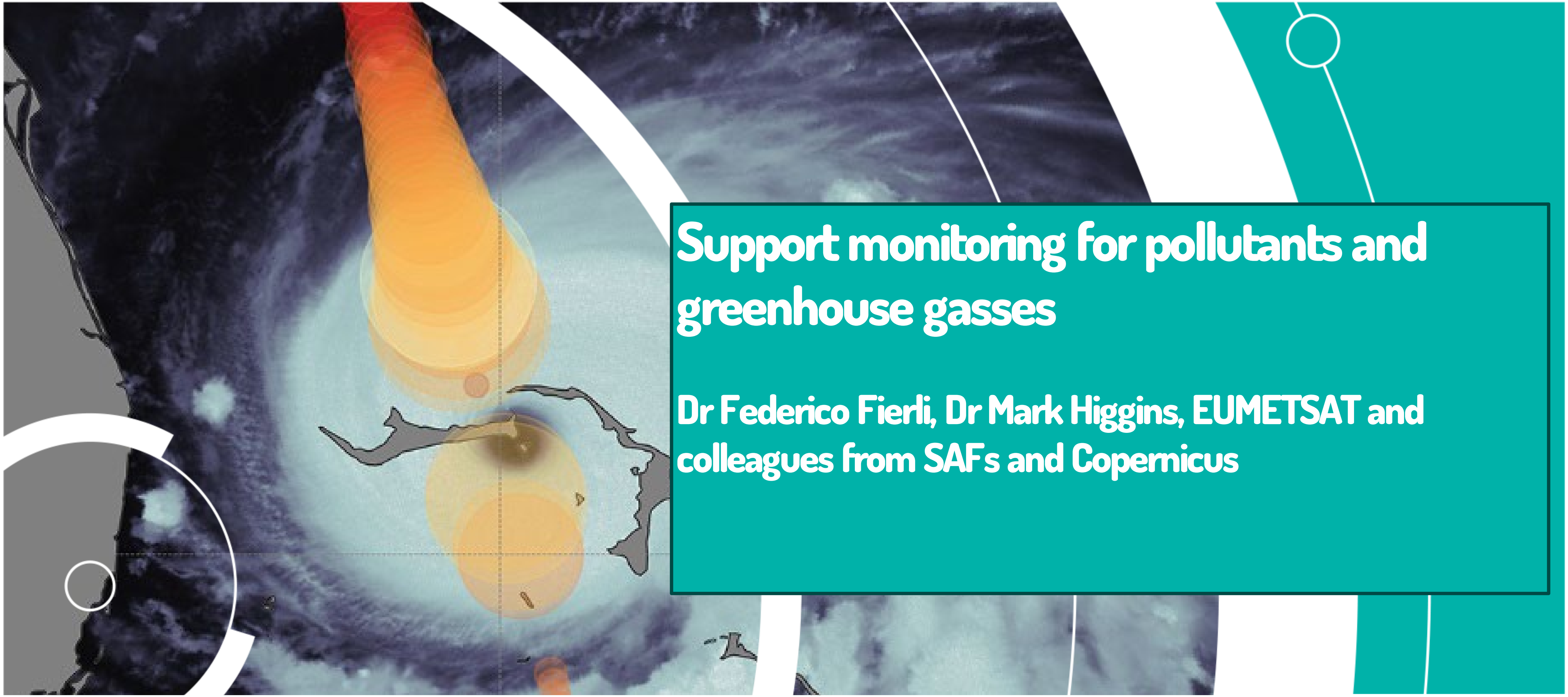

Support monitoring for pollutants and greenhouse gasses

Dr Federico Fierli, Dr Mark Higgins, EUMETSAT and colleagues from SAFs and Copernicus

An agenda for emission control

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INTEGRATED ASSESSMENT OF AIR POLLUTION AND CLIMATE CHANGE FOR SUSTAINABLE DEVELOPMENT IN AFRICA SUMMARY FOR DECISION MAKERS

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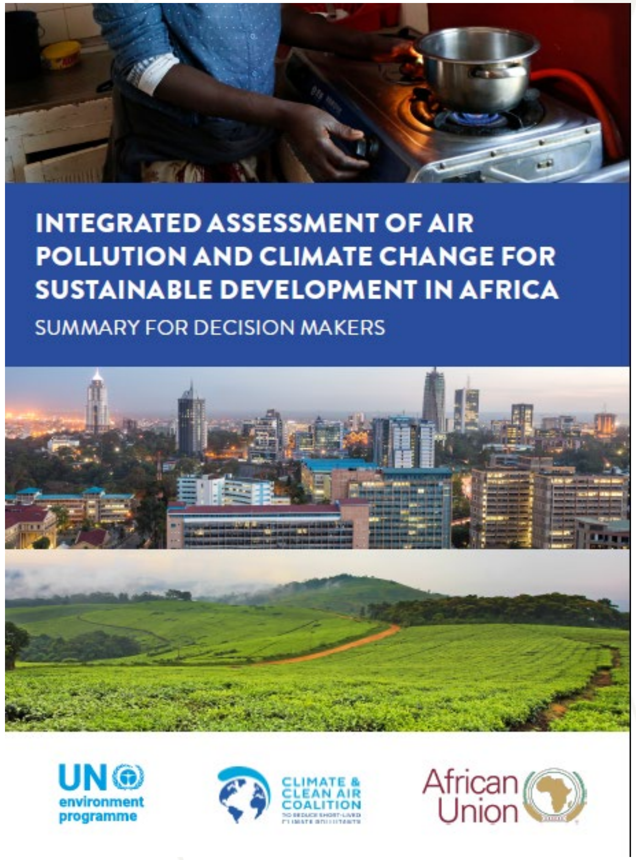


WHAT HAPPENS IF WE DON'T ACT?

Without changes in policy, greenhouse gas emissions will triple by 2063.

Outdoor air pollution is projected to get worse, causing about 930,000 premature deaths per year in 2030 and about 1.6 million premature deaths per year in 2063.

Despite advances in clean cooking technologies, household air pollution would still cause about 170,000 premature deaths per year in 2030 (150,000 by 2063.)

Without action, economic growth compounded by population growth, unplanned urbanization, and unsustainable lifestyles will exacerbate pressures on resources, the environment, and human health, and could increase inequalities and limit Africa's ability to achieve sustainable development.

Goal for emission reduction is stated in the UN Sustainable Development Goals (SDGs) and the AU Agenda 2063

INTEGRATED ASSESSMENT OF AIR POLLUTION AND CLIMATE CHANGE FOR SUSTAINABLE DEVELOPMENT IN AFRICA

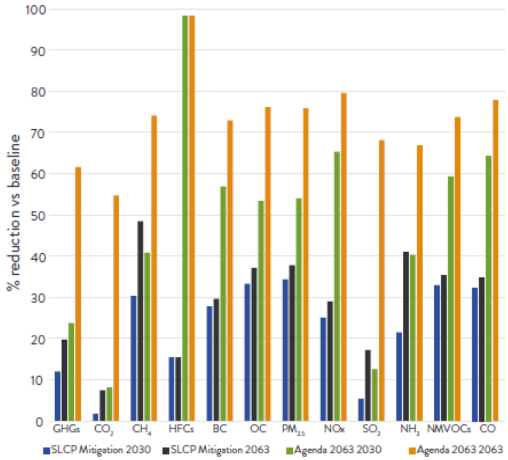


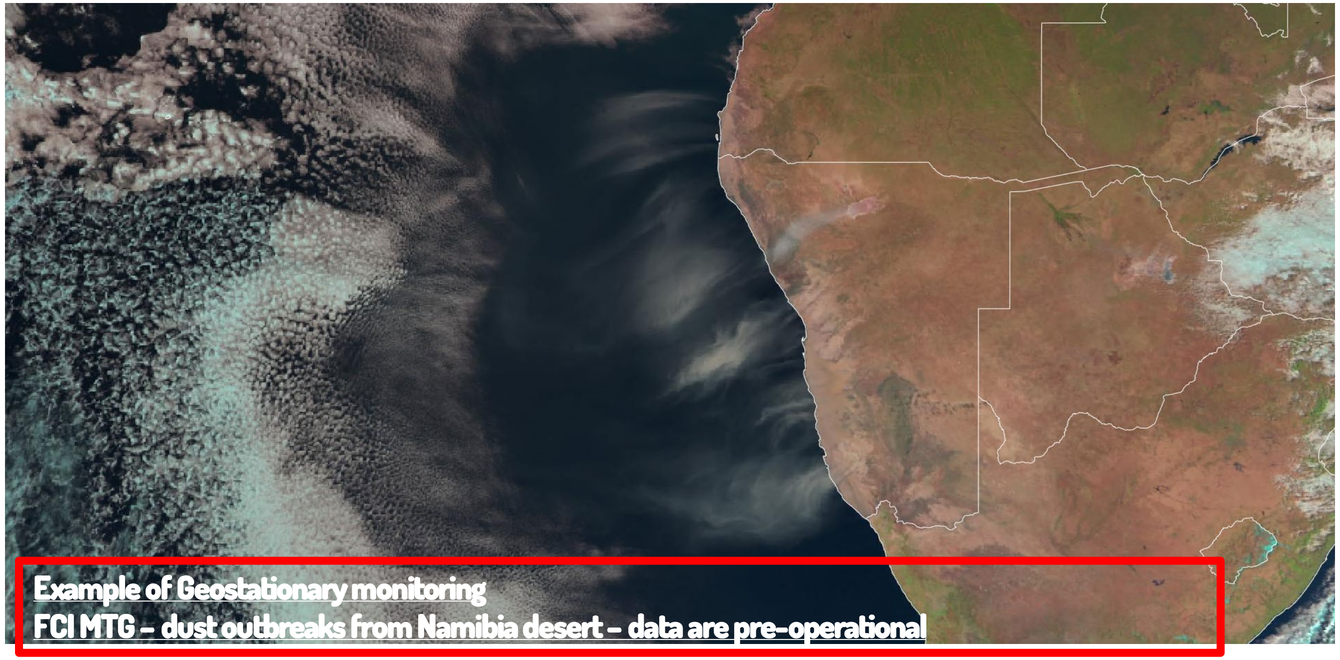
Figure S1 The percentage reduction in GHG, SLCP and air pollutant emissions in 2030 and 2063 for the SLCP Mitigation and Agenda 2063 scenarios versus the Baseline Scenario.

WIDESPREAD HUMAN HEALTH BENEFITS

- The emission reductions that could be achieved by the 37 measures are estimated to prevent about **180,000 premature deaths per year by 2030** and **800,000 deaths per year by 2063** from outdoor air pollution.
- Figure S2(a) shows how exposure to $PM_{2.5}$ can be significantly reduced under the SLCP Scenario, and further reduced under the Agenda 2063 Scenario, across the five major regions of Africa, bringing values closer to the WHO Air Quality interim targets and guideline.
- Figure S2(b) shows the improvements that can be made in reducing annual premature mortality attributed to $PM_{2.5}$ in the five major regions.
- Figure S3(a) and (b) show similar trends for tropospheric ozone, the other main pollutant affecting human health in Africa, and for ozone-attributable deaths. The human health benefits over time associated with reduced exposure to $PM_{2.5}$ and ozone are qualitatively similar, with those associated with $PM_{2.5}$ being larger.

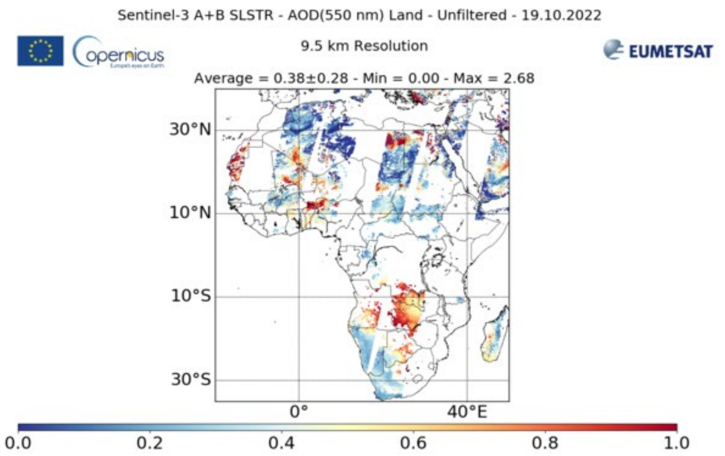
Monitoring aerosol

- Large number of species – distribution of aerosol (eg dust, smoke)
- Access to spatial and temporal scales impossible without the contribution of satellite
- Consistency of measurements worldwide
- Long-term coverage – climate data sets

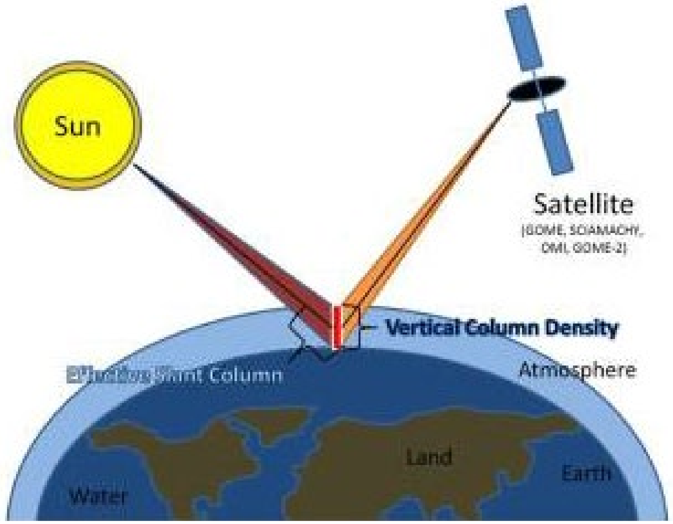


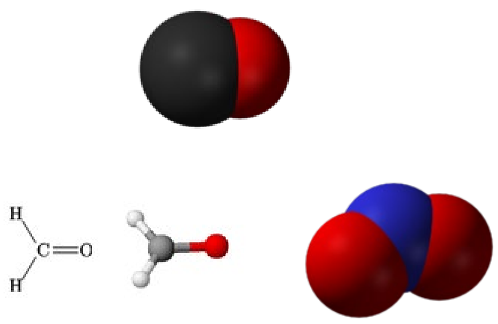
Example of Geostationary monitoring
FCI MTG – dust outbreaks from Namibia desert – data are pre-operational

Example of Polar monitoring
Sentinel-3 Aerosol optical depth – particulate from continental smoke and dust sources



Monitoring gaseous pollutants





	PRESENT			FUTURE	
Product	Metop GOME-2	Sentinel 5 and 5p	Metop IASI	Metop-SG IASI-NG	MTG-S S4/UVN
O_3 total column	√	√	√	√	√
O_3 profile (incl. troposphere)	√	√	√	√	
O_3 tropospheric column	√				√
NO_2 total column	√	√			√
NO_2 tropospheric column	√	√			√
SO_2	√	√	√	√	√
SO_2 Layer Height		√	√	√	
HCHO	√	√			√
CHOCHO	√	√			√
BrO	√	√			
OClO		√			
HNO_3			√	√	
NH_3			√	√	
CO		√	√	√	
CH_4		√	√	√	
SIF	√	√			
CO_2					
H_2O	√	√			√
UV Products	√	√			√

Observed species are produced by anthropogenic and natural.

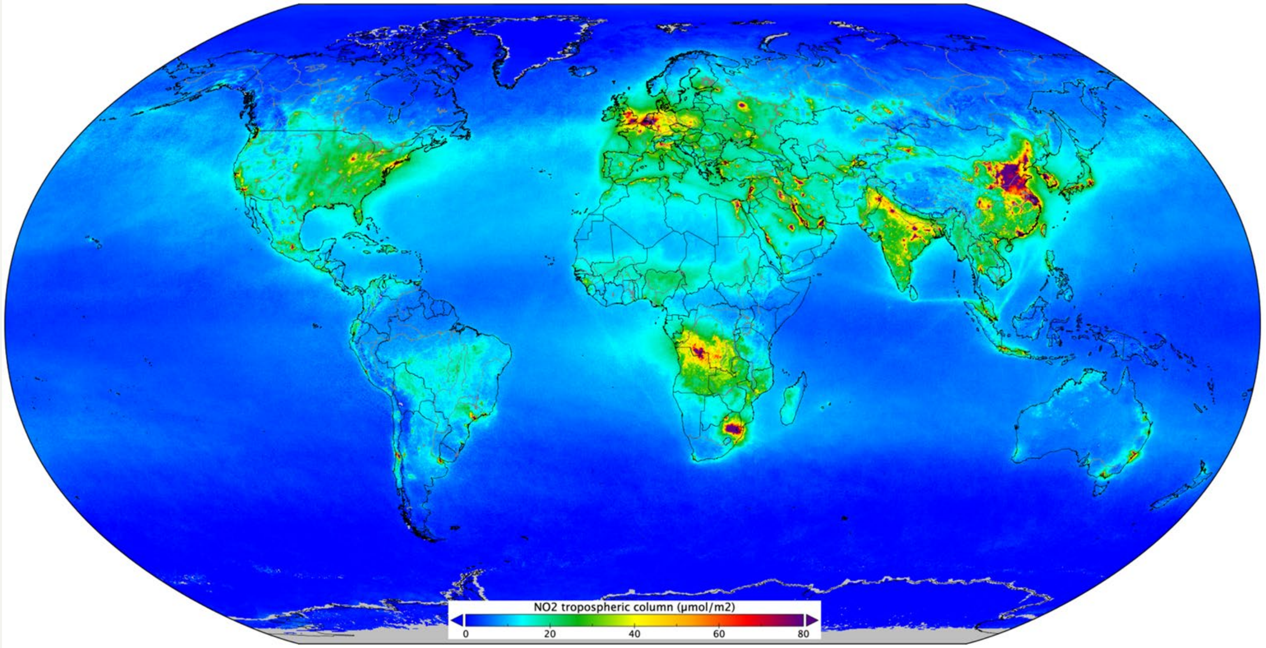
These are relevant for key policies.

However -

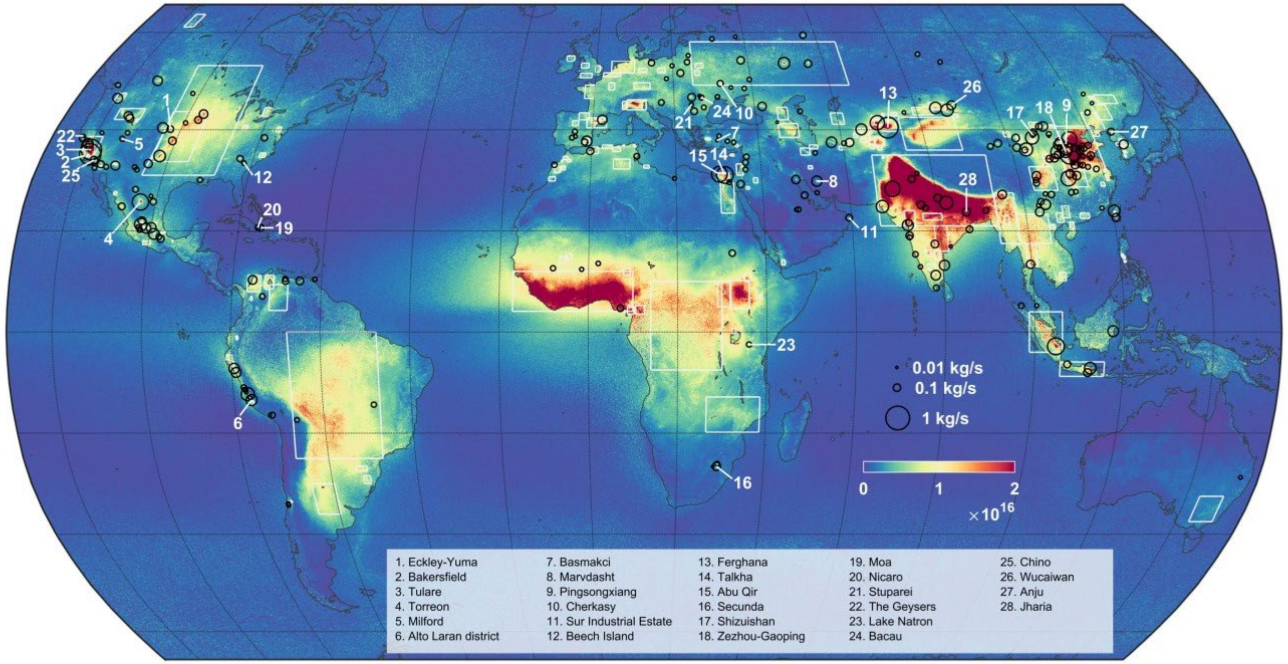
Uncertainty can be high – concentrations are small

Observations are not at nose levels – need of interpretation

Monitoring pollution from space – anthropogenic pollutants



Nitrogen Dioxide from 1 month TROPOMI data
© Copernicus program



Ammonia fluxes based on 9 years of IASI data
© Martin Van Damme and Lieven Clarisse / ULB

Example: Changes in ammonia concentrations

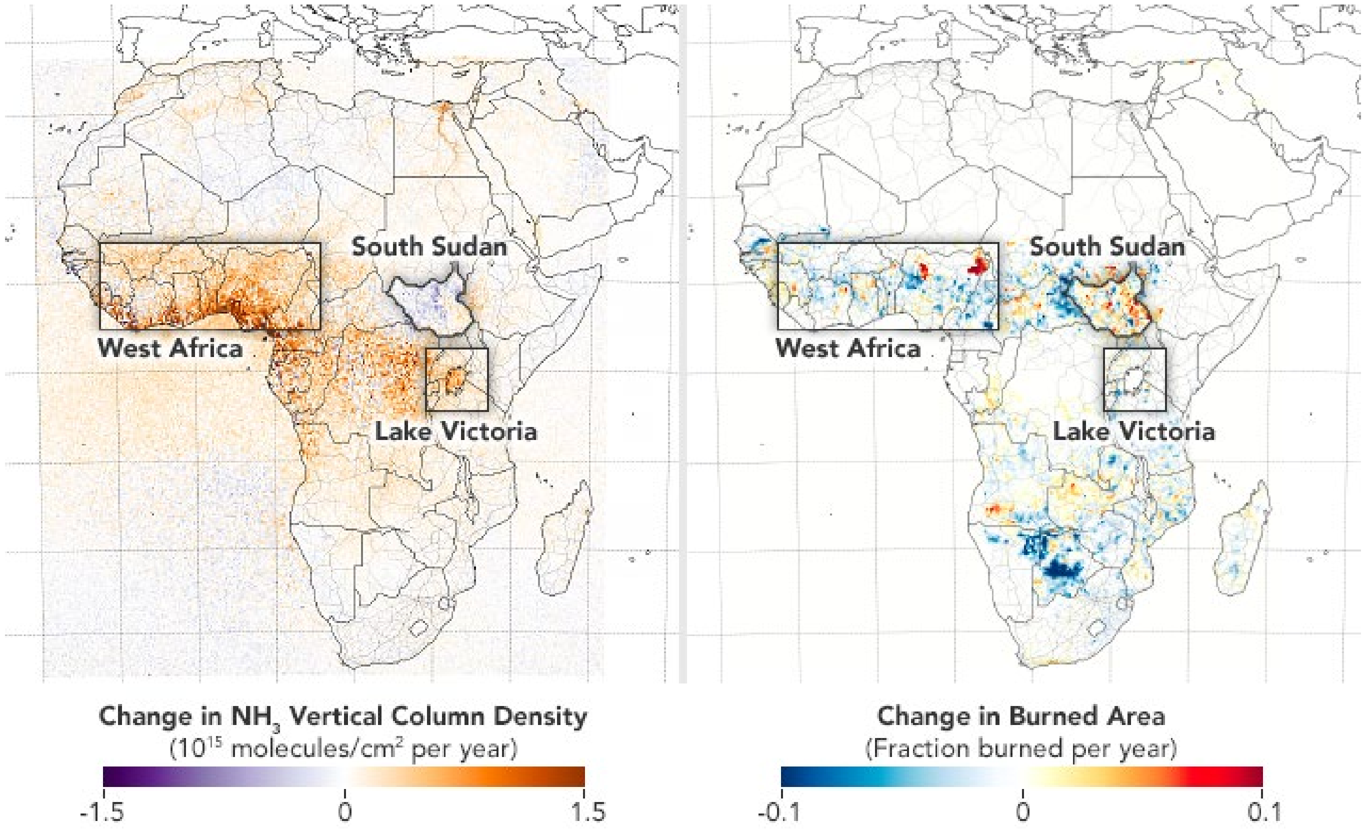
How IASI onboard METOP Support air quality monitoring

Changes related to increased agricultural Productivity (South Sahel)

Different wildfire activity leads to reduction (South Sudan)

Analysis of 7 years of IASI data

https://acp.copernicus.org/articles/21/16277/2021/



Example: Changes in nitrogen dioxide concentrations

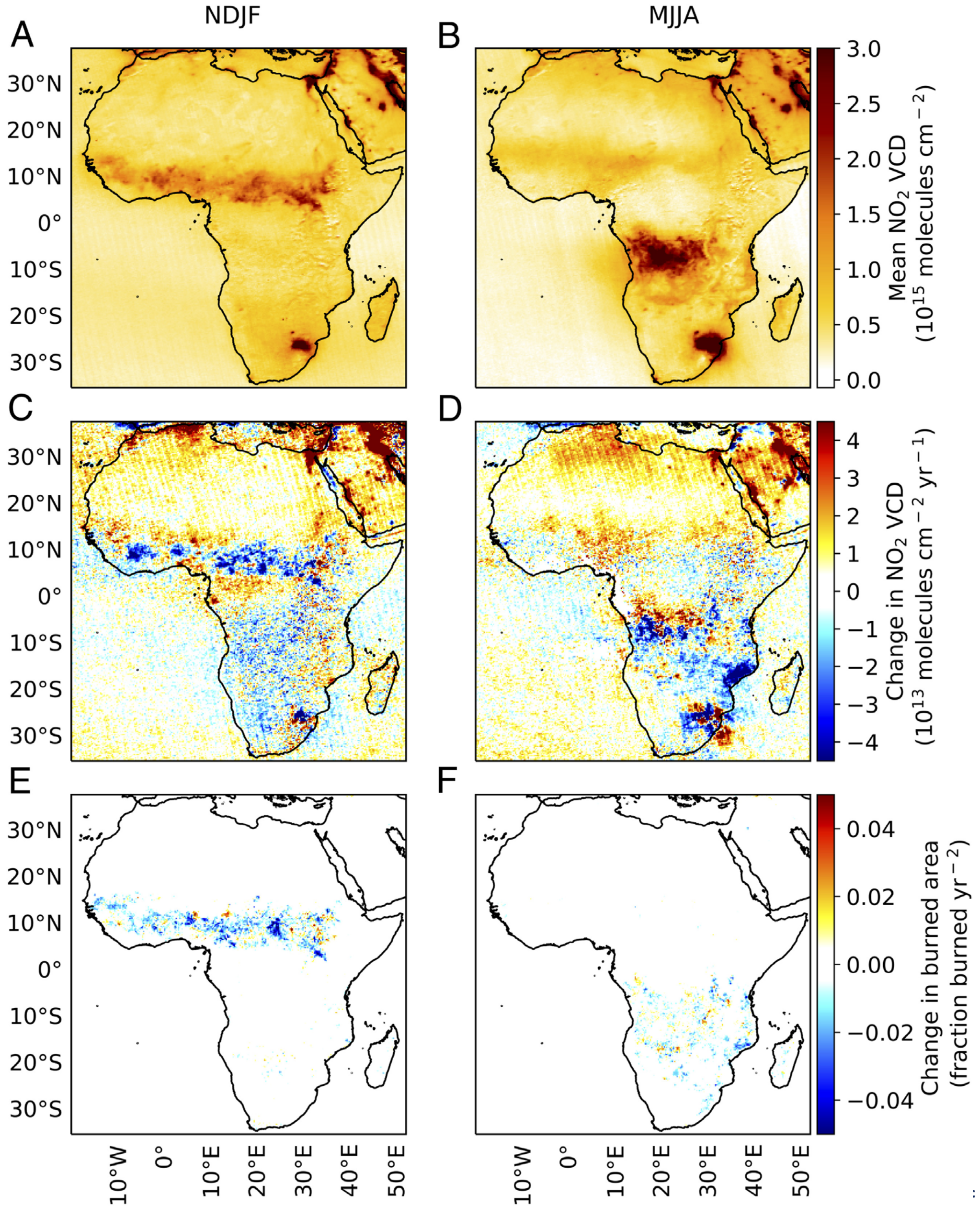
copernicus.eumetsat.int

GOME-2 and TROPOMI support air quality monitoring

Maximum concentration related to emissions in urban areas

Changes related to both increased anthropic pressure and natural sources (wildfires)

Analysis of 12 years of OMI, Sentinel-5P data from https://www.pnas.org/doi/10.1073/pnas.2002579118



Example: Synergy of observational datasets to monitor wildfires

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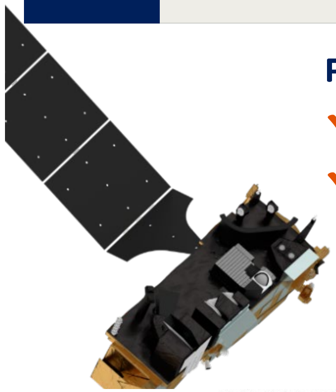
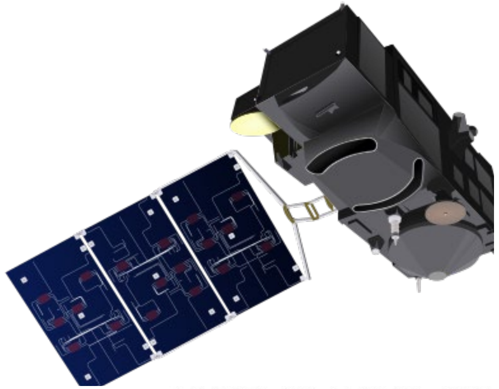
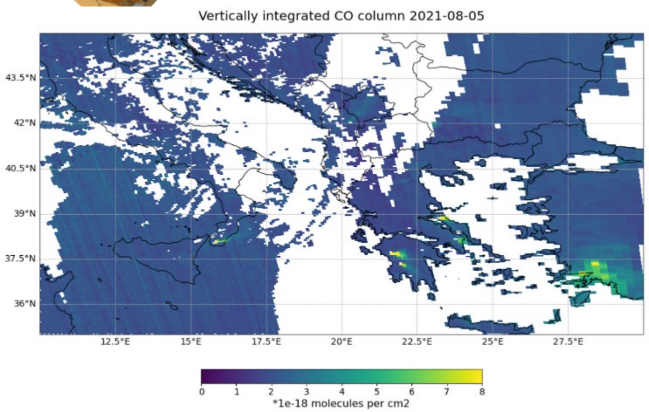
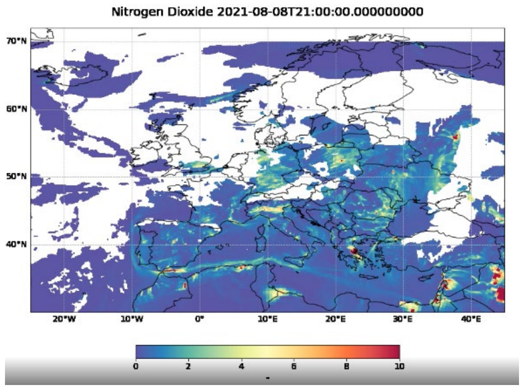


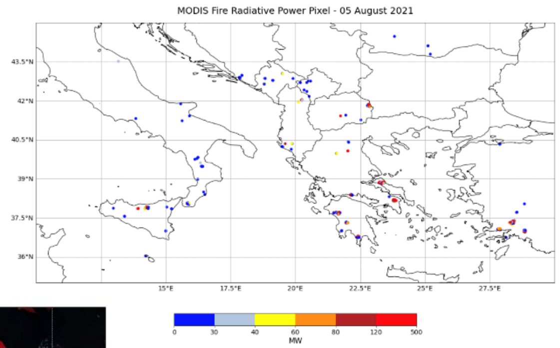
Pollutants, hot spots & intensity from satellite observations

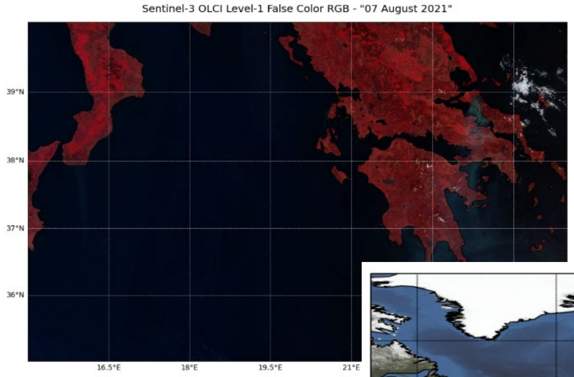
- ✓ Measurement of fire intensity
- ✓ Linked to emission of combustion gases & aerosols into the atmosphere

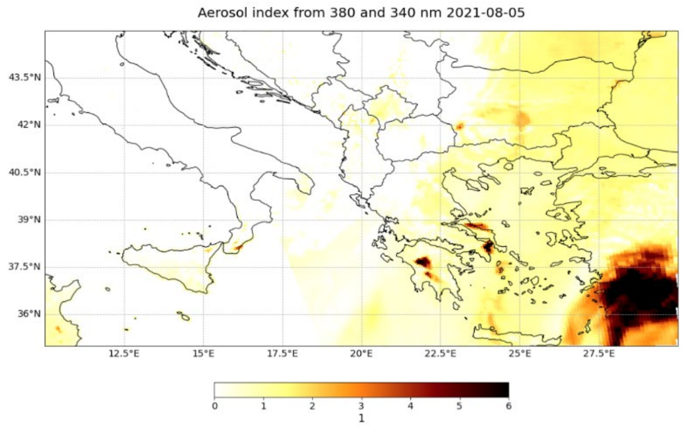








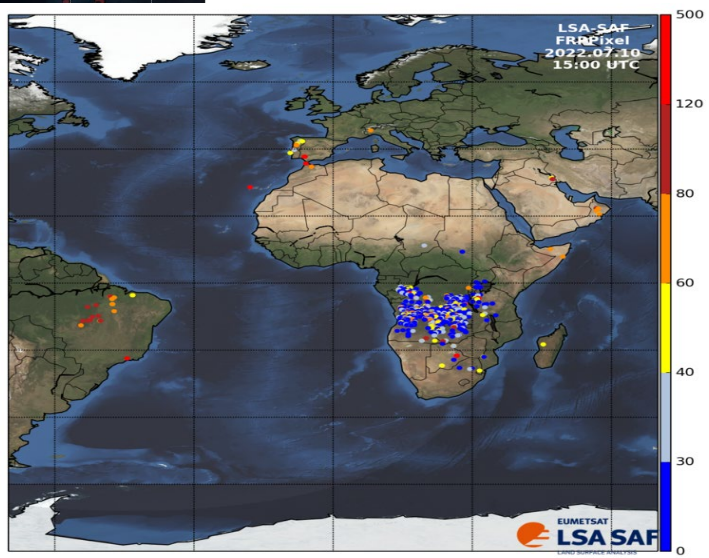




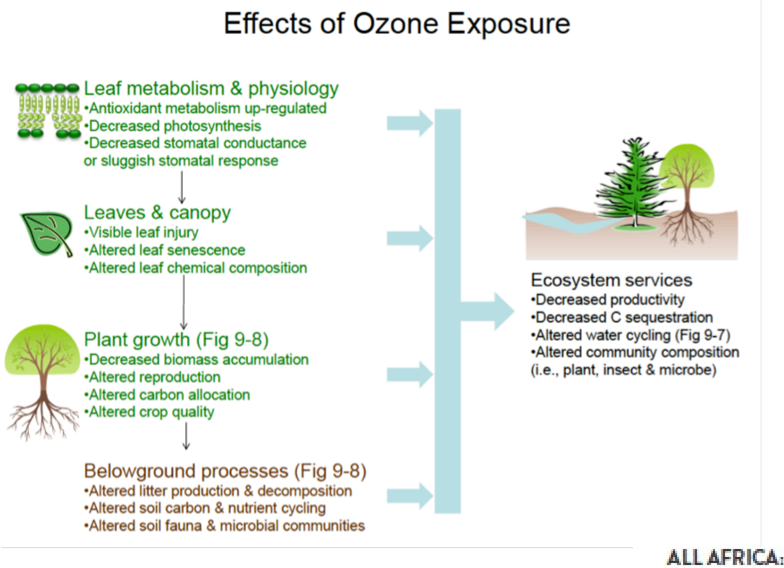
MSG/SEVIRI - every 15-minute allows:

- ✓ Strong seasonality
- ✓ Strong diurnal cycle

Fire Radiative Power



Example: Changes in tropospheric ozone and crop yields



Ozone in the troposphere increases worldwide

Ref:
TOAR assessment
IPCC - WG1

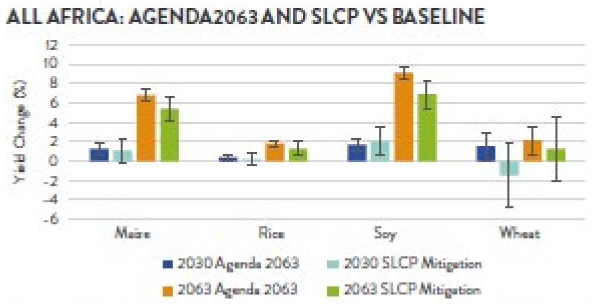
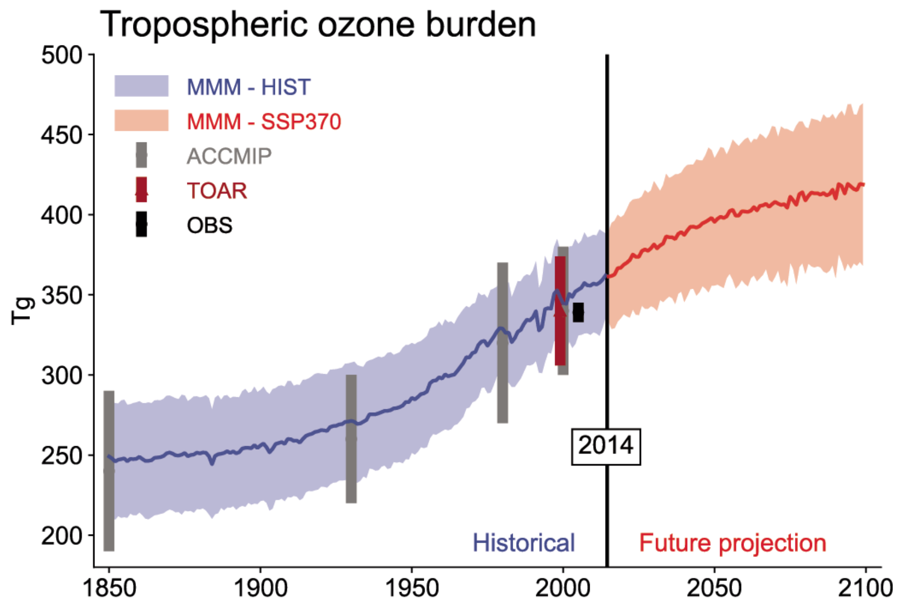
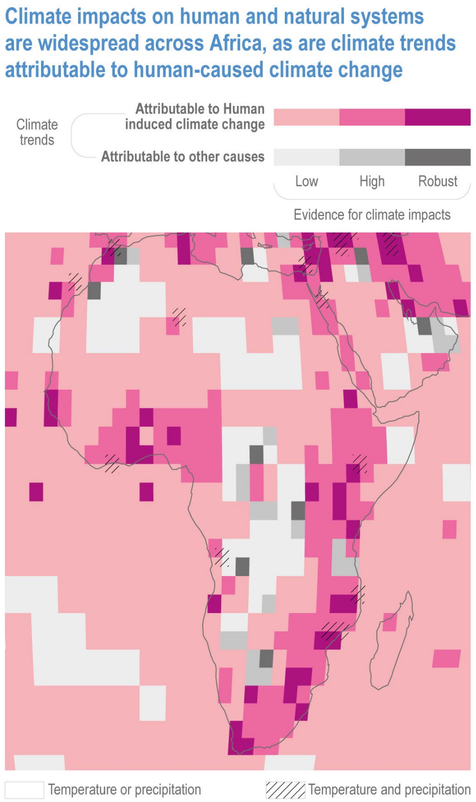


Figure S7 Simulated crop (maize, rice, soy and wheat) yield gain changes (per cent relative to baseline) under the SLCP scenario by 2030 (light blue) and 2063 (green) and the Agenda 2063 scenario by 2030 (blue) and 2063 (orange) in response to changes in ozone, CO_2, temperature, and precipitation, using data from the modeling for all of Africa, North, Central, West, Southern and East Africa. Uncertainty bars reflect the variability in climate and ozone across the five ensemble simulations completed for the baseline scenario and indicate when the modeled changes are statistically significant.



The need to control CO2 emissions – preparing for monitoring



IPCC - Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change
doi:10.1017/9781009325844.011.

CLIMATE CHANGE BENEFITS FOR AFRICA

- Implementing the 37 measures has the potential to greatly reduce regional climate change in Africa, significantly lessening further land degradation and desertification and improving food production and quality. If all the measures are implemented, in some areas there would be much smaller changes in local precipitation patterns than if there were no changes in policy. For example, the Assessment projects there will be reduced drying in the Sahel and West Africa in June–August and potentially also in southern parts of Africa in December-February due in part to reduced air pollution (Figure S5).

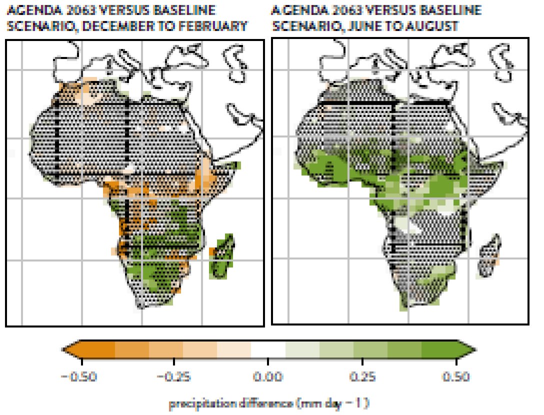


Figure S5 The difference between Africa seasonal average precipitation changes for 2050-2059 relative to 2015-2025 in the modeling for the Agenda 2063 and the baseline simulations for Dec-Feb (left) and Jun-Aug (right). Stippling indicates the differences are not statistically significant (95 per cent confidence).

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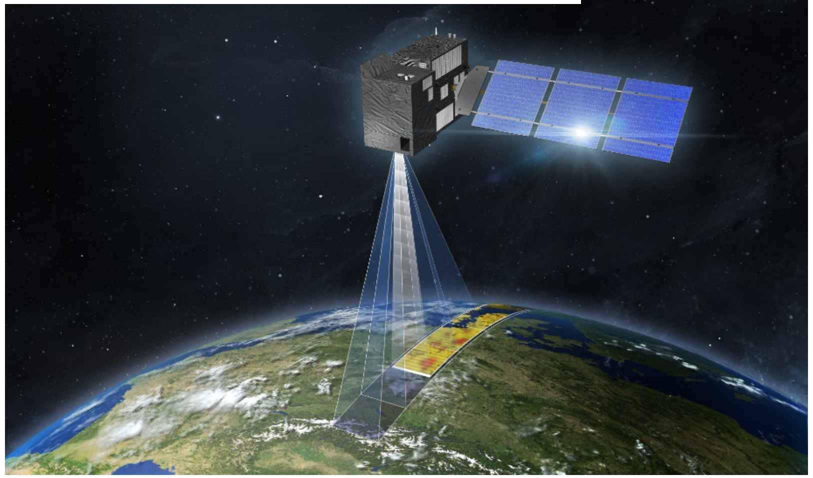
PROGRAMME OF THE EUROPEAN UNION
copernicus Europe's eyes on Earth
IMPLEMENTED BY EUMETSAT



Product	Spatial resolution	Precision
CO2	4 km²	0.5 – 0.7 ppm
CH4	4 km²	10 ppb
NO2	4 km²	1.5x10^{15} molec/cm²
SIF*	4 km²	0.7 mW m^{-2} sr^{-1} nm^{-1}
Aerosol	16 km²	0.05 AOD, 500 m LH
Clouds	<5% of FOV	Water & cirrus clouds

VIS band also covers CHOCHO (glyoxal)
VIS & SWIR band also covers water vapour
*Top-of-Atmosphere Solar Induced Fluorescence

Atmosphere Monitoring

CHALLENGES OF OBSERVATION-BASED EMISSION MONITORING

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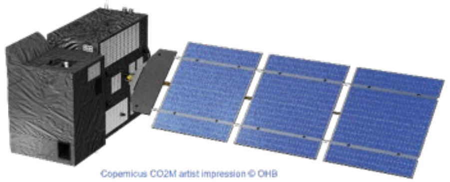
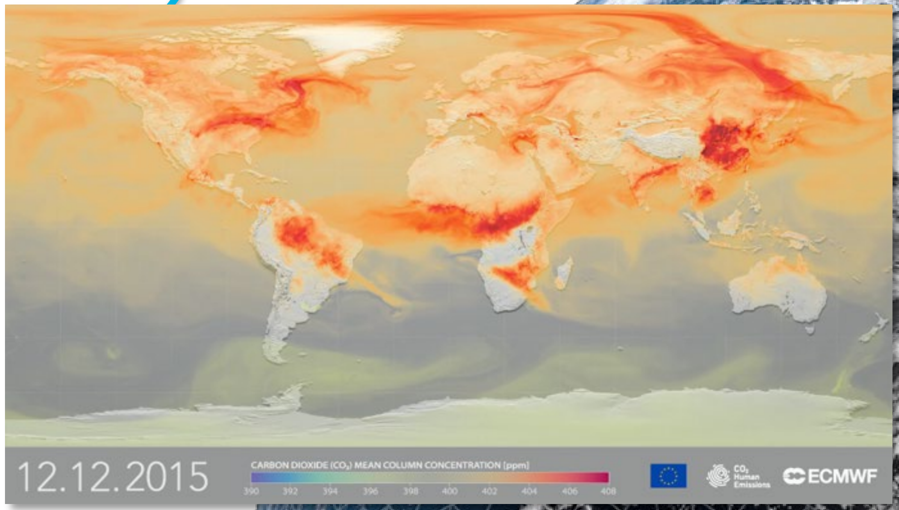
Satellites do not measure emissions directly; they measure the total impact of natural and anthropogenic emissions and removals on the atmosphere.

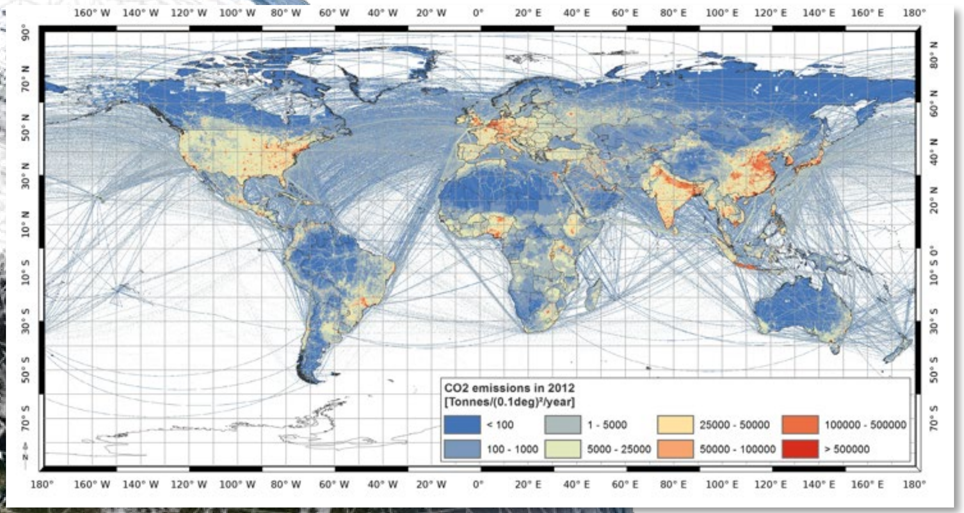


Copernicus CO2M artist impression © OHB

Earth System models are used to translate the **observations** into **emission estimates**.

Collaboration between space agencies, in-situ networks, and operational data assimilation centres.





Example: CO_2 monitoring from single point emissions

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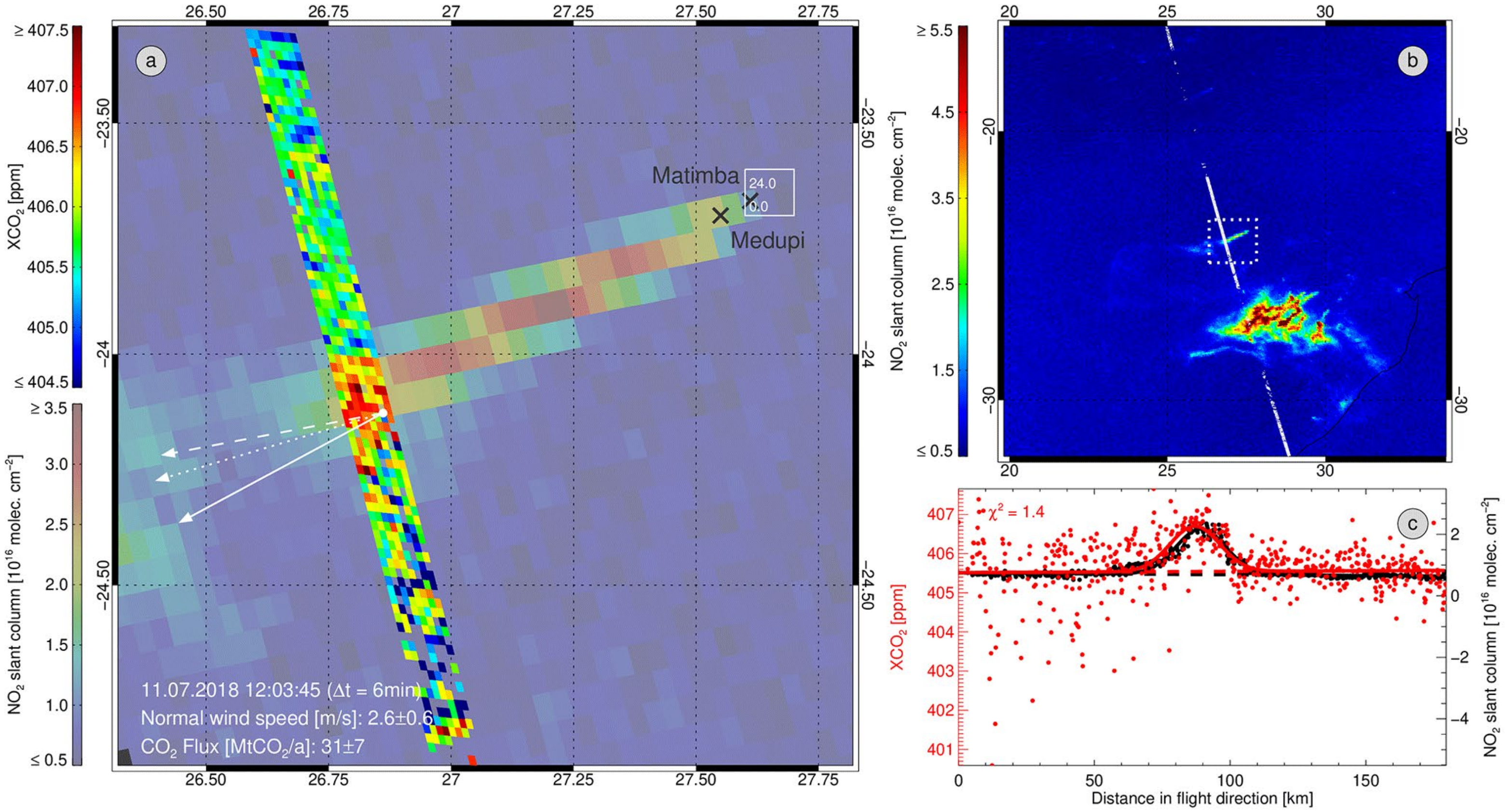

Experimental study on Matimba Power Station

Nitrogen Dioxide from TROPOMI data
© Copernicus program & CO2 from OCO2
Credit – Hakkarainen et al. 2020

Synergy in Copernicus: part of an unique data value chain

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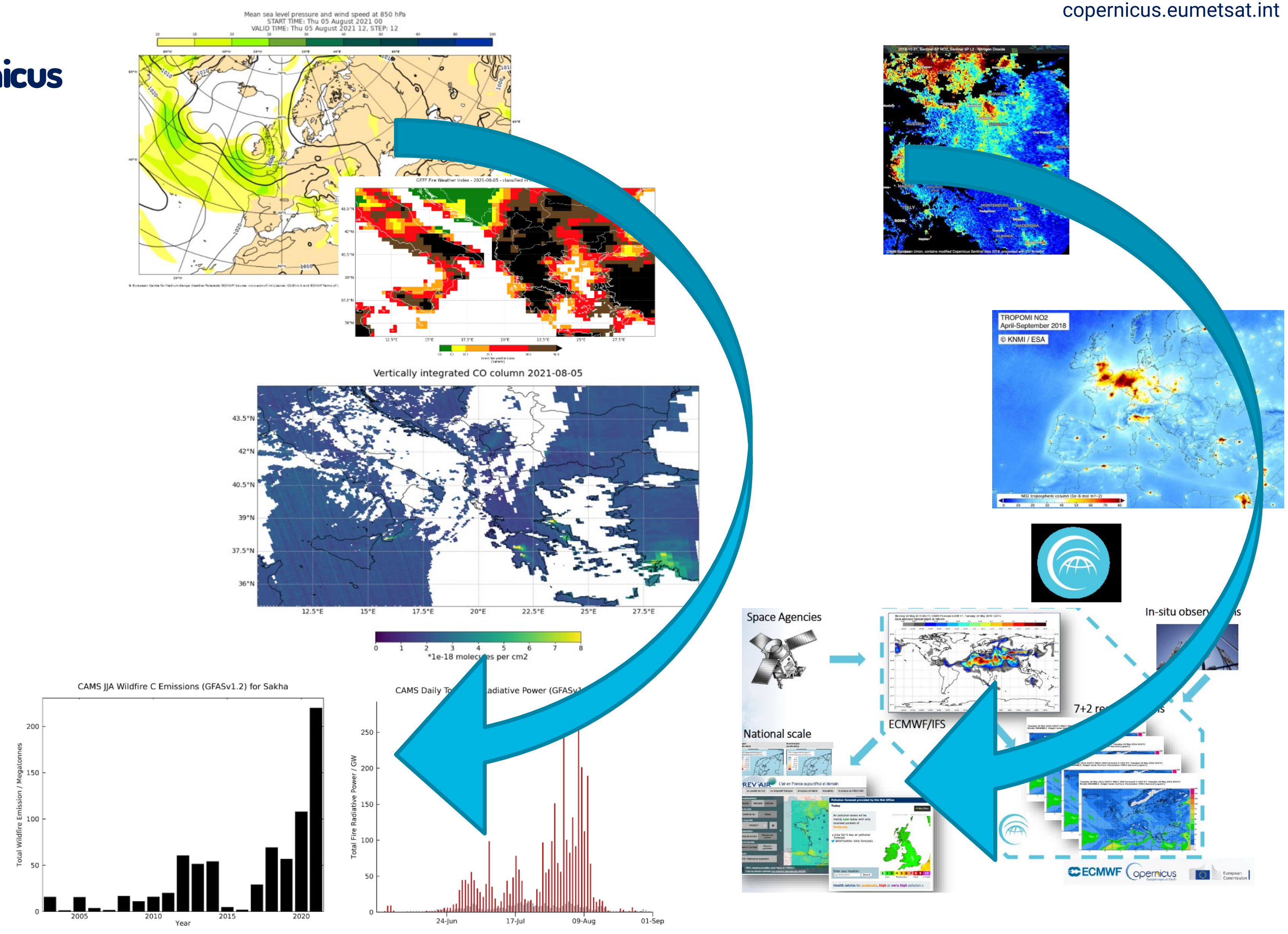
Bring to Users the concept of "Copernicus improves usability"

User journey encompassing:
→ Forecast
→ Monitoring and nowcasting
→ Estimate of impacts

Integrated system:
→ Satellite and non satellite, models
→ Support emission estimate
→ Generate added value products
→ Ensure Quality and usability



Outcomes

EUMETSAT and Copernicus missions are and will be unique to support policies in emission reduction for most species and to detect environmental risks

Observations needs support to be properly used – complexity – representativeness

Observations are used in services that provides added value products (CAMS)

Improve exploitation – eg combination with ground-based and in-situ

Applications of AI/ML

Atmosphere
Monitoring

CAMS: GHG MONITORING CAPACITY

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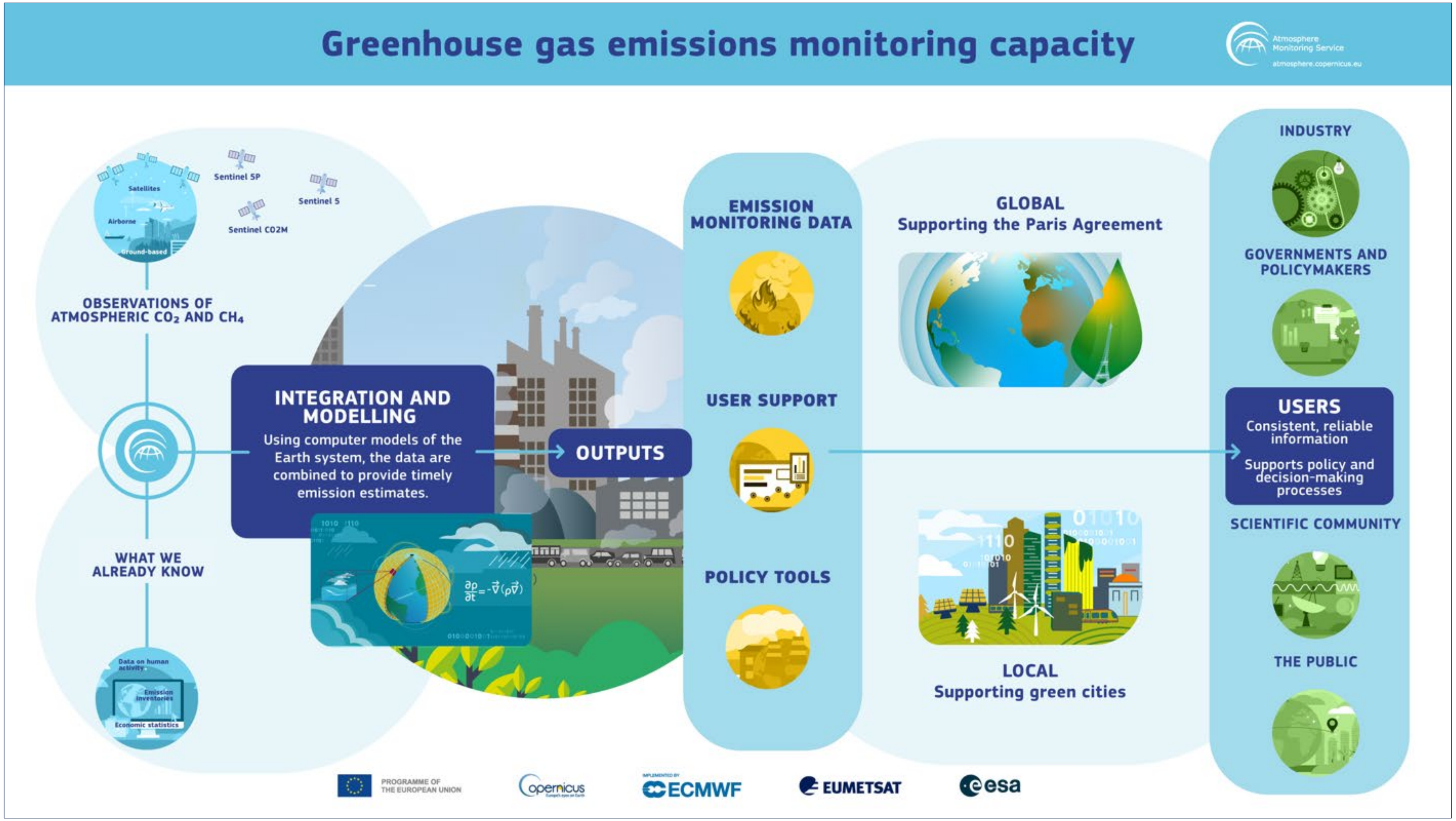

https://atmosphere.copernicus.eu/ghg-services