climate change initiative

LONG-LIVED GREENHOUSE GAS PRODUCTS PERFORMANCES

Operational monitoring of atmospheric composition: current status

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Operational monitoring

Operational monitoring in Europe

- **EUMETSAT** is the European operational satellite agency for ***monitoring weather, climate and the environment***. EUMETSAT is committed to delivering Earth observation satellite data 24/7, as well as to meeting the needs of the national weather services of its member states. We plan and develop the future satellite systems required to ensure continuity and adaptation to evolving ***forecasting and climate monitoring*** needs.
- **Copernicus** is providing accurate, timely and easily accessible information ***to improve the management of the environment, understand and mitigate the effects of climate change and ensure civil security***.
- **ESA's Earth Watch** provides missions operated in partnership with other organizations. The missions target specific strategic applications incl. operational add-ons

Definition of user requirements in Europe

2000-2005: Themes to be supported through operational monitoring of atmospheric composition (EU/ESA/IGACO/EUMETSAT)

Themes

(A) Stratospheric Ozone and Surface UV radiation

(B) Air Quality

(C) Climate

User categories

(1) Protocol monitoring and emission verification

(2) Near-real time data use / data assimilation

(3) Scientific assessment / research applications

2006-2010: The EU Sentinel program was defined without the user requirements for research applications (ESA Earth Explorers)

Operational Atmospheric Chemistry Monitoring Missions

ESA contract no. 17237/03/NL/GS

CAPACITY

Composition of the Atmosphere: Progress to Applications in the user CommunITY

October 2005

Tropomi – Sentinel 5P

Product	Application
Ozone	Ozone layer monitoring, UV-index forecast, Climate monitoring
NO_2	Air quality forecast and monitoring
CO	Air quality forecast and monitoring
CH_2O	Air quality forecast and monitoring
CH_4	Climate monitoring
SO_2	Air quality forecast and monitoring, Climate monitoring, Volcanic plume detection
Aerosol	Air quality forecast and monitoring, Climate monitoring, Volcanic plume detection
Clouds	Climate monitoring
UV-Index	UV index forecast

Current status (excl. research missions)

Copernicus

- Sentinel 4 2025-
- Sentinel 5p 2017-
- Sentinel 5 2025-
- CO2M 2027-

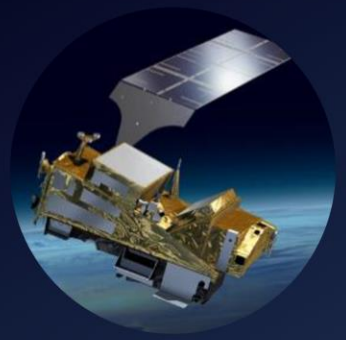
Eumetsat / Meteorology

- Metop/IASI 2006-
- Metop-SG/IASI-NG 2025-
- MTG/IRS 2025-

ESA Earth Watch

- Altius 2027-

S4, IASI-NG, S5, CO2M and Tango

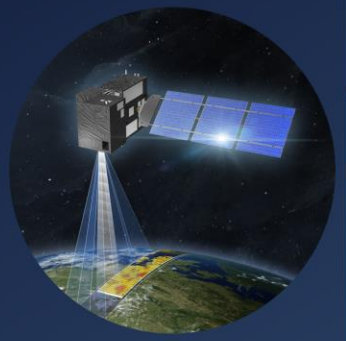


Metop SG

- S5/UVNS (Tropomi like)
- IAIS-NG
- 3MI
- Metimage
- Launched August 2025
- Morning orbit

Sentinel 4

- S4/UVN
- Resolution ~8x8 km^2
- Geostationary over Europe
- Launched July 2025
- On MTG-S with IRS

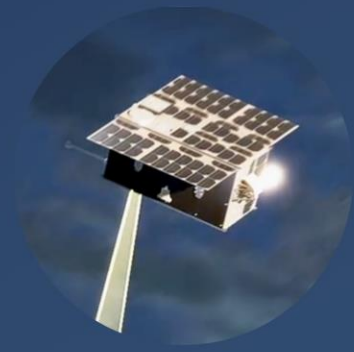


CO2M

- EU Copernicus programme
- CO_2, CH_4, NO_2, Sif
- Resolution 2x2 km^2
- Swath width ~270 km
- No earlier than 2027
- Constellation of 3 identical satellites

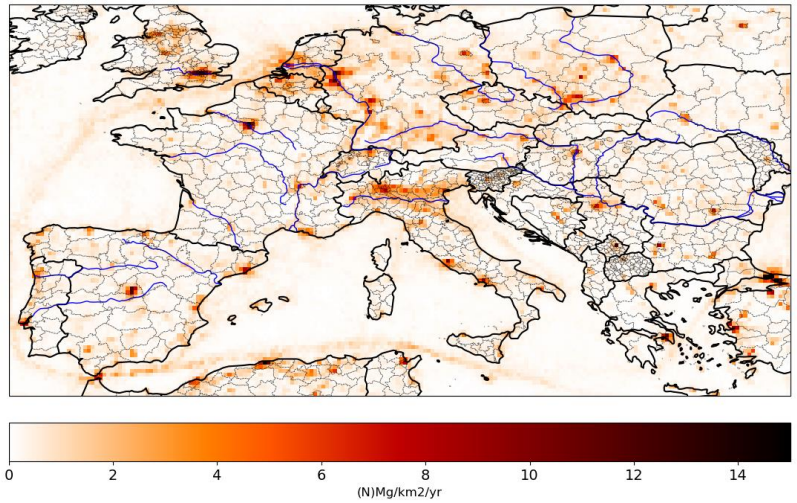
TANGO

- ESA scout programme
- CO_2, CH_4, NO_2
- Resolution 300x300 m^2
- Targets 30x30 km^2
- 2 cubesats flying in formation
- No earlier than 2028

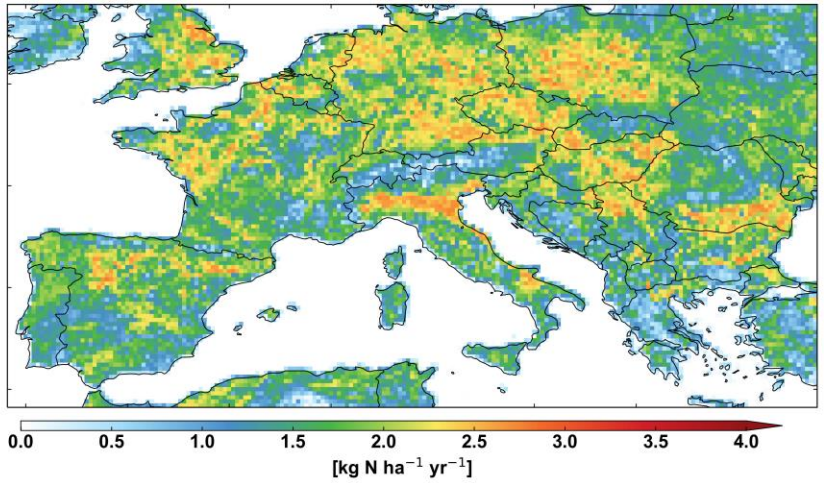


Tropomi NO_2 emissions

Anthropogenic NOx



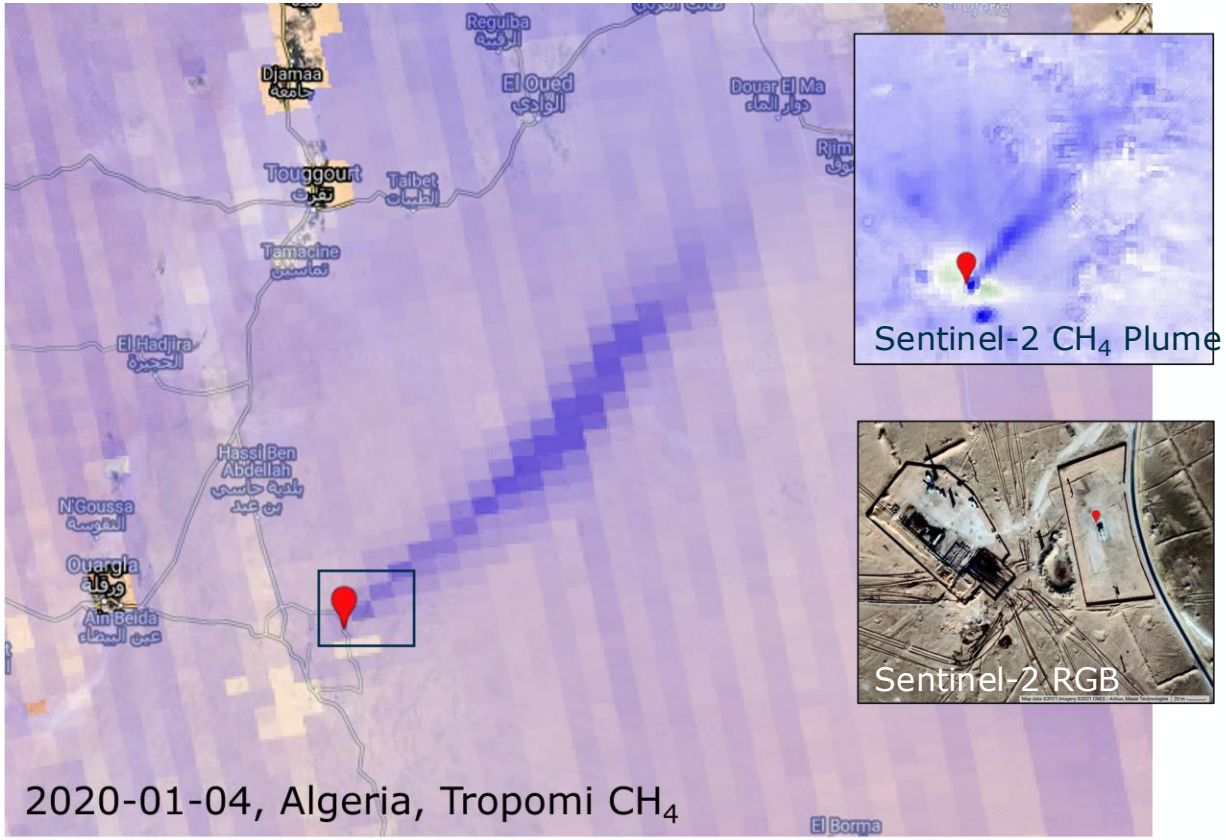
Soil NOx



Lin et al., 2024
https://doi.org/10.1029/2024JD041492

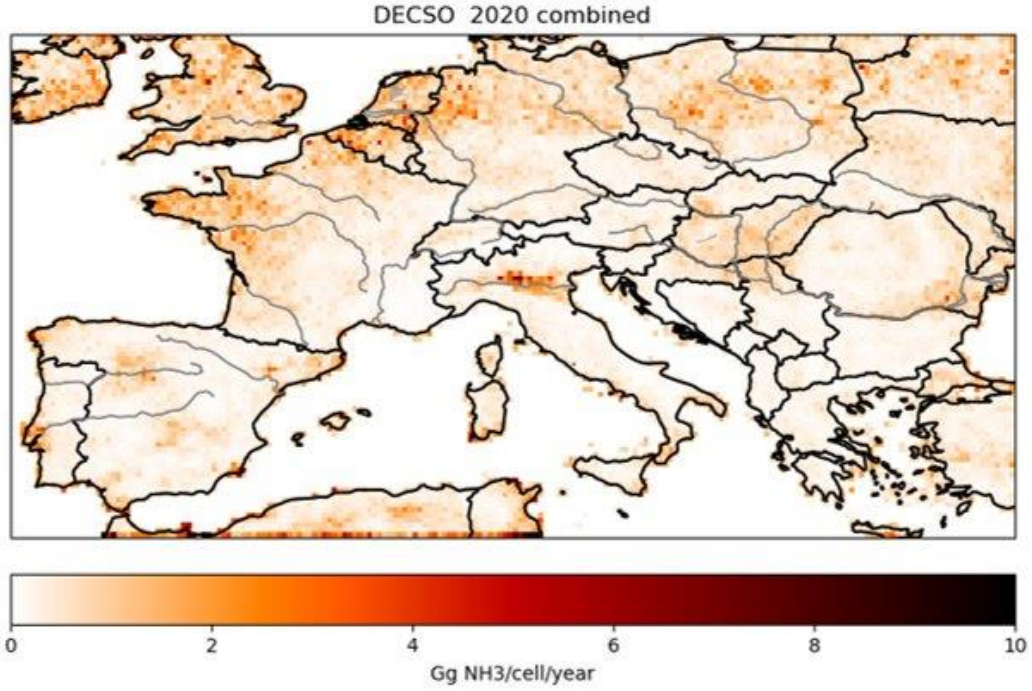
Methane emissions using Tropomi and Sentinel-2

- Satellites allow for the global verification of the Paris Agreement and the Methane Pledge.
- Satellites can detect methane leaks and provide data in near-real-time.
- Combined use of Sentinel 5P and (here) Sentinel 2 is crucial for **attribution** and **emission verification**
- Combination of ground-based and satellite observations in inverse models will contribute to the national reporting.
- Transparency through open data and open algorithms are essential for credibility.



Agriculture

Derived NH_3 Emissions



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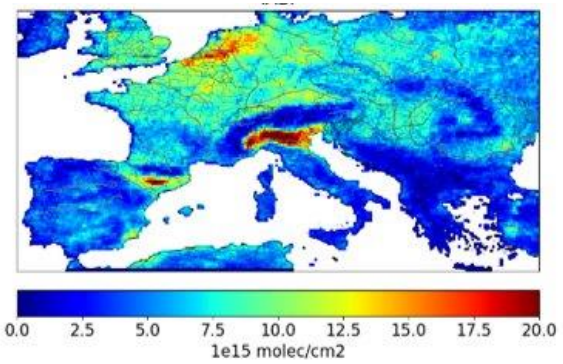
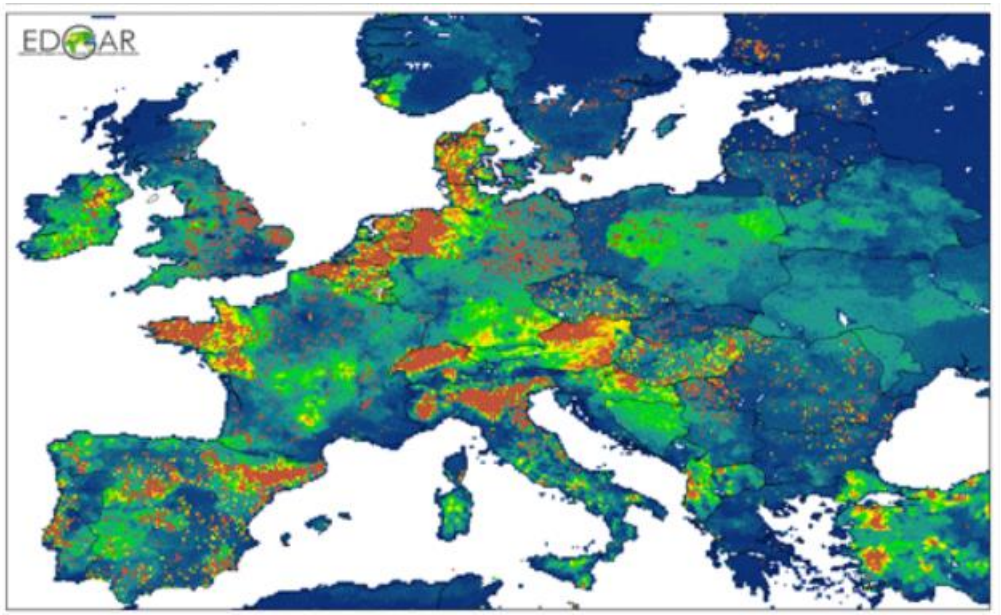


Bottom-up N_2O Emissions*



* intensive animal farming and manure management practices using NH3 hot spot observations

Crippa et al., 2024; https://doi.org/10.5194/essd-16-2811-2024

Summary

- The operational space monitoring system created by Europe encompasses multiple components including atmospheric composition
- Greenhouse gas monitoring is integral part of this system, with a focus on CO_2 and CH_4
- The operational space system however provides important constraints on unobserved components

- Short-lived precursor gases provide important fingerprinting for specific GHG emission monitoring
- Methods are developed to use NH_3 and soil NO_X products in constraining N_2O (and CH_4) surface fluxes
- Land use satellite data provide additional constraints for the N_2O and CH_4 budgets

=> Combination of multi-disciplinary operational satellite data and ancillary information is key for the operational attribution and verification of CO_2 and non-CO_2 GHG emission inventories.

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