been included by INERIS in the CAMS_50 verification reports for the IRA and VRA reanalyses will be continued.

More specifically, for both the IRA and VRA reanalyses from all operational models and the Ensemble we will show:

- Maps of statistical scores of the Ensemble and of the individual reanalyses computed at each station dedicated to verification. Bias, RMSE and correlation are plotted on a maps with colour bars and sign according to the category of the station(rural, suburban, urban);
- Bar charts for bias, correlation and RMSE, averaged over the whole domain but also for regions (Northern, Eastern, Southern, Western Europe) also splitted according to the categories of stations (rural, suburban, urban)
- Taylor diagrams which describe the performances of the individual reanalyses together with the Ensemble on a common figure;
- Temporal evolution of the reanalyses scores over the last few years;
- Time series of threshold exceedances over the year to evaluate the temporal consistency of the pollution episode observed and those computed by the reanalyses;
- Contingency tables (false alarms, missed alarms, …) and performance diagram assessing the ability of the reanalyses to correctly represent threshold exceedances;
- for the above-surface evaluation of IRA/VRA analyses, we will provide the same type of plots as in the quarterly EQC reports of WP CAMS2_8310, but only for the Ensemble.

Evaluation will be reported for the following components: O_3 (daily max), NO_2 (daily max), SO_2(daily mean), CO (daily mean), PM_{10} (daily mean), and $PM_{2.5}$ (daily mean).

Table 4.1 summarises the list of scores that can support the evaluation process of the reanalyses based on surface data.

Table 4.1: List of scores that can support the evaluation process of the reanalyses based on surface data.

Plot	Type of indicator	Period covered	Species
Analyses vs observations	Concentration maps	Seasonal and annual of the target year	O_3, NO_2, CO , SO_2, PM_{10}, $PM_{2.5}$

Mean scores	Bias, MMB, FGE, RMSE, Correlation	Seasonal and annual of the target year	O_3, NO_2, CO , SO_2, PM_{10}, $PM_{2.5}$
Scores on exceedances	Contingency table to compare simulated and observed exceedances Performance diagram to visualize a single plot the strength and weakness of each reanalyses (individual and Ensemble)	Seasonal and annual of the target year	O_3, NO_2, CO , SO_2, PM_{10}, $PM_{2.5}$
Taylor Diagrams	correlation, ratio of standard deviation	Seasonal and annual of the target year	O_3, NO_2, CO , SO_2, PM_{10}, $PM_{2.5}$

Additions to be implemented during the first 18 months of the project

The following additions will be implemented during the first 18 months of the project and be fully operational by 2023:

- FAIRMODE metrics will be implemented during the first 18 months of the project. After the interesting tests undertaken by CAMS_50 on several recent reanalyses evaluations, the objective will be to definitively include FAIRMODE metrics in the annual EQC reports no later than 2023; FAIRMODE metrics will be included in the verification reports associated to each new reanalyses (interim and validated). So-called target diagrams and summary reports as developed and used by FAIRMODE[5] will be created for O_3, NO_2, PM_{10} and $PM_{2.5}$ and support the assessment about the quality of reanalyses. Target diagrams are convenient ways to visualize model performance in terms of bias on the y-axis and CRMSE (Centralised RMSE) on the x-axis. Such scores and plots will be produced with the Evaltool software (developed by MétéoFrance and CNRS in open access under the CECILL-C licence and briefly described in Section 4.3);
- full harmonization of the verification processes used in the IRA/VRA (this WP) done by INERIS and the NRT (WPs CAMS2_8310 and CAMS2_8330) evaluations done by Meteo France will be considered, as these use the same Python library, Evaltools (developed during CAMS_50 and briefly described in Section 4.3). The choice of statistics and types of plots are different in the reports that are currently issued in the CAMS_50 and CAMS_71 projects. During the CAMS2_83 project, the possibility for some evolutions in the diagnostics, and for some harmonization of the plots in the daily/quarterly NRT and the annual IRA/VRA evaluations, will be discussed. For example, displaying all the models in the same plots (as is done in the IRA/VRA reports) may be an option for the NRT reports, too. In the web interface this can be chosen by the user (by switching on/off subsets of models). In addition to harmonizing the plots and tools, we will also consider harmonising the set of observation data to be used for assessment and assimilation. It was concluded during the current CAMS 50.II service that it is not obvious how to harmonize, but we will continue this effort during CAMS2_83;

- by 2023, the IRA/VRA reanalyses will be evaluated *above-surface* also for *individual models* (and not only for the Ensemble).

Workflow

INERIS will do the surface evaluation, while KNMI will provide plots for the above-surface evaluation.

Surface evaluation. The acquisition of model data (all individual reanalyses and the ENSEMBLE) will be done by Ineris once a year for each reanalysis stream (interim and validated) when data are available. The gathering of data will be on all pollutants considered for the ground-based evaluations. INERIS will also get information from CAMS2_40 about the splitting of stations (available from the European Environment Agency (EAA)) between those selected for assimilation and the others that will be used in this CAMS2_83 service for verification. Indeed, the computations of scores are restricted to this independent list of stations not assimilated by models when they compute reanalyses. Models and observations in-situ datasets will feed *evaltools* for the computations of scores described above. Maps and plots will support the writing of the EQC reports for interim and validated reanalyses.

Above-surface evaluation. The above-surface evaluation will be done by KNMI along the same lines as in WPs CAMS2_8310 and CAMS2_8330. Also in this case, assimilated data will not be used for the evaluation (in case any of the regional models should decide to assimilate any of the above-surface measurements used in CAMS2_83 (see section 4.2).

Report internal review. One could consider sending out the EQC reports to the modelling teams for commenting and include their comments in the final versions of the reports to be submitted as deliverables. This would mean that they become available to users about two weeks later, but with the advantage that modelling teams can contribute with their expertise before the reports are made public.

4.8 Work Package CAMS2_8330

The CAMS2_83 web interface

In this WP we will maintain and further develop specific daily-updated evaluation statistics and graphics for the past day, the past week and the past 3 months for the NRT analyses and forecasts, which are provided by the Regional Service Provider. This will be targeted at giving insight into the difference in performance between the individual members and the ensemble, the different European geographical areas as well as a function of the forecast horizon and of local time.

We will also maintain a web-based visualisation tool for giving insight on the ensemble and individual Regional Systems' performance over past quarters (SON, DFJ, MAM, JJA), at least the 8 last quarters, for all the observed pollutants and for all the sites considered in the corresponding EQC reports.

Such tools were already developed by Meteo France and MET Norway in CAMS_50 and CAMS_61, respectively (see e.g. https://regional.atmosphere.copernicus.eu/evaluation.php?interactive=cdf and https://aerocom-evaluation.met.no/main.php?project=cams61), but will in CAMS2_83 be merged in the new AeroVal tool of MET Norway (and also provide input to the quarterly EQC reports in WP CAMS2_8310).

The web interfaces (both at Meteo France and MET Norway) are based on the same statistics as the published quarterly EQC reports and are presented in the form of a zoomable geographical map,

allowing users to select sites and to obtain the statistical data and/or graphics corresponding to their selection.

AeroVal, which so far has been used only for CAMS_50 forecast data from previous years (and only for surface evaluation) cannot be fully operational with new model data from the beginning of the project. Meteo France will therefore continue the (automatized) evaluation, until now done in CAMS_50, ensuring seamless continuation of already existing evaluation products. During a transition period (estimated at about 18 months), the graphics will thus be shown at Meteo France (continuation of the visualizations developed in CAMS_50) but gradually replaced by MET Norway's AeroVal web interface. Similar to Meteo France's web interface, AeroVal will be embedded in the CAMS website. After the transition period, AeroVal will be ready to take over the entire set of evaluations produced in CAMS2_83. The contents of the evaluation pages are explained in more detail in the paragraphs below.

Status of already existing evaluation pages

For the whole domain (i.e. not country- or site-level), the following graphs are available at the server of Meteo France (see https://www.regional.atmosphere.copernicus.eu/ under 'Verification Results' and https://www.regional.atmosphere.copernicus.eu/evaluation.php?interactive=cdf):

- Median scores: Bias, modified mean bias, root mean square error, fractional gross error, and correlation, as a function of forecast hour (0-96), averaged over the last 3 months and the whole regional domain, for all models and species. The basetime can be chosen up to one month back in time;
- Taylor diagrams: forecast (for day D0) performance, averaged over the last week or the last 3 months and the whole model domain, for all models and species. The basetime can be chosen up to one month back in time;
- hourly time series: Bias, modified mean bias, root mean square error, fractional gross error, and correlation, as a function of forecast hour (0-24, either for D0 or D1 or D2 or D3 of the forecast, and displayed for the last 4 days up to a base time that can be chosen by the user (up to one month back in time);
- daily time series: Bias, modified mean bias, root mean square error, fractional gross error, and correlation of the daily mean (day D0). Base time can be chosen up to one month back in time;
- maps of modelled concentrations forecasts and analysis with observations superimposed as circles;
- bias, modified mean bias, root mean square error, fractional gross error, and correlation, as a function of the forecast (for day D0), as function of season (last 8 elapsed seasons), for all models, and for ozone, NO2, PM2.5 and PM10.

At country- and site-level, the following graphs are available at the server of Meteo France (see https://www.regional.atmosphere.copernicus.eu/evaluation.php?interactive=cdf for forecasts/NRT, https://regional.atmosphere.copernicus.eu/evaluation.php?interactive=cda for analyses/NRT, http://macc-raq-int.meteo.fr/cds/timeseries/forecast/scores_ts_F.html for forecasts/quarterly, and http://macc-raq-int.meteo.fr/cds/timeseries/analysis/scores_ts_A.html for analyses/quarterly):

- Bias, modified mean bias, root mean square error, fractional gross error, and correlation, as a function of forecast hour (0-96), averaged over a season chosen by the user (among the last 8 seasons) for all models, and for ozone, NO_2, $PM_{2.5}$ and PM_{10};

- bias, modified mean bias, root mean square error, fractional gross error, and correlation, as a function of analysis hour (0-24), averaged over a season chosen by the user (among the last eight seasons) for all models, and for ozone, NO_2, $PM_{2.5}$ and PM_{10};
- time series of hourly modeled and measured concentrations (for a period of up to about two years back in time can be chosen by the user);
- time series of daily bias, modified mean bias, root mean square error, fractional gross error, and correlation (for a period of up to about 2 years back in time can be chosen by the user).

These visualizations will be continued during the first 18 months of CAMS2_83.

MET Norway's AeroVal was tailored in CAMS2_61 to evaluate forecasts from the CAMS regional and global models. Graphs and scores that are displayed for each model and the Ensemble (e.g. https://aerocom-evaluation.met.no/intercomp.php?project=cams61&exp=2018-day1) include:

- Time series of spatial and temporal correlations, normalized mean bias, modified normalized mean bias, fractional gross error for the whole domain, at country- and at station level, against EEA rural and EEA urban stations, or various ranges of site (representativeness) classifications, for NO_2, O_3 daily maximum, $PM_{2.5}$ and PM_{10};
- linear regression analysis for the whole domain; same species as above;
- heatmaps giving a quick overview of the performances of many models and species;
- same statistics as above for the CAMS global model (so far available only for Aerosol Optical Depth and the Angstrom exponent, but the tool is easily extendable to other species) (https://aeroval.met.no/overall.php?project=cams84&exp_name=eval&tab=timeseries#)

Additions to be implemented during the first 18 months of the project

The Pyaerocom tool and the AeroVal web interface will in CAMS2_83 be modified to evaluate the CAMS regional and global models for the last day, the last week, the last 3 months and the last 8 seasons. The plots for the last 8 seasons will also include the latest (not fully elapsed) season up to the present day.

For the NRT evaluation (last day, last week), streams of NRT model and measurement data directly to MET Norway will be established. Nevertheless, it is envisaged that Meteo France will keep its evaluation scripts developed during CAMS_50 (or MET Norway's Pyaerocom scripts) running at Meteo France for the entire project period and only send json files to MET Norway, which can then be visualized by AeroVal. If the NRT model and measurement data streams to MET Norway turn out to be fast enough, MET Norway will run their Pyaerocom scripts in house also for the NRT evaluation.

The AeroVal web interface will combine all evaluations in the lists above, but presented in a new layout and embedded in the CAMS web site. The evaluations will be enhanced to cover above-surface aspects, to be produced at KNMI (against data mentioned in Section 4.2). Furthermore, the outcome of the new Model Output Statistics (MOS) recommended by CAMS_63 that will be implemented in CAMS2_40 will be integrated in the evaluation process once available in CAMS2_40 operational production, as well as metrics proposed by FAIRMODE (explained in Section 4.7). Close interaction with FAIRMODE will also be ensured through the attendance of FAIRMODE meetings by one or more CAMS2_83 project team members. Finally, pollen will be included when measurements are readily available, but only during the pollen season, consisting of a limited set in NRT and a full-data set evaluation after the end of the season.

The exact layout and contents of the web page should be discussed during the transition period (during which the Meteo France servers will be kept running), but the objective will in any case be to have a harmonized web interface where both users and providers can easily find the evaluation graphs and scores they are looking for.

In any case, the purpose of this web interface will be to allow users to judge model performance in near real time but also follow the evolution over time as a function of season. Providers of regional model results will make use of the web interface to detect any model deficiencies as early as possible (we are also going to inspect model performance on a daily basis, except weekends and holidays, and notify model teams in case of obvious discrepancies), or to evaluate improvements over time. In addition, the different statistics will help model teams to devise strategies for further model improvement.

4.9 Work Package CAMS2_8340

In this work package we will provide support to users of the delivered products and services. We will contribute to ECMWF's centralised Copernicus Service Desk, which provides multi-tiered technical support to all users of CAMS data, products, tools and services.

The Work package will be led by MET Norway, who is leading the user support work package in CAMS_81 since 2015 and until the end of October 2021 and thus can build on experience gained there. Early on in the project, a generic e-mail address will be established that the CAMS Service Desk can use in cases where Level 1 support (provided by ECMWF) cannot handle a user query raised in the JIRA system of ECMWF. In these cases, MET Norway will provide Level 2 support or forward the queries to relevant CAMS2_83 sub-contractors to provide Level 3 support. At least 80% of the assigned specialised user queries will be resolved within 15 days after being informed by the CAMS Service Desk.

CAMS2_83 will also contribute to the delivery of multi-tiered technical support for the data and services we provide, and to the CAMS Knowledge Base, user guides, the online Forum (when needed), tutorials etc.

The products of CAMS2_83 focus on the evaluation of forecasts and analyses provided by regional CAMS models. We will thus provide documentation of how the evaluations are done (species, used measurement data, statistics, etc.). These will be intended for the CAMS Knowledge Base and linked from the Atmosphere Data Store, and, if more detail is required, in reports that will be available to users through the CAMS website. The documentation in the Knowledge Base will be targeted at the general external user community, while the additional detailed reports will address the needs of expert users. Methodologies of evaluation have been provided in earlier CAMS contracts (mainly CAMS_50 and CAMS_84), but will in CAMS2_83 be updated in line with new developments.

While user engagement and training activities are not part of the scope of this ITT, we accommodate for eventual needs in providing technical and scientific expertise in support of these activities.

As specified in the CAMS2_83 ITT, requests to support activities may be raised on for example:

- Contribute with content specific input to training, education and capacity building material: development and/or review of learning resources in the domain of the contract, participation in train-the-trainer events and MOOCs (Massive Open Online Courses);

- contribute with content specific input to user-oriented communication material such as slides, story maps and user testimonials;
- contribute and attend User Uptake workshops and stakeholder meetings. Presentations in your mother tongue may be asked to be provided;
- input to the URDB with user requirements (cf. template as provided during the negotiation process) as well sharing needs and aspirations as raised by potential new user communities.

We suggest the following experts to provide this support: A. Mortier (technical aspects of surface evaluation), H. Fagerli (user support aspects), J. Palamarchuk (pollen aspects) and A. Ung (statistics and metrics).

We allocate a maximum budget of 5,000.- EUR to accommodate for these needs. Details on the required activities will be refined as part of the Annual Implementation Plans in WP CAMS2_8300.

As part of the CAMS user interaction, user requirements are continually collected in a User Requirements Database (URDB) in a structured and traceable way. CAMS2_83 will provide input to the User Requirements Database (URDB) regarding user requirements that are directly related to activities covered by the project. We will also support ECMWF and the contractor for User Interaction activities with the analysis of relevant user requirements in the URDB.

4.10 Summary of equipment

In Table 4.2 we identify and summarize the equipment (including hardware and software) to be used (by itself or by any sub-contractors) for the provision of the Service. The table also indicates whether equipment is owned, needs to be purchased or will be leased/rented, and which software is to be considered as Background IPR (Intellectual Property Rights) in this contract (Clause 3.3 of the *Terms and Conditions*).

More detailed technical descriptions of key tools to be employed in CAMS2_83 were provided in Section 4.3.

Table 4.2: 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	(for software) Background IPR
MET Norway				
Lustre PPI (post-processing infrastructure) at MET Norway	Hardware used for downloading, storing, and post-processing of model results	WP CAMS2_8310, WP CAMS2_8320, WP CAMS2_8330	Owned	
Pyaerocom	Software used for analysing model results and model performance	WP CAMS2_8310, WP CAMS2_8320, WP CAMS2_8330	Owned	Yes

AeroVal	Software used for visualization of model performance	WP CAMS2_8310, WP CAMS2_8320, WP CAMS2_8330	Owned	Yes
Meteo France				
Storage	For all model datasets/measurements storage	WP CAMS2_8310, WP CAMS2_8330	Owned	
Bandwidth	Bandwidth	WP CAMS2_8310, WP CAMS2_8330	To be Leased	
Measuring Probes	Software to monitor Website operation and utilization	WP CAMS2_8330	To be purchased	
KNMI				
Supercomputer (Bull),	storage (disk/tape archive), network and internet facilities	WP CAMS2_8310, WP CAMS2_8320, WP CAMS2_8330	owned	
LOTOS-EUROS Air Quality Model including required software libraries	NetCDF, hdf, etc.) and Software shell for running KNMI's operational applications	WP CAMS2_8310, WP CAMS2_8320, WP CAMS2_8330		Yes
INERIS				
Research high performance computer	HPC hosted by CEA for post-processing and EQC	WP CAMS2_8320	In leasing	
Operational High Performance Computer Cluster with high level of service	CCA HPC hosted by ECMWF for post-processing and EQC	WP CAMS2_8320	In kind access	
Air quality verification processing	Set of in-house tools and scripts allowing to evaluate the individual and ENSEMBLE reanalyses.	WP CAMS2_8320		yes

Evaltools: Air quality verification processing	Set of in-house tools and scripts developed on the basis of initial developments of CNRM/Meteo-France allowing to evaluate the individual and ENSEMBLE analyses.	WP CAMS2_8330		No (CNRM)
FMI				
Pollen retrospective evaluation suite	A set of Python modules for handling pollen data and model predictions, with output meeting the needed list of quantities	WP CAMS2_8310, WP CAMS2_8330	owned	Yes, GPL license

4.11 Deliverables Management

All deliverables of CAMS2_83 that can be archived (i.e. graphs, reports and product documentation generated in CAMS2_83) will be archived at MET Norway for at least six (6) years after the contract (ref. Clause 5.1.1 of the *Terms and Conditions*). Upon request, ECMWF and the European Commission should be able access the Deliverables.

There are no deliverables that will be subject to third party Intellectual Property Rights or will have to be considered as Improvements. Any software that is used to produce the deliverables of CAMS2_83 (graphs, reports and product documentation) and that has to be considered as Background IPR was identified in Table 4.2 in Section 4.10.

4.12 References

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5 Management and implementation plan

5.1 Introduction

Prime contractor: MET Norway

MET Norway, as ECMWF's contractor, will be responsible for all management aspects of the project (Work Package CAMS2_8300, see Section 4.5), including:

- Fitness for purpose and quality of the services and products delivered
- Timeliness of deliverables
- Communication and interaction with users
- Interface with ECMWF on scientific, technical and administrative aspects
- Management of scientific, technical and administrative aspects
- Coordination and management of the sub-contractors

Michael Gauss is the contract and project manager. He has previous experience in project leadership but will also be supported by Hilde Fagerli and Michael Schulz. Michael Gauss will also be the main responsible for reporting in WPs CAMS2_8300, CAMS2_8310, CAMS2_8330, and CAMS2_8340.

MET Norway's technical team (mainly Hans Brenna and Augustin Mortier) will be dealing with the technical aspects of the project, in particular WPs CAMS2_8310 and CAMS2_8330.

MET Norway will build on its vast experience from earlier CAMS contracts it has been involved in, mainly CAMS_61 (regional modelling aspects and evaluation), but also CAMS_50 (AQ forecasts and analyses), CAMS_84 (evaluation), and CAMS_81 (user support).

At MET Norway, all administrative tasks, related to interactions with ECMWF and with sub-contractors will be managed by Per Helmer Skaali from the financial services. He will be ECMWF's contact at MET Norway for all administrative and financial issues. He has previous experience from numerous other CAMS and C3S contracts, also with coordinating roles.

Timeshare: 17.3 person months in total (of which A. Mortier: 5.1; D. Heinesen: 4.7; M. Gauss: 4.5; H. Fagerli: 2; M. Schulz: 1).

Sub-contractors

Meteo France: Meteo France will be mainly involved in the surface evaluation (scores and graphs) of WPs CAMS2_8310 and CAMS2_8330 and contribute with its tools and experience from CAMS_50.

Timeshare: 10.83 person months in total (of which V. Petiot: 6.3; M. Joly: 2.56; Loïc Martin: 1.1; E. Blot: 0.88).

KNMI: with their experience as leader of CAMS_84, KNMI will be responsible for the above-surface evaluation in WPs CAMS2_8310, CAMS2_8320, and CAMS2_8330, and the boundary conditions assessments of WP CAMS2_8310. As sub-contractor to KNMI, CNRS-LAERO will deal with the above-surface evaluation against IAGOS measurement data in particular. Timeshare: 13.92 person months in total (of which J. Douros: 6.65; Y. Bennouna: 5.05; H. Eskes: 2.22).

INERIS: INERIS will deal with the IRA/VRA evaluation in WP CAMS2_8320 (as continuation of the corresponding task in CAMS_50), and be responsible for the inclusion of new metrics suggested by FAIRMODE. Timeshare: 5 person months in total (of which B. Raux: 3.7; A. Colette/F. Meleux : 0.75; A. Ung: 0.55).

FMI: FMI will contribute to the proper evaluation of pollen, building on their experience in CAMS_23 and their pollen module development work in CAMS_50 and precursor projects. Timeshare: 1.78 person months in total (of which J. Palamarchuk: 1.18; M. Sofiev: 0.6).

All sub-contractors confirmed formally their interest in contributing to this project team led by MET Norway. Conflicts, if any, will be resolved according to the terms of the contracts set between MET Norway and its sub-contractors.

Bilateral phone meetings between MET Norway and its sub-contractors during the first 2 months of the project will ensure an efficient start of the various services to be provided in CAMS2_83 (partly as a continuation from the previous CAMS_50 and CAMS_84 contracts). During a face-to-face kickoff meeting, to be held in early 2022, plans will be made in more detail, focussing essentially on technical aspects, but also on reporting and user interaction.

Monitoring, reporting and planning activities

The various technical tasks will be allocated to task leaders at MET Norway and in the sub-contracting organizations. Distributing task management will allow us to share management activities and to motivate all the contributors as well, giving them responsibilities in the achievement of the project. Each task leader will be responsible for the products and deliverables associated with their task, and for the milestone completion.

The project manager will organize regular phone or video conferences (at least quarterly, but monthly if needed), where all contractors will be represented. When needed, in regard to issues that can arise during the project, ECMWF may be invited to participate in those meetings.

Progress and results will be formally reported to ECMWF through monthly teleconferences, organized by ECMWF where the Project manager will attend.

MET Norway plans to attend several meetings organized by ECMWF which are essential for monitoring progress of work:

- CAMS General Assemblies within EU member states;
- six-monthly project review meetings organized by ECMWF (linked to Payment milestones);
- additional meetings (with users, country or European authorities), for which ECMWF would require MET Norway's support in order to present the CAMS policy products and how to implement them.

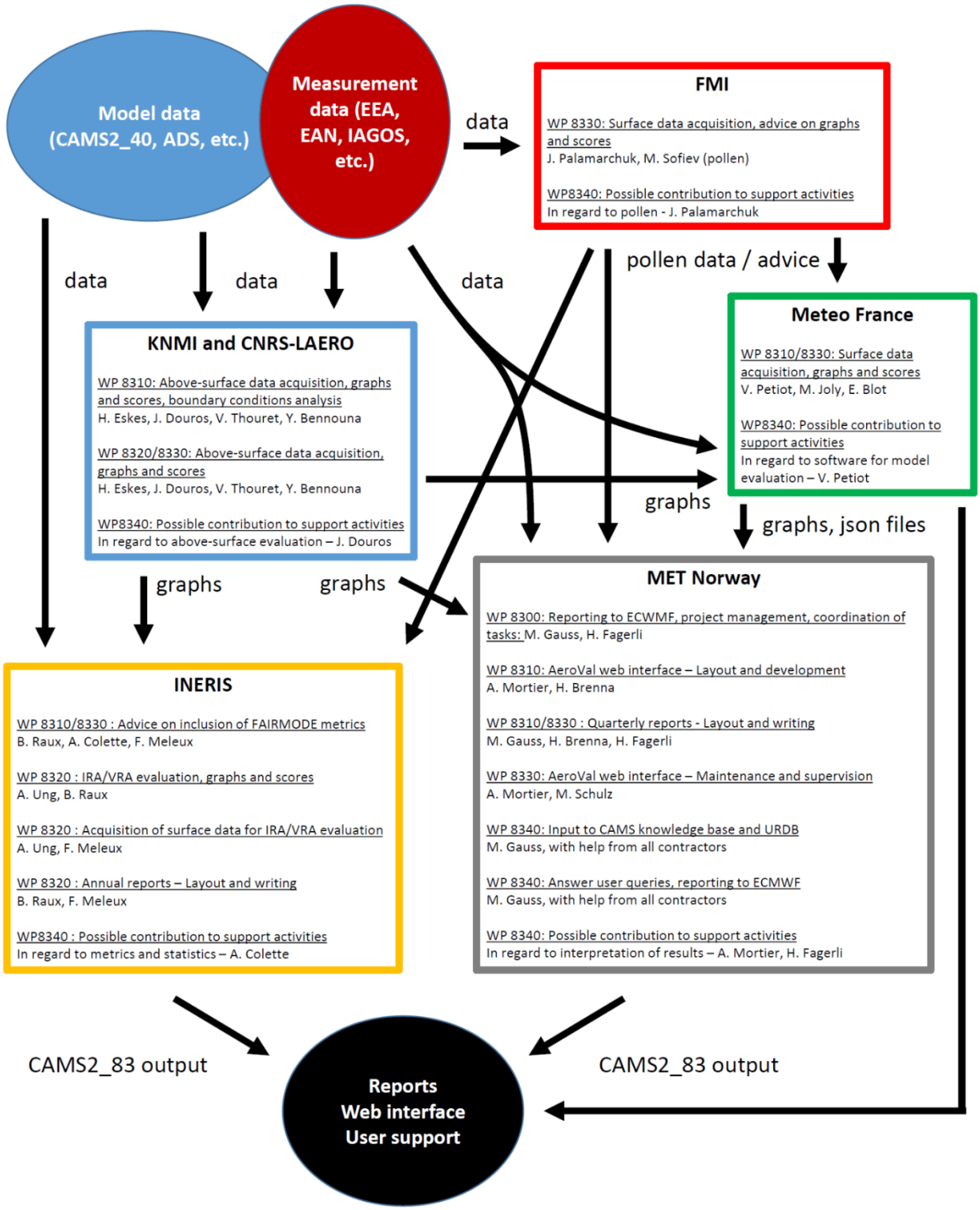
According to the clause 2.3 of the framework agreement, a number of reports have to be delivered to monitor progress of the implementation of the service tasks:

- The annual implementation reports describe the work carried out and the achievements of the previous year, regarding implementation of the work plan;
- The annual preliminary financial forms delivered by January each year, including information about the completion of the service contract over the previous year: estimate of the percentage completion of each Milestone and Deliverable, amount invoiced as at 31 of December of the previous Year, any comments on ongoing activities and Services, and justification of any deviation from the Implementation Plan and an estimate of the expected completion date for delayed Milestones;
- The quarterly implementation reports, describing achievements and progress of work for the previous quarter. They detail deliverables, compliance with the milestones, solutions to fix potential deviations from the implementation plan.

The implementation plan is reviewed and revised each year. A draft version will be submitted to ECMWF by the end of September each year for the year thereafter. It describes in detail the activities to develop and deliver the services, the Deliverables and the Milestones.

5.2 Organigram

The organigram below reflects how MET Norway and its sub-contractors will work together. Reporting (done by INERIS in WP CAMS2_8320 and by MET Norway in the other WPs), as well as names and functions of individuals are indicated. ('CAMS2' is omitted in WP names in the organigram.)



5.3 Gantt chart and PERT chart

In this sub-section we present a Gantt chart to illustrate the schedule of activities and a PERT chart visualising the critical linkages and dependencies between work packages and tasks.

Given the length of this project, the table is divided into two parts, the first (Table 3a) extending from November 2021 to July 2023, and the second one (Table 3b) from August 2023 to April 2025.

Table 3a: Gantt chart illustrating the schedule of activities (Nov 2021 - July 2023).

	2021		**2022**												**2023**						
	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J
WP CAMS2_8300																					
Interaction with sub-contractors																					
Quarterly implem. reports			D			D			D			D			D			D			D
Annual implem. reports				D												D					
Preliminary financial forms			D												D						
Annual implem. plans										D											
Updated KPIs (list, targets, …)														D							
WP CAMS2_8310																					
Generating scores and graphs																					
Quarterly EQC reports			D			D			D			D			D			D			D

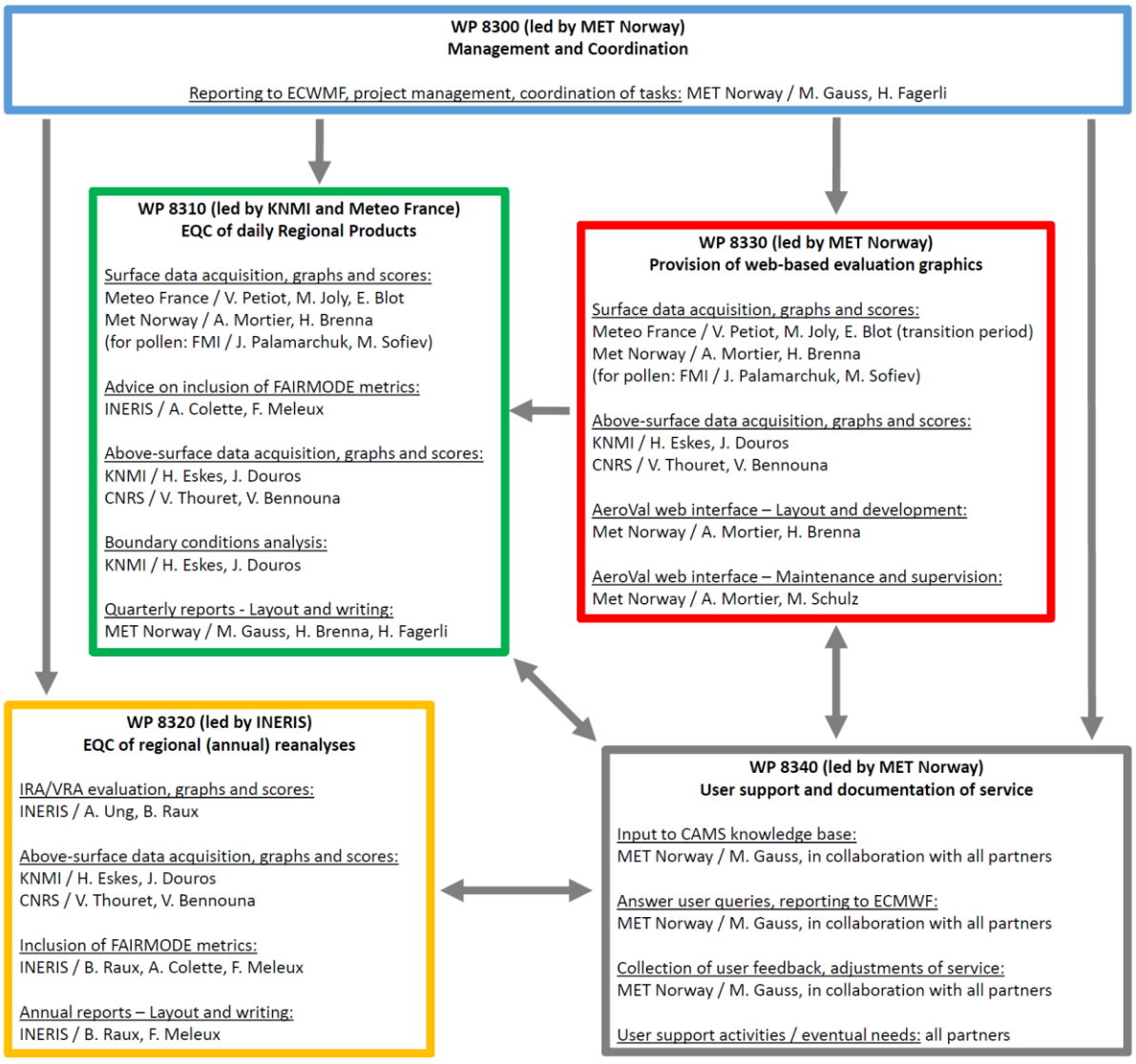
WP CAMS2_8320																					
Processing IRA evaluation																					
IRA evaluation reports							D												D		
Processing VRA evaluation																					
VRA evaluation reports	D											D									
Including FAIRMODE metrics																					
WP CAMS2_8330																					
Meteo F web interf.																					
AeroVal web interf.																					
web interf. reports				D			D			D			D			D			D		
WP CAMS2_8340																					
Answering user queries																					
Input to CAMS knowledge								D												D	
Input to CAMS URDB													D								
User engagemt. activities																					

Table 3b: Gantt chart illustrating the schedule of activities (Aug 2021 - Apr 2025).

	2023					2024												2025			
	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A
WP CAMS2_8300																					
Interaction with sub-contractors																					
Quarterly implem. reports			D			D			D			D			D			D			D
Annual implem. reports							D												D		
Preliminary financial forms						D												D			
Annual implem. plans		D												D							
WP CAMS2_8310																					
Generating scores and graphs																					
Quarterly EQC reports			D			D			D			D			D			D			D
WP CAMS2_8320																					
Processing IRA evaluation																					
IRA evaluation reports										D											
Processing VRA evaluation																					
VRA evaluation reports			D												D						

Updating FAIRMODE metrics																					
WP CAMS2_8330																					
Meteo F web interf.																					
AeroVal web interf.																					
Web interf. reports	D			D			D			D			D			D			D		
WP CAMS2_8340																					
Answering user queries																					
Input to CAMS knowledge											D										
Input to CAMS URDB				D												D					
User engagemt. activities																				D	

As this project is mainly about data flows, evaluation and visualization, the dependencies between tasks are critical to understanding the technical solution and thus are visualized in Figure 1 of this work plan (Section 4.4). The PERT chart below only briefly summarizes the critical linkages between work packages and, in contrast to Figure 1, also includes the coordination and user support Work Packages CAMS2_8300 and CAMS2_8340. ('CAMS2' is omitted in the WP names in the PERT chart.)



5.4 Work package descriptions

In the following tables key information about the 5 Work packages are summarized. More detailed descriptions of each Work Package are found in Sections 4.5 to 4.9.

Table 3.1: WP CAMS2_8300

Work package #	WP CAMS2_8300	**Start/End date**	**M1/M42**
Work package title	**Management and coordination**		

Main objectives

- Ensure a smooth workflow and timely provision of deliverables
- Ensure optimal collaboration between contractors

Description of activities

Task 8301 : This WP has one task - management and coordination of the project team. The deliverables consist of quarterly implementation (progress) reports, annual implementation (progress) reports, preliminary financial forms (each year), and annual implementation plans. In addition, the key performance indicators will be updated with ECMWF after the first year of the project, and a final report will be written and made available 2 months after the end of the project. To ensure that the progress of the project is in line with ECMWF's expectations, review meetings will be held with ECMWF about every 6 months. Regular meetings will also occur among the contractors of CAMS2_83, at least once every quarter, and most probably by video-conferencing.

For a more detailed description of this Work Package, please see Section 4.5 of this work plan.

WP CAMS2_8300 Deliverables

#	Type	Title	Due
D83.0.1.1-2022Q1	Report	Quarterly Implementation Report Q1 2022 (covering Jan/Feb/Mar 2022)	M6 (Apr 2022)
… every quarter …	*… every quarter …*	*… every quarter …*	*… every quarter (except Oct/Nov/Dec)*
D83.0.1.1-2025Q1	Report	Quarterly Implementation Report Q1 2025 (covering Jan/Feb/Mar 2025)	M42 (Apr 2025)
D83.0.1.2-2021	Report	Annual Implementation Report for 2021	M4 (Feb 2022)
… every year …	*… every year …*	*… every year …*	*… every year …*
D83.0.1.2-2024	Report	Annual Implementation Report for 2024	M40 (Feb 2025)
D83.0.1.3-2021	Other	Preliminary financial form for 2021	M3 (Jan 2022)
… every year …	*… every year …*	*… every year …*	*… every year …*

D83.0.1.3-2024	Other	Preliminary financial form for 2024	M39 (Jan 2025)
D83.0.1.4-2023	Report	Implementation plan for 2023	M11 (Sep 2022)
D83.0.1.4-2024	Report	Implementation plan for 2024	M23 (Sep 2023)
D83.0.1.4-2025	Report	Implementation plan for 2025	M35 (Sep 2024)
D83.0.1.5-2021	Other	Copy of prime contractor's general financial statements and audit report 2021	M8 (Jun 2022)
… every year …	*… every year …*	*… every year …*	*… every year …*
D83.0.1.5-2024	Other	Copy of prime contractor's general financial statements and audit report 2024	M44 (Jun 2025, 60 days after end of contract)
D83.0.1.6	Other	Updated KPIs (list, targets...) after review with ECMWF	M13 (Nov 2022)
D83.0.1.7	Report	Final report	60 days after end of contract

WP CAMS2_8300 Milestones			
#	**Title**	**Means of verification**	**Due**
M83.0.1.1	Progress review meeting with ECMWF / Payment milestones	Minutes of meeting	M6
… every 6 months...	… every 6 months...	… every 6 months...	… every 6 months...
M83.0.1.7	Progress review meeting with ECMWF / Payment milestones	Minutes of meeting	M42

Table 3.2: WP CAMS2_8310

Work package #	WP CAMS2_8310	**Start/End date**	**M1/M42**
Work package title	**EQC of daily Regional Products**		

Main objectives

- Issue quarterly reports on the performances of the CAMS regional models and the ensemble
- Include both surface and above-surface evaluation
- Assess the correct uptake of boundary conditions and compare performances between the regional and global models of CAMS

Description of activities

Task 8311 : Surface evaluation

Scores and graphs for the surface evaluation of the CAMS regional models and the Ensemble will be produced at Meteo France (until 2023) and MET Norway (from 2023 at the latest) and be included in the quarterly EQC reports of Task 4. They will also feed into the web interface of WP CAMS2_8330.

Task 8312 : Above-surface evaluation

Scores and graphs for above-surface evaluation will be produced at KNMI (with help from CNRS-LAERO) and be included in the quarterly EQC reports of Task 4. They will also feed into the IRA/VRA evaluation reports and the web interface of WP CAMS2_8330.

Task 8313 : Effect of boundary conditions

Graphs illustrating the uptake of boundary conditions by the CAMS regional models will be produced at KNMI and be included in the quarterly EQC reports of Task 4.

Task 8314 : Production of quarterly EQC reports

In total, 14 quarterly EQC reports for the NRT forecasts and analyses will be produced at MET Norway over the course of the project, with input from the three previous tasks, containing scores and graphs for each of the operational systems as well as the Ensemble. The reports will also contain comparisons of performance between the CAMS regional and global models, as well as illustrations of the uptake of boundary conditions by the regional models. During the project, the evaluation of pollen will be included, and new metrics suggested by FAIRMODE will be used. The new Model Output Statistics (MOS), as recommended by CAMS_63, will be included in the evaluation in 2023.

The first report will be issued in February 2022 and cover the period SON2021, while the last report will be due in April 2025 and cover the period DJF 2024/25.

For a more detailed description of this Work Package, please see Section 4.6 of this work plan.

WP CAMS2_8310 Deliverables

#	Type	Title	Due
D83.1.4.1-2021Q4	Report	Quarterly EQC report for the NRT forecasts and analyses, for each of the operational systems as well as the ensemble (for SON 2021)	M4 (Feb 2022)
… every quarter...	… every quarter...	… every quarter...	… every quarter...
D83.1.4.1-2025Q1	Report	Quarterly EQC report for the NRT forecasts and analyses, for each of the operational systems as well as the ensemble (for DJF 2024/25)	M42 (Apr 2025)

Table 3.3: WP CAMS2_8320

Work package #	WP CAMS2_8320	**Start/End date**	**M1/M36**
Work package title	**EQC of regional (annual) reanalyses**		

Main objectives

- Perform a detailed evaluation of the CAMS regional systems' interim and validated reanalysis results after these have been provided by CAMS2_40

- Issue annual reports on the results from this evaluation, both for the interim reanalysis (spring each year, for the year before) and the validated reanalysis (autumn each year, for two years before)

Description of activities

Task 8321 : Evaluation of the interim reanalysis results from each regional model and the Ensemble

3 reports will be issued from this task by INERIS, containing the evaluation results from all regional models for the interim reanalysis for 2021, 2022 and 2023. The reports will be provided by the end of May in the year after the year they refer to. In addition to surface evaluation, the reports will also include an evaluation against above-surface evaluation provided by KNMI. The species to be evaluated are O_3 (daily max), NO_2 (daily max), SO_2(daily mean), CO (daily mean), PM_{10} (daily mean), and $PM_{2.5}$ (daily mean). Scores to be shown are bias, correlation and RMSE, averaged over the whole domain but also for regions (Northern, Eastern, Southern, Western Europe). Performances for representing the threshold exceedances are also assessed. FAIRMODE metrics will be definitely implemented during 2022 in the EQC report for IRA 2021.

Task 8322 : Evaluation of the validated reanalysis results from each regional model and the Ensemble

4 reports will be issued from this task by INERIS, containing the evaluation results from all regional models for the validated reanalysis for 2019, 2020, 2021 and 2022. The reports will be provided by the end of October two years after the year they refer to (except the first one, which will be provided in January 2022 as the project starts only in November 2021). In addition to surface evaluation, the reports (except the first one) will also include an evaluation against above-surface evaluation provided by KNMI. The species to be evaluated are O_3 (daily max), NO_2 (daily max), SO_2, CO, PM_{10} (daily mean), and $PM_{2.5}$ (daily mean). Scores to be shown are bias, correlation and RMSE, averaged over the whole domain but also for regions (Northern, Eastern, Southern, Western Europe). Performances for representing the threshold exceedances are also assessed. FAIRMODE metrics will be definitely implemented during 2022 in the EQC report for VRA 2020.

For a more detailed description of this Work Package, see Section 4.7 of this work plan.

WP CAMS2_8320 Deliverables

#	Type	Title	Due
D83.2.1.1-2021	Report	Annual EQC report for the interim reanalysis for 2021, for each of the operational systems as well as the ensemble	M7 (May 2022)
D83.2.1.1-2022	Report	Annual EQC report for the interim reanalysis for 2022, for each of the operational systems as well as the ensemble	M19 (May 2023)
D83.2.1.1-2023	Report	Annual EQC report for the interim reanalysis for 2023, for each of the operational systems as well as the ensemble	M31 (May 2024)
D83.2.2.1-2019	Report	Annual EQC report for the validated reanalysis for 2019, for each of the operational systems as well as the ensemble	no later than 2 months after the VRA for 2019 has been published
D83.2.2.1-2020	Report	Annual EQC report for the validated reanalysis for 2020, for each of the operational systems as well as the ensemble	no later than 2 months after the VRA for 2020 has been published (~M12, Oct 2022)
D83.2.2.1-2021	Report	Annual EQC report for the validated reanalysis for 2021, for each of the operational systems as well as the ensemble	no later than 2 months after the VRA for 2021 has been published (~M24, Oct 2023)
D83.2.2.1-2022	Report	Annual EQC report for the validated reanalysis	no later than 2 months after

		for 2022, for each of the operational systems as well as the ensemble	the VRA for 2022 has been published (~M36, Oct 2024)

WP CAMS2_8320 Milestones			
#	**Title**	**Means of verification**	**Due**
M83.2.1.1-2021	IRA 2021 model data available from Regional Service Provider	Model database at INERIS	M5 (Mar 2022)
M83.2.1.1-2022	IRA 2022 model data available from Regional Service Provider	Model database at INERIS	M17 (Mar 2023)
M83.2.1.1-2023	IRA 2023 model data available from Regional Service Provider	Model database at INERIS	M29 (Mar 2024)
M83.2.2.1-2019	VRA 2019 model data available from Regional Service Provider	Model database at INERIS	M1 (Nov 2021)
M83.2.2.1-2020	VRA 2020 model data available from Regional Service Provider	Model database at INERIS	M10 (Aug 2022)
M83.2.2.1-2021	VRA 2021 model data available from Regional Service Provider	Model database at INERIS	M22 (Aug 2023)
M83.2.2.1-2022	VRA2022 model data available from Regional Service Provider	Model database at INERIS	M34 (Aug 2024)

Table 3.4: WP CAMS2_8330

Work package #	WP CAMS2_8330	**Start/End date**	**M1/M42**
Work package title	**Provision of web-based evaluation graphics**		

Main objectives

- Maintain a web interface showing evaluation of CAMS regional model and Ensemble results daily (for the past day, past week, and past 3 months) and averaged over the regional model domain
- Maintain a web interface showing evaluation of CAMS regional model and Ensemble results per season (for the past 8 seasons: DJF, MAM, JJA, SON, …), averaged over the regional model domain, but also at country- and (measurement)site-level
- Provide quarterly updated reports about uptime statistics of the web interface
- During a transition phase of about 18 months, harmonize the different visualizations developed during previous CAMS projects (CAMS_50, CAMS_61, CAMS_84) in AeroVal, to be embedded in the CAMS website.

Description of activities

Task 8331 : Evaluation for the past day, past week and past 3 months of the NRT regional analyses and forecasts

Maintenance and further development of daily updated evaluation graphics and provision of quarterly reports about uptime statistics during the last 3 months. This task will deal with all near real time evaluations for the whole domain.

Task 8332 : Seasonal evaluation (DJF, MAM, JJA, SON) for the past 8 (fully elapsed) seasons

Maintenance and further development of daily updated evaluation graphics and provision of quarterly reports about uptime statistics during the last 3 months. This task will deal with seasonal evaluations (last 8 quarters plus the quarter that has started, up to the present day), on country and site level.

Task 8333: This task will run in parallel with the first two tasks and is about the development of the AeroVal web interface, which will replace the evaluation pages developed in earlier projects into one harmonized web interface to be embedded in the CAMS website.

For a more detailed description of this Work Package, please see Section 4.8 of this work plan.

WP CAMS2_8330 Deliverables

#	Type	Title	Due
D83.3.1.1-2021Q4	Online graphics & report	Quarterly report showing examples and documenting the relevant KPIs for evaluation graphics for the past day/week/3 months/past 8 quarters of the NRT FC/AN (contract start to Jan 2022)	M4 (Feb 2022)
… every quarter...	… every quarter...	… every quarter...	… every quarter...
D83.3.1.1-2024Q4	Online graphics & report	Quarterly report showing examples and documenting the relevant KPIs for evaluation graphics for the past day/week/3 months/past 8 quarters of the NRT FC/AN (until Jul 2024)	M40 (Feb 2025)

WP CAMS2_8330 Milestones

#	Title	Means of verification	Due
M83.3.1.1	Implementation of daily evaluation graphics for the past day, past week and past 3 months of the NRT regional analyses and forecasts (continuation from CAMS_50.II)	Graphics available via CAMS website via Meteo France	M1 (Nov 2021)
M83.3.1.2	Implementation of daily evaluation graphics for the past day, past week and past 3 months of the NRT regional analyses and forecasts (complete and fully operational)	Graphics available via CAMS website via MET Norway (AeroVal, fully operational)	M18 (Apr 2023)
M83.3.2.1	Implementation of daily	Graphics available via CAMS	M1 (Nov 2021)

	updated graphical presentation of NRT analyses and forecasts site-level evaluation statistics for the past 8 quarters (continuation from CAMS_50.II)	website via Meteo France	
M83.3.2.2	Implementation of daily updated graphical presentation of NRT analyses and forecasts site-level evaluation statistics for the past 8 quarters (complete and fully operational)	Graphics available via CAMS website via MET Norway (AeroVal, fully operational)	M18 (Apr 2023)
M83.3.3.1	Implementation of daily evaluation graphics for the past day, past week and past 3 months of the NRT regional analyses and forecasts (prototype)	Graphics available via CAMS website via MET Norway (AeroVal, prototype)	M6 (Apr 2022)
M83.3.3.2	Implementation of daily updated graphical presentation of NRT analyses and forecasts site-level evaluation statistics for the past 8 quarters (prototype)	Graphics available via CAMS website via MET Norway (AeroVal, prototype)	M6 (Apr 2022)
M83.3.3.3	Decision on where to run the evaluation scripts once AeroVal goes from 'prototype' to 'fully operational'.	Outcome of discussions available on request	M9 (Jul 2022)

Table 3.5: WP CAMS2_8340

Work package #	WP CAMS2_8340	**Start/End date**	**M1/M42**
Work package title	**User support and documentation of service**		

Main objectives

- Detailed documentation of CAMS2_83 products
- Answering user queries in a timely manner
- Keep track of user requirements
- Contribute to user engagement activities

Description of activities

Task 8341 : Collect and update documentation of statistics used in this contract. Formulas for how they are

calculated and which data are used.

Documentation as to how we calculate scores and which data we use will be collected and kept up to date and be available to/at the CAMS Knowledge Base. This will also include the new (FAIRMODE) statistics.

Task 8342 : Answer user queries as they are raised (e.g. through Copernicus Helpdesk at ECMWF / JIRA)

User queries about CAMS2_83 products and services, received through the Copernicus Helpdesk, will be answered in a timely manner by relevant CAMS2_83 contractors.

Task 8343 : Collect input for the User Requirements Data Base (URDB)

Here we will make sure that any CAMS2_83-relevant user requirement that comes to our attention will be conveyed to CAMS_94 and the User Requirements Data Base.

Task 8344 : User engagement activities

This task accommodates for eventual needs in providing technical and scientific expertise in support of user engagement and training activities.

For a more detailed description of this Work Package, please see Section 4.9 of this work plan.

WP CAMS2_8340 Deliverables

#	Type	Title	Due
D83.4.1.1-2022	Other	Contribution to CAMS Knowledge Base to ensure up-to-date information about products and services covered under this contract, status 2022.	M8 (Jun 2022)
D83.4.1.1-2023	Other	Contribution to CAMS Knowledge Base to ensure up-to-date information about products and services covered under this contract, status 2023.	M20 (Jun 2023)
D83.4.1.1-2024	Other	Contribution to CAMS Knowledge Base to ensure up-to-date information about products and services covered under this contract, status 2024.	M32 (Jun 2024)
D83.4.3.1-2022	Other	Input to CAMS URDB - 2022	M13 (Nov 2022)
D83.4.3.1-2023	Other	Input to CAMS URDB - 2023	M25 (Nov 2023)
D83.4.3.1-2024	Other	Input to CAMS URDB - 2024	M37 (Nov 2024)
D83.4.4.1	Report	Summary of user engagement activities.	M41 (Mar 2025)

WP CAMS2_8340 Milestones

#	Title	Means of verification	Due
M83.4.1.1	Plan for how to update CAMS Knowledge Base	e-mail exchange can be made available	M3 (Jan 2022)

	established		
M83.4.2.1	Plan for how to handle user queries established	e-mail exchange can be made available	M2 (Dec 2021)

5.5 Key Performance Indicators

Table 4 : Key Performance Indicators

KPI #	KPI Title	Performance Target and Unit of Measure	Frequency of Delivery	Explanations / Comments
KPI_83.1	On-time delivery of quarterly EQC reports	Reports should always be on time, provided that the CAMS2_40 model results are received on time	quarterly	refers to WP CAMS2_8310
KPI_83.2	Content of quarterly EQC reports	Quarterly EQC reports should have the contents as specified in the work plan.	quarterly	refers to WP CAMS2_8310
KPI_83.3	On-time delivery of annual IRA reports	Reports should always be on time, provided that the CAMS2_40 model results are received on time	annually	refers to WP CAMS2_8320
KPI_83.4	On-time delivery of of annual VRA reports	Reports should always be on time, provided that the CAMS2_40 model results are received on time	annually	refers to WP CAMS2_8320
KPI_83.5	Uptime of daily updated graphics	The web interface should be available on at least 95% of all days	daily	refers to WP CAMS2_8330 web interface (hosted by Meteo France until 2023, but gradually replaced by MET Norway's AeroVal, which will be fully operational in 2023)
KPI_83.6	On-time delivery of web interface reports (uptime statistics)	Reports should always be on time, provided that the CAMS2_40 model results are received on time	quarterly	refers to WP CAMS2_8330
KPI_83.7	User support service on Service Desk tickets	80% of the assigned specialised user queries should be resolved within 15	dependent on the number of tickets	This KPI refers to WP CAMS2_8340 and indicates the success of resolving user queries

		days after being informed by the CAMS Service Desk		sent do the CAMS Service Desk facility
KPI_83.8	User engagement and training activities	Activities (within the 5000 Euro budget) occur as requested.	Depends on the number of requests.	This KPI refers to WP CAMS2_8340 and indicates the success of user engagement and training activities to the extend they are requested by ECWMF and within the allocated budget of 5000 Euro.

5.6 Risk management

Table 5: Risk Register for each Work package

Work package: WP CAMS2_8300					
Risk Name	**Description**	**Likelihood**	**Impact**	**Response Strategy**	**Period**
Underestimation of the work to be done	Risk of having underestimated the amount of work to be provided.	2 (likelihood will decrease over time)	3	This situation would be discussed with the CAMS Management. Evolutions will be prioritised during the preparation of the annual implementation plan as well as over the year, keeping the CAMS Management informed. An intermediate progress update will be achieved during the Review meetings.	M1-M42
Misunderstanding of the project by the WP teams	Risk that a project team misinterprets the project goals and requirements, which may lead to irrelevant expectations on the work to be done.	2	3	Project execution will be monitored tightly thanks to a range of communication channels: - regular phone or video conferences bringing together representatives of each WP, and providing an update of progress status and plans for the next month. - A project-wide mailing list. - ad hoc video conferences, in case of need, for further explanations.	M1-M42

Inaccurate project estimates planned vs actual	Risk of errors in estimates planned vs actual with regard to spending, resources and schedule.	2	3	MET Norway will use a project management software to keep track of project progress as an ongoing process.	M1-M42
Poor deliverable quality	Risk that deliverables do not meet the quality level required by the overall CAMS management team.	2	3	In case a report is not considered of acceptable quality, its delivery will be postponed to make the necessary changes. Feedbacks received from ECMWF following the delivery of the first reports will be taken into account for future deliverables.	M1-M42
Late delivery of reports	Risk of reporting delays in the months when there is a conjunction of reports to be produced (several reporting periods, reports due within several WPs, inputs from several institutes, late delivery of templates from ECMWF or difficulties with the templates layout, or late comments on previous deliverables by ECMWF).	3 (likelihood will decrease over time)	2	Expected inputs and internal deadlines will be planned well ahead of official delivery deadlines, and announced to sub-contractors during visio conferences, e-mails and on the wiki.	M1-M42
Incomplete reports	Risks that some reports may be incomplete, due to technical issues or a failure of one of the participants, or the delivery of new templates from ECMWF.	3	2	When such difficulties are encountered, explanations will be provided to CAMS Management and the full deliverables will be produced as soon as possible. When new reporting templates are issued by the CAMS Management, substantial efforts will be made to match the templates, which will entail guiding the staff members involved.	M1-M42

Sub-contractor leaving	Risk of a sub-contractor leaving the project for financial, human resources or other reasons.	1	4	Regular exchanges with all sub-contractors will enable to identify any potential issues in order to overcome any difficulties and suggest appropriate solutions as soon as possible.	M1-M42
Sub-contractor of KNMI leaving	Risk of CNRS-LAERO leaving the project for financial, human resources or other reasons.	1	4	Regular exchanges with CNRS-LAERO will enable to identify any potential issues in order to overcome any difficulties and suggest appropriate solutions as soon as possible.	M1-M42

Work package: WP CAMS2_8310					
Risk Name	**Description**	**Likelihood**	**Impact**	**Response Strategy**	**Period**
Risk of potential early departure of the staff members	Difficulties to find a new staff member and train him/her --> potential delay for the reports and/or lower reactivity for the graph production maintenance	3	4	knowledge of the production processes are shared between 2 people.	M1-M42
Data transfer from EEA to Meteo France	Measurement data from EEA delayed or not delivered	3	3	this will be solved within CAMS2_40	M1-M18
Data transfer from EEA to MET Norway	Measurement data from EEA delayed or not delivered	3	3	data will be transferred from Meteo France instead	M19-M42
Server downtime at Meteo France	Evaluation will not be visible at Meteo France in cases of server failure	2	3	Usually, problems are solved within minutes by the IT department of Meteo France	M1-M18
Server downtime at MET Norway	Evaluation will not be visible at AeroVal in cases of server failure	2	3	Usually, problems are solved within minutes by the IT department of MET Norway	M19-M42
Development failure	Failure to implement developments in pyaerocom or AeroVal (MET Norway)	1	4	Reports would remain on the same format as before (i.e. based on Meteo France's scores and graphs) for a longer time than anticipated, but every effort would be made to accelerate the operationalization of AeroVal	M19-M30

CAMS2_40 contract not delivering on time	Model data and tables of evaluation and assimilation measurements not delivered on time to CAMS2_83	1	2	Issue will be discussed with CAMS2_40 prime contractor immediately to get data as soon as possible.	M1-M18

Work package: WP CAMS2_8320					
Risk Name	**Description**	**Likelihood**	**Impact**	**Response Strategy**	**Period**
CAMS2_40 does not deliver IRA/VRA	Evaluation of IRA&VRA cannot be made if model data not available	1	5	Usually, only short delays occur	M1-M36
Server downtime at INERIS	Evaluation of IRA&VRA cannot be made in cases of server failure	2	3	Usually, problems are solved within minutes by the IT department of ECMWF and INERIS	M1-M36
Simultaneous CAMS deliverables	In some situations an expert assigned to CAMS2_83 and another ECMWF contract may have prioritize temporally, which can lead to minor delays.	3	1	Duplication of resources un the various work packages should avoid difficulties and impacts on the work plan.	M1-M36

Work package: WP CAMS2_8330					
Risk Name	**Description**	**Likelihood**	**Impact**	**Response Strategy**	**Period**
risks are the same as for WP CAMS2_8310					

Work package: WP CAMS2_8340					
Risk Name	**Description**	**Likelihood**	**Impact**	**Response Strategy**	**Period**
failure to answer user queries on time	answer to user queries delayed	2	3	improve procedure to shorten response times	M1-M42

Table 6: Guidance Table for Risk Register

Entry	*Guidance*
Risk Name	Title to identify the risk
Risk Description	High level description of the risk scenario and consequences Please use the following structure: Risk of [event]…due to [cause]…that may result in [consequence]
Risk Likelihood	A numeric value denoting the estimate of the probability that the residual risk will occur. The possible values are: 5 – very likely (> 70% prob of occurrence) 4 – likely (between 50% and 70% prob of occurrence) 3 – possible (between 20% and 50% prob of occurrence)

	2 – unlikely (between 5% and 20% prob of occurrence) 1 – remote (< 5% prob of occurrence)
Risk Impact	A numeric value denoting the severity of the impact of the residual risk (should it occur). The possible values are: 5 – catastrophic (Critical impact impeding the achievement of the strategic objectives) 4 – damaging (Damaging impact impeding the achievement of the strategic objectives) 3 – significant (Significant impact affecting achievement of operational objectives) 2 – moderate (Moderate impact on the achievement of an operational objective) 1 – low (Minor impact on the global performance)
Risk Response Strategy	The available strategies to deal with the identified risks are: Avoid: risk avoidance, working around those conditions or activities which introduce the risks; Reduce: risk mitigation or reduction through the proactive implementation of risk reduction activities; Accept: acceptance of the risk; in these cases, contingency plans can also be defined in case the risk occurs; Transfer/share: transfer or share a risk with other entities e.g. through subcontracting, insurances etc.

5.7 Data Protection Information Form

The following form will need to be completed for the purposes of Appendix 1 to Annex 6 of the Framework Agreement (see Volume V of the ITT documents). The Contractor is not required to complete this form at this stage, however will be requested to do that if it is selected as a preferred bidder following the evaluation.

[[[THIS FORM HAS BEEN COMPLETED AND PROVIDED IN A SEPARATE FILE]]]

	Answer from the Contractor
Contactor's Data Protection officer's name and email address (if applicable)	
A brief description of the Contractor's activities relevant to the processing	
Categories of Data Subjects - please list the relevant data subjects i.e. ECMWF's staff, ECMWF's business partners	
Categories of Data i.e. Business contact details of ECMWF's partners including name and corporate title, email addresses, telephone numbers, business address	
Special Category Data (if appropriate)	
Nature of Processing - the type of operations performed as part of the processing (for example storing, recording, archiving etc)	
Purpose of Processing - a short description	

Annex 1

In the following we present the CVs in EuroPass format of all key persons involved in CAMS2_83, in the same order as they appear in the partner descriptions of Section 2.

CV

Europass Curriculum Vitae

Personal information

Surname(s) / First name(s)	**Fagerli, Hilde**
Address(es)	The Norwegian Meteorological Institute (MET Norway) P.O. Box 43, Blindern, Norway
E-mail	hilde.fagerli@met.no

Desired employment / Occupational field

Work experience

2009-Present **Head of Division for Climate Modelling and Air Pollution and of EMEP/MSC-W at the Research and Development Department**

The Norwegian Meteorological Institute (MET Norway) P.O. Box 43, Blindern, Norway

- Management of a group of 30 scientists working in the field of air pollution from local to global scale, climate modelling, evaluation systems for air quality and climate models based on in situ observations, lidars, satellite data etc., emergency modelling of radioactivity and volcanic ash
- Head of EMEP/MSC-W, a scientific/centre in the EMEP Programme (UN-ECE) under the Convention on Long Range Transboundary Air Pollution. The EMEP Programme aims at providing scientific basis in the fields of air quality emissions, monitoring, modelling and integrated assessment for the implementation of international regulation for the management of long range air pollution in Europe
- Responsibility for the development, application and validation of the EMEP/MSC-W chemical transport models for particulate matter and photo-oxidant pollution to support the development of air emission control policies in Europe.
- Project management and coordination (air pollution modelling, emergency modelling) and participation in several national and international research projects and services, the most recent ones being: EMEP, CAMS_61, CAMS_71, AAQD (Service contract study to support the impact assessment for a revision of the EU Ambient Air Quality Directives), Air Quality forecasting for Norway, Measure calculator for Norway, NKL projects 'Revising historical PM2,5 emissions from residential combustion to consistently include condensable organics and assess the implication for the review of Gothenburg protocol' and 'How should condesnables be included in PM emission inventories reported to EMEP/CLRTAP?'

2007-2009 **Senior scientist at the section for Air Pollution at the Research and Development Division**

The Norwegian Meteorological Institute (MET Norway) P.O. Box 43, Blindern, Norway

- Chemistry transport model development and evaluation
- EU projects CARBOSOL, NitroEurope

2000-2007 **Scientist at the Research and Development Division, for work related to the air pollution section (EMEP project)**

The Norwegian Meteorological Institute (MET Norway) P.O. Box 43, Blindern, Norway

- Chemistry transport model development and evaluation
- Air pollution modelling for the EMEP project

Education and training

Dates	29.09.2000
Title of qualification awarded	Dr. Scient
Name and type of organisation providing education and training	Department of Chemistry, University of Tromsø, Norway

Mother tongue(s) **Norwegian**

Other language(s) **English**

Self-assessment	Understanding		Speaking		Writing
European level (*)	Listening	Reading	Spoken interaction	Spoken production	
English	C2	C2	C1	C1	C1

(*) Common European Framework of Reference for Languages

Communication skills

- Experience in writing scientific articles and reports
- Presentations at scientific meetings/conferences
- Experience in presenting scientific results to non-scientific audience

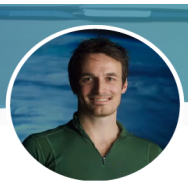
Organisational/management skills

- Manager of a team with 30 qualified scientists, budget management
- Head of EMEP MSC-W, a scientific/technical centre under the EMEP Programme/CLRTAP
- Experience in project management

Publications

Author of more than 50 peer reviewed publications (with an h-index of 23) and >30 reports related to air pollution modelling. Recent publications:

- Denby, Bruce, Gauss, Michael….**Fagerli, Hilde.** Description of the uEMEP_v5 downscaling approach for the EMEP MSC-W chemistry transport model. GPublished: Dec 2020 in Geoscientific Model Development DOI: 10.5194/gmd-13-6303-2020
- Amann, Markus; Kiesewetter, Gregor ... **Fagerli, Hilde**, Pavarini, Claudia. Reducing global air pollution: the scope for further policy interventions. Published: Oct 2020 in Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences DOI: 10.1098/RSTA.2019.0331
- Jonson, Jan Eiof; Gauss, Michael ... **Fagerli, Hilde**. Effects of global ship emissions on European air pollution levels. Published: Oct 2020 in Atmospheric Chemistry and Physics DOI: 10.5194/ACP-20-11399-2020
- Pommier, Matthieu; **Fagerli, Hilde** ... Schaap, Martijn. Prediction of source contributions to urban background PM10 concentrations in European cities: a case study for an episode in December 2016 using EMEP/MSC-W rv4.15 and LOTOS-EUROS v2.0-Part 1: The country contributions.Published: Apr 2020 in Geoscientific Model Development DOI: 10.5194/GMD-13-1787-2020
- Aas, Wenche; Mortier, Augustin ... **Fagerli, Hilde**, Xu, Xiaobin. Global and regional trends of atmospheric sulfur (vol 9, 953, 2019). Published: Mar 2020 in Scientific Reports DOI: 10.1038/S41598-020-62441-W



Augustin Mortier

Date of birth: 15/02/1988 | **Gender:** Male | **Nationality**: French

Mobile: (+47) 41355647

Email address: augustinm@met.no

Work: Henrik Mohns Plass 1, 0371 Oslo, Norway

WORK EXPERIENCE

Post-Doctoral

Norwegian Meteorological Institute

09/2014 – 2017

Oslo, Norway

- Processing and analysis of ceilometer measurements
- Comparison of aerosols properties between model and measurements

Research Assistant

Chinese Academy of Sciences - Institute of Remote Sensing and Digital Earth

05/2014 – 07/2014

- Lidar calibration and data processing
- Knowledge transfer

Research Engineer

CIMEL Electronics company

01/2014 – 03/2014

- Development of an user-friendly interface for Lidar and Sunphotometer data processing

Researcher

Norwegian Meteorological Institute

2017 – Current

Oslo, Norway

- Climate and air quality models evaluation (CAMS, AeroCom projects)
- Aerosol trends
- Ceilometer data processing

EDUCATION AND TRAINING

Laboratoire d'Optique Atmospherique - Universite de Lille 1

Ph. D. Thesis in Atmospheric Physics (with honours)

2011 – 2013

Trends and Variability of aerosols combining micro Lidar and Sun-photometer over Lille and Dakar

Universite de Lille 1

Research Master (with honours)

2008 – 2010

Optics, Molecular and Atmospheric Physics

LANGUAGE SKILLS

Mother tongue(s): French

Foreign language(s)	UNDERSTANDING		SPEAKING		WRITING
	Listening	Reading	Spoken interaction	Spoken production	
English	B2	B2	B2	B2	B2

Levels: A1 and A2: Basic user - B1 and B2: Independent user - C1 and C2: Proficient user
Common European Framework of Reference for Languages

DIGITAL SKILLS

Other

Programmin language PYTHON

Web Development: HTML 5, CSS, JavaScript

GIT (GitHub)

FORTRAN 77/90/95

Proficient User of MATLAB

MySQL (Beginner)

Linux / Ubuntu

PUBLICATIONS

Publications

- "Derimian, Y; Dubovik, O; Tanre, D; Goloub, P; Lapyonok, T; Mortier, A; ","Optical properties and radiative forcing of the Eyjafjallajökull volcanic ash layer observed over Lille, France, in 2010",Journal of Geophysical Research: Atmospheres (1984–2012),117,D9,,2012,Wiley Online Library
- "Mortier, A; Goloub, P; Podvin, T; Deroo, C; Chaikovsky, A; Ajtai, N; Blarel, L; Tanre, D; Derimian, Y; ",Detection and characterization of volcanic ash plumes over Lille during the Eyjafjallajökull eruption.,Atmospheric Chemistry & Physics,13,7,,2013,
- "Cuevas, Emilio; Camino, C; Benedetti, A; Basart, S; Terradellas, E; Baldasano, JM; Morcrette, JJ; Marticorena, B; Goloub, P; Mortier, A; ",The MACC-II 2007–2008 reanalysis: atmospheric dust evaluation and characterization over northern Africa and the Middle East,Atmospheric chemistry and physics,15,8,3991-4024,2015,Copernicus GmbH
- "Bovchaliuk, Valentyn; Goloub, Philippe; Podvin, Thierry; Veselovskii, Igor; Tanre, Didier; Chaikovsky, Anatoli; Dubovik, Oleg; Mortier, Augustin; Lopatin, Anton; Korenskiy, Mikhail; ","Comparison of aerosol properties retrieved using GARRLiC, LIRIC, and Raman algorithms applied to multi-wavelength lidar and sun/sky-photometer data",Atmospheric Measurement Techniques,9,7,3391-3405,2016,Copernicus GmbH
- "Mortier, A et al.,",Climatology of aerosol properties and clear-sky shortwave radiative effects using Lidar and Sun photometer observations in the Dakar site,Journal of Geophysical Research: Atmospheres,121,11,6489-6510,2016,
- "Fagerli, Hilde; Tsyro, Svetlana; Jonson, Jan Eiof; Nyíri, Ágnes; Gauss, Michael; Simpson, David; Wind, Peter; Benetictow, Anna; Klein, Heiko; Mortier, Augustin; ","Transboundary particulate matter, photo-oxidants, acidifying and eutrophying components",,,,,2019,METEOROLOGISK iNSTITUTT Norwegian Meteorological Institute
- "Aas, Wenche; Mortier, Augustin; Bowersox, Van; Cherian, Ribu; Faluvegi, Greg; Fagerli, Hilde; Hand, Jenny; Klimont, Zbigniew; Galy-Lacaux, Corinne; Lehmann, Christopher MB; ",Global and regional trends of atmospheric sulfur,Scientific reports,9,1,1-11,2019,Nature Publishing Group
- "Mortier, Augustin et al.,",Evaluation of climate model aerosol trends with ground-based observations over the last 2 decades–an AeroCom and CMIP6 analysis,Atmospheric Chemistry and Physics,20,21,13355-13378,2020,Copernicus GmbH
- "Gliß, Jonas; Mortier, Augustin; Schulz, Michael; ","Multi-model evaluation of aerosol optical properties in the AeroCom phase III Control experiment, using ground and space based observations from AERONET, MODIS, AATSR and a merged satellite product as well as surface in-situ observations from GAW sites",EGU General Assembly Conference Abstracts,,,18390,2020,
- "Laj, Paolo et al.,; ",A global analysis of climate-relevant aerosol properties retrieved from the network of Global Atmosphere Watch (GAW) near-surface observatories,Atmospheric Measurement Techniques,13,8,4353-4392,2020,Copernicus GmbH

Daniel Heinesen

Date of birth: 10/01/1991

Nationality: Norwegian

Gender: Male

CONTACT

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0774 Oslo, Norway

daniel.heinesen@sf-nett.no

danielh@met.no

(+47) 91524198

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WORK EXPERIENCE

19/07/2021 – CURRENT – Oslo, Norway

Researcher/Scientific Programmer

Norwegian Meteorological Institute

15/06/2018 – 15/11/2018 – Oslo, Norway

Reseach Assistent

UiO:Life Science

Machine learning applied to immunology. Summer job and part time job after the summer (until November)

15/06/2016 – 31/12/2017 – Oslo, Norway

Reseach Assistent

UiO, Department of Computational Physics

Modelling and simulation of friction on nano patterns. Two summer jobs and part time work while studying.

EDUCATION AND TRAINING

15/08/2015 – 15/06/2018 – Sem Sælandsvei 24, Oslo, Norway

Bachelor in "Physics, Astronomy and Meterology"

University of Oslo, Department of Physics

https://www.mn.uio.no/fysikk/english/

15/01/2019 – 28/06/2021 – Sem Sælands vei 13, Oslo, Norway

Masters in Astronomy

University of Oslo, Institute of Theoretical Astrophysics

https://www.mn.uio.no/astro/english/

LANGUAGE SKILLS

MOTHER TONGUE(S): Norwegian

OTHER LANGUAGE(S):

English

Listening	Reading	Spoken production	Spoken interaction	Writing
C2	C2	C2	C2	C2

DIGITAL SKILLS

Git / LaTex / Linux / Python / C / C++ / Fortan

PERSONAL INFORMATION

Schulz Michael

Liljeveien 2a, 1452 Nesoddtangen (Norway)

+47 98 47 16 72

michael.schulz@met.no

WORK EXPERIENCE

01/09/2010–Present — Senior Researcher

Norwegian Meteorological Institute, Oslo (Norway)

Deputy Head of Climate and Air Pollution Section, Aerosol and Climate Research, Project management, Professor at UiO

01/01/2017–Present — Adjunct Professor II

University of Oslo, Dept of Geosciences, Oslo (Norway)

01/06/1999–30/08/2010 — Senior Research Scientist

Laboratoire des Sciences du Climat et de l'Environnement, CEA, Gif-sur-Yvette (France)

Group Leader, Modelling of Biogeochemical Cycles

EDUCATION AND TRAINING

01/01/2007–31/12/2007 — Habilitation

Université Pierre & Marie Curie, Paris VI (University), Paris (France)

Constraining Model Estimates of the Aerosol Radiative Forcing

01/01/1987–31/12/1993 — Dr. rer nat

University of Hamburg, Chemistry Department, Hamburg (Germany)

Thesis title: "Spatial and temporal distribution of airborne inputs of trace elements into the North Sea"

PERSONAL SKILLS

Mother tongue(s): German

Foreign language(s)

	UNDERSTANDING		SPEAKING		WRITING
	Listening	Reading	Spoken interaction	Spoken production	
English	C2	C2	C1	C1	C1
French	C1	C1	C1	C1	B2
Norwegian	C1	C1	B1	B1	B1

Levels: A1 and A2: Basic user - B1 and B2: Independent user - C1 and C2: Proficient user
Common European Framework of Reference for Languages

Organisational / managerial skills

Group leader, EU and national research project management experience

Scientific Management:

Lead&contributing author of the IPCC 4th/5th AssessmentReport 2007 / 2013

Co-chair of AerChemMIP CMIP6 intercomparison initiative (since 2015)

Coordinator of international AeroCom initiative "Aerosol Comparisons between Observations and Models" (since 2002)

Chairman of Regional Steering Group forregional node North Africa-Middle East-Europe of "WMO Sand and Dust StormWarning Advisory and Assessment System" (2008-2014)

Grant Management:

PI (work package leader) for numerous EU and ESA projects ECLIPSE, IMPLICC, ACTRIS, ISENES, EUCAARI, GEOMON, GEMS/MACC, PHOENICS, BASYS-Atmosphere, cci-aerosol

Coordinator in Norwegian, French, German projects funded by national research agencies AeroCom-P3, N-TWO-O, AtmoMar PI for EU-CREATE “Creation and Exploitation of a European Aerosol Database" 2003-2005

ADDITIONAL INFORMATION

Publications

((h-index 66, more than 18800 citations)

Mortier, A., Gliß, J., Schulz, M., et al..: Evaluation of climate model aerosol trends with ground-based observations over the last 2 decades – an AeroCom and CMIP6 analysis, Atmos. Chem. Phys., 20, 13355–13378, https://doi.org/10.5194/acp-20-13355-2020, 2020.

Pommier, M., Fagerli, H., Schulz, M., Valdebenito, A., Kranenburg, R., and Schaap, M.: Prediction of source contributions to urban background PM10 concentrations in European cities: a case study for an episode in December 2016 using EMEP/MSC-W rv4.15 and LOTOS-EUROS v2.0 – Part 1: The country contributions, Geosci. Model Dev., 13, 1787–1807, https://doi.org/10.5194/gmd-13-1787-2020, 2020.

Jonson, J. E., Schulz, M., Emmons, L., Flemming, J., Henze, D., Sudo, K., Lund, M. T., Lin, M., Benedictow, A., Koffi, B., Dentener, F., Keating, T., Kivi, R., Davila, Y., The effects of intercontinental emission sources on European air pollution levels. Atmos. Chem. Phys. 2018, 18 (18), 13655-13672.

Eskes, H., Huijnen, V., Arola, ..**M., Schulz**, ...: Validation of reactive gases and aerosols in the MACC global analysis and forecast system, Geosci. Model Dev., 8, 3523-3543, doi:10.5194/gmd-8-3523-2015, 2015.

Samset B.H:, G. Myhre, **M. Schulz**: Upward adjustment needed for aerosol radiative forcing uncertainty; Nature Climate Change 4, 230–232 (2014); doi:10.1038/nclimate2170

Bond, T. C., Doherty, S. J., Fahey, ... **Schulz, M**., et al: Bounding the role of black carbon in the climate system: A scientific assessment, Journal of Geophysical Research: Atmospheres, doi:10.1002/jgrd.50171

Myhre G., B. H. Samset, **M. Schulz** et al.: Radiative forcing of the direct aerosol effect from AeroCom Phase II simulations; *Atmos. Chem. Phys., 13, 1853-1877;* doi:10.5194/acp-13-1853-2013

Schulz, M., C. Textor, S. Kinne, et al. Radiative forcing by aerosols as derived from the AeroCom present-day and pre-industrial simulations. Atmos Chem Phys, 6, 5225-5246.

Schwarz, J. P., R. S. Gao, D. W. Fahey, ... **M. Schulz**, et al. Single-particle measurements of midlatitude black carbon and light-scattering aerosols from the boundary layer to the lower stratosphere. Journal of Geophysical Research, doi:16210.11029/12006JD007076.

Textor, C., **M. Schulz**, S. Guibert, et al.: Analysis and quantification of the diversities of aerosol life cycles within AeroCom. Atmos. Chem. Phys., 6, 1777-1813..

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Michael Gauss

Date of birth: 2 Jun 1970 | **Nationality:** German | **Gender** Male | (+47) 91001495 | michael.gauss@met.no |

Norwegian Meteorological Institute, PB43 Blindern, 0313, Oslo, Norway

WORK EXPERIENCE

2006 – CURRENT
RESEARCHER – NORWEGIAN METEOROLOGICAL INSTITUTE

- Air quality modelling
- Project management (air quality, climate change, policy support)
- Acting Head of Division for Climate Modelling and Air Pollution (2010-2011)

2004 – 2010
RESEARCHER – UNIVERSITY OF OSLO

- Chemistry Transport Modelling
- Climate Modelling

1999 – 2003
RESEARCH FELLOW – UNIVERSITY OF OSLO

- Chemistry Transport Modelling
- Chemistry transport model development

1997 – 1998
RESEARCH ASSISTANT – NORWEGIAN INSTITUTE FOR AIR RESEARCH (NILU)

- Chemistry transport model development

EDUCATION AND TRAINING

1999 – 2003
DOCTORATE (DR.SCIENT.) – University of Oslo

Atmospheric chemistry, chemistry transport modelling

1994 – 1998
MASTER OF SCIENCE (CAND.SCIENT.) – University of Oslo

Meteorology, atmospheric chemistry

1991 – 1993
BACHELOR DEGREE (VORDIPLOM) – Ludwig-Maximilians Universität München

Physics, solid Earth physics

LANGUAGE SKILLS

Mother tongue(s): GERMAN

Other language(s):

	UNDERSTANDING		SPEAKING		WRITING
	Listening	Reading	Spoken production	Spoken interaction	
NORWEGIAN	C1	C2	C2	C1	C1
ENGLISH	C1	C2	C2	C1	C1
FRENCH	B2	C1	B2	B2	B2

Levels: A1 and A2: Basic user; B1 and B2: Independent user; C1 and C2: Proficient user

PROJECTS

Projects

- CAMS-50 (team leader of MET Norway contribution)
- CAMS-81 (team leader of MET Norway contribution and provider of ocean emission data)
- EU-H2020 MACC-III (subproject leader and Management Board member)
- EU-H2020 PAPILA (work package leader and Management Board member)
- Norwegian Research Council project AIRQUIP (coordinator)
- EU-FP7 CityZen (project coordinator)
- EU-FP7 Impact2C (performing EMEP model calculations on air quality climate interactions)
- member of iCACGP

ORGANISATIONAL SKILLS

Organisational skills

- Experience in research group management from position as acting Head of Division (17 employees) in 2010/11
- Experience in project management experience from leading MET Norway's contribution to more than ten international research projects during the last 5 years.
- Experience in project coordination from several research projects (EU project CityZen project - coordinator; EU project MACC-II and -III POL-subproject leader; EU projects PANDA and PAPILA - Work package leader; etc.)

COMMUNICATION AND INTERPERSONAL SKILLS

Communication and interpersonal skills

- Experience in writing scientific articles and reports
- Presentations at scientific conferences
- Communication through social media
- Cofounder of ESPERE to communicate climate science (www.espere.net)

JOB-RELATED SKILLS

Job-related skills

- Experience in organizing conferences and workshops
- Experience in presenting scientific results to a scientific and non-scientific audiences.

PERSONAL INFORMATION

Mathieu Joly

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Sex Male | Date of birth 11/12/1978 | Nationality French

POSITION

Atmospheric Scientist

WORK EXPERIENCE

Since 2008

Atmospheric Scientist

CNRM (Université de Toulouse, Météo-France, CNRS), 42 Avenue G. Coriolis, 31057 TOULOUSE cedex 1, France

- Member of the GMGEC-PLASMA team

EDUCATION AND TRAINING

2005-2008

PhD
CNRM-GAME, Université Paris-Est

Role of the oceans in the interannual variability of the African monsoon

2002-2005

Master's Degree in Engineering

Ecole Nationale de la Météorologie, TOULOUSE, France

PERSONAL SKILLS

Mother tongue(s): French

Other language(s):

	UNDERSTANDING		SPEAKING		WRITING
	Listening	Reading	Spoken interaction	Spoken production	
English	C1	C1	C1	C1	C1
Italian	B1	B1	B1	B1	B1

ADDITIONAL INFORMATION

Publications

- Barré, J., Petetin, H., Colette, A., Guevara, M., Peuch, V. H., Rouil, L., ... & Kouznetsov, R. (2020). Estimating lockdown induced European NO 2 changes. *Atmospheric Chemistry and Physics Discussions*, 1-28. https://doi.org/10.5194/acp-21-7373-2021
- Joly, D., Gilbert, D., de-Quijano, M.D., Hilal, M., Joly, M. and Bernard, N., 2020: Enhancing air quality forecasts by geomatic downscaling: an application to daily PM10 concentrations in France. Theoretical and Applied Climatology. DOI: 10.1007/s00704-020-03418-7
- Quesada-Ruiz, S., Attié, J.-L., Lahoz, W.A., Abida, R., Ricaud, P., Amraoui, L.E., Zbinden, R., Piacentini, A., Joly, M., Eskes, H., Segers, A., Curier, L., de Haan, J., Kujanpää, J., Nijhuis, A.C.P.O., Tamminen, J., Timmermans, R. and Veefkind, P., 2020: Benefit of ozone observations from Sentinel-5P and future Sentinel-4 missions on tropospheric composition. Atmospheric Measurement Techniques Vol. 13(1), pp. 131-152. DOI: 10.5194/amt-13-131-2020
- Guth, J., B. Josse, V. Marécal, M. Joly, and P. D. Hamer, 2016 : First implementation of secondary inorganic aerosols in the MOCAGE version 2.15.0 chemistry transport model. Geoscientific Model Development, Volume : 9, Issue : 1, Pages : 137-160, Doi : 10.5194/gmd-9-137-2016. Published : 2016.
- Marécal., V., V.-H. Peuch, C. Andersson , S. Andersson, J. Arteta, M. Beekmann, A. Benedictow, R. Bergström, B. Bessagnet, A., Cansado, F. Chéroux, A. Colette, A. Coman, R.L. Curier, H. A. C. Denier van der Gon, A Drouin, H. Elbern, E. Emili, R. J. Engelen, H. J. Eskes, G. Foret, E. Friese, M. Gauss, C. Giannaros, J. Guth, M. Joly, E. Jaumouillé, B. Josse, N. Kadygrov, J. W. Kaiser, K. Krajsek, J. Kuenen, U. Kumar, N. Liora, E. Lopez, L. Malherbe, I. Martinez, D. Melas, F. Meleux, L. Menut, P. Moinat, T. Morales, J. Parmentier, A. Piacentini, M. Plu, A. Poupkou, S. Queguiner, L. Robertson, L. Rouïl, M. Schaap, A. Segers, M. Sofiev, M. Thomas , R. Timmermans, Á. Valdebenito, P. van Velthoven, R. van Versendaal, J. Vira, A. Ung, 2015: A regional air quality forecasting system over Europe: the MACC-II daily ensemble production. Geoscientific Model Development, Volume: 8, Issue: 9, Pages: 2777-2813, Doi : 10.5194/gmd-8-2777-2015. Published: 2015.
- Sic, B., L. El Amraoui, V. Marécal, B. Josse, J. Arteta, J. Guth, M. Joly, and P. Hamer, 2015 : Modelling of primary aerosols in the chemical transport model MOCAGE: development and evaluation of aerosol physical parameterizations. Geoscientific Model Development, Volume: 8, Issue: 2, Pages: 381-408, Doi : 10.5194/gmd-8-381-2015. Published : 2015.
- Foret, G., Eremenko, M., Cuesta, J., Sellitto, P., Barré, J., Gaubert, B., Coman, A., Dufour, G., Liu, X., Joly, M., and others, 2014: Ozone pollution: What can we see from space? A case study. Journal of Geophysical Research: Atmospheres, volume 119, number 13, pages=8476-8499, year 2014.
- Lacressoniere, G., V.-H. Peuch, J. Arteta, B. Josse, M. Joly, V. Marecal, D. Saint-Martin, M. Deque, and L. Watson, 2013 : How realistic are air quality hindcasts driven by forcings from climate model simulations? Geoscientific Model Development, Volume : 5, Pages : 1565-1587, DOI:10.5194/gmd-5-1565-2012.
- Joly, M., and V.-H. Peuch, 2012 : Objective classification of air quality monitoring sites over Europe. Atmospheric Environment, Volume 47, Pages 111–123.
- Rodriguez-Fonseca, B., S. Janicot, E. Mohino, T. Losada, J. Bader, C. Caminade, F. Chauvin, B. Fontaine, J. Garcia-Serrano, S. Gervois, M. Joly, I. Polo, P. Ruti, P. Roucou, and A. Voldoire, 2011 : Interannual and decadal SST-forced responses of the West African monsoon. Atmospheric Science Letters, Volume : 12, Issue : 1, Special Issue: Sp. Iss. SI Pages : 67-74 Published: JAN-MAR 2011. Doi :10.1002/asl.308.
- Joly, M., and A. Voldoire, 2010 : Role of the Gulf of Guinea in the interannual variability of the West African monsoon: what do we learn from CMIP3 coupled simulations? International Journal of Climatology, Volume : 30, Issue : 12, Pages : 1843-1856, Published : OCT 2010. Doi : 10.1002/joc.2026.
- Joly, M., and A. Voldoire, : Influence of ENSO on the West African monsoon: temporal aspects and atmospheric processes. Journal of Climate, Volume : 22, Issue : 12, Pages : 3193-3210, Published : JUN 2009. Doi : 10.1175/2008JCLI2450.1.
- Joly, M., 2008: Rôle des océans dans la variabilité climatique de la mousson africaine. Thèse de doctorat de l'Université Paris-Est, soutenue le 27 novembre 2008 au CNRM-GAME, 194 pp.
- Joly, M., A. Voldoire, H. Douville, P. Terray, and J.-F. Royer, 2007 : African monsoon teleconnections with tropical SSTs:validation and evolution in a set of IPCC4 simulations. Climate Dynamics, Volume : 29, Issue : 1, Pages : 1-20, Published : JUL 2007. Doi : 10.1007/s00382-006-0215-8.

Valentin Petiot

Nationality: French

Date of birth: 08/03/1992

Gender: Male

Email address: valentin.petiot@meteo.fr

WORK EXPERIENCE

Air quality modelling research engineer

METEO-FRANCE [01/11/2017 – Current]

City: Toulouse

Country: France

In the context of the European programme CAMS (Copernicus Atmosphere Monitoring Service), I carry out various tasks within the French National Meteorological Research Centre (CNRM), for example:

- participation in the development of the Météo-France chemistry transport model (MOCAGE)

- surface evaluation of CAMS partners models and the ensemble model.

EDUCATION AND TRAINING

Master's degree in Applied Mathematics

Université de Bourgogne [01/09/2015 – 01/09/2017]

Address: Dijon (France)

LANGUAGE SKILLS

Mother tongue(s):

French

Other language(s):

English

LISTENING B2 **READING** B2 **WRITING** B2

SPOKEN PRODUCTION B2 **SPOKEN INTERACTION** B2

DIGITAL SKILLS

Python for statistic / Linux Bash / Good knowledge of git. / Basic HTML CSS / PHP, SQL (basic level) / Fortran (Basic) / Proficient User of Latex / Python (Advanced) / HTML CSS javascript (Basic)

Etienne
BLOT

CONTACT

Nationality: French

Gender: Male

Météo-France Météopole, 42 avenue Gaspard Coriolis
31057 TOULOUSE, France

etienne.blot@meteo.fr

(+33) 561078098

europass

WORK EXPERIENCE

01/03/2020 – CURRENT – TOULOUSE, France

Environment and Health division deputy manager

Météo France

Environmental emergencies, Air Quality and Health : operational modelisation, production support, partnerships and consultancy.

Co-managment of an operational and development team (10 members)

Copernicus Atmosphere Monitoring Service (CAMS_50) : production manager.

01/09/2017 – 01/03/2020 – TOULOUSE, France

National Forecast Center - "genaral meteorology" forecaster

Météo France

Meteorolgical analyse, national forecast framing, operational procedures for the Environemental Emergencies (nuclear and chemical).

2013 – 2017 – TOULOUSE, France

Studies manager and forecaster

Ministry of Ecology

National Floodings Severe Forecasting operator, National Production Process Manager

EDUCATION AND TRAINING

TOULOUSE, France

Engineer in Meteorolgy

Ecole Nationale de la Météorologie

NANTES, France

Engineer in Wood and biosourced materials science and technologies

Ecole Supérieure du Bois

LANGUAGE SKILLS

MOTHER TONGUE(S): French

OTHER LANGUAGE(S):

English

Listening	Reading	Spoken production	Spoken interaction	Writing
C1	C1	B2	B2	B2

Spanish

Listening	Reading	Spoken production	Spoken interaction	Writing
A2	B2	A2	A2	A2

PERSONAL INFORMATION

Henk Eskes

KNMI, Utrechtseweg 297, 3731GA De Bilt, The Netherlands
+31 30 2206 352
eskes@knmi.nl
www.knmi.nl

Sex Male| Date of birth 11/02/1964 | Nationality Dutch

WORK EXPERIENCE

1997—now

Senior Scientist, KNMI

The research of Dr. Eskes focusses on the composition of the atmosphere. He is an expert on atmospheric chemistry modelling, chemical data assimilation, validation and satellite observations of trace gases in the atmosphere.

Henk Eskes is strongly involved in the Copernicus Atmosphere Monitoring Service (CAMS), implemented by ECMWF, and was involved in the European research projects MACC and GEMS preparing for the CAMS operational service. He is currently the coordinator of the CAMS validation contract (CAMS-84), leading a consortium of 14 partners. Furthermore, he is involved in the CAMS regional ensemble air quality analyses and forecasting, where KNMI together with TNO is responsible for the daily forecasts with the Dutch LOTOS-EUROS model.

Henk Eskes is also product lead for the NO_2 product of TROPOMI on the Sentinel-5P satellite, coordinating the development of the satellite retrievals. He has participated in the production of a new satellite NO_2 retrieval product for OMI as results of the European QA4ECV project (Boersma, 2019). He is involved in future satellite mission concepts (e.g. NITROSAT), and the preparation for Sentinels 4 and 5 as co-author of the ATBDs.

EDUCATION AND TRAINING

1982 – 1987

Study Theoretical Physics

- University of Groningen, The Netherlands

1987 – 1997

PhD and postdoc positions in Theoretical Physics

- University of Groningen, The Netherlands (PhD 1992)
- Defence Research Agency, Great Malvern, England
- Max Planck Instutute for Solid State Research, Stuttgart
- University of Leiden, Netherlands

PERSONAL SKILLS

Mother tongue(s) Dutch

Other language(s) English (level C1/2: Proficient user), German (level A1/2: Basic User)

Organisational / managerial skills

Project leader, team co-ordinator, supervisor

- Management of the CAMS-84 project.
- Experienced as project leader and team leader for groups of highly educated researchers in many projects, national and European.
- Supervisor of master students and PhD students.

Computer skills

- Programming skills in Fortran, Python, R, IDL
- Office Suites and LaTeX

Other skills Research, publications
Method development, theory

ADDITIONAL INFORMATION

Publications

- Wagner, A., .., Eskes, H., ...: Comprehensive evaluation of the Copernicus Atmosphere Monitoring Service (CAMS) reanalysis against independent observations: Reactive gases. Elementa: Science of the Anthropocene (2021) 9 (1): 00171, https://doi.org/10.1525/elementa.2020.00171, 2021.
- Gkatzelis, Georgios I., .., Henk Eskes, .. The global impacts of COVID-19 lockdowns on urban air pollution: A critical review and recommendations. Elementa: Science of the Anthropocene 21 January 2021; 9 (1): 00176. doi: https://doi.org/10.1525/elementa.2021.00176
- Verhoelst, T., .., Eskes, H. J., ...: Ground-based validation of the Copernicus Sentinel-5P TROPOMI NO2 measurements with the NDACC ZSL-DOAS, MAX-DOAS and Pandonia global networks, Atmos. Meas. Tech., 14, 481–510, https://doi.org/10.5194/amt-14-481-2021, 2021.
- Miyazaki, K., .., Eskes, H., ...: Updated tropospheric chemistry reanalysis and emission estimates, TCR-2, for 2005–2018, Earth Syst. Sci. Data, 12, 2223–2259, https://doi.org/10.5194/essd-12-2223-2020, 2020.
- van Geffen, J., Boersma, K. F., Eskes, H., Sneep, M., ter Linden, M., Zara, M., and Veefkind, J. P.: S5P TROPOMI NO2 slant column retrieval: method, stability, uncertainties and comparisons with OMI, Atmos. Meas. Tech., 13, 1315–1335, https://doi.org/10.5194/amt-13-1315-2020, 2020.
- Boersma, K. F., Eskes, H. J., et al., Improving algorithms and uncertainty estimates for satellite NO_2 retrievals: results from the quality assurance for the essential climate variables (QA4ECV) project, Atmos. Meas. Tech., 11, 6651-6678, https://doi.org/10.5194/amt-11-6651-2018, 2018.
- Inness, … Eskes, H., et al., The CAMS reanalysis of atmospheric composition, Atmos. Chem. Phys., 19, 3515-3556, https://doi.org/10.5194/acp-19-3515-2019, 2019.
- Timmermans, R., … Eskes, et al.: Impact of synthetic spaceborne NO_2 observations from the Sentinel-4 and Sentinel-5p platforms on tropospheric NO_2 analyses, Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2018-1360, in review, 2019.
- Eskes, H. et al., *Validation of reactive gases and aerosols in the MACC global analysis and forecast system*, Geosci. Model Dev. Discuss., 8, 1117-1169, doi:10.5194/gmdd-8-1117-2015, 2015.
- van der A, R. J., Allaart, M. A. F., and Eskes, H. J., *Extended and refined multi sensor reanalysis of total ozone for the period 1970-2012,* Atmos. Meas. Tech. Discuss., 8, 3283-3319, doi:10.5194/amtd-8-3283-2015, 2015.
- Belmonte Rivas, M., Veefkind, P., Eskes, H., and Levelt, P., *OMI tropospheric NO2 profiles from cloud slicing: constraints on surface emissions, convective transport and lightning NOx,* Atmos. Chem. Phys. Discuss., 15, 8017-8072, doi:10.5194/acpd-15-8017-2015, 2015.
- Bocquet, M., Elbern, H., Eskes, H., Hirtl, M., Zabkar, R., Carmichael, G. R., Flemming, J., Inness, A., Pagowski, M., Perez Camano, J. L., Saide, P. E., San Jose, R., Sofiev, M., Vira, J., Baklanov, A., Carnevale, C., Grell, G., and Seigneur, C., *Data assimilation in atmospheric chemistry models: current status and future prospects for coupled chemistry meteorology models*, Atmos. Chem. Phys. Discuss., 14, 32233-32323, doi:10.5194/acpd-14-32233-2014, 2014.
- Curier, R.L., R. Timmermans, S. Calabretta-Jongen, H. Eskes, A. Segers, D. Swart, M. Schaap, *Improving ozone forecasts over Europe by synergistic use of the LOTOS-EUROS chemical transport model and in-situ measurements*, Atmospheric Environment, 60, 217-226, doi:10.1016/j.atmosenv.2012.06.017, 2012.
- Veefkind, P., … Eskes, H. et al *TROPOMI on the ESA Sentinel-5 Precursor: A GMES mission for global observations of the atmospheric composition for climate, air quality and ozone layer applications*, Remote Sensing of the Environment, doi:10.1016/j.rse.2011.09.027, 2012.
- Hollingsworth, A., and Coauthors, *Toward a Monitoring and Forecasting System For Atmospheric Composition: The GEMS Project,* Bull. Amer. Meteor. Soc., 89, 1147-1164 doi:10.1175/2008BAMS2355.1, 2008.
- H.J. Eskes, and K.F. Boersma, *Averaging Kernels for DOAS Total-Column Satellite Retrievals*, Atmos. Chem. Phys., 3, 1285-1291, 2003.
- Henk Eskes, Peter van Velthoven, Pieter Valks and Hennie Kelder, *Assimilation of GOME total ozone satellite observations in a three-dimensional tracer transport model*, Q.J.R.Meteorol.Soc. 129, 1663, 2003.

See https://henkeskes.nl/publications.html for a full list

John
Douros

DATE OF BIRTH:
04/07/1974

CONTACT

Nationality: Greek

Gender: Male

KNMI, Utrechtseweg 297, null
3731GA De Bilt, Netherlands

john.douros@knmi.nl

(+31) 625142315

www.knmi.nl

EDUCATION AND TRAINING

10/10/1993 – 10/06/1998 – Thesssaloniki, Greece

BSc in Physics

Physics Department, Aristotle University of Thessaloniki

EQF level 6

10/10/1998 – 10/09/1999 – London, United Kingdom

MSc in Environmental Technology

ICCET, Imperial College of Science Technology and Medicine, University of London

EQF level 7

16/09/2003 – 13/11/2012 – Thessaloniki, Greece

PhD

Mechanical Engineering Department, Aristotle University of Thessaloniki

EQF level 8

WORK EXPERIENCE

15/01/2015 – CURRENT – De Bilt, Netherlands

Researcher

KNMI

- Involvement in CAMS activities (CAMS_50 on regional production and operational delivery of the European-scale air quality, CAMS_84 on a posteriori model validation, CAMS_42 on development of global reactive gasses aspects)

- Regional and air quality model development and evaluation.

- Development of synthetic measurements for observation system simulation experiments (OSSEs) for low-earth orbiting satellites.

- Utilization of satellite retrievals for model validation and assimilation studies.

15/06/2014 – 15/01/2015

Member of the Laboratory and Teaching Staff of the University of Thessaloniki

Mechanical Engineering Department, Aristotle University of Thessaloniki

01/06/2001 – 15/06/2014 – Thessaloniki, Greece

Research associate

Laboratory of Heat Transfer and Environmental Engineering, Mechanical Engineering Department,

- Meteorological and air photochemical dispersion modelling from the regional to the local scale.

Thessaloniki, Greece

LANGUAGE SKILLS

MOTHER TONGUE(S): Greek

OTHER LANGUAGE(S):

English

Listening	Reading	Spoken production	Spoken interaction	Writing
C2	C2	C1	C1	C2

French

Listening	Reading	Spoken production	Spoken interaction	Writing
B2	B2	B1	B2	B2

ORGANISATIONAL SKILLS

Organisational skills

Substantial experience at working in teams and coordinating smaller teams dealing with atmospheric science issues.

JOB-RELATED SKILLS

Job-related skills

Numerical model development, evaluation and use for the purposes of air quality assessment studies.

Participation, since September 2001 in a number of EU and nationally funded research projects, dealing with the development and validation of modelling tools for the improved assessment of air quality in the urban and regional scales, as well as the use of satellite observations to validate and improve atmospheric composition modelling. Examples of such projects: MEGAPOLI (Megacities: Emissions, urban, regional and Global Atmospheric POLlution and climate effects, and Integrated tools for assessment and mitigation), TRANSPHORM (Transport related Air Pollution and Health impacts - Integrated Methodologies for Assessing Particulate Matter), NEEDS (New Energy Externalities Developments for Sustainability); Air4EU (Air for Europe); APPRAISAL (Integrated assessment for regional and local air quality policies); CAMS_50 Regional air quality production, CAMS_84 A posteriori model validation, CAMS_42 Development of reactive gasses aspects, CAMS_95 Downstream use of CAMS data.

PUBLICATIONS

*

2020

Dimakopoulou K, Douros J, Samoli E, Karakatsani A, Rodopoulou S, Papakosta D, Grivas G, Tsilingiridis G, Mudway I, Moussiopoulos N, Katsouyanni K. Long-term exposure to ozone and children's respiratory health: Results from the RESPOZE study. Environ Res. 2020 Mar; 182:109002. doi: 10.1016/j.envres.2019.109002. Epub 2019 Dec 5. PMID: 31855698.

Akritidis, D., Katragkou, E., Georgoulias, A. K., Zanis, P., Kartsios, S., Flemming, J., Inness, A., Douros, J., and Eskes, H.: A complex aerosol transport event over Europe during the 2017 Storm Ophelia in CAMS forecast systems: analysis and evaluation, Atmos. Chem. Phys., 20, 13557–13578, https://doi.org/10.5194/acp-20-13557-2020, 2020.

Ialongo, I., Virta, H., Eskes, H., Hovila, J., and Douros, J.: Comparison of TROPOMI/Sentinel-5 Precursor NO_2 observations with ground-based measurements in Helsinki, Atmos. Meas. Tech., 13, 205–218, https://doi.org/10.5194/amt-13-205-2020, 2020.

Barré, J., Petetin, H., Colette, A., Guevara, M., Peuch, V.-H., Rouil, L., Engelen, R., Inness, A., Flemming, J., Pérez García-Pando, C., Bowdalo, D., Meleux, F., Geels, C., Christensen, J. H., Gauss, M., Benedictow, A., Tsyro, S., Friese, E., Struzewska, J., Kaminski, J. W., Douros, J., Timmermans, R., Robertson, L., Adani, M., Jorba, O., Joly, M., and Kouznetsov, R.: Estimating lockdown induced European NO_2 changes, Atmos. Chem. Phys. Discuss. [preprint], https://doi.org/10.5194/acp-2020-995, in review, 2020.

*

2018

Verstraeten, W., Boersma, F., Douros, D., Williams, J., Eskes, H., Liu, F., Beirle, S. and Delcloo. A., Top-Down NOX Emissions of European Cities Based on the Downwind Plume of Modelled and Space-Borne Tropospheric NO2 Columns, 2018, Sensors 18 (9), 2893

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2017

Manders, A. M. M., Builtjes, P. J. H., Curier, L., Denier van der Gon, H. A. C., Hendriks, C., Jonkers, S., Kranenburg, R., Kuenen, J. J. P., Segers, A. J., Timmermans, R. M. A., Visschedijk, A. J. H., Wichink Kruit, R. J., van Pul, W. A. J., Sauter, F. J., van der Swaluw, E., Swart, D. P. J., Douros, J., Eskes, H., van Meijgaard, E., van Ulft, B., van Velthoven, P., Banzhaf, S., Mues, A. C., Stern, R., Fu, G., Lu, S., Heemink, A., van Velzen, N., and Schaap, M.: Curriculum vitae of the LOTOS–EUROS (v2.0) chemistry transport model, 2017, Geosci. Model Dev., 10, 4145-4173, https://doi.org/10.5194/gmd-10-4145-2017.

Sofiev, M., Ritenberga, O., Albertini, R., Arteta, J., Belmonte, J., Bernstein, C. G., Bonini, M., Celenk, S., Damialis, A., Douros, J., Elbern, H., Friese, E., Galan, C., Oliver, G., Hrga, I., Kouznetsov, R., Krajsek, K., Magyar, D., Parmentier, J., Plu, M., Prank, M., Robertson, L., Steensen, B. M., Thibaudon, M., Segers, A., Stepanovich, B., Valdebenito, A. M., Vira, J., and Vokou, D.: Multi-model ensemble simulations of olive pollen distribution in Europe in 2014: current status and outlook, 2017, Atmos. Chem. Phys., 17, 12341-12360, https://doi.org/10.5194/acp-17-12341-2017

*

2016

Carnevale, C., Douros, J., Finzi, G., Graff, A., Guariso, G., Nahorski, Z., Pisoni, E., Ponche, J-L., Real, E., Turrini, E., Vlachokostas, Ch., Uncertainty evaluation in air quality planning decisions: a case study for Northern Italy, Environmental Science & Policy, Volume 65, November 2016, Pages 39-47, ISSN 1462-9011, http://dx.doi.org/10.1016/j.envsci.2016.02.001.

Kukkonen, J., Karl, M., Keuken, M. P., Denier van der Gon, H. A. C., Denby, B. R., Singh, V., Douros, J., Manders, A., Samaras, Z., Moussiopoulos, N.,

Jonkers, S., Aarnio, M., Karppinen, A., Kangas, L., Lützenkirchen, S., Petäjä, T., Vouitsis, I., and Sokhi, R. S.: Modelling the dispersion of particle numbers in five European cities, Geosci. Model Dev., 9, 451-478, doi:10.5194/gmd-9-451-2016, 2016.

Thunis, P., Miranda, A., Baldasano, J.M., Blond, N., Douros, J., Graff, A., Janssen, S., Juda-Rezler, K., Karvosenoja, N., Maffeis, G., Martilli, A., Rasoloharimahefa, M., Real, R., Viaene, P., Volta, M., White, L., Overview of current regional and local scale air quality modelling practices: Assessment and planning tools in the EU, Environmental Science & Policy, Volume 65, November 2016, Pages 13-21, ISSN 1462-9011, http://dx.doi.org/10.1016/j.envsci.2016.03.013.

PERSONAL INFORMATION

Valérie Thouret

8 résidence du chateau, 31320 Auzeville-Tolosane, France
05 61 33 27 40 06 20 77 54 42
Valerie.Thouret@aero.obs-mip.fr

Sex Female | Date of birth 02/02/1971 | Nationality French

WORK EXPERIENCE

2000-present

Laboratoire d'Aérologie (CNRS and Université Paul Sabatier, UMR 5560), Toulouse, France.
Physicist (equivalent to Professor) since 2011.

- Chair of IAGOS-AISBL Executive Board (since Feb. 2014)
- Coordinator of IAGOS-France (since mid-2012)
- Deputy director of Laboratoire d'Aérologie (since January 2021).
- PI for UPS-LA in the frame of the EU IGAS project (2013-2015)
- PI for the CNRS-LA in the frame of MACC-II and MACC-III project (2011-2015)
- PI for ozone and CO in the frame of the MOZAIC program (2001-2014)
- PI for the "ozone soundings program" in the frame of the AMMA EU project (2004-2008)

EDUCATION AND TRAINING

1994-1998

Doctor of Philosophy, University Paul Sabatier, Toulouse, France

Thesis title: Study of spatial and temporal variations of ozone in the troposphere and lower stratosphere based on the first results of the MOZAIC airborne program.

PERSONAL SKILLS

Mother tongue(s) French
Other language English

Communication skills

- Good communication skills gained through my experience as lecturer and researcher for the past 18 years.
- Participations to different Scientific advisory boards (GAW/WMO, ACTRIS, EUFAR)

Organisational / managerial skills

- Leadership (currently responsible for a team of 12 people since mid-2012)
- Supervisor of 5 PhD students since 2001 and 10 post-docs and engineers since 2010
- Chair of the IAGOS-AISBL executive board since February 2014

PUBLICATIONS

Total of 120 publications since 1998. Below is a selection of the most relevant publications (related to this project), restricted to the 2013-2020 period :

- Zbinden R. M., V. Thouret, P. Ricaud, F. Carminati, J.-P. Cammas, and P. Nédélec, Climatology of pure Tropospheric profiles and column contents of ozone and carbon monoxide using MOZAIC in the mid-northern latitudes (24° N to 50° N) from 1994 to 2009, Atmos. Chem. Phys., 13, 12363-12388, 2013.
- Inness, A., F. Baier, A. Benedetti, I. Bouarar, S. Chabrillat, H. Clark, et al, The MACC reanalysis: An 8-year data set of atmospheric composition, Atmos. Chem. Phys., 13, 4073-4109, 2013.
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- Nédélec P. R. Blot, D. Boulanger, G. Athier, J.-M. Cousin, B. Gautron, A. Petzold, A. Volz-Thomas, and V. Thouret, Instrumentation on commercial aircraft for monitoring the atmospheric composition on a global scale : the IAGOS system, technical overview of ozone and carbon monoxide measurements., Tellus B 2015, 67, 27791, 2015.
- H. L. Clark, B. Sauvage, V. Thouret, et al., The first regular measurements of ozone and carbon monoxide and water vapour in the Pacific UTLS by IAGOS, Tellus B 2015, 67, 28385, 2015.
- A. Petzold, V. Thouret et al., Global-Scale Atmosphere Monitoring by In-Service Aircraft – Current Achievements and Future Prospects of the European Research Infrastructure IAGOS, Tellus B 2015, 67, 28452, 2015.
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europass Curriculum vitae

PERSONAL INFORMATION

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yasminebennouna@gmail.com yasmine.bennouna@aero.obs-mip.fr

Gender Female | Date of birth July 18th, 1978 | Nationality French

WORK EXPERIENCE

Since January 2021 — Research Engineer

Koninklijk Nederlands Meteorologisch Instituut (KNMI), De Bilt, Netherlands

CAMS-84 Position funded by the European Union. CAMS-84 is a sub-project of CAMS (Copernicus Atmosphere Monitoring Service), dealing with the a-posteriori validation of the products from the global and regional services for the quality of the atmospheric composition. The tasks carried out are related to the validation of CAMS products using in-situ observations from the IAGOS european infrastructure (In-service aircraft for a global observing system) in collaboration with the Laboratoire d'Aérologie (in Toulouse, France).

October 2017 - December 2020 — Research Engineer

Laboratoire d'Aérologie (LA), UMR 5560 CNRS/Université Paul Sabatier(UPS), Toulouse, France

CAMS-84 Same project description as above

Apr 2016 - Sep 2017 — Postdoctoral Researcher

Centre National de Recherche Meteorologiques (CNRM), UMR 3589 CNRS/Météo-France, France

Aeolus-EarthCARE Aerosol Assimilation Study Position funded by European Spatial Agency (ESA). The main goal of the A3S project is to prepare for the AEOLUS and EarthCare missions to detect and characterize vertical profiles of aerosols, using MOCAGE and IFS models.

Dec 2013 - Mar 2016 — Postdoctoral Researcher

Laboratoire d'Aérologie, UMR 5560 CNRS/Université Paul Sabatier (UPS), Toulouse, France

IAGOS for GMES (IGAS) Position funded by the European Union. The IGAS project has the goal to facilitate the use of the data provided by the European Research Infrastructure IAGOS (In-service Aircraft for a Global Observing System) and in particular its link with the Copernicus Atmosphere Monitoring Service (CAMS), previously called GEMS (Global Environment Monitoring System). This project also aims at developing tools for the validation of satellite products, including collocation, profile completion, and the application of averaging kernels. In this framework, the task carried out at the LA was the application of IAGOS measurements for the validation of satellite products from IASI for Carbon Monoxyde and Ozone.

Apr 2009 - Nov 2013 — Postdoctoral Researcher

Grupo de Óptica Atmosférica (GOA), Universidad de Valladolid (UVa), Valladolid, Spain

Participation to various projects funded by the Spanish Government, by the Regional Government of Castilla y Leon and by the European Union (non-exhaustive list) :

CGL2012-33576 Study of the spatio-temporal variability and characterization of precipitable water vapor content (PWV) using different measurement techniques

CGL2010-09480-E Ayuda para la Operación de la Red Ibérica de Medida Fotométrica de Aerosoles durante 2010 (AO-RIMA'10)

GR220 Research activity of the GOA-UVA during the next three years

CGL2008-09740 Characterization of aerosol observations from the AERONET over Europe within the objectives of EMEP (AEROPA)

ACTRIS Aerosol, Clouds, and Trace gases Research Infraestructure Network (ACTRIS)

Dec 2013 - Feb 2016 **PhD student**

Netherlands Organisation for Applied Scientific Research (TNO), Den Haag, Netherlands

EO-077 Position funded by Netherlands Institute for Space Research (SRON) under project EO-077: Synergistic use of AATSR, MSG and ground-based data to provide aerosol products.

EDUCATION AND TRAINING

2005 - 2009 **PhD degree in Applied Physics**

Université du sud Toulon Var (USTV) / Eindhoven University of Technology (TU/e)

Title *"Aerosol remote sensing from Geostationnary Observations with MSG-SEVIRI"*

Topic Development and validation of an algorithm for the retrieval of the aerosol optical depth from observations of the SEVIRI (Spinning Enhanced Visible and InfraRed Imager) instrument onboard of the MSG (Meteosat-Second generation) satellite.

2003 -2004 **Post-graduate degree of Advanced Studies (French DEA)**

Major in Marine Environmental Sciences

Université du sud Toulon Var (USTV), Toulon, France

1999 - 2002 **Master's degree in Engineering**

Major in Marine Engineering

Institut des Sciences de l'Ingénieur de Toulon et du Var (ISITV now Seatech), Toulon, France

PERSONAL SKILLS

Mother tongue French, Arabic

Other Languages English (Proficient use), Spanish (Proficient use)

Computer skills Operating systems: Linux/Unix, Windows

Office suites: LibreOffice, Microsoft Office, Latex

Programming languages: Matlab, IDL, NCL, Python, C, Fortran 77/90/95, Shell

ARTICLES (SELECTION)

[1] Y.S. Bennouna, G. de Leeuw, J. Piazzola, and J. Kusmierczyk-Michulec.
Aerosol remote sensing over the ocean using MSG-SEVIRI visible images.
Journal of Geophysical Research, 114:D23203, 2009.

[2] Y.S. Bennouna, V.E. Cachorro, C. Toledano, A. Berjón, N. Prats, D. Fuertes, R. Gonzalez, R. Rodrigo, B. Torres, and A. de Frutos.
Comparison of atmospheric aerosol climatologies over southwestern Spain derived from AERONET and MODIS.
Remote Sensing of Environment, 115:1272–1284, 2011.

[3] Y.S. Bennouna, V.E. Cachorro, B. Torres, C. Toledano, A. Berjón, A. de Frutos, and I. Alonso Fernández Coppel.
Atmospheric turbidity determined by the annual cycle of the aerosol optical depth over north-center Spain from ground (AERONET) and satellite (MODIS).
Atmospheric Environment, 67:352–364, 2012.

[4] Y.S. Bennouna, B. Torres, V.E. Cachorro, J.P. Ortiz de Galisteo, and C. Toledano.
The evaluation of integrated water vapor annual cycle over the Iberian Peninsula from EOS-MODIS against different ground-based techniques.
Quarterly Journal of the Royal Meteorological Society, 2012.

[5] B. Barret, B. Sauvage, Y. Bennouna, and E. Le Flochmoen.
Upper-tropospheric CO and O_3 budget during the Asian summer monsoon.
Atmospheric Chemistry and Physics, 16(14):9129–9147, 2016.

[6] H. Clark, Y. Bennouna, M. Tsivlidou, P. Wolff, B. Sauvage, B. Barret, E. Le Flochmoën, R. Blot, D. Boulanger, J.-M. Cousin, P. Nédélec, A. Petzold, and V. Thouret.
The effects of the covid-19 lockdowns on the composition of the troposphere as seen by iagos.
Atmospheric Chemistry and Physics Discussions, 2021:1–33, 2021.

[7] A. Wagner, Y. Bennouna, A.-M. Blechschmidt, G. Brasseur, S. Chabrillat, Y. Christophe, Q. Errera, H. Eskes, J. Flemming, K. M. Hansen, A. Inness, J. Kapsomenakis, B. Langerock, A. Richter, N. Sudarchikova, V. Thouret, and C. Zerefos.
Comprehensive evaluation of the Copernicus Atmosphere Monitoring Service (CAMS) reanalysis against independent observations: Reactive gases.
Elementa: Science of the Anthropocene, 9(1), 05 2021.

TECHNICAL REPORTS (SELECTION)

[8] A.J.M. Piters, Y. Bennouna, and B. Barret.
Guidelines and tools for collocation of IAGOS data with satellite data, IGAS Deliverable 2.4.
Technical report, Seventh Framework Programme, August 2014.

[9] A.J.M. Piters, Y. Bennouna, S. Verma, and B. Barret.
Report on demonstration of satellite validation with IAGOS data, IGAS Deliverable 2.5.
Technical report, Seventh Framework Programme, October 2015.

[10] Douros, J., H.J. Eskes, D. Akritidis, T. Antonakaki, Y. Bennouna, A.-M. Blechschmidt, T. Bösch, H. Clark, C. Gielen, F. Hendrick, J. Kapsomenakis, S. Kartsios, E. Katragkou, D. Melas, A. Mortier, E. Peters, K. Petersen, A. Piters, A. Richter, M. van Roozendael, M. Schulz, N. Sudarchikova, A. Wagner, P. Zanis, C. Zerefos.
Validation of CAMS regional services: concentrations above the surface, Status update for December 2020 - February 2021.
Technical report, Copernicus Atmosphere Monitoring Service (CAMS) report, CAMS84_2018SC3_D4.1.1-DJF2021, June 2021.

[11] Errera, Q., Y. Bennouna, M. Schulz, H.J. Eskes, S. Basart, A. Benedictow, A.-M. Blechschmidt, S. Chabrillat, H. Clark, E. Cuevas, H. Flentje, K.M. Hansen, U. Im, J. Kapsomenakis, B. Langerock, K. Petersen, A. Richter, N. Sudarchikova, V. Thouret, A.Wagner, Y. Wang, T. Warneke, C. Zerefos.
Validation report of the CAMS global Reanalysis of aerosols and reactive gases, years 2003-2020.
Technical report, Copernicus Atmosphere Monitoring Service (CAMS) report, CAMS84_2018SC3_D5.1.1-2020.pdf, June 2021.

[12] Eskes, H. J., S. Basart, A. Benedictow, Y. Bennouna, A.-M. Blechschmidt, Q. Errera, K. M. Hansen, J. Kapsomenakis, B. Langerock,A. Richter, N. Sudarchikova, M. Schulz, C. Zerefos.
Upgrade verification note for the CAMS real-time global atmospheric composition service: Evaluation of the e-suite for the CAMS 47R2 upgrade of 18 May 2021.
Technical report, Copernicus Atmosphere Monitoring Service (CAMS) report, CAMS84_2018SC3_D3.2.1-202105_esuite.pdf, May 2021.

[13] Schulz, M., Q. Errera, M. Ramonet, Sudarchikova, N., H. J. E skes, S. Basart, A. Benedictow, Y. Bennouna, A.-M. Blechschmidt, S. Chabrillat, Christophe, Y., E. Cuevas, A. El-Yazidi, H. Flentje, P. Fritzsche, K.M. Hansen, U. Im, J. Kapsomenakis, B.Langerock, A. Richter, V. Thouret, A. Wagner, T. Warneke, C. Zerefos.
Validation report of the CAMS near-real-time global atmospheric composition service: Period December 2020 – February 2021.
Technical report, Copernicus Atmosphere Monitoring Service (CAMS) report, CAMS84_2018SC3_D1.1.1_DJF2021.pdf, June 2021.

PERSONAL INFORMATION

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Sex Male | Date of birth 03/04/1978 | Nationality French

JOB APPLIED FOR
POSITION
PREFERRED JOB
STUDIES APPLIED FOR

Atmospheric science for air quality management

INTENDED ROLE IN ETC HE

Senior Expert
Areas of expertise: 1.1, 1.6, 2.1, 3.1, 4.1, 8.1, 13.1, 16.2

WORK EXPERIENCE

Since June 2016

Head of Unit - Atmospheric Modelling and Environmental Mapping

Ineris, MIV/MOCA, Parc Technologique ALATA - 60550 Verneuil-en-Halatte – France

Business or sector

- French public research body of an industrial and commercial character under the aegis of the French Ministry for Ecology. The main duties of INERIS regard risk assessment for policy support, with also academic research activities as well as consulting for private clients.
- The Atmospheric Modelling and Environmental Mapping Unit of INERIS focuses on short-term air quality forecast at national (www.prevair.org) and European scale (Copernicus Atmosphere Monitoring Service), air quality management in support to policy decision making, and local scale air quality modelling including for emergency situations.

Main duties

- Head of a team of a dozen scientists specialised in atmospheric sciences, high performance computing and statistics, in addition to several PhD and Post-doctoral interns.
- Responsible for the development of the activities of the Unit in the field by managing projects and answering competitive calls.
- Chair of the Task Force on Measurement and Modelling of the United Nations Convention on Long Range Transboundary Air Pollution. The Task Force is in charge of the definition and the implementation of the EMEP monitoring strategy throughout Europe. It assesses and promotes use of modelling and monitoring tools in support of the implementation of emission control policies.
- Scientific Advisor of the Copernicus Atmosphere Monitoring Service Regional Production of Air Quality Forecasts for Europe
- Member of the Management Committee of the European Topic Centre on Air pollution, Transport, Noise and Industry in support of the European Environment Agency.
- Member of Scientific Committee of the French AQACIA Research programme, and the Atmospheric Research Working Group of the French Environmental Alliance.
- Editor for the Scientific journal Geoscientific Model Development.

Skills

- Management of a team of qualified scientist involved in numerous national and international projects
- Thorough expertise of air quality management issues with a wide-ranging understanding of science-based modelling and monitoring evidences
- Forecaster for the French air quality forecasting platform PREV'AIR
- Participation in several international research projects (CITYZEN, MEGAPOLI, ATOPICA, EURODELTA, BIODIV-Support), including in a coordination role
- PhD Advisor

2009-2016 **Senior Scientist - Atmospheric Modelling and Environmental Mapping**

INERIS, Parc Technologique ALATA - 60550 Verneuil-en-Halatte - FRANCE

Business or sector

- French public research body of an industrial and commercial character under the aegis of the French Ministry for Ecology. The main duties of INERIS regard risk assessment for policy support, with also academic research activities as well as consulting for private clients.
- The Atmospheric Modelling and Environmental Mapping Unit of INERIS focuses on short-term air quality forecast at national (www.prevair.org) and European scale (Copernicus Atmosphere Monitoring Service), air quality management in support to policy decision making, and local scale air quality modelling including for emergency situations

Main duties

- Conduct scientific research in the field of air quality modelling
- Participate and lead collaborative research project and answer to competitive call
- Contribute to policy-support activities, in particular at European and International level.

Skills

- Long term evolution of air quality and interlinkages with climate change.
- Development and advanced use of the open source chemistry transport model CHIMERE
- Forecaster for the French air quality forecasting platform PREV'AIR
- PhD Advisor

2007-2009 **Senior Catastrophe Risk Modeler for Natural Hazards**

Risk Management Solutions, London UK

Business or sector

- RMS is a California-based SME also operating in Europe and beyond. It develops actuarial software for the insurance industry based on innovative statistical and geophysical models for natural hazards.

Duties

- Undertake research on atmospheric dynamics of tropical cyclones

Skills

- Mesoscale dynamical atmospheric modelling
- Development of statistical stochastic models for risk assessment

2007 **Post-Doctoral Fellow: Air Quality Modelling**

Ecole Polytechnique, Institut Pierre Simon Laplace, Laboratoire de Météorologie Dynamique, Palaiseau, France

Business or sector

- Academic research

Duties

- Contribute to the development of the CHIMERE open-source air quality model
- Publish research on atmospheric chemistry and physics

Skills

- Numerical modelling of atmospheric chemistry and physics

2006 **Consultant: Climate Change impacts on International policy**

UNESCO, World Heritage Centre, Paris, France

Business or sector

- International governmental organisation

Duties

- Build scientific evidence on the impacts of climate change on the World Heritage
- Prepare supporting documents to add Climate Change as a criterion to list a site as "in danger"

Skills
- Scientific synthesis in support of international policy
- Publication of technical and laymen material

2001-2002 **Research Assistant: Atmospheric modelling**

Stanford University, CA, USA

Business or sector
- Academia

Duties
- Conduct research on atmospheric dispersion in mountain valleys

Skills
- Numeric modelling in the open source ARPS model (WRF predecessor)

EDUCATION AND TRAINING

2002 – 2005 **Ph.D. with Honors**

Sorbonne University, Paris, France

- Atmospheric Physics and Chemistry Doctorate under the supervision of Gérard Ancellet at Laboratoire Atmosphères, Milieux, Observations Spatiales (LATMOS/IPSL)

1998-2000 **Batchelor, Master of Science and Master of Engineering**

Ecole Centrale, Lyon, France

- Major in fluid mechanics and environment in a top French “Grande Ecole”

PERSONAL SKILLS

- 35yr of musical practice, upright bass, cello.

Mother tongue(s): French

Other language(s)

	UNDERSTANDING		SPEAKING		WRITING
	Listening	Reading	Spoken interaction	Spoken production	
English	C1	C2	C1	C1	C1
Spanish	A1	A1	A1	A1	A1

Levels: A1/2: Basic user - B1/2: Independent user - C1/2 Proficient user
Common European Framework of Reference for Languages

Communication skills
- Excellent communication skills developed through oral presentations in conferences and chairing international working group of experts
- Media interviews on air quality

Organisational / managerial skills
- Synthetic and analytic thinking
- Professional expertise in a variety of contexts (institutional, business, academia both national and international)
- Manager of a team of a dozen qualified scientists

Computer skills
- Extended knowledge of programming, including in high-performance computing environment.

Driving licence
- Private cars

ADDITIONAL INFORMATION

About 85 ISI publications, Google Scholar H-index 36 (2021)

Most relevant publications in the occupational field:

- G. Ciarelli, A. Colette, S. Schucht, M. Beekmann, C. Andersson, A. Manders-Groot, M. Mircea, S. Tsyro, H. Fagerli, A.G. Ortiz, M. Adani, G. Briganti, A. Cappelletti, M. D'Isidoro, C. Cuvelier, F. Couvidat, F. Meleux and B. Bessagnet, Long-term health impact assessment of total PM2.5 in Europe during the 1990–2015 period, Atmospheric Environment: X 3(2019a), p. 100032.
- Z.L. Fleming, R.M. Doherty, E. Von Schneidemesser, C.S. Malley, O.R. Cooper, J.P. Pinto, A. Colette, X. Xu, D. Simpson and M.G. Schultz, Tropospheric Ozone Assessment Report: Present-day ozone distribution and trends relevant to human health, (2018).
- A. Fortems-Cheiney, G. Foret, G. Siour, R. Vautard, S. Szopa, G. Dufour, A. Colette, G. Lacressonniere and M. Beekmann, A 3 °C global RCP8.5 emission trajectory cancels benefits of European emission reductions on air quality, Nature Communications 8(2017), p. 89.
- V.N. Likhvar, M. Pascal, K. Markakis, A. Colette, D. Hauglustaine, M. Valari, Z. Klimont, S. Medina and P. Kinney, A multi-scale health impact assessment of air pollution over the 21st century, Science of The Total Environment 514(2015), pp. 439-449.
- A. Colette et al., Is the ozone climate penalty robust in Europe?, Environmental Research Letters 10(2015), p. 084015.
- S. Schucht, A. Colette, S. Rao, M. Holland, W. Schoepp, P. Kolp, Z. Klimont, B. Bessagnet, S. Szopa, R. Vautard, J.-M. Brignon and L. Rouïl, Moving towards ambitious climate policies: Monetised health benefits from improved air quality could offset mitigation costs in Europe, Environmental Science & Policy 50(2015), pp. 252-269.A. Colette et al., European atmosphere in 2050, a regional air quality and climate perspective under CMIP5 scenarios, Atmos. Chem. Phys. 13(2013), pp. 7451-7471.
- A. Colette et al., Future air quality in Europe: a multi-model assessment of projected exposure to ozone, Atmos. Chem. Phys. 12(2012), pp. 10613-10630.

PERSONAL INFORMATION

MELEUX Frédérik

INERIS – Parc Technologique Alata – 60550 Verneuil en Halatte - France

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frederik.meleux@ineris.fr

www.prevair.org

Sex: Male | Date of birth: 23/08/1973 | Nationality: French

JOB APPLIED FOR
POSITION
PREFERRED JOB
STUDIES APPLIED FOR

Air quality forecasting and management

WORK EXPERIENCE

From June 2005 – onwards

Research engineer for Air quality Monitoring and Forecasting over Europe and France

INERIS – Parc Technologique Alata – 60550 Verneuil en Halatte – France - www.ineris.fr

- Prev'Air (National air quality system) coordination
- Air quality expert for public body, decision-makers, and public in France and Europe (www.prevair.org; European air quality | Copernicus Atmosphere Monitoring Service)
- Research project manager in:
  - Operational air quality system development with the CHIMERE air quality model
  - Emissions for improving air quality system (ammonia, pollen …)
- Work package leader in Copernicus atmospheric services CAMS-50, CAMS-63 and contributor in CAMS-71
- Coordinator of Copernicus use case service CAMS-95h
- Auditor of regional air quality organisations (AASQA)

From November 2004 to May 2005

Visiting scientist

ICTP, Strada Costiera 11, I-34014 Trieste - www.ictp.it

- Research activity on Modelling tool for long term air quality predictions over Europe

Abdus Salam International Centre for Theoretical Physics (ICTP) operates under the aegis of two United Nations Agencies: UNESCO and IAEA (www.ictp.it)

From April 2004 to October 2004

Research engineer for Air quality Monitoring and Forecasting over Europe and France

INERIS – Parc Technologique Alata – 60550 Verneuil en Halatte – France - www.ineris.fr

- Air quality short term forecast for: public body, decision-maker, and public awareness

French public research body of an industrial and commercial character under the aegis of the French Ministry for Ecology

From December 2002 to July 2003

Research engineer for nuclear pollutant modelling

IRSN, BP 3- F-13115 Saint-Paul-Lez-Durance Cedex (www.irsn.fr)

- Development of a modelling tool to monitor the fate of hazardous nuclear pollutants in the biosphere, Assessment of the human exposure in case of accidental nuclear emissions

Public establishment of an industrial and commercial nature placed under the joint authority of the Ministries of the Environment, Health, Industry, Research and Defence

EDUCATION AND TRAINING

From 1998 to 2002

PhD

Université Paul Sabatier - 118 Route de Narbonne, 31400 Toulouse

- Thesis subject: Air pollution modelling at various scales, from local to continental.
- Modelling about atmospheric dynamics (pollutant transport) and tropospheric chemistry, with a focus over a complex zone: The Marseille area.
- Programming activities in Fortran. Preparation of experimental campaign (Escompte).

- Teaching in mathematics

From 1997 to 1998

DEA in Oceanography; Atmospheric and Biosphere

Université Paul Sabatier - 118 Route de Narbonne, 31400 Toulouse

- Meteorology, atmospheric dynamics, tropospheric chemistry, interactions between media, climate change

PERSONAL SKILLS

Mother tongue(s): French

Other language(s)

	UNDERSTANDING		SPEAKING		WRITING
	Listening	Reading	Spoken interaction	Spoken production	
English	C1	C1	B2	B2	B2

Levels: A1/2: Basic user - B1/2: Independent user - C1/2 Proficient user
Common European Framework of Reference for Languages

Communication skills

- Good working ability in a team, good capacity to communicate in a foreign context, attendance and participation to European workshops and conferences

Organisational / managerial skills

- Research manager for several French and European Research projects in air quality. Technical manager for the Prev'Air system (air quality monitoring and forecasting system in France and Europe)

Computer skills

- Robust programming skills in Fortran, C++, and mapping software language (Matlab ….)
- Knowledge of office software

Driving licence

- B

ADDITIONAL INFORMATION

Publications
Presentations
Projects
Conferences
Seminars
Honours and awards
Memberships
References

Most relevant publications in the occupational field :

Barré, Jérôme, Hervé Petetin, Augustin Colette, Marc Guevara, Vincent-Henri Peuch, Laurence Rouil, Richard Engelen, et al. « Estimating Lockdown-Induced European NO₂ Changes Using Satellite and Surface Observations and Air Quality Models ». *Atmospheric Chemistry and Physics* 21, nº 9 (17 mai 2021): 7373-94. https://doi.org/10.5194/acp-21-7373-2021.

Colette, Augustin, Laurence Rouïl, Frédérik Meleux, Vincent Lemaire, et Blandine Raux. « Air Control Toolbox (ACT_v1.0): a machine learning flexible surrogate model to explore mitigation scenarios in air quality forecasts ». Preprint. Atmospheric sciences, 23 avril 2021. https://doi.org/10.5194/gmd-2020-433.

Mailler, Sylvain, Laurent Menut, Dmitry Khvorostyanov, Myrto Valari, Florian Couvidat, Guillaume Siour, Solène Turquety, et al. « CHIMERE-2017: From Urban to Hemispheric Chemistry-Transport Modeling ». *Geoscientific Model Development* 10, nº 6 (28 juin 2017): 2397-2423. https://doi.org/10.5194/gmd-10-2397-2017.

Vautard, Robert, Augustin Colette, Erik van Meijgaard, Frederik Meleux, Geert Jan van Oldenborgh, Friederike Otto, Isabelle Tobin, et Pascal Yiou. « Attribution of Wintertime Anticyclonic Stagnation Contributing to Air Pollution in Western Europe ». *Bulletin of the American Meteorological Society* 99, nº 1 (1 janvier 2018): S70-75. https://doi.org/10.1175/BAMS-D-17-0113.1.

- Honoré C, Rouil L, Vautard R, Beekmann M, Bessagnet B, Malherbe L, **Meleux F**, Dufour A. Elichegaray C, Flaud J-M, Menut L, Martin D, Peuch V-H, Poisson N. Predictability of regional air quality in Europe: the assessment of three years of operational forecasts and analyses over France, Journal of Geophysical Research, Atmospheres 113, D04301 (2008),
- **Meleux F.,** Solmon F., Giorgi F. Increase in summer European ozone amounts due to climate change, Atmospheric Environment 41, 7577-7587 (2007),
- Giorgi f., **Meleux F**. Modeling the regional effects of climate change on air quality. Geosciences 339, 721-733 (2007),

PERSONAL INFORMATION

UNG Anthony

INERIS – Parc Technologique Alata – 60550 Verneuil en Halatte - France

+33 3 44 55 63 68 +33 6 09 74 47 78

anthony.ung@ineris.fr

www.prevair.org

Sex Male | Date of birth 20/08/1976 | Nationality French

JOB APPLIED FOR
POSITION
PREFERRED JOB
STUDIES APPLIED FOR
PERSONAL STATEMENT

Research engineer for Air Quality Monitoring and Forecasting

WORK EXPERIENCE

2007- onwards

Research engineer for Air Quality Monitoring and Forecasting

Institut National de l'Environnement Industriel et des Risques (INERIS)

Parc Technologique Alata BP2, 60550 Verneuil-en-Halatte, FRANCE

- Development and maintenance of the operational air quality short term forecast with the CHIMERE air quality model (www.prevair.org).
- Development of the analysis tools dedicated to several European research projects: GEOMON (FP6), GEMS (FP6), and MACC (FP7).
- Development of the common air quality index forecast for CITEAIR2 (INTERREG IVC).

Business or sector French public research body of an industrial and commercial character under the aegis of the French Ministry for Ecology

EDUCATION AND TRAINING

2000-2004

PhD

Ecole des Mines de Paris, Sophia Antipolis, France

- Thesis subject: Air quality monitoring over urban area using multisource and remotely sensed data.

PERSONAL SKILLS

Mother tongue(s) French

Other language(s)	UNDERSTANDING		SPEAKING		WRITING
	Listening	Reading	Spoken interaction	Spoken production	
English	C1	C1	C1	C1	C1

Communication skills

- Attendance and participation to European project workshops and conferences

Job-related skills

At MOCA unit (Modelling and Mapping), in charge of the development of the Prevair (http://www2.prevair.org) and associated CAMS (Copernicus Atmosphere Monitoring Service) products and services.

In CAMS_50: contribution to the observation acquisitions and observation processing. Provision assistance to the partners for using the observations in the reanalysis productions.

- Good working ability in a team.
- Good capacity to communicate in a foreign context.
- Air quality modeling and atmospheric chemistry

Digital skills

SELF-ASSESSMENT				
Information processing	Communication	Content creation	Safety	Problem solving

- Windows & Linux platform;
- Advanced Bash scripting;
- Advanced Fortran programming;
- Advanced R-base statistics computing;
- Build/Connect/Install/Configure Computer;
- good command of office suite (word processor, spread sheet, presentation software);
- good command of photo editing software gained as an amateur photographer.

Driving licence

No driving license

ADDITIONAL INFORMATION

Publications

- UNG, Anthony, WALD, Lucien, RANCHIN, Thierry, WEBER, Christiane, HIRSCH, Jacky, PERRON, Gilles, KLEINPETER, Joseph, 2002. Satellite data for the air pollution mapping over a city - The use of virtual station. In Proceedings of the 21th EARSeL Symposium, Observing our environment from space: new solutions for a new millenium, Paris, France, 14-16 may 2001, Gérard Begni editor, A. A. Balkema,, Lisse, Abingdon, Exton (PA), Tokyo, pp. 147-151.
- UNG A., Ranchin T., Wald L., Weber C., Hirsch J., Perron G., Kleinpeter J., 2002, Cartographie de la pollution de l'air : une nouvelle approche basée sur la télédétection et les bases de données géographiques. Application à la ville de Strasbourg. PhotoInterprétation, 2000 3/4, pp. 53-64
- UNG A., Meleux F., Rouil L., Kacenelengen M., Leon J.F., Chiapello I., Lifermann A. - the use of polder satellite data for chimere chemistry transport model - egu general assembly, 15-20 avril 2007, vienne, autriche. [Poster], geophysical research abstracts, 2007, vol. 9, 01033
- FORET, G., M. Beekmann, M. Eremenko, L. Hamaoui, C. Schmechtig, C. Keim, G. Dufour, A. Boynard, and A. Ung, Evaluating the potential of IASI ozone observations to constrain simulated surface ozone concentrations, Atmos. Chem. Phys. Discuss., 9, 12829-12856, 2009

PERSONAL INFORMATION

Blandine Raux

1031 route du Chaffard, 38630 Les Avenières, France

07 64 35 34 36

blandine.raux@ineris.fr

Sex F | Date of birth 16/02/1996 | Nationality French

INTENDED ROLE IN ETC HE

Data science and Air quality modelling Engineer

WORK EXPERIENCE

Since 2018

Data science and air quality modelling engineer

INERIS, France - https://www.ineris.fr

- Air pollution and air quality modelling and evaluation
- Development of IT tools (pre- and post-treatment)
- Development of web applications for public viewing of the team's work

Business or sector Air pollution modelling

EDUCATION AND TRAINING

From 2015 to 2018

Engineering diploma from the National School of Electronics, Computer Science, Telecommunications, Mathematics and Mechanics,

Mathematics and Mechanics specialty, High Performance Computing option

ENSEIRB-MATMECA, France - https://enseirb-matmeca.bordeaux-inp.fr

- Mechanics (materials, structures, fluids, energetics)
- Mathematics and digital methods
- Scientific and high-performance computing

PERSONAL SKILLS

Mother tongue(s) French

Other language(s)

	UNDERSTANDING		SPEAKING		WRITING
	Listening	Reading	Spoken interaction	Spoken production	
English	C1	C1	C1	C1	C1
	TOEIC – score of 950				
German	B1	B1	A2	A2	A2
Spanish	A1	A1	A1	A1	A1

Levels: A1/2: Basic user - B1/2: Independent user - C1/2 Proficient user
Common European Framework of Reference for Languages

Computer skills

Programming languages:
- Python: used during my studies and for my current position
- R (shiny): learned for my current position
- Fortran90: learned during my studies
- PHP/HTML: self-taught for a personal project

Operating systems:
- Linux
- Windows

Other skills

- Team working
- Good communication

ADDITIONAL INFORMATION

Projects

- Co-development of a python library for simulations' evaluations, https://opensource.umr-cnrm.fr/projects/evaltools, since 2018

PERSONAL INFORMATION

Mikhail Sofiev

Erik Palmenin Aukio 1 00560, Helsinki, Finland
+358 295395433 +358503290578
Mikhail.sofiev@fmi.fi

Sex male | Date of birth 06/08/1967 | Nationality Finland, Russia

WORK EXPERIENCE

]

1999 - c.m. — Research Professor, deputy leader of modelling group

Finnish Meteorological Institute

- Mathematical modelling of atmospheric composition. Development and application of atmospheric composition and air pollution models for various scales – from meso- to globe – and compounds – acidifying, ozone, toxic, aerosols, radioactive, etc. Related fields – climate forcing, model evaluation, data assimilation, statistical methodology, ensemble construction and evaluation, data analysis, computer experiments, etc.
- Coordination of international scientific and application work.

1997 - 1999 — Infrastructure manager

Procter and Gamble Manager in the IT department of Moscow subsidiary of Procter and Gamble, infrastructure manager of Novomoskovskbythim chemical plant; manager of the infrastructure group. Responsible for the computer infrastructure (~300 computers) and telecommunication systems of the plant.

1992 - 1997 — Senior scientist, chief engineer

Meteorological Synthesising Centre East of the UN ECE European Monitoring and Evaluation Programme (EMEP)

- Mathematical modelling of atmospheric composition. Development and application of air pollution models for various scales – from meso- to globe – and compounds – acidifying, toxic, aerosols, radio-active accidental releases, etc. Related fields – model evaluation, data assimilation, statistical methodology, ensemble prediction, data analysis, computer experiments, etc.
- Management of computing centre: organizational issues, infrastructure planning and development, hard- and software acquisition, installation and maintenance.

EDUCATION AND TRAINING

2007 — Adjunct Professor of Physics

University of Helsinki

1996 — Oxford International Business English, executive level

Oxford International English Courses, Moscow

1994 — Doctor of science in technology (PhD)

Moscow Institute of Program Systems, Russian Academy of Sciences

Master of Science, applied mathematics and physics

Moscow Institute of Physics and technology

- Higher education in the field of applied mathematics and physics

Mother tongue: Russian

	Listening	Reading	Spoken interaction	Spoken production	Writing
English	C2	C2	C2	C2	C2
Finnish	B1	B1	B1	B1	A2

Communication skills

- Extensive communication skills acquired through many years of work experience at senior researcher and infrastructure manager positions, over 400 presentations and lectures at various international meetings, organization and follow-up of international projects, negotiations, managing conferences, schools, etc.

Organisation / managerial skills

- Co-ordination and management of a mid-sized group of researchers and technicians. Practical experience in organization of work on the model development and application by the team of researchers and programmers; management of IT support and infrastructure groups.
- Management of computing centre at a position of a chief engineer. Practical experience in organizational issues, infrastructure planning and development, hard- and software acquisition, installation and maintenance. A 1.5-year experience at IT managerial position, incl. Infrastructure Manager position at the chemical plant Novomoskovskbythim.

Job-related skills

- Extensive practical experience in development and application of air pollution models from meso- to global scales for acidifying, toxic, aerosols, radio-active compounds, accidental releases, etc. Extensive experience in the related fields – model evaluation, data assimilation, statistical methodology, ensemble prediction, data analysis, computer experiments, etc.
- Supervisor of 14 academic theses. On-going: 1 PhD, Completed: 5 PhD, 6 MSc, 2 intern. scholarships, opponent to 2 doctoral dissertations.
- Reviewer in: Journal of Geophysical Research, Atmospheric Environment, Water, Air and Soil Pollution, Boreal Environment, Atmospheric Chemistry and Physics, International Journal on Environment and Pollution, Boundary Layer Meteorology, International Journal of Biometeorology, Science of Total Environment, European Journal of Forest Research, Geoscience and Model Development, Environmental Modelling and Software, Geophysical Model Development
-

Computer skills

Computer expert. Extensive practical experience in setup of computers on various platforms and operation systems; installation, configuration and application of office and professional software, information systems, telecommunications, Internet. Programming experience on 6 languages.

Publications

252 scientific publications; 155 of these have been published in refereed journals and books (Google-Scholar h-index = 46, accessed 7.7.2021, ISIWebOfScience h-index = 35, accessed 21.7.2021).

Presentations

Over 400 lectures and presentations: at scientific and application conferences

Projects

Participated and coordinated 49 international research projects. Examples of the on-going ones:

1. EXHAUSTION (2019-2023) Exposure to heat and air pollution in EUrope – cardiopulmonary impacts and benefits of mitigation and adaptation. H2020, Task leader,
2. EMERGE (2020-2024) Evaluation, control and Mitigation of the EnviRonmental impacts of shippinG Emissions, H2020, WP co-leader
3. GLORIA (2018-2021). Global health risks related to atmospheric composition and weather. Academy of Finland. WP co-leader.
4. PS4A (2018-2022): Advanced study of Pollen, Spores, and air pollutants for predicting the human Allergy. Academy of Finland, PI

Schools

FMI Met PD course, IAEA regional development, summer schools in Finland, Russia, Portugal, and Ukraine

Memberships

- Member of WMO Scientific Advisory Group on Applications
- Member of WHO Science Advisory Group ofn Desert dust and health
- Board Member of European Aeroallergen Network
- Editorial board member of Aerobiologia
- Associated Editor of Atmospheric Environment
- Member of International Biometeorological Society, European Aerobiological Society, European Academy of Allergology and Clinical Immunology.
- Member of Emergency Response team of Finnish Meteorological Institute

Selected publications, inverse chronological order (totally, 252 scientific works, excl. abstracts, 155 published in peer-reviewed literature, H-index = 46)

Damialis, A., Gilles, S., **Sofiev, M.**, Sofieva, V. and Kolek, F. Bayr, D. Plaza, Maria P. Leier-Wirtz, V. Kaschuba, S. Ziska, L. H. Bielory, L. Makra, L., del Mar Trigo, M. Traidl-Hoffmann, C. (2021) Higher airborne pollen concentrations correlated with increased SARS-CoV-2 infection rates, as evidenced from 31 countries across the globe. Proc. Nat. Academy of Sciense, 118, 12, doi = 10.1073/pnas.2019034118, https://www.pnas.org/content/118/12/e2019034118

Sofiev, M. (2019) On possibilities of assimilation of near-real-time pollen data by atmospheric composition models. Aerobiologia, DOI: 10.1007/s10453-019-09583-1, http://link.springer.com/article/10.1007/s10453-019-09583-1, 35(3), 523-531.

Sofiev, M., Winebrake, J.J., Johansson, L., Carr, E.W., Prank, M., Soares, J., Vira, J., Kouznetsov, R., Jalkanen, J.-P., Corbett,J.-J. (2018) Cleaner fuels for ships provide public health benefits with climate tradeoffs. Nature Comm. DOI: 10.1038/s41467-017-02774-9, www.nature.com/naturecommunications

Kukkonen J., Kangas L., Kauhaniemi M,, **Sofiev M.**,, Aarnio M., Jaakkola J.J.K., Kousa A., Karppinen A., (2017) Modelling of the urban concentrations of PM2.5 for a period of 35 years, for the assessment of lifetime exposure and health effects. Atmos. Chem. Phys., 18, 8041–8064, 2018. https://doi.org/10.5194/acp-18-8041-2018.

Sofiev, M., Vira, J., Kouznetsov, R., Prank, M., Soares, J., Genikhovich, E. (2015) Construction of the SILAM Eulerian atmospheric dispersion model based on the advection algorithm of Michael Galperin, *Geosci.Model Developm.* 8, 3497-3522, doi:10.5194/gmd-8-3497-2015.

Sofiev, M., Ritenberga, O., Albertini, R., et al (2017) Multi-model ensemble simulations of olive pollen distribution in Europe in 2014, Atmos. Chem. Phys. doi:10.5194/acp-2016-1189,.

Sofiev, M., Vankevich, R., Ermakova, T., Hakkarainen, J. (2013) Global mapping of maximum emission heights and resulting vertical profiles of wildfire emissions. *Atmos. Chem. Phys.*, **13**, 7039-7052, doi. 10.5194/acp-13-7039-2013

Vira, J., **Sofiev**, M. (2012) On variational data assimilation for estimating the model initial conditions and emission fluxes for the short-term forecasting of SOx concentrations. *Atmosph. Environ*., **46**, pp.318-328, doi:10.1016/j.atmosenv.2011.09.066.

Kouznetsov, R., **Sofiev**, M. (2012) A methodology for evaluation of vertical dispersion and dry deposition of atmospheric aerosols. *JGR*, **117**. doi: 10.1029/2011JD016366.

Sofiev, M., Soares, J., Prank, M., de Leeuw, G., Kukkonen, J. (2011) A regional-to-global model of emission and transport of sea salt particles in the atmosphere. *JGR*, 116, D21302, doi:10.1029/2010D014713.

PERSONAL INFORMATION

Julia (Yuliia) Palamarchuk

Erik Palmenin Aukio 1 00560, Helsinki, Finland
/ +358503518857
Yuliia.palamarchuk@fmi.fi

Sex female | Date of birth 03/07/1983 | Nationality Ukraine

WORK EXPERIENCE

2017 - c.m.

Researcher

Atmospheric Composition Unit, Finnish Meteorological Institute

- Mathematical modelling of atmospheric dynamics and air pollution. Extensive experience in application and evaluation of numerical weather prediction and air pollution models for various scales; bioaerosols measurements and modelling.
- Automatic real time pollen monitors and related recognition algorithms

Business or sector Government research institute

2011 - 2017

Researcher, lecturer

Dynamical Meteorology and Forecasts Dep., Odessa State Environmental University, Odessa, Ukraine.

- lecturing and giving practical exercises on dynamical meteorology and atmospheric physics for student of the third and fourth levels.
- Numerical simulations with the weather forecast model MM5 in pursuit estimates of the model error growth rate and forecast sensitivity to model formulations: the model grid resolution and physical parameterization schemes including convection and microphysics. Numerical experiments with the HARMONIE model at the ECMWF High Performance Computing Facility system to investigate the meteorology-chemistry/aerosols feedbacks and interactions in weather forecasting.

Business or sector Government educational University

2004 - 2011

Meteorologist, technician (2004-2007); Head of forecast verification department (2007-2011)

Hydrometeorological Centre Black and Azov Seas, Odessa, Ukraine.

- Processing of meteorological weather charts and weather reports/messages; support of the release of storm weather alerts and its dissemination to the governmental institutions and to public.
- Operational computations of high resolution downscaled pressure and wind fields for the Black Sea region; supporting the operational satellite processing.
- Responsible for the routine verifications of weather forecasts, compilation of the verification reports.
- Development of methodology and guidance of the marine forecasts evaluation.

Business or sector Government hydrological and meteorological regional centre

EDUCATION AND TRAINING

2014

Doctor of Philosophy in Geosciences (PhD)

Odessa State Environmental University, Odessa, Ukraine.

2005 - 2009

PhD student

Dynamical Meteorology and Forecasts Dep., Odessa State Environmental University

Post-graduate course in a field meteorology, climate, agricultural meteorology and related areas.

2004 - 2005

Master of science in meteorology

Dynamical Meteorology and Forecasts Dep., Odessa State Environmental University

2000 - 2004

Student

Dynamical Meteorology and Forecasts Dep., Odessa State Environmental University

High education in the field of meteorology.

PERSONAL SKILLS

Mother tongue(s): Ukrainian, Russian

Other language(s)

	UNDERSTANDING		SPEAKING		WRITING
	Listening	Reading	Spoken interaction	Spoken production	
English	B2	B2	B2	B2	B2

Communication skills

- Good communication skills acquired through the working experience as the researcher, by extensive collaboration in international projects, lecturing, by presenting the scientific results at numerous international conferences/meetings.

Organisational / managerial skills

- Managerial experience in organization of scientific work in group of students
- Assistance in co-ordination and management of small group of researchers (measurement campaign)

Job-related skills

- Practical experience in mathematical modelling of atmospheric dynamics and air pollution. Extensive experience in application and evaluation of numerical weather prediction and air pollution models for various scales.
- Good skills in operation of automatic real time pollen monitors and development of related pollen recognition algorithms

Computer skills

- Advanced user. Practical experience in installation, configuration and application of office and professional software. Experienced user of UNIX based systems. Programming experience on 3 languages.

Publications

40 scientific publications; 15 of these have been published in refereed journals and books (Google-Scholar h-index = 6, accessed 21.7.2021).

Presentations

Over 40 lectures and presentations: at scientific and application conferences

Projects

Participated in 15 national and international research projects. Examples of the on-going ones:

1. GLORIA (2018-2021). Global health risks related to atmospheric composition and weather. Academy of Finland. Researcher.
2. PS4A (2018-2022): Advanced study of Pollen, Spores, and air pollutants for predicting the human Allergy. Academy of Finland. Researcher.

Conferences Seminars

Attended over 40 international scientific conferences/workshops covering the meteorology, aerobiology, air quality and health assessment topics.

Selected publications, inverse chronological order

Sofiev, M., **Palamarchuk, Y.**, Bédard, A., Basagana, X., Anto, JM., Kouznetsov, R., Delgado, R., Bergmann, KC., Fonseca, J., De Vries, G., Van Erd, M., Annesi-Maesano, I., Laune, D., Pépin, JL., Zeng, S., Czarlewski, W., Bousquet. J. A demonstration project of Global Alliance against Chronic Respiratory Diseases: Prediction of interactions between air pollution and allergen exposure—the Mobile Airways Sentinel NetworK-Impact of air POLLution on Asthma and Rhinitis approach, Chinese Medical Journal, 2020 – Vol.133 - Issue 13 – p. 1561-1567, doi: 10.1097/CM9.0000000000000916

Lugonja, P., Brdar, S., Simović, I., Mimić, G., **Palamarchuk, Y.**, Sofiev, M., Šikoparija, B. Integration of in situ and satellite data for top-down mapping of Ambrosia infection level. Remote Sensing of Environment Vol. 235. http://www.sciencedirect.com/science/article/pii/S0034425719304742, doi: https://doi.org/10.1016/j.rse.2019.111455. 2019

Korhonen, A., Lehtomäki, H., Rumrich, I., Karvosenoja, N., Paunu, V-V., Kupiainen, K., Sofiev, M., **Palamarchuk, Y.,** Kukkonen, J., Kangas, L., Karppinen, A., Hänninen, O. (2019) Influence of spatial resolution on population PM2.5 exposure and health impacts, Air Qual Atmos Health (2019) 12: 705, DOI: https://doi.org/10.1007/s11869-019-00690-z

Lehtomäki, H., Korhonen, A., Asikainen, A., Karvosenoja, N., Kupiainen, K., Paunu V.-V., Savolahti, M., Sofiev, M., **Palamarchuk, Y**., Karppinen, A., Kukkonen, J., Hänninen, O. (2018) Health impacts of ambient air pollution in Finland. Int. J. Environ. Res. Public Health, 2018, 15(4), 736; doi:10.3390/ijerph15040736

Palamarchuk I., Ivanov S., Ruban I., Pavlova H. Influence of aerosols on atmospheric variables in the HARMONIE model. Atmospheric Research (2015) 169 (2016) 539–546, http://dx.doi.org/10.1016/j.atmosres.2015.08.001

Ivanov S., **Palamarchuk J**. Heat and energy fluxes in the convective cell behind a cold front. Adv. Geosci., 8, 1–7, 2010.

Signature: