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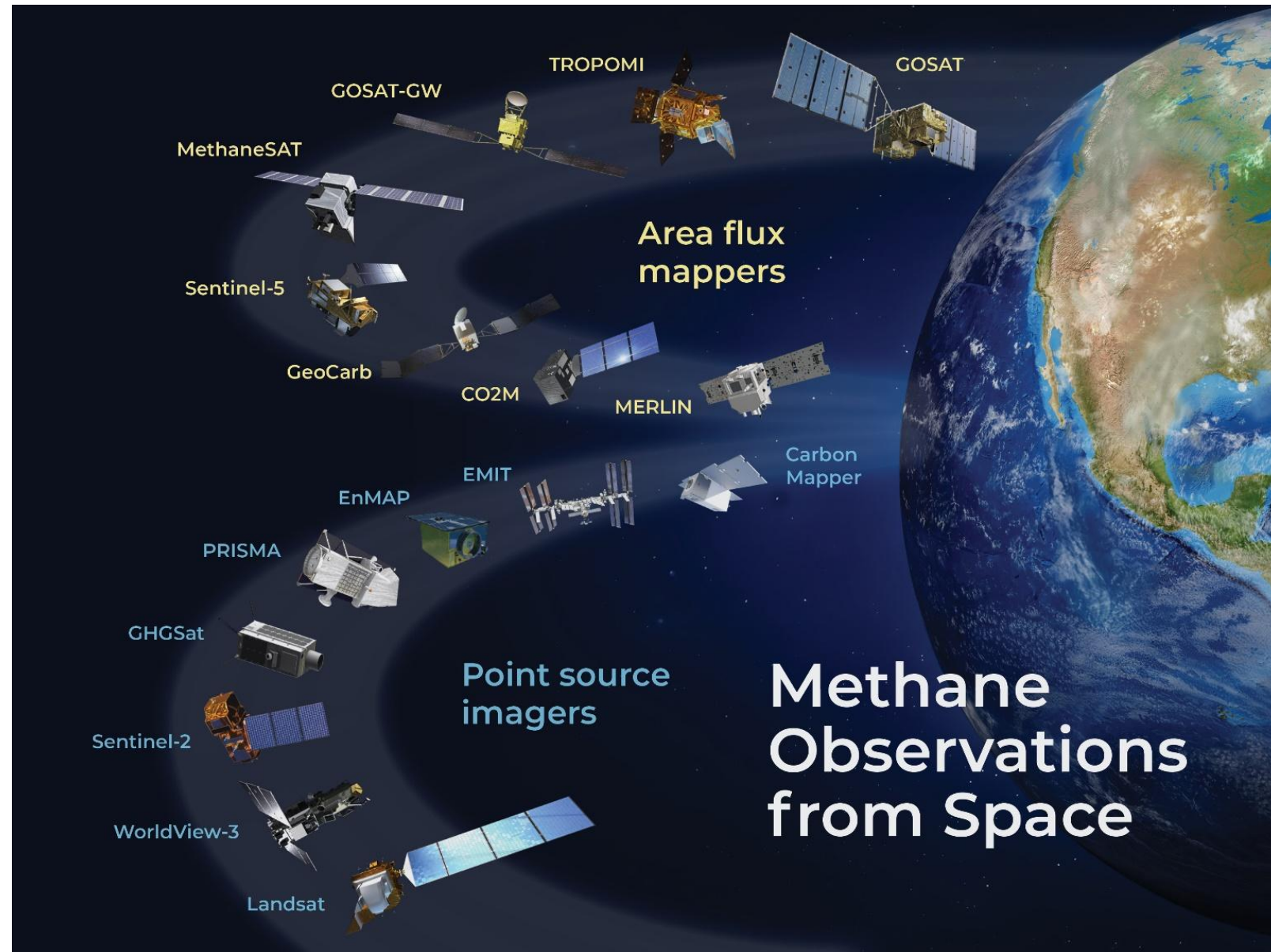
# Satellite-based remote sensing of anthropogenic methane sources & UNEP's International Methane Emissions Observatory

Luis Guanter (UPV/EDF), Itziar Irakulis-Loitxate (UNEP)



# Satellite-based remote sensing of anthropogenic methane sources

- **>50% of global methane emissions** stem from human activities in 3 sectors: fossil fuels (O&G+coal mining, 35%), waste (20%) and agriculture (livestock+rice, 40%)
- **The fossil fuel sector has the greatest potential** for targeted mitigation by 2030
- A **rich ecosystem of methane-sensitive satellites** has emerged in the last years
- **Remote detection, quantification and monitoring** of human-based methane emissions is key to guide mitigation efforts:
  - Quantification of emissions at regional-level
  - Detection, quantification and monitoring of active point sources

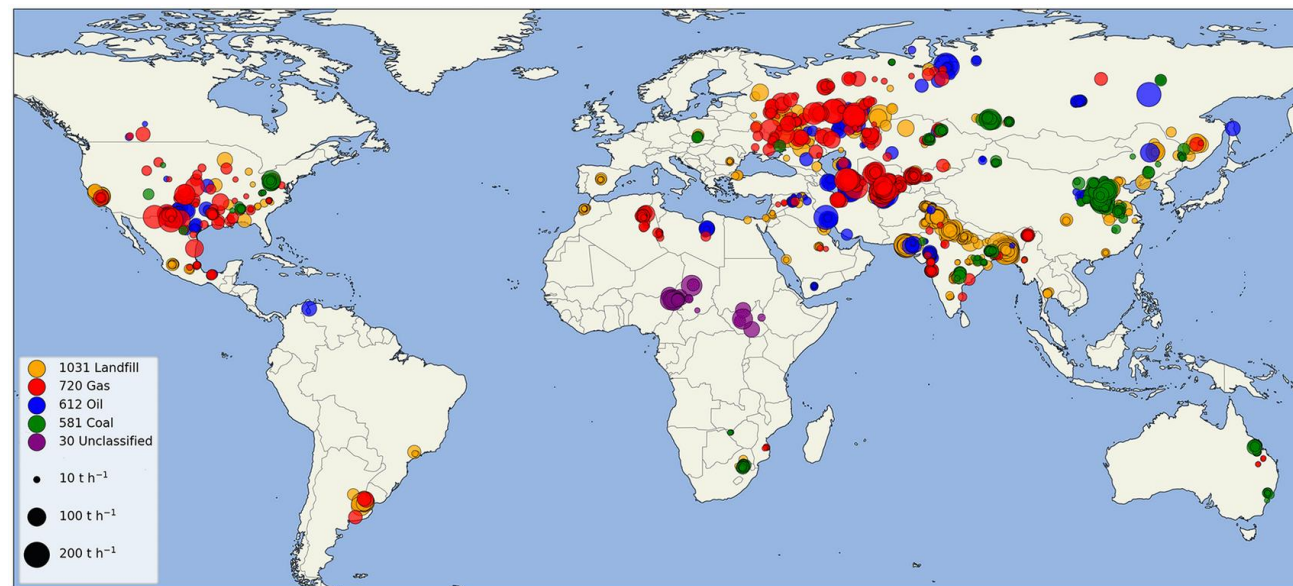


# Copernicus Sentinel-5P/TROPOMI (area flux mapper)

- TROPOMI - operational, global and daily sampling, but coarse resolution

## Application #1

Detection of individual ultra-emission events and hotspot regions (daily global surveillance, very large plumes)

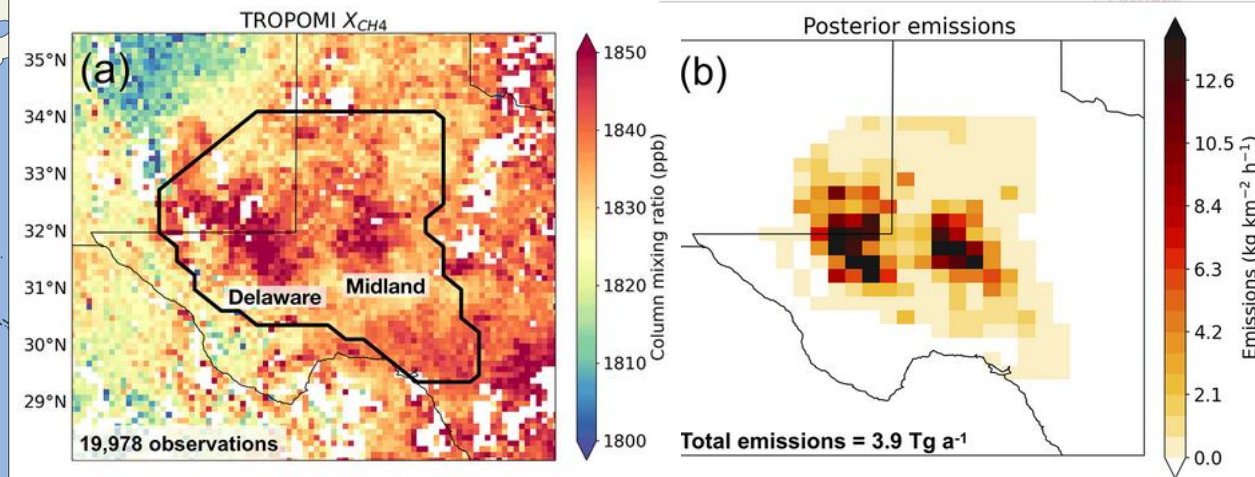


2974 super-emission detections during 2021

[Schuit et al., ACP, 2021](#)

## Application #2

Estimation of regional fluxes through the inversion of atmospheric transport models



Varon et al., Integrated Methane Inversion (IMI 1.0)

<https://doi.org/10.5194/gmd-15-5787-2022>



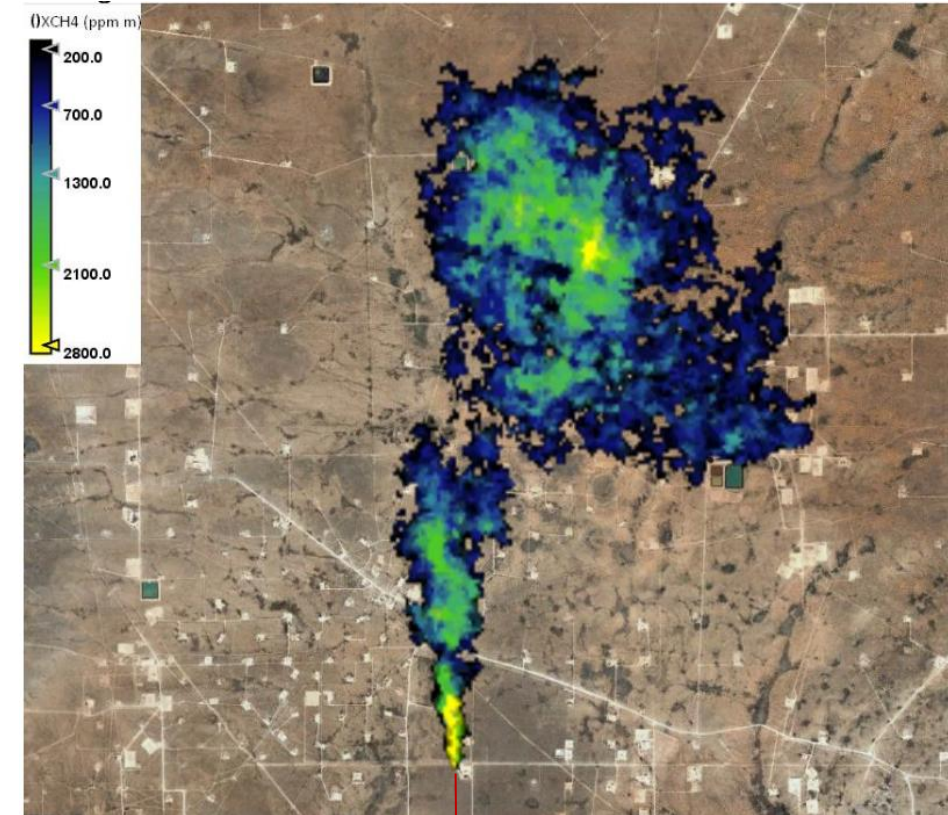
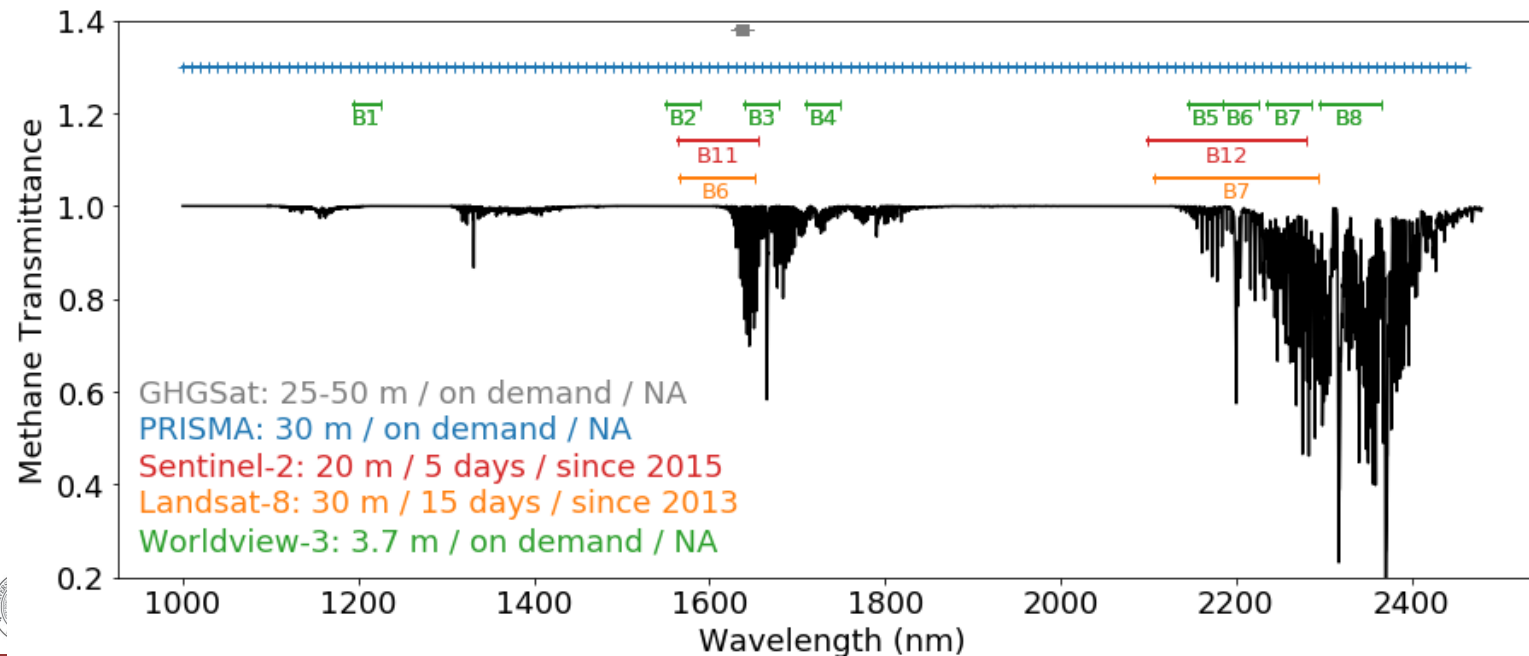
# Methane mapping with point source imagers

Instruments covering methane absorptions in 1600-2450 nm

Allow attribution to sources and lower detection limits ( $>100$  kg/h)

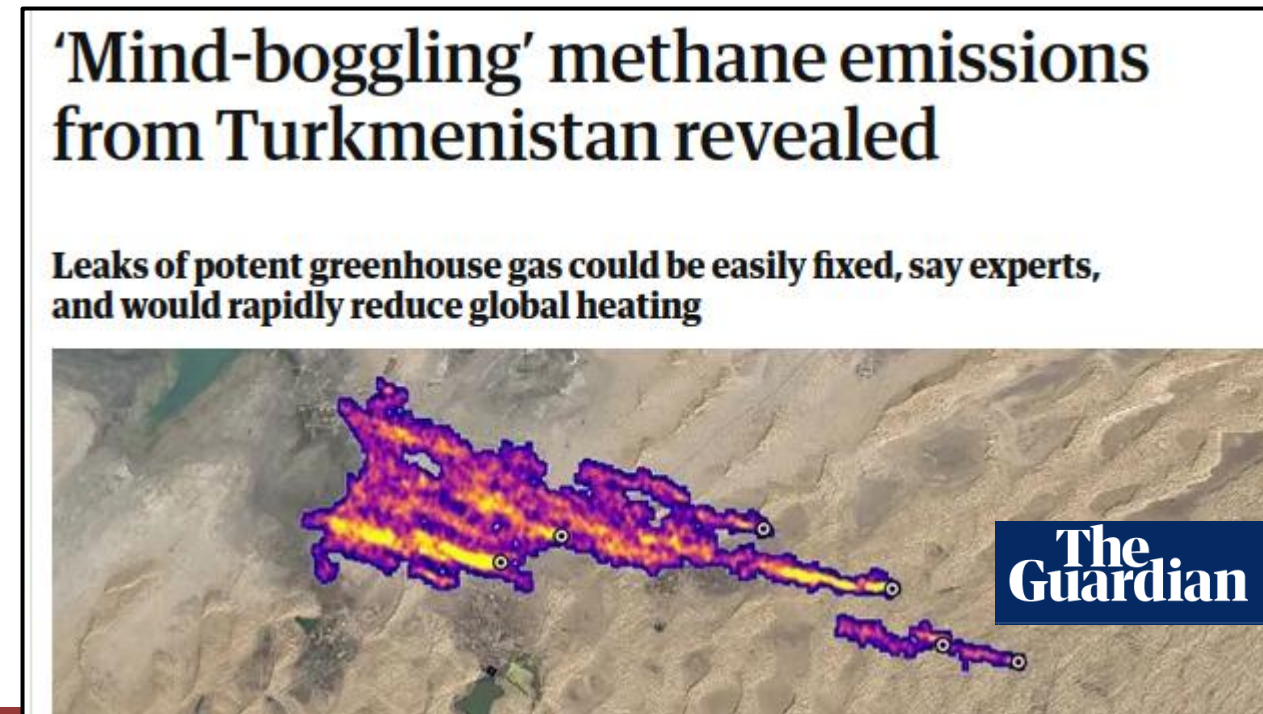
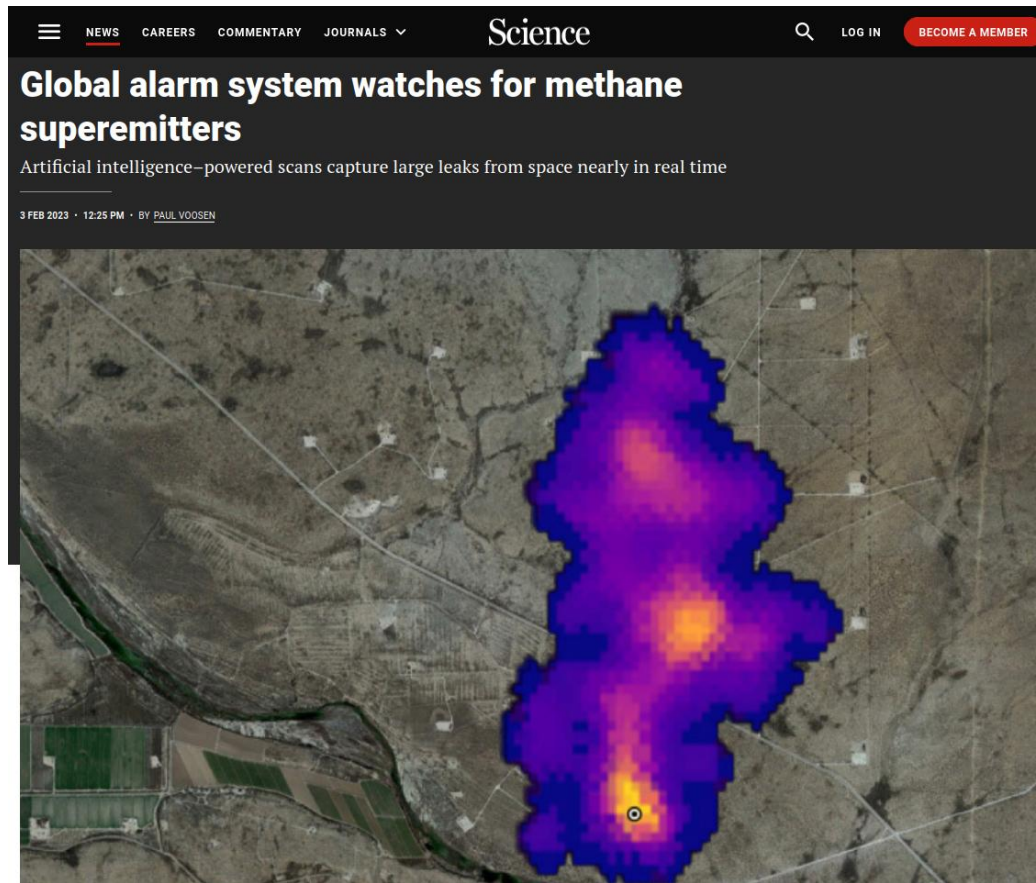
Two classes of missions

- Hyperspectral missions (GHGSat, EnMAP, PRISMA, ...): 30-m resolution, medium sensitivity (high for GHGSat!), sporadic acquisitions, spatial coverage 30-60 km, require tasking
- Multispectral missions (S-2/Landsat): 20-30 m resolution, low sensitivity, but “monitoring” with frequent and global coverage





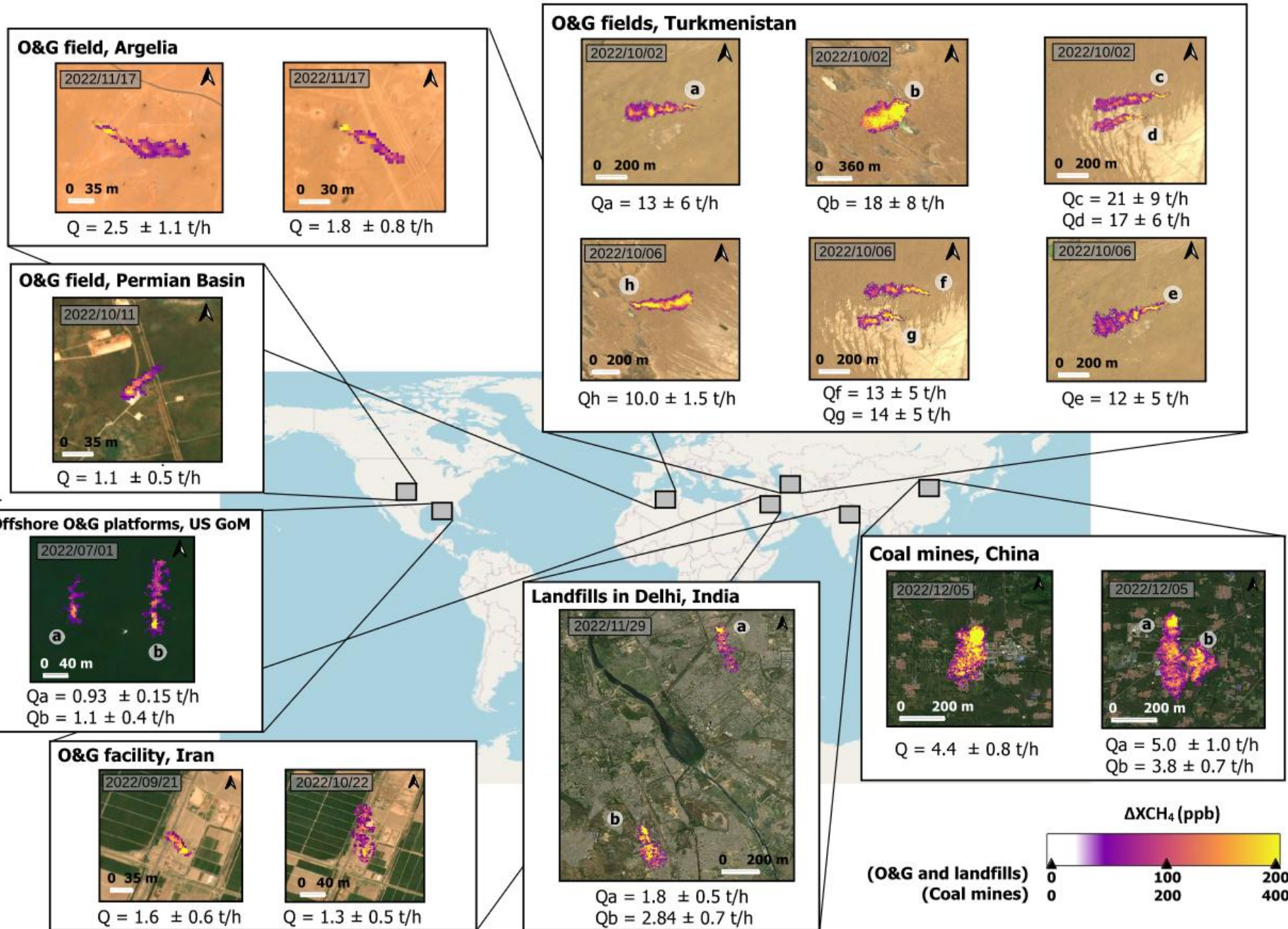
# The detection of methane sources from space is on the focus





# Methane plume detections with the EnMAP satellite mission

- High resolution methane mapping with the open-access EnMAP imaging spectroscopy mission (DLR)
- Hundreds of sites around the world sampled for the detection of methane emissions



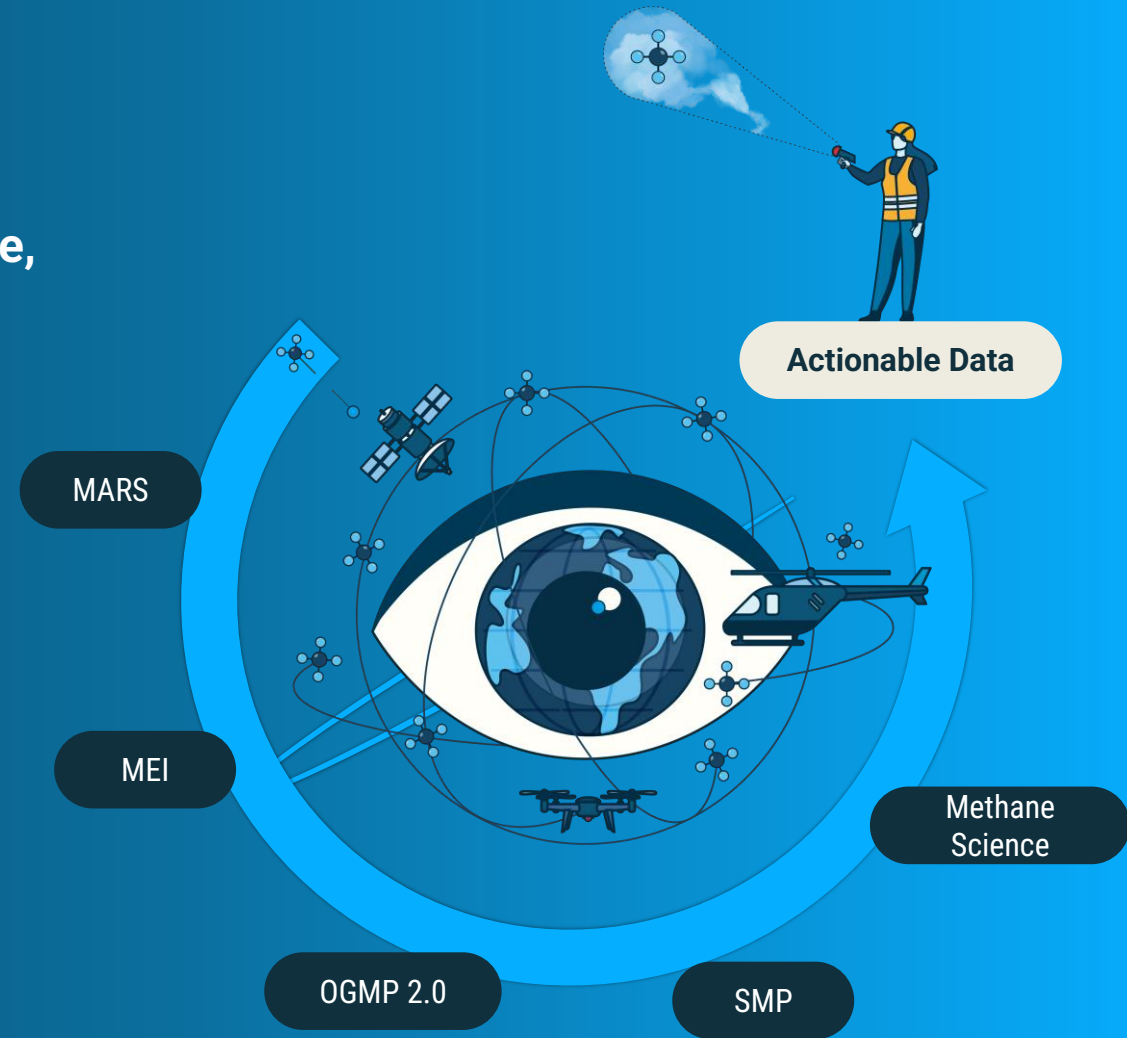
[Roger et al.,  
IEEE TGRS \(2024\)](#)

# UNEP's IMEO

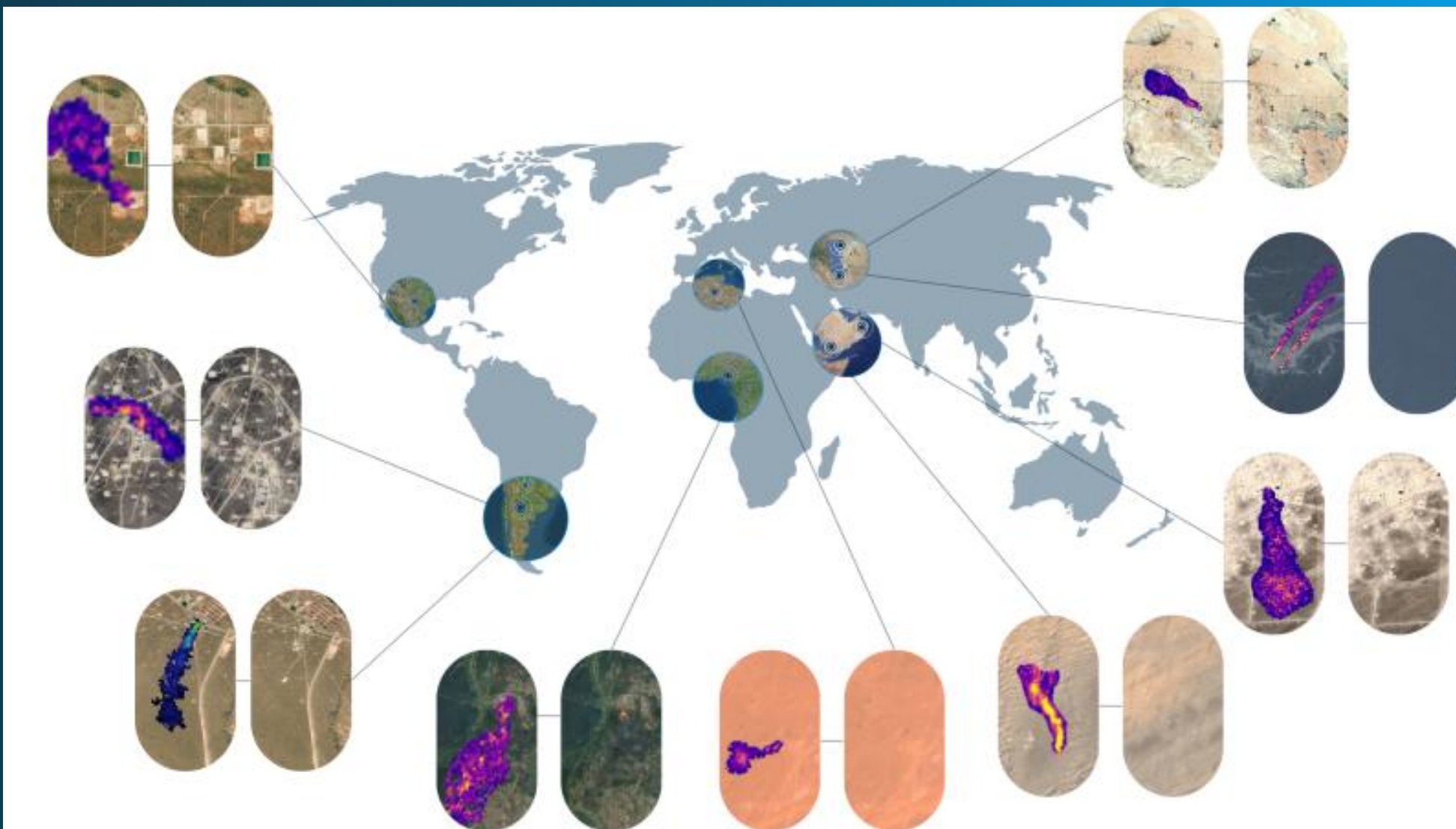
- UNEP's **International Methane Emissions Observatory (IMEO)** exists to provide open, reliable, and actionable data to the individuals with the agency to reduce methane emissions.

- IMEO consists of several projects

→ **Methane Alert and Response System (MARS):** A system to detect and notify large methane emissions to governments and companies worldwide based on satellite observations



# Verified mitigation cases around the world



More information on mitigation cases:

<https://www.unep.org/topics/energy/methane/mars-case-studies>



# Mitigation case in Algeria

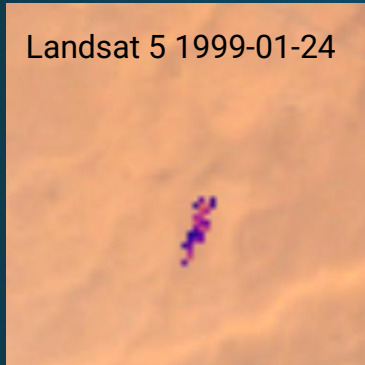
- Persistent emissions from a gas disposal facility in Hassi Messaoud Oil field
- First detected plume in Jan. 1999
- Mean emission flux rate  $\sim 3.1 \text{ t/h} \approx >27,000$  tonnes of methane per year
- In September 2024 closer connection with the operator and new Algerian focal points
- In October 14 we stopped seeing emissions until the present
- Algerian focal points confirmed the mitigation action and the cessation of emissions from the ground.

NO-PLUMES

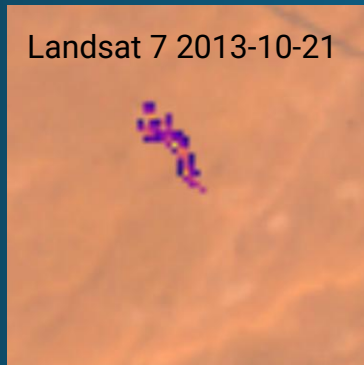
PLUMES

|                   |                 |                   |
|-------------------|-----------------|-------------------|
| ← next            | prev →          |                   |
| 2024-12-21 S2B    | 2024-12-18 S2B  | 2024-12-16 S2C    |
| 2024-12-16 S2A    | 2024-12-14 LC08 | 2024-12-13 S2C    |
| 2024-12-13 S2A    | 2024-12-08 S2B  | 2024-12-06 S2A    |
| 2024-12-06 LC09   | 2024-12-03 S2A  | 2024-12-01 S2B    |
| 2024-11-28 S2B    | 2024-11-28 LC08 | 2024-11-25 PRISMA |
| 2024-11-23 S2A    | 2024-11-21 S2B  | 2024-11-20 LC09   |
| 2024-11-18 S2B    | 2024-11-17 MSAT | 2024-11-16 S2A    |
| 2024-11-13 S2A    | 2024-11-12 LC08 | 2024-11-11 S2B    |
| 2024-11-08 S2B    | 2024-11-06 S2A  | 2024-11-04 LC09   |
| 2024-11-03 S2A    | 2024-11-01 S2B  | 2024-10-29 S2B    |
| 2024-10-27 PRISMA | 2024-10-27 LC08 | 2024-10-24 S2A    |
| 2024-10-22 S2B    | 2024-10-19 S2B  | 2024-10-19 LC09   |
| 2024-10-17 S2A    | 2024-10-15 EMIT | 2024-10-14 S2A    |
| 2024-10-12 S2B    | 2024-10-11 LC08 | 2024-10-09 S2B    |
| 2024-10-07 S2A    | 2024-10-03 LC09 | 2024-10-02 S2B    |
| 2024-09-29 EMIT   | 2024-09-29 S2B  | 2024-09-27 S2A    |
| 2024-09-25 LC08   | 2024-09-24 S2A  | 2024-09-22 S2B    |
| 2024-09-17 S2A    | 2024-09-17 LC09 | 2024-09-14 S2A    |
| 2024-09-12 S2B    | 2024-09-09 LC08 | 2024-09-09 S2B    |
| 2024-09-07 S2A    | 2024-09-04 S2A  | 2024-09-02 S2B    |
| 2024-09-01 LC09   | 2024-08-30 S2B  | 2024-08-28 S2A    |
| 2024-08-25 S2B    | 2024-08-24 LC08 | 2024-08-23 S2B    |
| 2024-08-20 S2B    | 2024-08-18 S2A  | 2024-08-16 LC09   |
| 2024-08-15 S2A    | 2024-08-13 S2B  | 2024-08-10 S2B    |
| 2024-08-08 S2A    | 2024-08-08 LC08 | 2024-08-06 EMIT   |
| 2024-08-05 S2A    | 2024-08-03 S2B  | 2024-08-02 EMIT   |
| 2024-07-31 LC09   | 2024-07-31 S2B  | 2024-07-29 S2A    |
| 2024-07-26 S2A    | 2024-07-24 S2B  | 2024-07-23 LC08   |

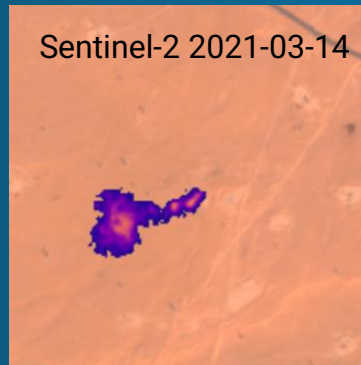
Landsat 5 1999-01-24



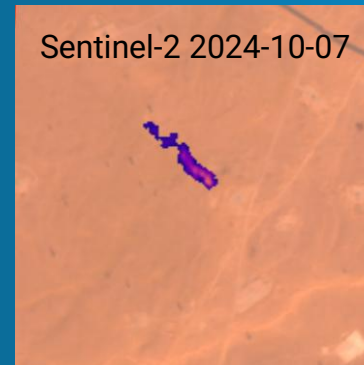
Landsat 7 2013-10-21



Sentinel-2 2021-03-14



Sentinel-2 2024-10-07



Sentinel-2 2024-10-14

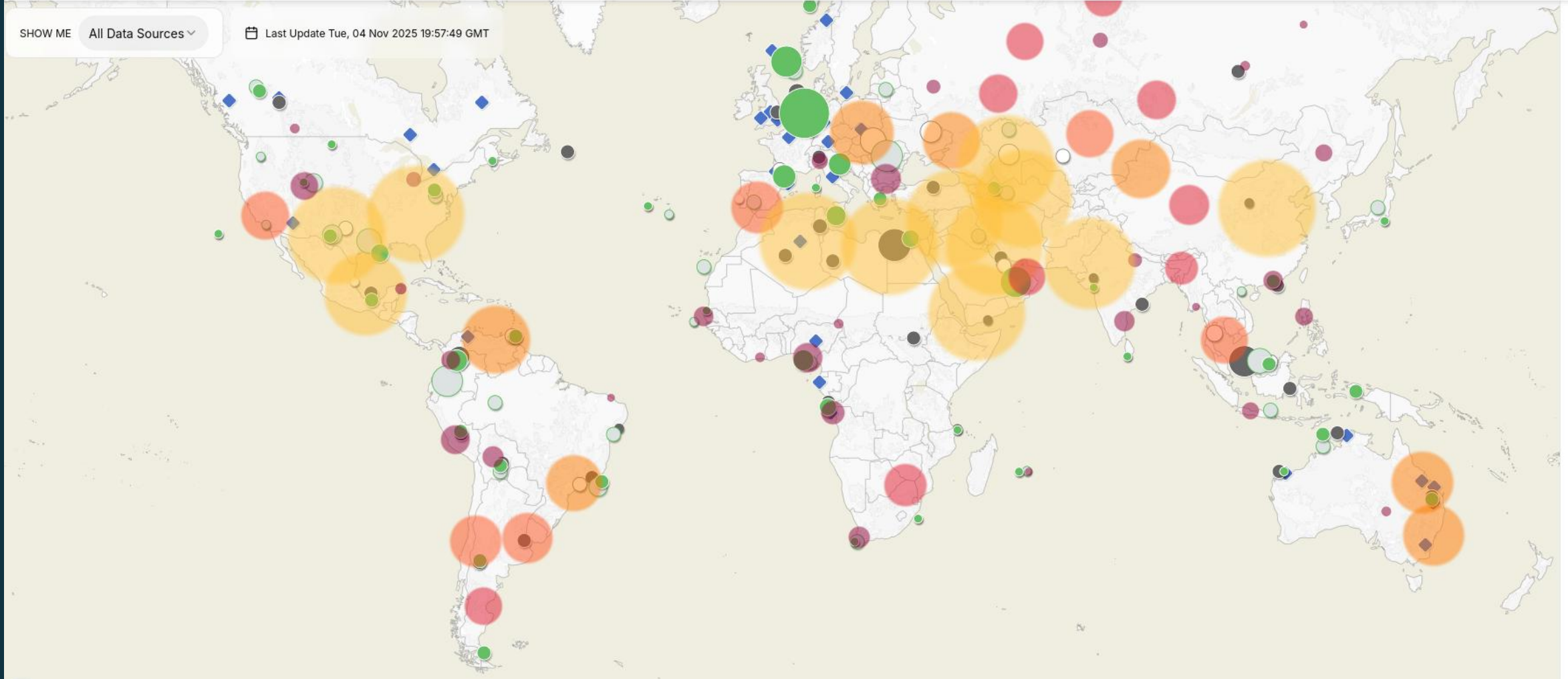


# Database of global methane emission data

SHOW ME All Data Sources

Last Update Tue, 04 Nov 2025 19:57:49 GMT

ACCESS DATA

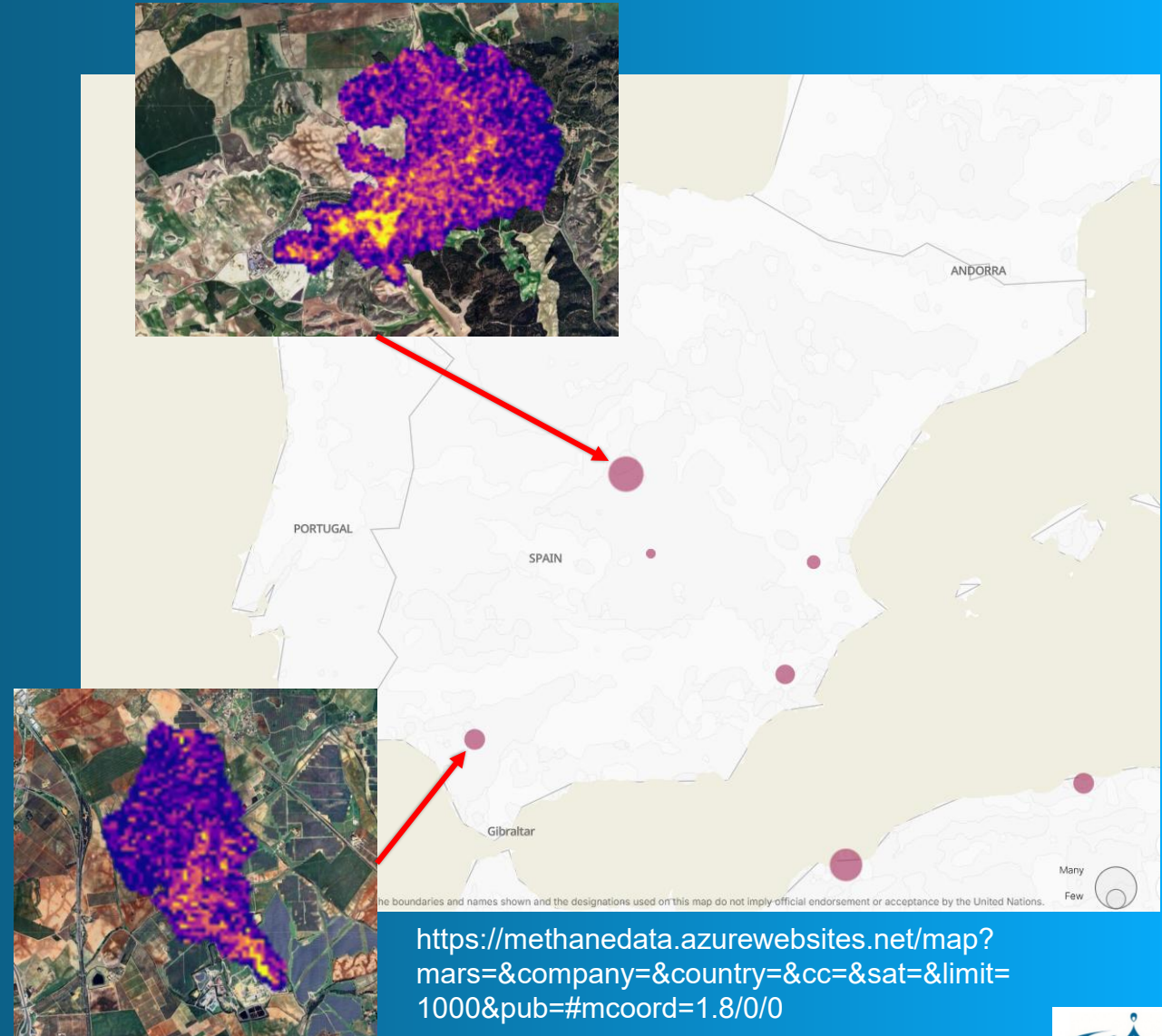


<https://methanedata.azurewebsites.net/map?mars=&company=&country=&cc=&sat=&limit=1000&pub=#mcoord=1.8/0/0>



# Methane sources at the national level

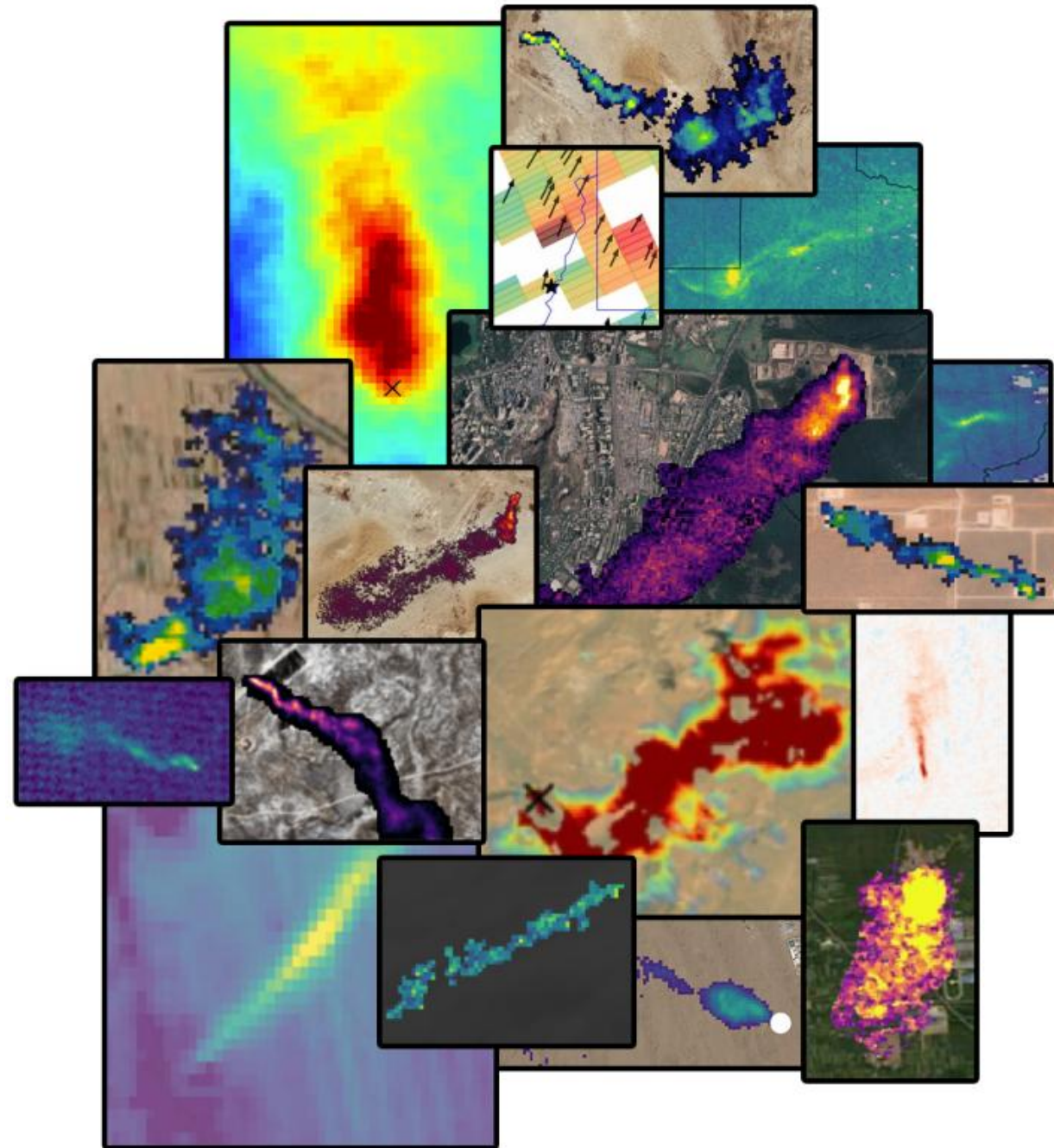
- In Spain, the main sources of methane emissions are landfills.
- IMEO is currently working with the Madrid City Council.
- At least one plume detected from ENAGAS' compression station in Alcazar de San Juan
- Moving into new sectors: starting next year, MARS will begin reporting emissions from the waste sector and metallurgical coal mines.



# Methane Emissions Detection Using Satellites Assessment (MEDUSA)

- Project funded by the ESA Climate Office
- Budget >2M€
- Partners: SRON (lead), UPV, IUP Bremen, U. Leicester, GHGSat, Kayrros, BIRA
- Main Goal: comparing and evaluating methane data products on hot spot and point sources (super-emitters) from a large variety of satellites.

<https://climate.esa.int/en/supporting-the-paris-agreement/medusa/>



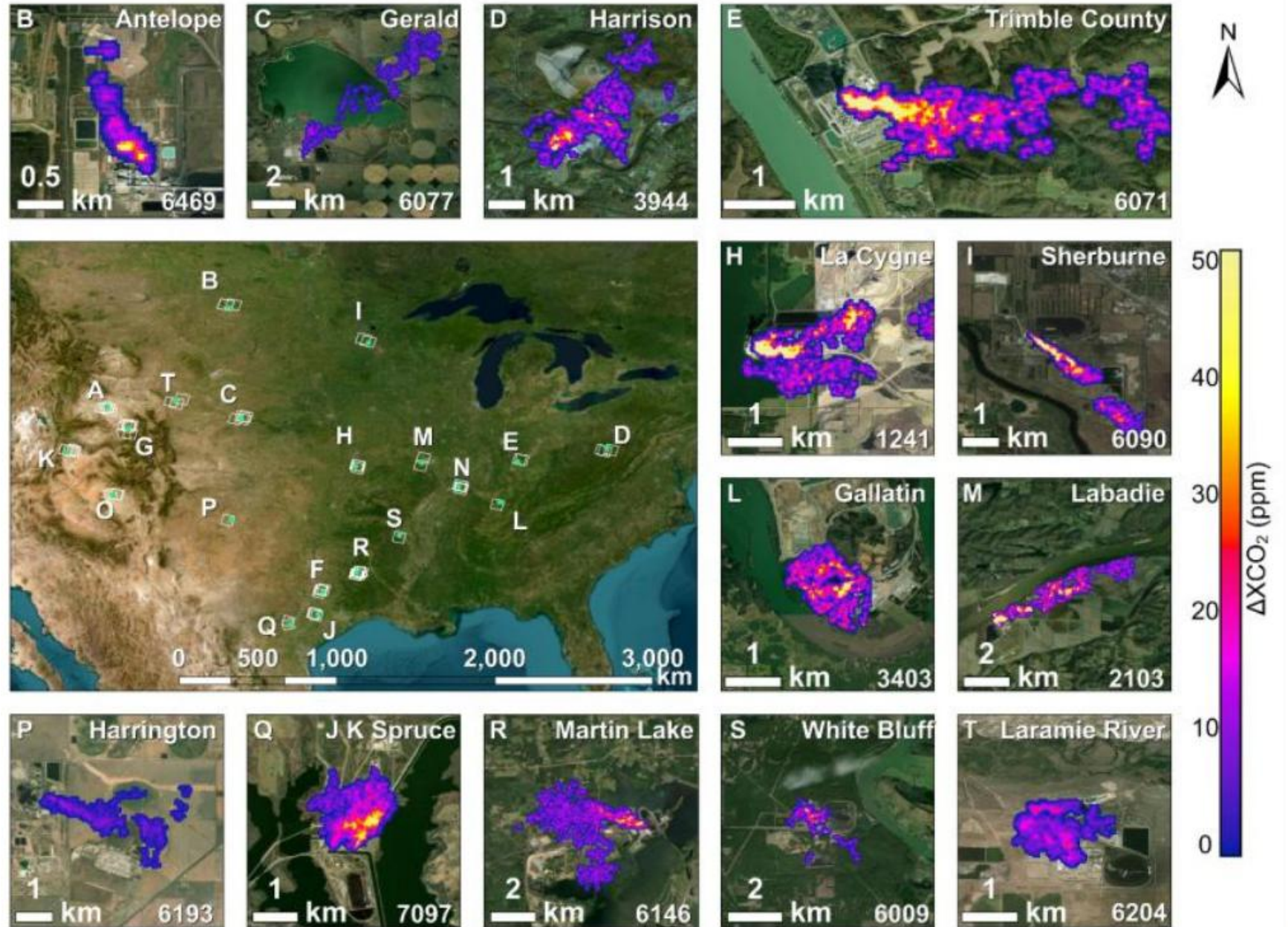


# Monitoring of CO2 super-emissions

- The space-based hi-res spectrometers used for methane are becoming also useful to monitor CO2 super-emitters

Han et al., “Towards global carbon transparency: Spaceborne imaging spectroscopy enables precise CO2 emission quantification at facility scale”, preprint, 2025

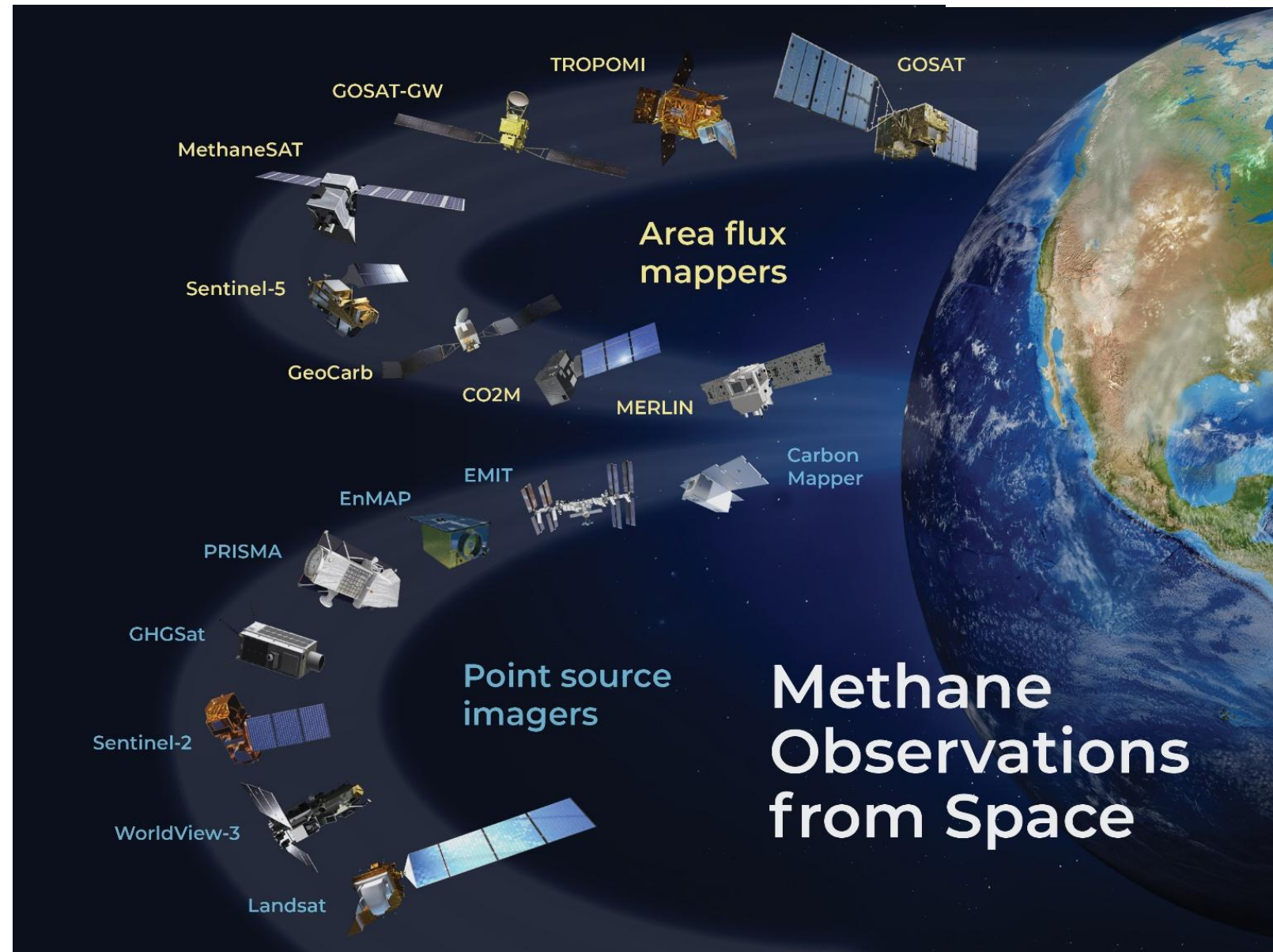
<https://www.researchsquare.com/article/rs-5913782/v1>





# Take home messages

- Satellites being used operationally for the mitigation of active methane sources
- Methane super-emissions in Spain due to landfills
- UNEP's IMEO:
  - Repository for open data on methane emissions
  - focus so far on the O&G sector, but extending to waste and coal



¡Gracias por la atención!