

2020-2022 GEO Work Programme

Copernicus Atmosphere Monitoring Service

1. Executive Summary

The Copernicus Atmosphere Monitoring Service (CAMS) is one of the 6 core services of the European Union's flagship programme Copernicus. It provides consistent and quality-controlled information based on Earth Observation and related to air pollution and health, solar energy, greenhouse gases and climate forcing, anywhere in the world. All these CAMS information products are available to all, following a full-free-open data policy.

CAMS has been operating in operational mode since 2015, building on a decade of R&D precursor projects and activities of user consultation. CAMS is managed and partly implemented by the European Centre for Medium-Range Weather Forecasts and partly by means of contracts involving over 130 public and private entities from more than 28 European countries. The work programme of CAMS beyond 2021 will seek enhanced continuity and will depend upon the wider programmatic elements of the future Multi-Financial Framework of the European Commission and, in particular, the future Space regulation.

2. Purpose

Copernicus is the European Union (EU) flagship programme for monitoring the Earth's environment using space and in-situ observations. Copernicus delivers operational data and information services on a range of topical areas. Based upon these baseline services, many other value-added products can be tailored to more specific public, policy or commercial needs.

Copernicus includes six core thematic services: Atmosphere monitoring, Land Monitoring, Marine Environment Monitoring, Emergency Management, Security and Climate Change. The Atmosphere Monitoring Service (CAMS) includes monitoring for air quality and UV forecasts at global and European level, greenhouse gases, climate forcing and emissions. The Land Monitoring Service includes the monitoring for water management, agriculture and food security, land-use change, forest monitoring, soil quality, urban planning and natural protection services. The Marine Environment Monitoring Service includes the monitoring for marine safety and transport, oil-spill detection, water quality, ocean forecasting and the polar environment. The Emergency Management Service supports mitigating the effects of natural and manmade disasters such as floods, forest fires and earthquakes and contribute to humanitarian aid exercises. The Security supports peace-keeping efforts, maritime surveillance and border control. Last but not least, the Climate Change Service (C3S) cuts across all the above themes and is about providing authoritative, quality-assured information about the past, current and future states of the climate in Europe and worldwide.

All Copernicus products including the information services provided are freely and openly accessible to users worldwide.

CAMS addresses some of today's most important environmental concerns, which are related to the composition of the atmosphere. Most prominent is the increasing concentration of the long-lived and reactive greenhouse gases. Climate warming and linked impacts such as sea-level rise and changes in rainfall distributions are offset to a degree by a cooling effect of aerosol concentrations, but the extent of the offset and the role played by aerosol-cloud interactions are key uncertainties in the driving of climate change. Other uncertainties relate to recent changes in the rate of growth of methane concentrations, the roles of different factors increasing tropospheric ozone concentrations, the quantification of

land/atmosphere fluxes and the causes of changes in stratospheric water vapor and its associated radiative forcing. There are also important effects of short-term variations in atmospheric composition. At the Earth's surface, aerosols, ozone and other reactive gases such as nitrogen dioxide determine the quality of the air around us, affecting human health and life expectancy, the health of ecosystems and the fabric of the built environment. Ozone distributions in the stratosphere influence the amount of ultraviolet radiation reaching the surface, again with impacts on human, animal and plant health. Dust, sand, smoke and volcanic aerosols affect the safe operation of transport systems. Aerosols also affect the availability of power from solar generation, the formation of clouds and rainfall, and the remote sensing by satellite of land, ocean and other atmospheric properties. Accompanying these environmental concerns is a parallel set of needs for data and processed information. CAMS is organised to meet these needs, aiming at supporting policymakers, business and citizens with enhanced environmental information. CAMS also addresses policy objectives, bringing an essential contribution to the 7th EU Environment Action Programme, whose motto is "living well, within the limits of our planet".

3. Background and Previous Achievements

CAMS combines observations from satellite remote-sensing and from other sources and numerical models to deliver value added information services about atmospheric composition and its changes over the globe and, with refined resolution, over Europe.

Specifically, it delivers the following services:

- daily production of near-real-time analyses and forecasts of global atmospheric composition;
- reanalyses providing consistent multi-annual global datasets of atmospheric composition with a frozen model/assimilation system;
- daily production of near-real-time European air quality analyses and forecasts (including also pollens) with a multi-model ensemble system;
- reanalyses providing consistent annual datasets of European air quality with a frozen model/assimilation system, supporting in particular policy applications;
- products to support users in the environmental policy sector, adding value to "raw" data products in order to deliver information products in a form adapted to policy applications and policy-relevant work;
- solar and UV radiation products supporting the planning, monitoring, and efficiency improvements of solar energy production and providing quantitative information on UV irradiance for downstream applications related to health and ecosystems;
- greenhouse gas surface flux inversions for CO₂, CH₄ and N₂O, allowing the monitoring of the evolution in time of these fluxes;
- climate forcing from aerosols and long-lived (CO₂, CH₄) and shorter-lived (stratospheric and tropospheric ozone) agents.

All the products can be found on the CAMS website at <http://atmosphere.copernicus.eu> using the catalogue search tool. Support functions are also available to the users.

User uptake is continually monitored in CAMS and through surveys. At the end of 2018 number of registered users is in excess of 10500. On a quarterly basis, the number of "active" users (effectively downloading data) is in excess of 2600. But this only represent the direct users: the audience of CAMS is much larger. CAMS air quality bulletins aired several times daily on Euronews are seen by 18 million users. CAMS global air quality forecasts are also used by the default Apple "weather" iphone app as well as by The Weather Channel, with audience of several hundred million people. Many more smartphone applications relying on CAMS data have numbers of downloads between tens and hundreds of thousands. In short, CAMS is now a mainstream global source of air quality monitoring and forecasting information.

CAMS supports several policy areas that are pivotal for the European Union, especially in the areas of air quality, of greenhouse gases and of the ozone layer. Working with the World Meteorological Organization and the World Health Organization, CAMS intends to support monitoring the indicators of the Sustainable Development Goals which are within its thematic areas.

The two key highlights of 2018 were:

- CAMS has released in September its global reanalysis of atmospheric composition, covering the period 2003 to 2018. It is a quite unique dataset, which allow users to look at trends and impacts over the past 15 years -the period with satellite instruments measuring atmospheric composition.
- The uptake of observations from the Copernicus Sentinel-5P satellite in the CAMS operational streams. Sentinel-5P is now an essential input contributing to the quality of most CAMS products and to the resilience of the system in case of issues.

4. Key Activities

The current Delegation Agreement signed between ECMWF and the European Commission covers the period November 2014 until December 2020. Some provisions have been made to ensure operations of the Service until mid 2021 or so. This means that the current GEO work programme 2020-2022 goes beyond the current arrangement with the European Commission and we will report here only what activities are envisaged until the end of 2020 (assuming continuity 6 months into 2021).

CAMS will continue to deliver its portfolio of operational information products and services throughout the period. This portfolio is organised into four main categories and 15 product groups, as outlined in the table below. In this table, “analyses” or “re-analyses” refer to products which are obtained by combining different streams of observations using a modelling system: these correspond to 3D fields, which correspond to the best and most comprehensive picture one can have given the observations considered and taking into account their respective errors.

Portfolio	Product groups
A. Regional products	European AQ NRT analyses
	European AQ NRT forecasts
	European AQ interim reanalyses
	European AQ reanalyses
B. Global products (troposphere and stratosphere)	Global atmospheric composition NRT analyses
	Global atmospheric composition NRT forecasts
	Global atmospheric composition reanalyses
C. Supplementary products	Policy support products
	Solar radiation
	Greenhouse gas fluxes
	Climate forcings
D. Emissions products	European anthropogenic emissions
	Global anthropogenic and shipping emissions
	Global fire emissions
	Global natural, biogenic and volcanic emissions

In 2019 and 2020, CAMS activities will include:

- the consolidation of the operational use of all the Sentinel-5p products available (O_3 , NO_2 , CO , SO_2 , $HCHO$ and CH_4) and of Sentinel-3 data (AOD and FRP, as soon as available) in the CAMS global system;

- the promotion of the first CAMS reanalysis, covering 2003 to present (calculation to be completed to cover the entire year 2018 in 2019, and the year 2019 in 2020);
- the extension from 7 to 9 members of the operational regional air quality ensemble, expected to bring additional performance and resilience to issues;
- the upgrade to fully new emissions datasets for both global and regional systems operations;
- the completion of the migration of the CAMS products onto the Atmosphere Data Store (ADS) and DIAS;
- the continuation of efforts to consolidate the use of CAMS policy products at the European (DG-ENV, DG-CLIMA, EEA, JRC...) and international (WMO, WHO, UN/SDGs...) levels, as well as to increase their uptake at national level.

5. Relationship to GEO Engagement Priorities and to other Work Programme Activities

By making this information freely available to users, CAMS supports the United Nations Sustainable Development Goals (SDGs). By providing a wealth of operational, quality-controlled products on air quality, solar radiation and surface fluxes of natural and anthropogenic emissions, CAMS is a resource for initiatives such as EUROGEOSS.

6. Governance

The governance of CAMS follows the Delegation Agreement signed between ECMWF and the European Commission. CAMS is an operational programme scrutinised by the European Union's Copernicus Committee and Copernicus User Forum.

7. Data Policy

CAMS follows the Copernicus Programme Data Policy. Currently, The Regulation requires Copernicus data and information to be made available on a full, open and free of charge basis, subject to limitations concerning registration, dissemination formats, and access restrictions.

8. Annexes:

1. Brief CV of Project Leaders

Vincent-Henri Peuch: Head of the Copernicus Atmosphere Monitoring Service

Dr. Vincent-Henri Peuch is the Head of the Copernicus Atmosphere Monitoring Service (CAMS) and Deputy Director of Copernicus Services at the European Centre for Medium-Range Weather Forecasts (ECMWF).

Dr. Vincent-Henri Peuch, a native of France, obtained his PhD from Ecole Normale Supérieure de Lyon in 1996. Before joining ECMWF in 2011 to lead the precursor R&D European project of CAMS, Vincent-Henri was a scientist and then the Section Lead for Research on atmospheric composition data assimilation and forecasting at France's National Meteorological Service, Météo-France for 15 years. He has been involved in the design and development of Copernicus (formerly known as GMES, Global Monitoring for Environment and Security) since 2003.

He is an internationally respected scientist on atmospheric environment issues and has over 85 international peer reviewed publications to his credit. He is a member of several international scientific and advisory committees, including for the European Environment Agency and the World Meteorological Organisation's Global Atmospheric Watch programme.