



Atmosphere Monitoring

CAMS: The Copernicus Atmosphere Monitoring Service

Laurence Rouil - Richard Engelen
(ECMWF)
Lieven Bydekerke
(EUMETSAT)



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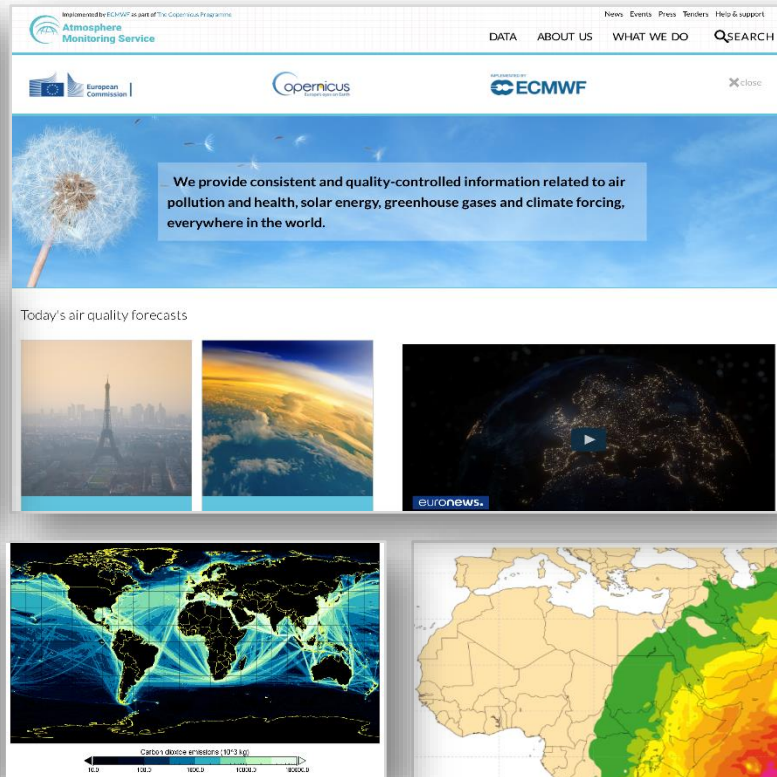
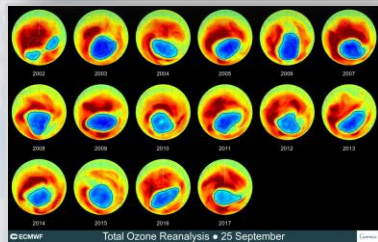
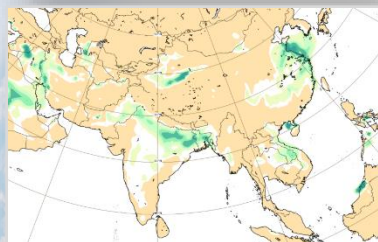
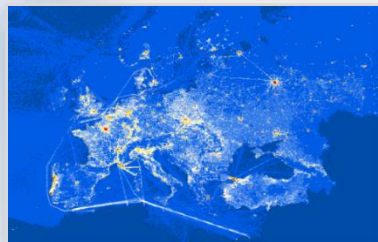
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Atmosphere
Monitoring

CAMS SCOPE – Atmospheric Composition



CAMS provides open & free information products based on Earth Observation about:

- past, current and near-future (forecasts) global atmospheric composition;
- the ozone layer;
- European air quality;
- emissions and surface fluxes of key pollutants and greenhouse gases;
- solar radiation;
- climate radiative forcing.

<http://atmosphere.copernicus.eu>
<http://ads.atmosphere.copernicus.eu>



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Europe's eyes on Earth

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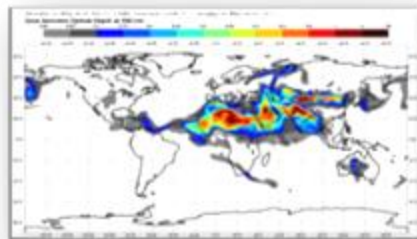
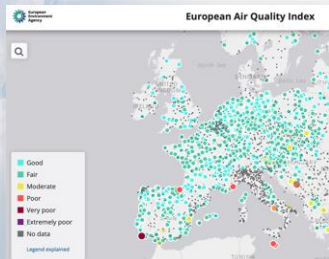


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CAMS INFORMATION FLOW

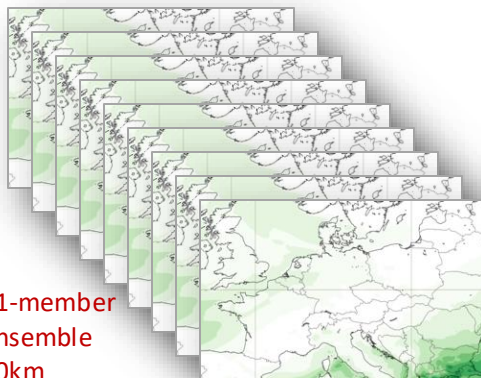


Earth Observation
from satellite (>75
instruments) and in-
situ (regulatory and
research)



IFS 40km (oper) / 80km (rean) Globe

CAMS main operational data
assimilation and modelling systems



11-member
ensemble
10km
Europe



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... in support to European legislations

Atmosphere
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Ambient Air Quality (AAQ) Directives

Maximum concentrations of
air polluting substances
(PM₁₀, PM_{2.5}, SO₂, NO₂, O₃ + 8 more)

Reactive gas,
aerosols



GHG



SETTING OBJECTIVES
FOR GOOD AIR QUALITY

REDUCING EMISSIONS
OF POLLUTANTS



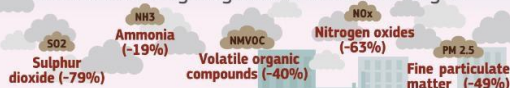
National Emission reduction
Commitments Directive

National emission totals
(SO₂, NO_x, NMVOC, PM_{2.5}, NH₃)

Source-specific
emission standards

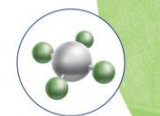
- IED Directive
- MCP Directive
- Eco-design Directive
- Energy efficiency
- Euro and fuel standards

Pollutants covered by EU National
Emission Ceilings legislation and 2030 targets



Solar radiation

EU Methane
Strategy



Covenant of Mayors
for Climate & Energy
EUROPE



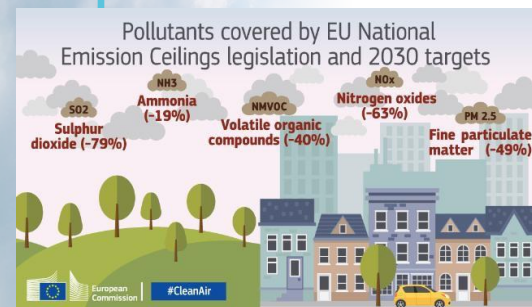
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Exciting times...

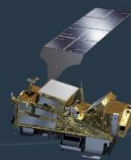
- EUMETSAT Polar System – Second Generation (EPS-SG)
- Meteosat Third Generation (MTG)

www.eumetsat.int

Greece
July 2023

The Flexible Combined Imager on board MTG-I1 can show fires and smoke (position, intensity, dynamics) in much higher resolution than was previously possible

Metop-SGA
Sounding and imagery
Sentinel-5



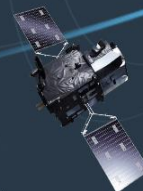
Metop-SGB
Microwave imagery



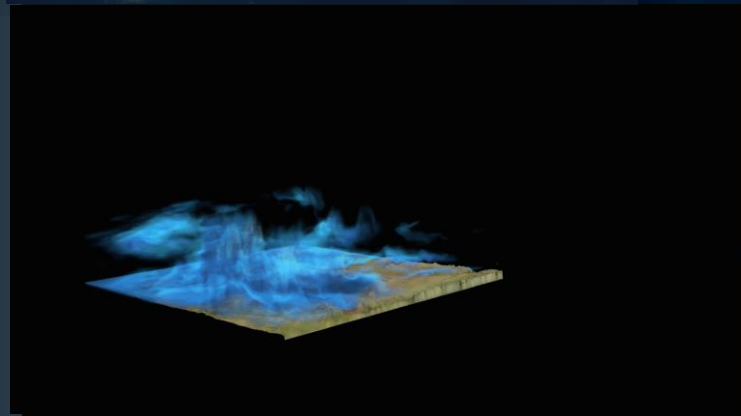
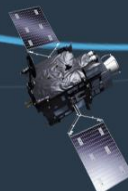
MTG-I
Full disc image service



MTG-S
Full disc sounding service
Sentinel-4



MTG-I
Rapid scanning service





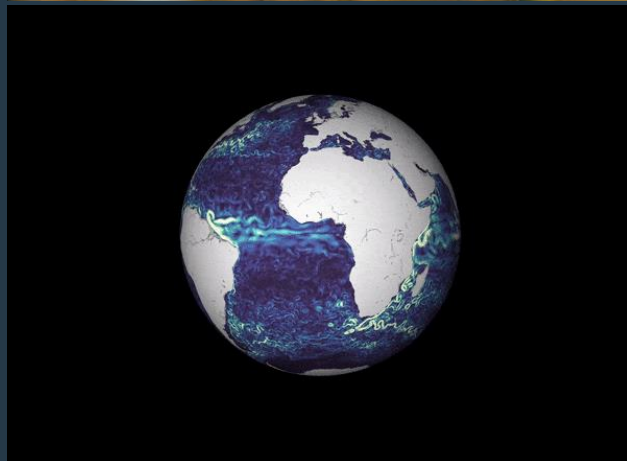
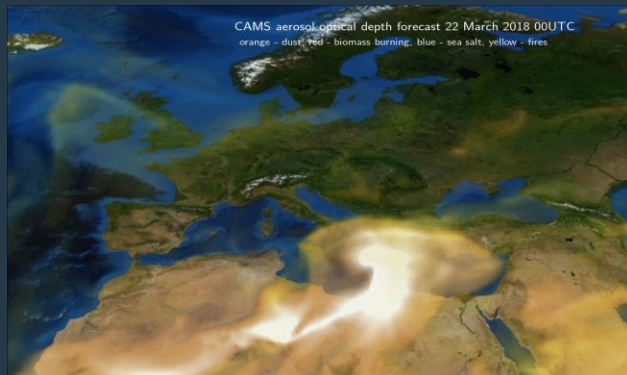
From weather to environmental forecasting



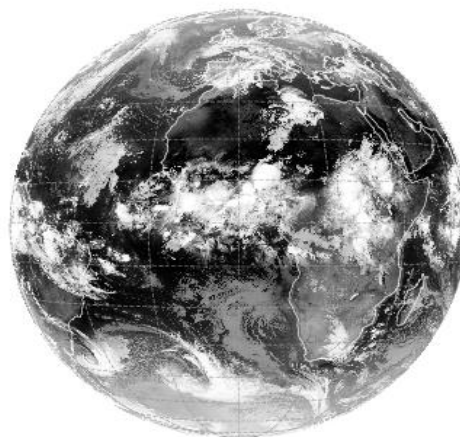
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Copernicus
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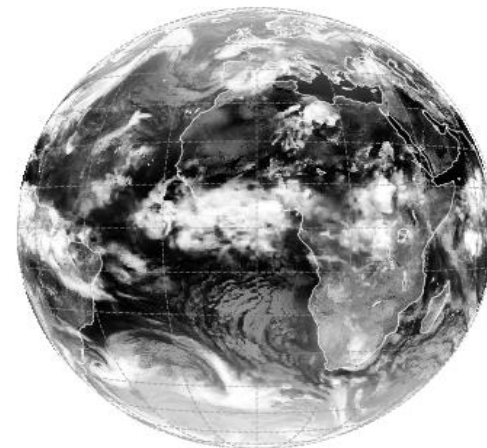
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Meteosat 9 IR10.8 20080525 0 UTC



ECMWF Fc 20080525 00 UTC+0h:





Sentinel-4 and -5: monitoring air quality



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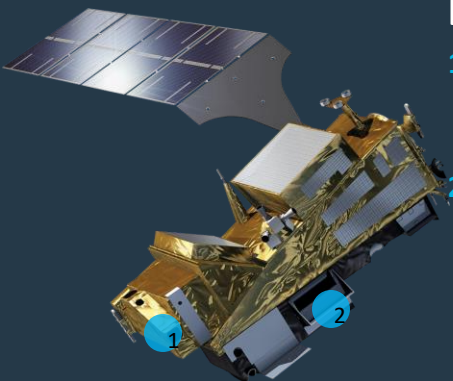


MTG-S

1. **Infrared Sounder (IRS)**
2. **Copernicus Sentinel-4**
Ultraviolet, visible and near-infrared sounding

Delivering observations over Europe on an hourly basis

Ozone (O₃)
Nitrogen dioxide (NO₂)
Sulfur Dioxide (SO₂)
Clouds
Aerosols
Glyoxal
Formaldehyde



EPS-SG A

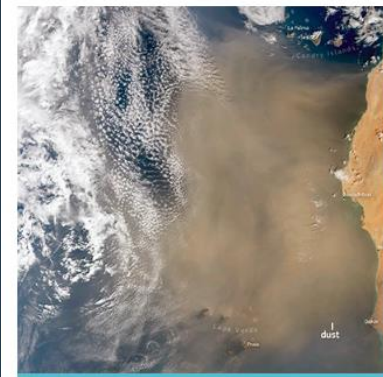
1. **Infrared Atmospheric Sounding Interferometer (IASI-NG)**
Infrared atmospheric sounding
2. **Copernicus Sentinel-5**
Ultraviolet, visible, near-infrared and short wavelength infrared (UV/VIS/NIR/SWIR) sounding

Delivering global observations on a daily basis

Ozone (O₃)
Nitrogen dioxide (NO₂)
Sulfur Dioxide (SO₂)
Clouds
Aerosols
Glyoxal
Formaldehyde
Methane (CH₄)
Carbon Monoxide



CAMS on Air



Seasonal Atmospheric Recon



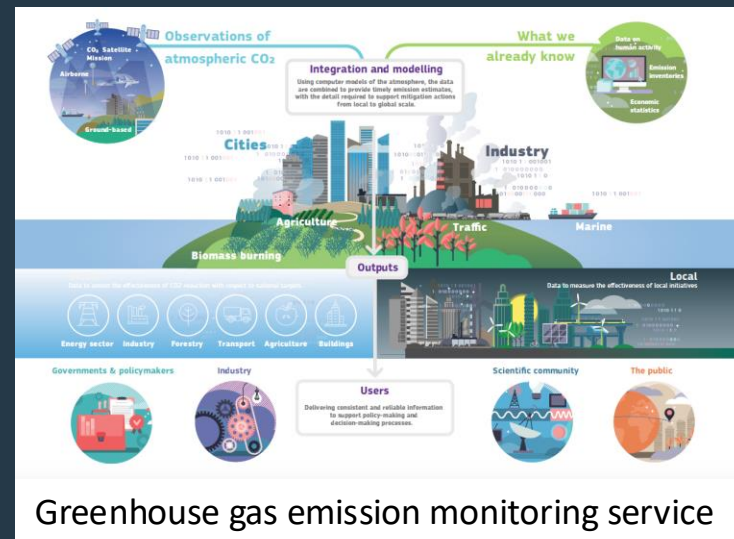
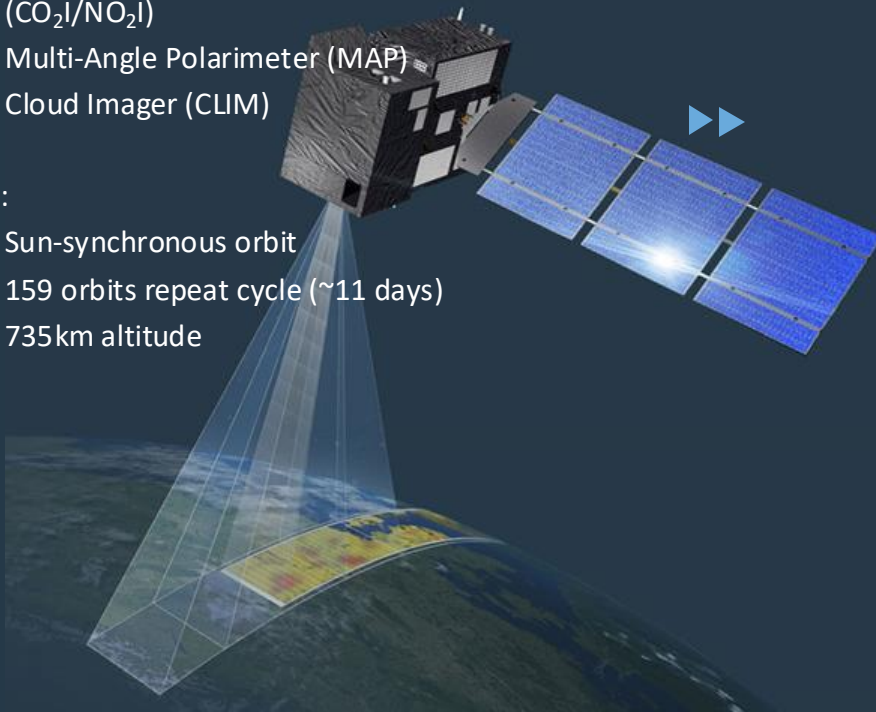
Home / CAMS air quality forecasts /
European air quality hourly forecast of regulated air pollutants

European air quality hourly forecast of regulated air pollutants



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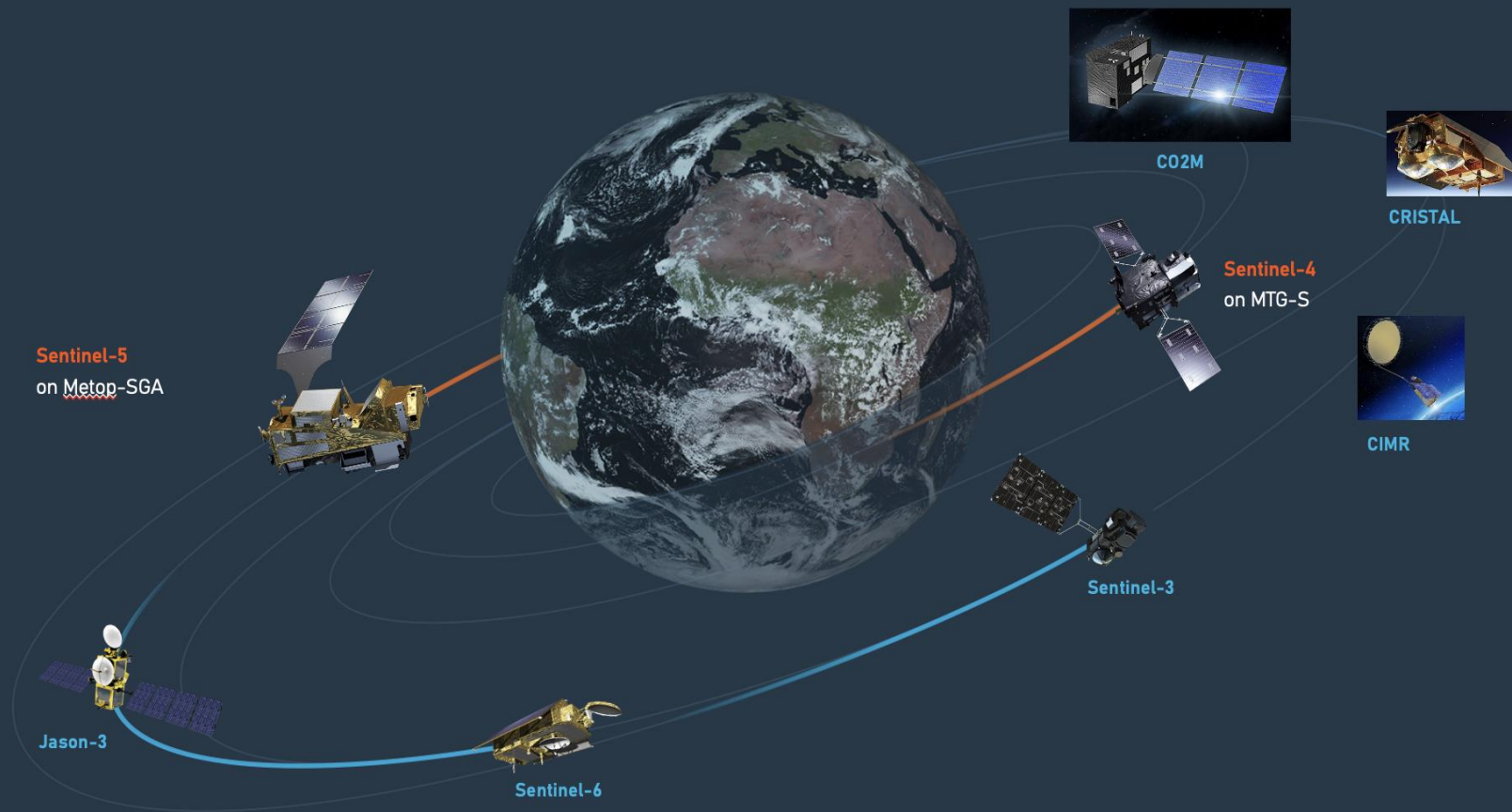
- Three satellite missions each with >250km swath
- Three instruments per platform:
 1. CO₂/NO₂ push-broom grating spectrometer (CO₂I/NO₂I)
 2. Multi-Angle Polarimeter (MAP)
 3. Cloud Imager (CLIM)
- Orbit:
 1. Sun-synchronous orbit
 2. 159 orbits repeat cycle (~11 days)
 3. 735km altitude





EUMETSAT & third-party programmes supporting Copernicus

www.eumetsat.int





The screenshot shows the European Parliament News page. The header includes the European Parliament logo and the word 'News'. Below the header is a navigation bar with links: Homepage, Press room (selected), Agenda, FAQ, and Press Kit. The main content area has the title 'Air pollution: Parliament adopts revised law to improve air quality' and a sub-header 'Press Releases' with tags 'PLenary session' and 'ENV'. The date '24-04-2024 - 12:40' is also present. A list of bullet points follows: '• Stricter 2030 limits for several air pollutants', '• Air quality indices to be comparable across all member states', '• Access to justice and right to compensation for citizens', and '• Air pollution leads to around 300,000 premature deaths per year in the EU'. Below the text is a photo of a woman wearing a face mask and a backpack, walking in an urban setting. The photo is captioned 'Air pollution leads to around 300,000 premature deaths per year in the EU © Adobe Stock / narawit'. At the bottom, a paragraph states: 'The revised law aims to reduce air pollution in the EU for a clean and healthy environment for citizens, and to achieve the EU's zero air pollution vision by 2050.'

➤ **Explicit reference in recital 13 of the AAQD proposal:**

“Where applicable, modelling applications should be applied to enable point data to be interpreted in terms of geographical distribution of concentration of pollutants, which can help to detect breaches of air quality standards, and to inform air quality plans and air quality roadmaps and the placement of sampling points. In addition to the requirements for air quality monitoring laid down in this Directive, for monitoring purposes, Member States are encouraged to exploit information products and supplementary tools such as by regular evaluation and quality assessment reports or policy online applications, provided by the Earth Observation component of the EU Space Programme, in particular the Copernicus Atmosphere Monitoring Service (CAMS).”

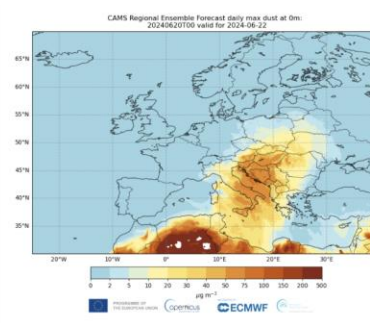
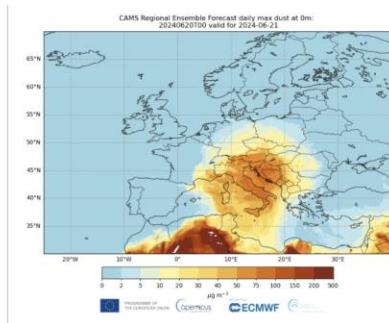
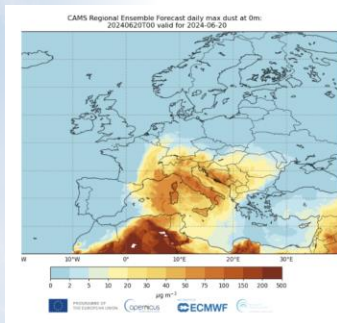




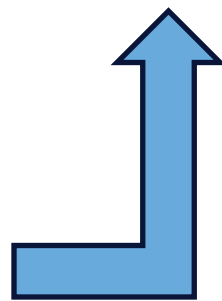
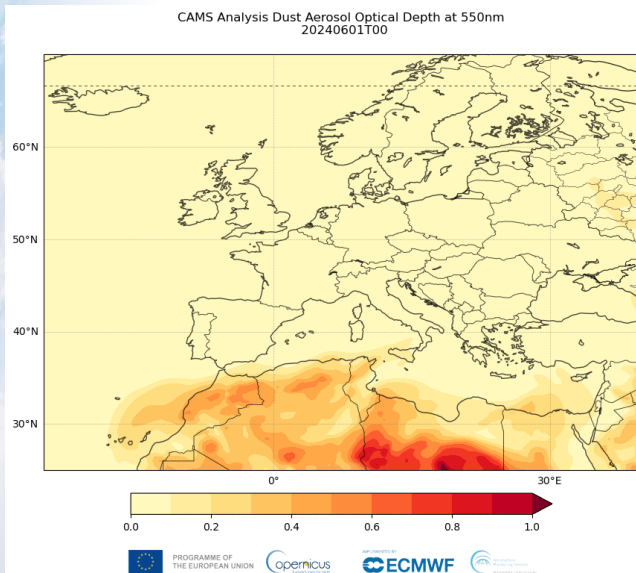
Atmosphere
Monitoring



Transboundary air pollution events – Saharan dust

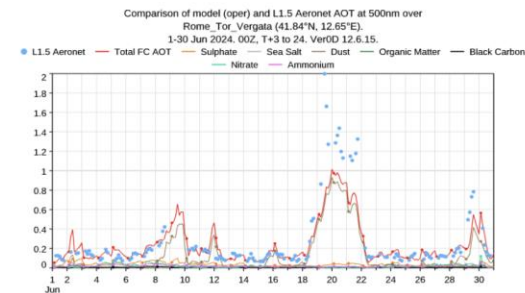


... European forecast



Global
forecast...

... feeds
into...



Evaluation of forecast quality



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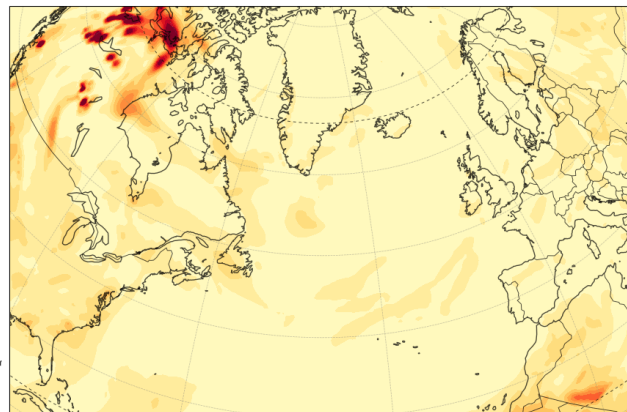
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Monitoring



Monitoring transboundary air pollution events: wildfires



CAMS Analysis Total Aerosol Optical Depth at 550nm
20240810T00



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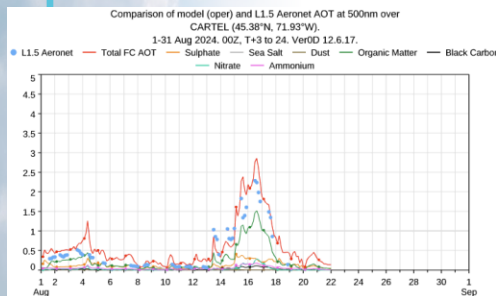
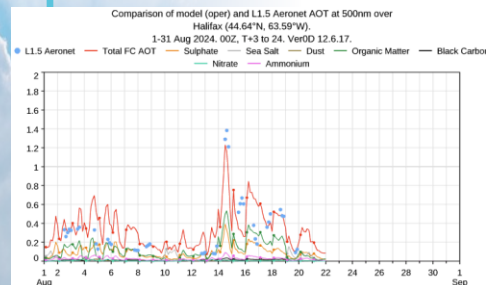
ECMWF



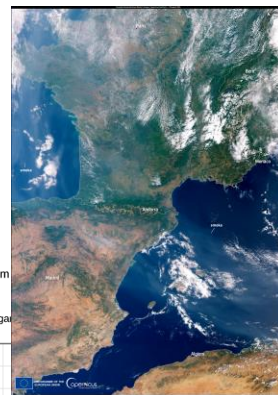
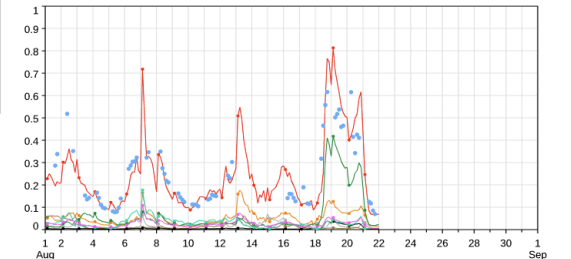
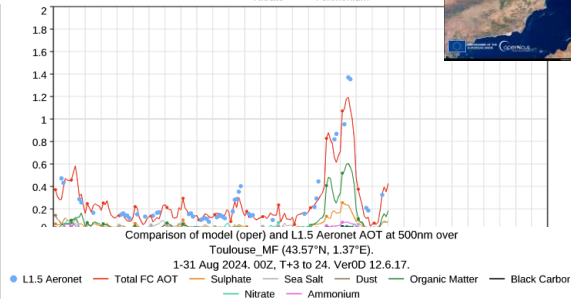
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ECMWF



Comparison of model (oper) and L1.5 Aeronet AOT at 500nm
Herstmonceux (50.87°N, 0.33°E).
1-31 Aug 2024, 00Z, T+3 to 24, Ver0D 12.6.17.



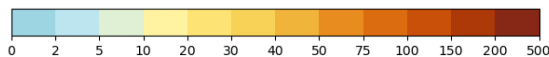
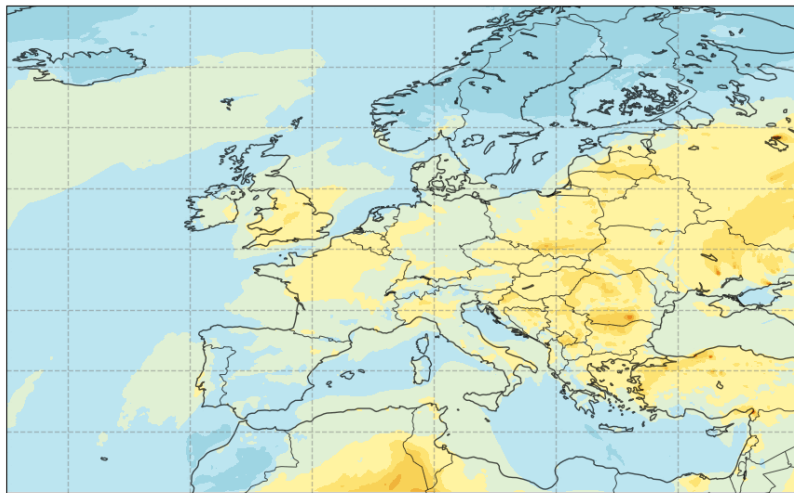


Atmosphere
Monitoring

Forecasting and monitoring air quality



CAMS Regional Ensemble Analysis Daily Mean pm2p5_conc at 0m:
valid for 2025-03-01



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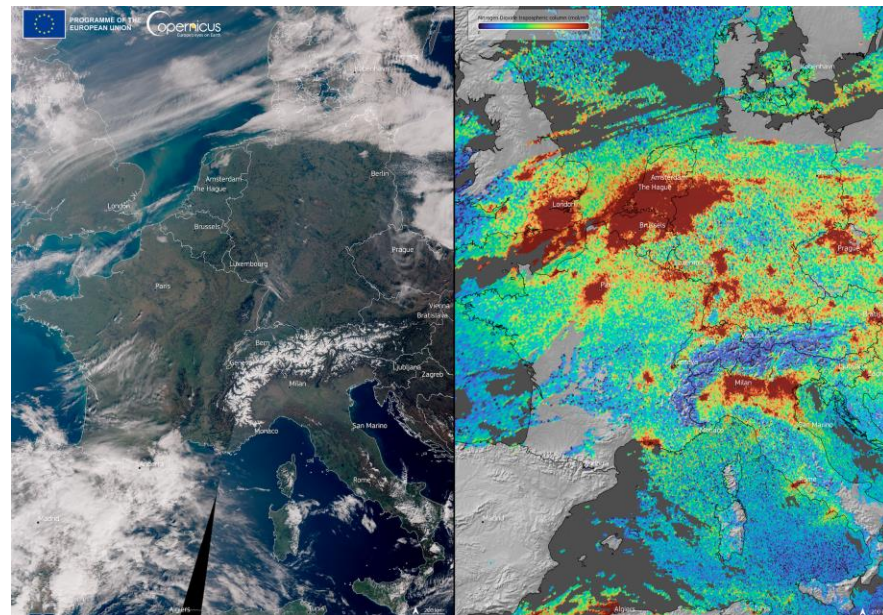


copernicus



ECMWF

CAMS regional PM2.5 forecasts



Sentinel-3

Sentinel-5p – NO2



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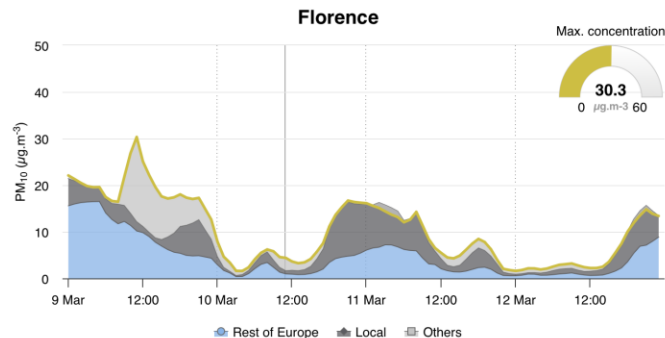
Atmosphere
Monitoring

Assessing air pollution drivers

Policy-oriented services are developed using modelling and AI approaches to address specific questions

PM₁₀ PM_{2.5} O₃ NO₂

Impact of long range transport of air pollution



Assessing the sectors that contribute the most to episodes

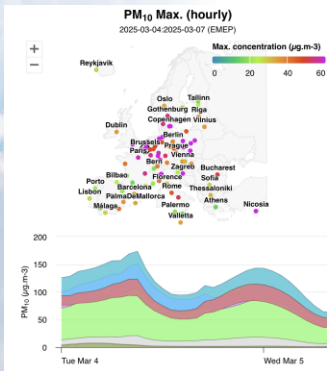
Potential impact on PM₁₀ in Brussels

2025-03-04T00:00:00 - 2025-03-06T23:00:00 (mean)

($\mu\text{g}\cdot\text{m}^{-3}$)

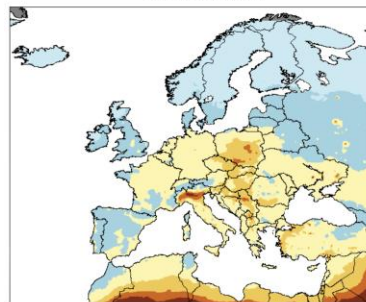


Shipping Natural Others Agriculture Industry Residential Residual Traffic

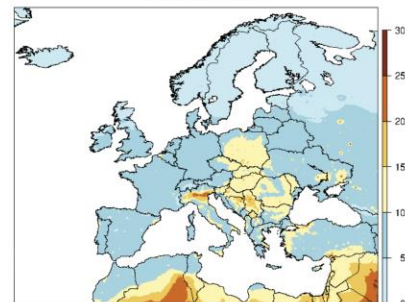


Assessing trends

PM_{2.5} 2015 analysis
Annual average in $\mu\text{g}/\text{m}^3$



PM_{2.5} 2023 analysis
Annual average in $\mu\text{g}/\text{m}^3$



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5th Clean Air forum - 2025

- Co-organised by the European Commission and ECMWF/CAMS
- Will be held in the 1-2 December 2025 in Bonn, World Conference Centre



- Discussions on NEC evaluation
- 1year after the AAQD adoption
- After COP30
- After launch of Sentinel 4 Copernicus satellite
- ...



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Atmosphere
Monitoring

EU Methane
Strategy



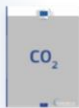
Towards satellite-based emission monitoring

ECMWF ESA EUMETSAT



Sentinel 5p

CO₂ TASK FORCE
GUIDANCE DOCUMENTS



2015



2017



2019



2018



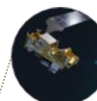
2017

SATELLITE MISSIONS



Sentinel 4

Operational
ramp-up in CAMS



Sentinel 5

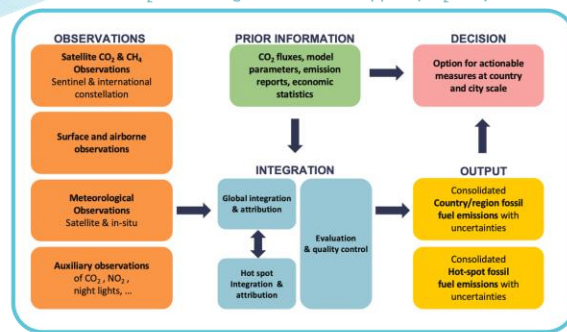


CO₂ Mission

Air Quality emissions
2025

SERVICE
COMPONENTS

2026
CO₂ Monitoring & Verification Support (CO₂MVS)



RESEARCH AND
PREPARATORY
PROJECTS

2021
CoCo2
Prototype system for a
Copernicus CO₂ service
ICOS Cities

2022
horizon
europe



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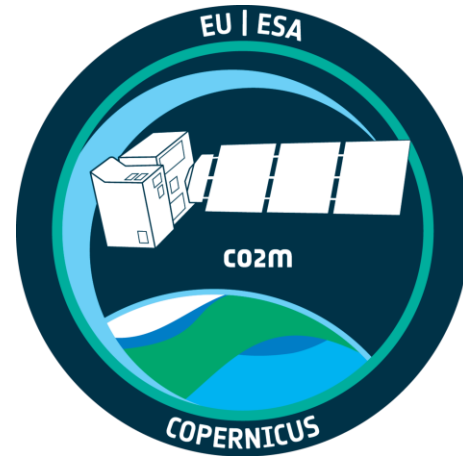
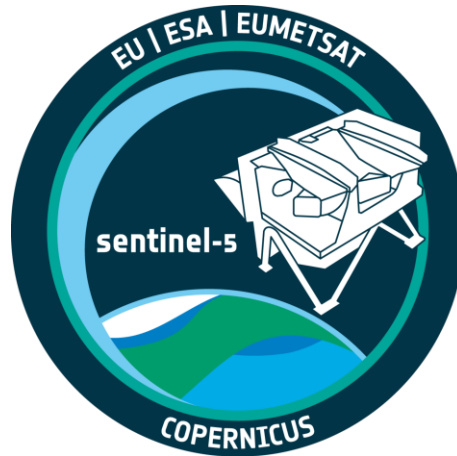
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Combining EU and national satellite missions

Atmosphere
Monitoring

EU Methane
Strategy



Spain



France



France



Germany/France



Netherlands



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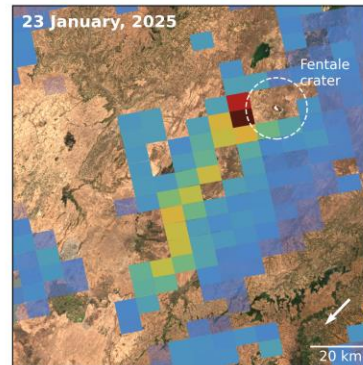
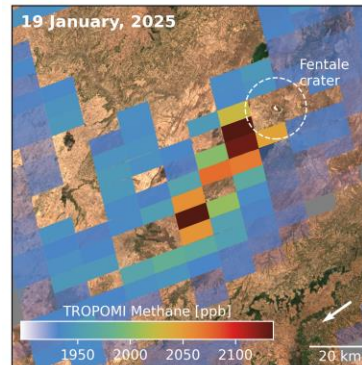
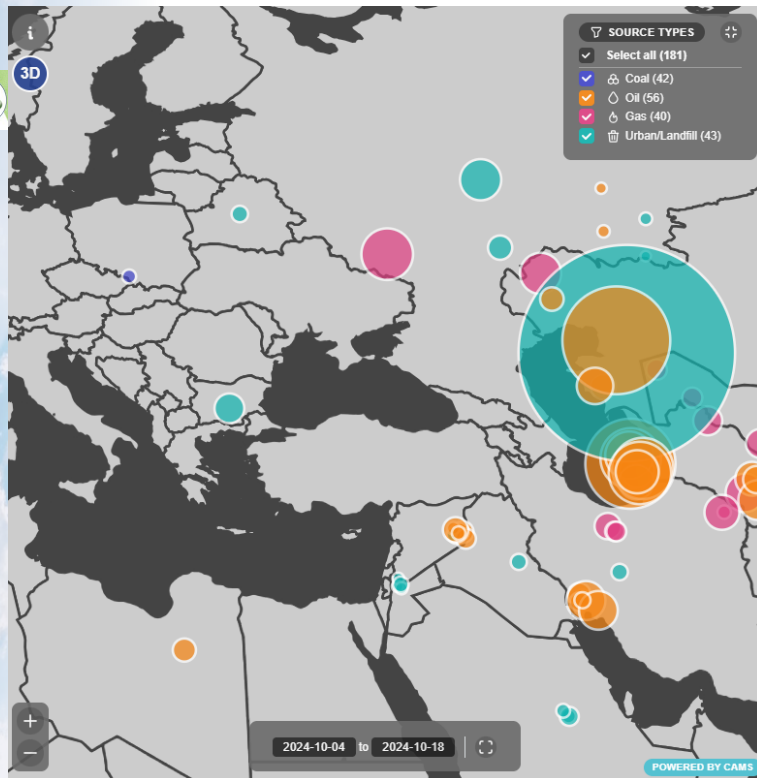


Atmosphere
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EU Methane
Strategy



Methane facility-level emissions



Routine detection of large local methane emissions that can trigger further investigation with small satellite missions to zoom in at a specified location.



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EU Methane
Strategy

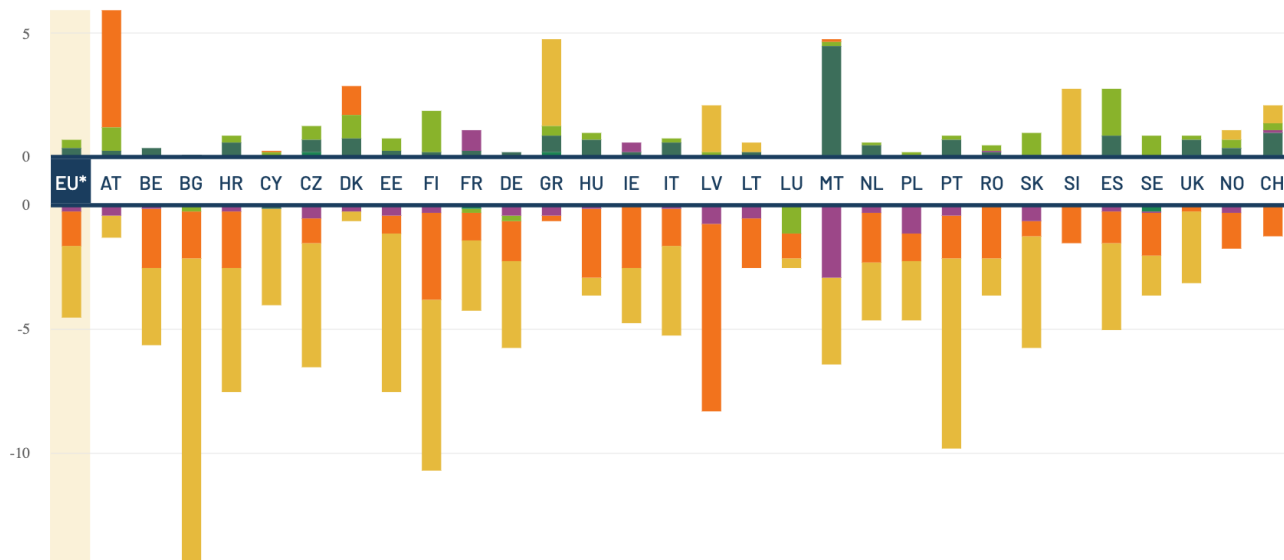


Activity-based emission estimates for Europe

Last data update: March 9th, 2025

CO₂ EMISSIONS VARIATION (%) In all sectors 🌐

January 1st → December 31st, 2024 vs January 1st → December 30th, 2023



*EU : EU27 + United Kingdom



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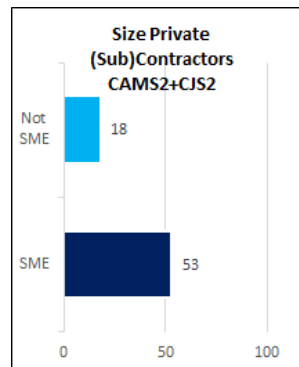
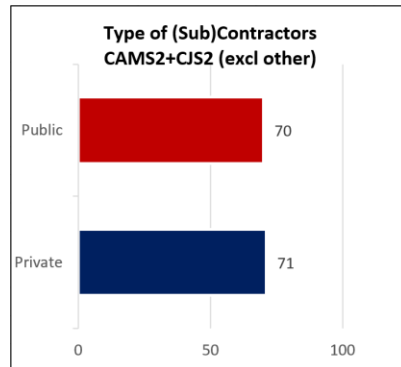
A community built upon the best European expertise

169

Entities involved as
contractor or
subcontractor

from

27 Countries EU / MS
and Cop participating
countries
and **1** third country



79

Signed
Contracts

Total value of
signed Framework
Agreements
~60.9 M €



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ECMWF



Atmosphere
Monitoring

National Collaboration Programme

Involved countries



Austria



Bulgaria



Cyprus



Denmark



Estonia



Finland



France



Germany



Greece



Hungary



Iceland



Italy



The Netherlands



Norway



Poland



Portugal



Slovakia



Slovenia



Spain



Sweden

First Phase Modules (2021-2023)

- ✓ CAMS products to support regulatory reporting
- ✓ Direct use of CAMS products at national level
- ✓ CAMS air quality products downscaled at national level
- ✓ Exploitation of the CAMS emission data set at national level
- ✓ Support monitoring to in-situ network
- ✓ Communication about CAMS at national level
- ✓ Training and knowledge transfer

Second Phase Modules (2024-2027)

- ✓ Support to air quality data reporting
- ✓ Direct use of CAMS products
- ✓ Air Quality downscaling
- ✓ Emissions
- ✓ Support to in-situ monitoring network
- ✓ Communication and user outreach
- ✓ Training
- ✓ Development of demonstrators for the Energy and/or Health user communities



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Thank you

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