UNEP's Methane Alert and Response System (MARS): achievements and new steps towards notifications in other sectors

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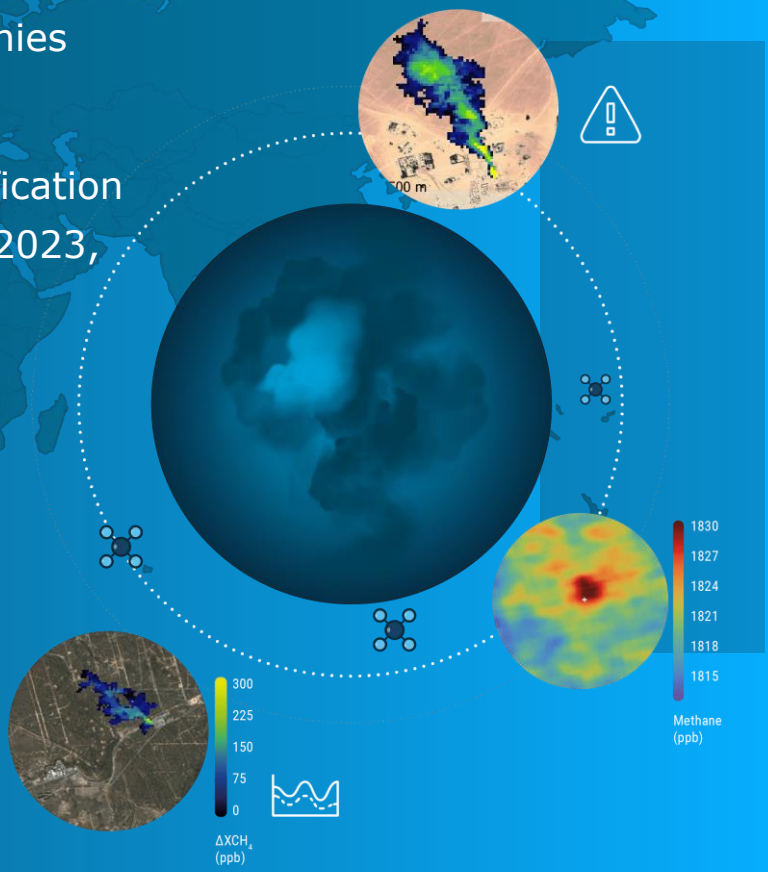
UNEP's IMEO & MARS

The goal of UNEP's **International Methane Emissions Observatory (IMEO)** to provide open, reliable, and actionable data to those individuals who can act to reduce methane emissions. IMEO consists of several efforts including:

- → A portfolio of **Methane Science Studies** (e.g., multi-scale measurement campaigns)
- → An innovative, transparent emissions reporting framework for Oil & Gas companies **(OGMP2.0)**
- → **Methane Alert and Response System (MARS)** – Satellite data to drive notification and mitigation processes; officially announced at COP 27 and launched in Jan. 2023, in pilot pase. In nominal phase from COP 28 in Dec. 2023

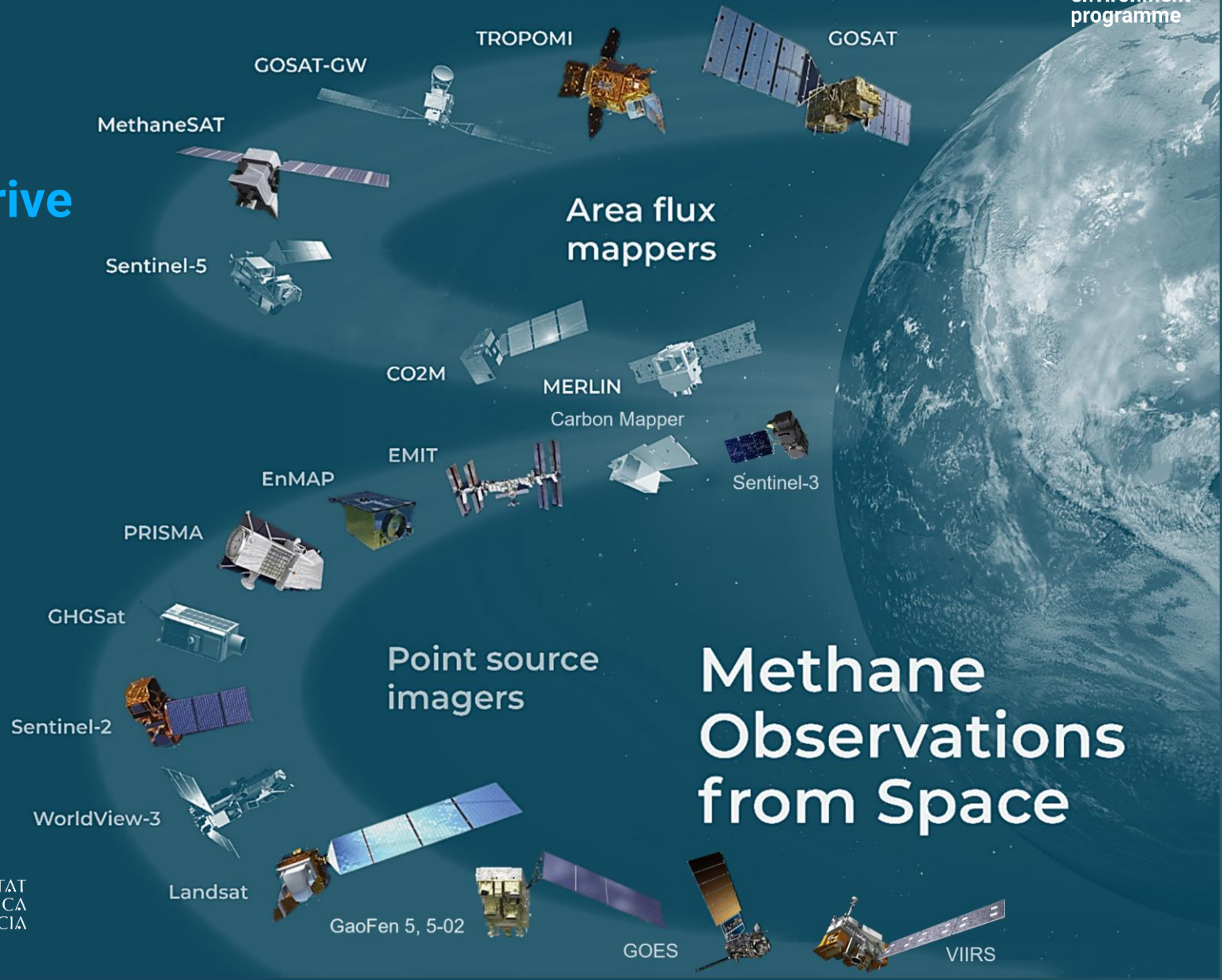
METHANE	→	Detect and Attribute
ALERT	→	Notify and Engage Stakeholders
RESPONSE	→	Stakeholders Take Action
SYSTEM	→	Track, Learn, Collaborate, Improve



Component 1: MARS uses state-of-the-art, publicly available satellite data to drive notification and mitigation processes

Global mapping satellites are used to identify very large methane plumes and methane hot spots

Further analysis using other satellites and datasets **enables attribution**



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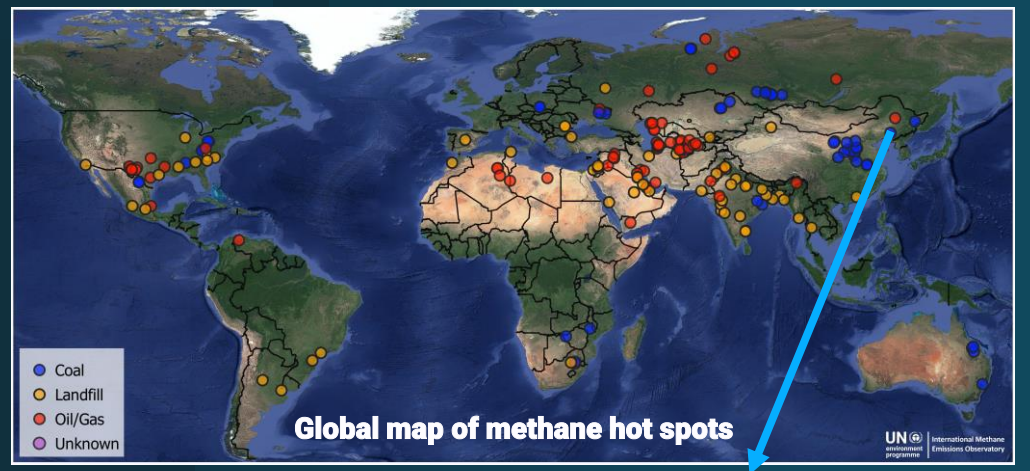
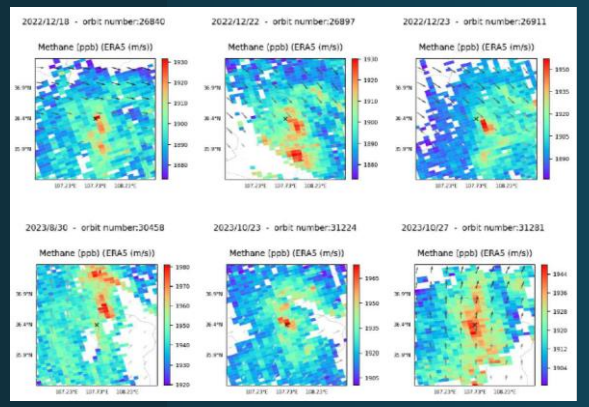
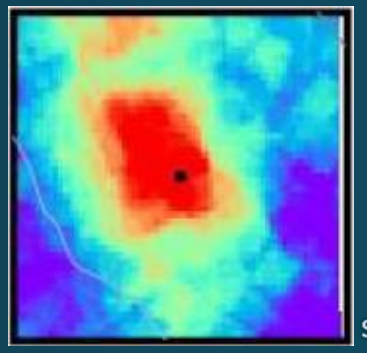
Jacob et al., ACP, 2022

→ **Global mapping satellites** are used to identify very large methane plumes and methane hot spots







Hots pots data from SRON: **> 220 hot spots** in exploration

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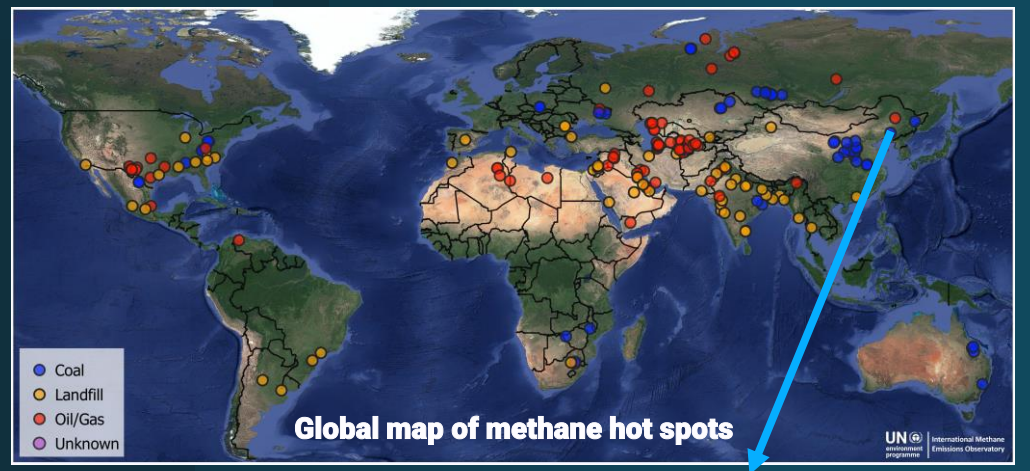
UN environment programme

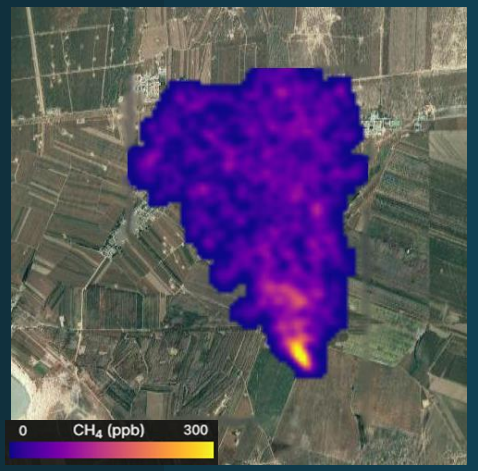
GOSAT-GW
TROPOMI
GOSAT
MethaneSAT
Sentinel-5
Area flux mappers
CO2M
MERLIN
Carbon Mapper
EMIT
EnMAP
Sentinel-3
PRISMA
GHGSat
Point source imagers
Sentinel-2
WorldView-3
Landsat
GaoFen 5, 5-02
GOES
VIIRS

Methane Observations from Space

Jacob et al., ACP, 2022

→ **Further analysis using other satellites and datasets enables attribution**





EMIT detection at an O&G facility, Jilin, China. 11 Oct. 2023
Plume detection through the MARS Plume Viewer

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UN environment programme

Methane Observations from Space

Area flux mappers

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Jacob et al., ACP, 2022

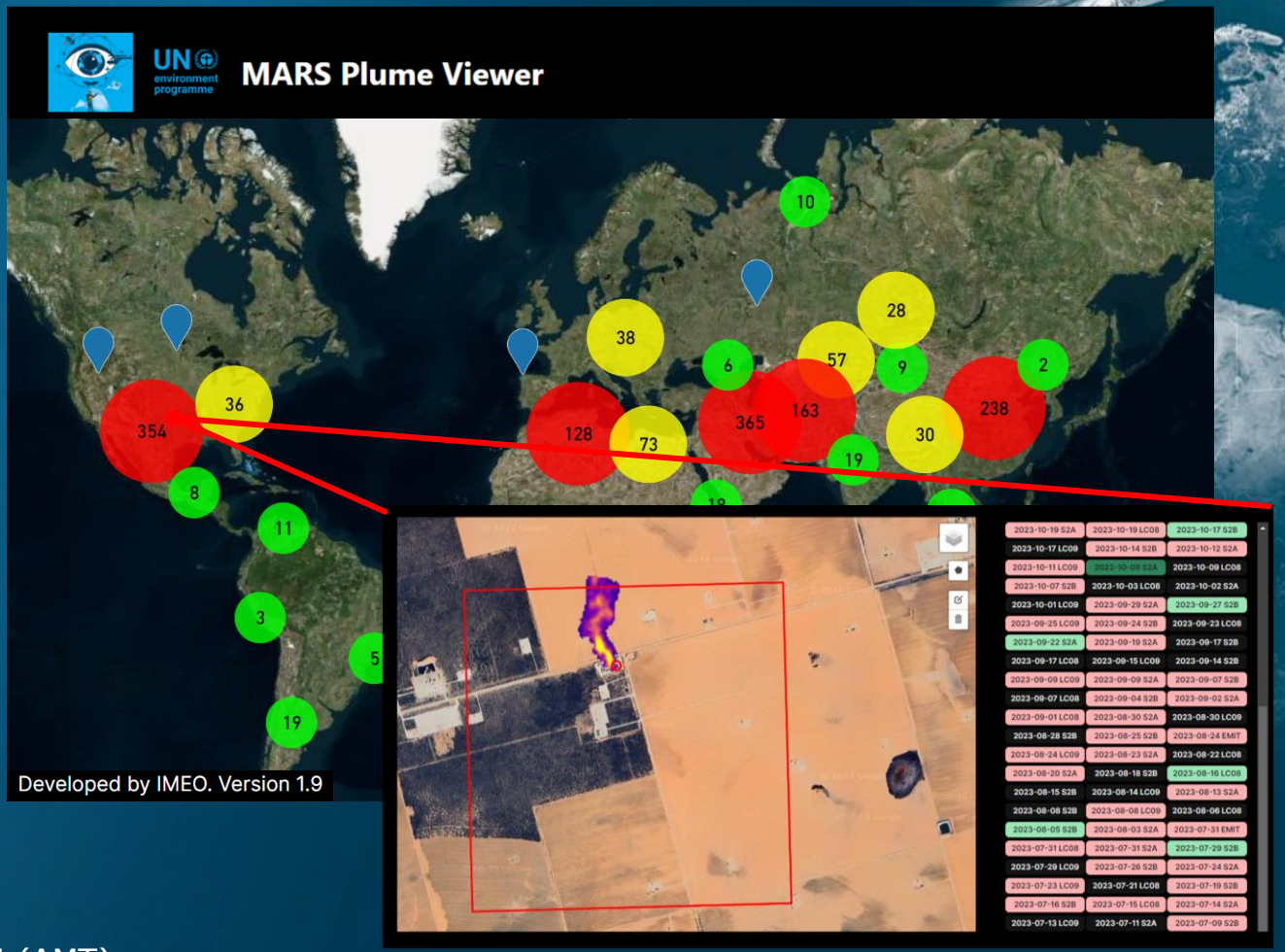
MARS' Plume Viewer: data integration, emission detection and monitoring tool

- Locations where an emissions have been detected at some point are added to the Plume Viewer
  - **Browse available satellite data over these locations**
  - Keep the location monitored in case the leak persists or reappears.

- Alert system
  - The Plume Viewer integrates a ML model to automatically detect potential emissions in the monitoring areas.
  - Alerts are supervised and validated by humans before sending the notification

- Continuous development
  - Improving ML models and integrating new satellite data.
  - Adding new locations as new emission areas are explored.

→ More info about the ML model in Vaughan et al., 2024 (AMT)



Images from IMEO-UNEP

Component 2: Notification Process

Initial Notification

As soon as possible after the detection

Notice of the event, location, and potential operator

Governments and MARS-participating OGMP 2.0 companies **notified simultaneously**
If non-OGMP 2.0, government **then** companies

Preliminary Acknowledgement

- Acknowledgement and initial feedback

Follow Up

Within one week of the initial notification

Additional analysis, including potential source, shared

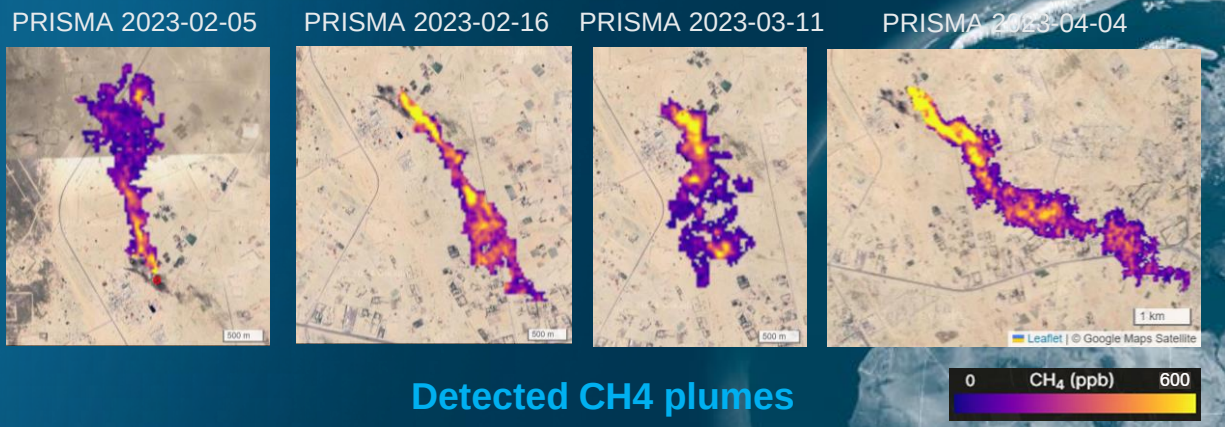
Governments and companies notified **simultaneously with feedback form and support options**

Mitigation and Tracking

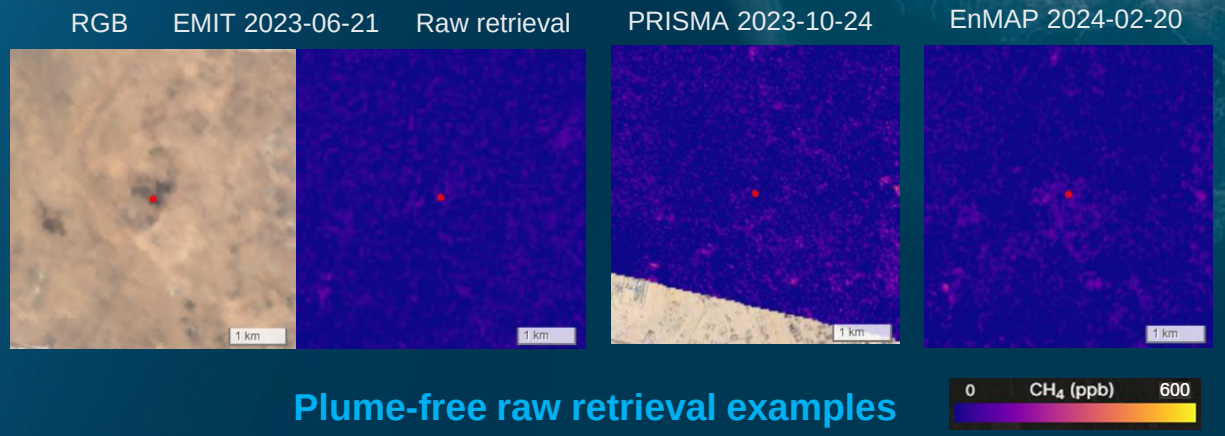
After 45-75 days, all non-proprietary data and metadata is made publicly available

Example of notification case in Iraq (during the pilot phase)

- → MARS notified recurrent emissions coming from a flaring area
- → Operators were aware of the emissions. Short term mitigation proposals under investigation
- → Weeks later MARS stopped seeing emissions
- → In a more detailed feedback, operators confirmed that emission mitigation actions were taken.
- → No further emissions have been seen to date



Detected CH4 plumes



Plume-free raw retrieval examples

Images from IMEO-UNEP

Plumes detected from all sectors:

4620

940 from TROPOMI

3680 from point source imagers (high-resolution)

Notified plumes:

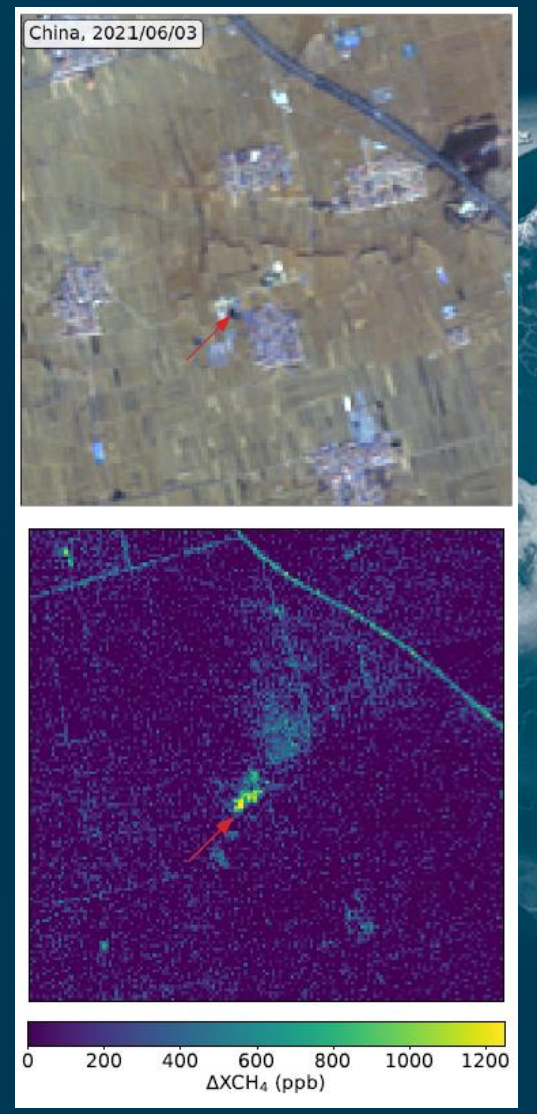
296

Requirements for notification:

- **High-resolution** plume
- **Recent** plume (not older than 10-15 days)
- **O&G** emission

Adding new sectors: coal mine methane emissions

- MARS was designed to include new sectors as it grows.
- There is a large uncertainty on the amount of methane emitted from coal mines in most coal-producing countries, mainly due to the lack of technology to measure and monitor emissions
- SMP (Steel Methane Program) is coming: new emission reporting framework for thermal coal companies with set emission reduction targets.
- Several studies have demonstrated that detection of coal mine methane emissions from space is possible.



Images subset from Guanter et al., 2021 RSE

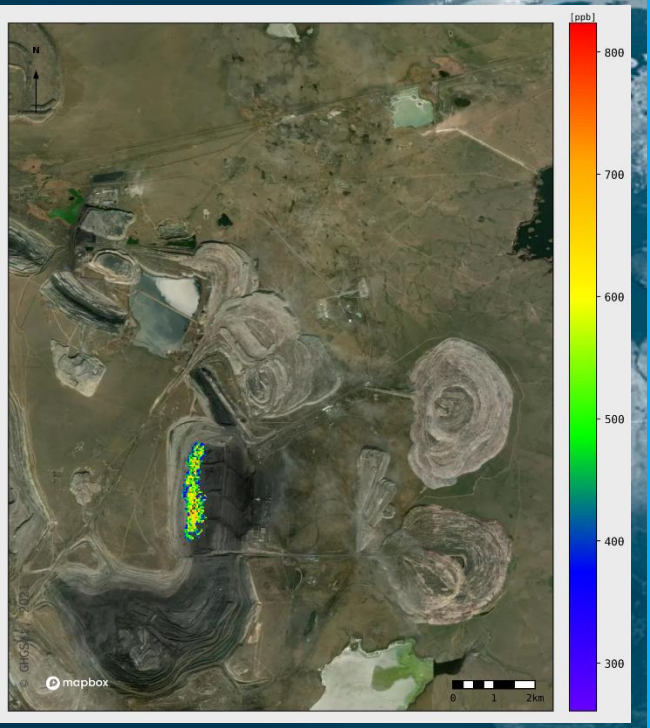
Challenges:

Logistical challenges:

- Less rapid mitigation options in coal mines, so the notification approach must be different from the O&G alerts.
- High level of scepticism about satellite technology in the sector and reluctance to accept the measures as "real".
- Lack of regulation and policy gaps on methane emissions, so encouraging them to respondto the notification will be challenging.

Scientific challenges:

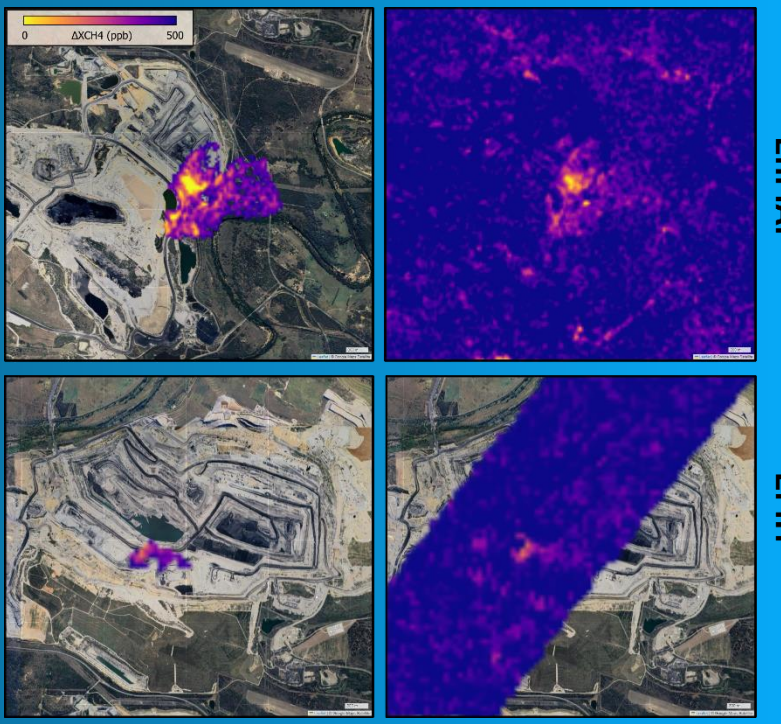
- Open pit mines:
  - Diffuse emissions
  - Abrupt topographic changes
  - Wind flow change in the mine cavity
  - Methane accumulation effect at the mine edges
- Underground mines:
  - Most mines are in heterogeneous and dark surface areas so hyperspectral satellites are the best option (e.g. EnMAP, EMIT, PRISMA), but the amount of data is limited.
  - Many mines are in hilly areas, where wind data have higher uncertainty, and effective wind calibration may be less accurate



Images from ESA website GHGSat detection in a Kazakhstan coal mine

Solving challenges: several projects and ideas under development

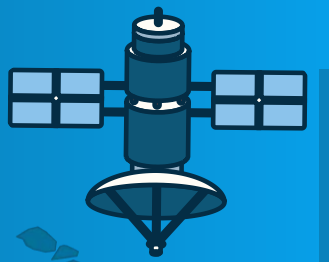
- Compare Bottom-Up and Top-Down measurements thanks to collaboration with coal companies/agencies in Poland, US and Australia.
  - Know the accuracy of current measurements
  - Find ways to correct/improve estimates if needed
- Improve the effective wind calibration under different scenarios to improve the flux rate estimates
  - Alternatively, look for viable emission flux quantification methods without relying on wind data (ideas welcome).
- Open pit emissions analysis will be done with TROPOMI.
- Explore the potential of new high-resolution satellites to detect open pit mine emissions (e.g., EnMAP, EMIT, MethaneSAT, Carbon Mapper).



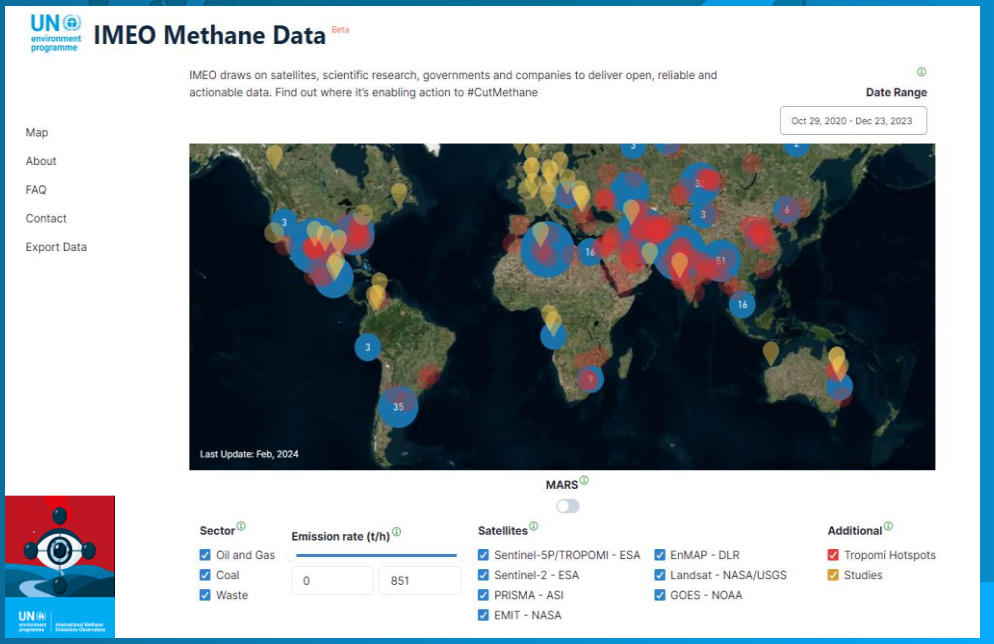
Images from IMEO-UNEP

Thank you !

Wrap-up



- **MARS is a satellite-based methane emissions alert system.**
- **After one year in pilot phase and ~half a year in nominal phase focusing on O&G emissions:**
  - **~300 emissions notified in different countries of the world**
  - **> 4600 emissions detected from all sectors**
- **We will continue to explore areas with potential O&G methane emissions and notify them.**
- **We are now expanding into other sectors, starting with the coal sector.**
- **All data is publicly available:** https://methanedata.unep.org/plumemap?mars=false



New version of the platform expected for COP29