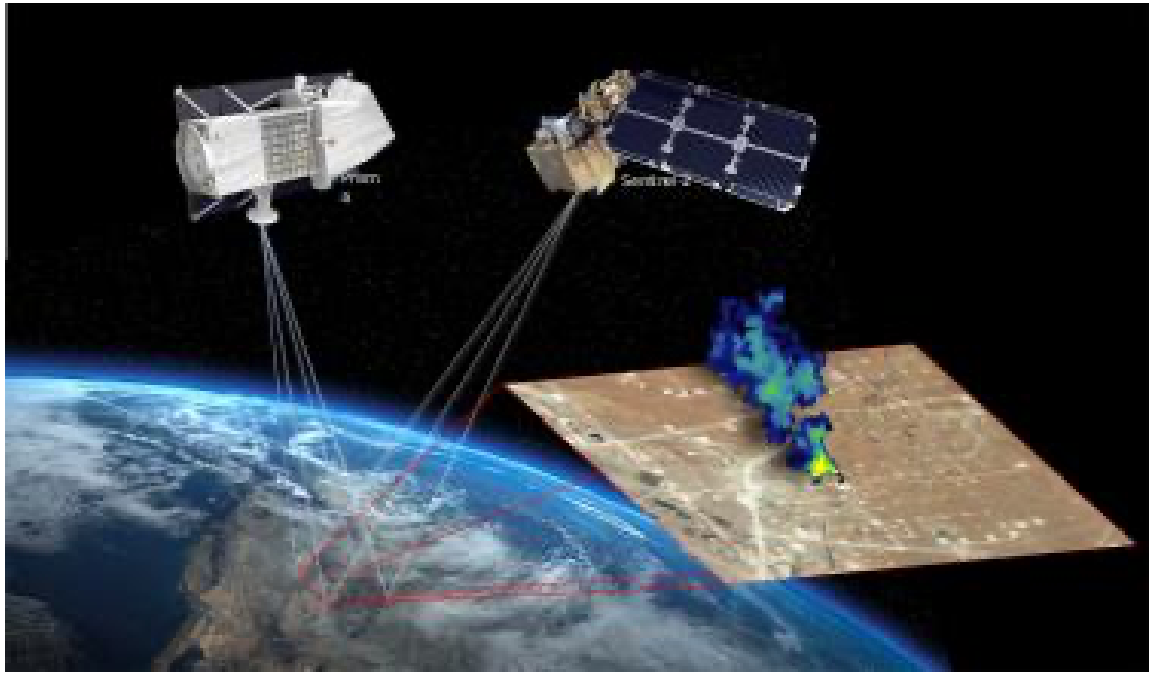

Mapping Methane Point Sources with Satellite Imaging Spectroscopy Missions

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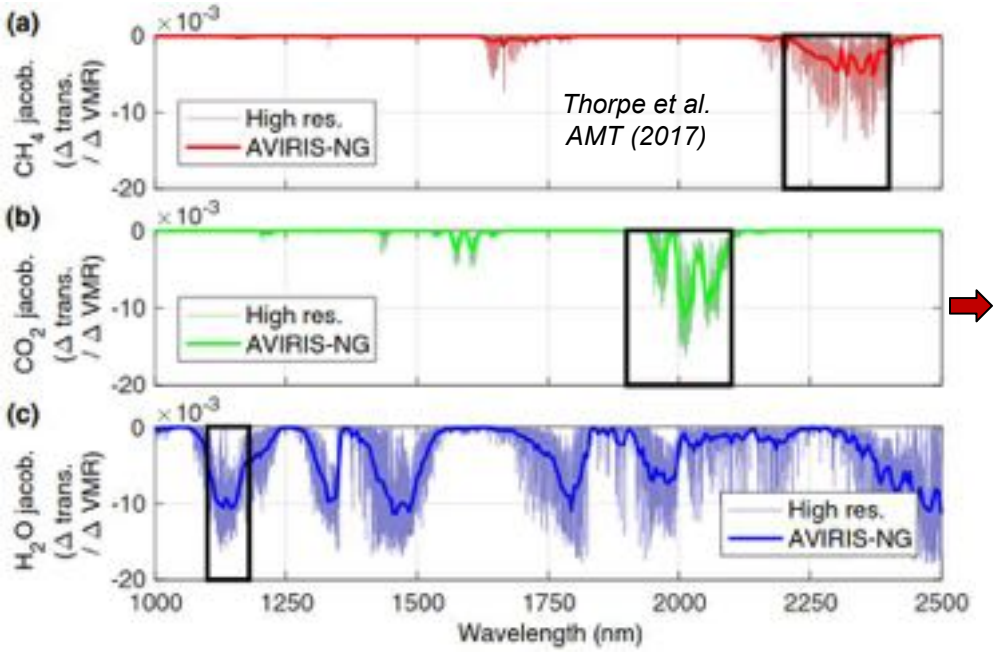
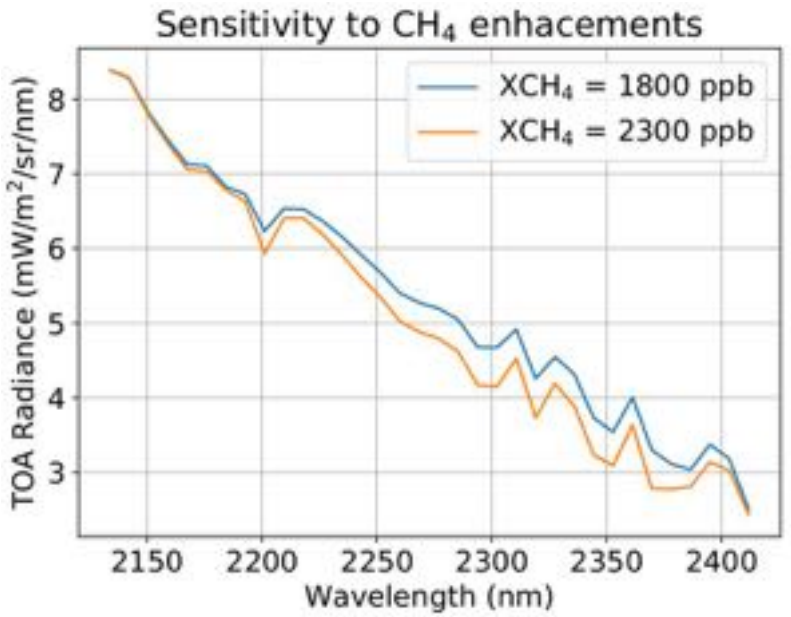
Imaging spectroscopy and methane mapping

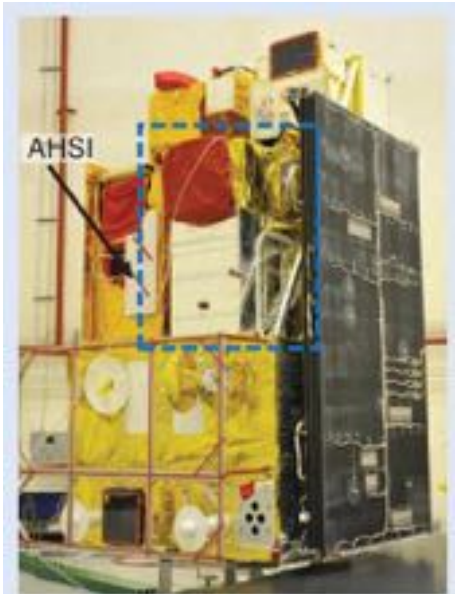
- Detection of methane point sources associated to fossil fuel production (e.g. oil & gas extraction, coal mining) is key to guide climate change mitigation efforts
- The potential of imaging spectroscopy in SWIR wavelengths (~2300 nm) for methane mapping demonstrated for the first time in ~2010 with AVIRIS, and then from space in 2015 with Hyperion (Thompson et al.)
- Extension to other satellite imaging spectrometers achieved in the last years (PRISMA, GF-5, ...)

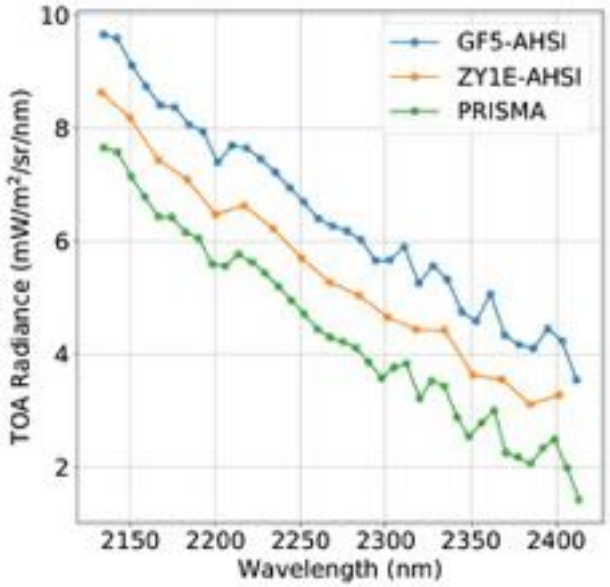




Satellite imaging spectroscopy for methane mapping

- Imaging spectroscopy satellite data are being used to map methane plumes in different oil&gas or coal extraction regions: Permian Basin (USA), Shanxi Coal Mine region (China), Turkmenistan, Algeria, ...
- Available spaceborne imaging spectroscopy missions:
  - **PRISMA** (Italy) / **EnMAP** (Germany): GSD=30 m, SSD~10 nm, medium/low SNR, swath=30 km
  - **GaoFen5-02 AHSI** (China): GSD=30 m, SSD~8 nm, high SNR, swath=60 km
  - **ZY1 AHSI** (China): same as GF5's but with 2x spectral binning, higher SNR
  - **EMIT** (USA): GSD=60 m, SSD~7 nm, high SNR, swath~80 km, coverage of semi-arid regions

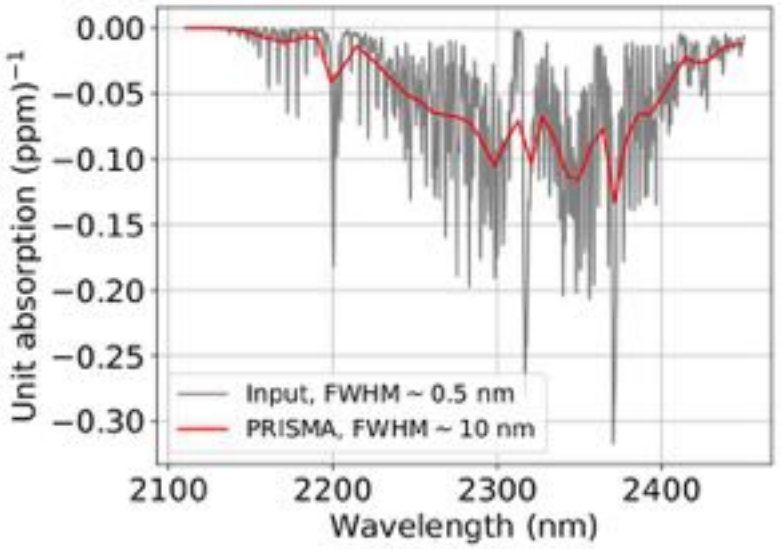




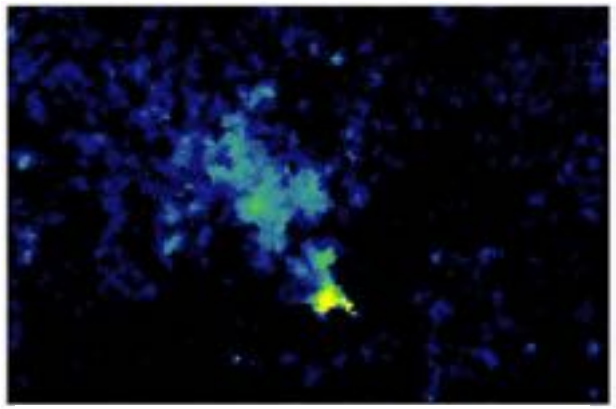
Yin-Nian Liu et al., IEEE GRSM 2019

From TOA radiances to ΔXCH4 maps and emission flux rates

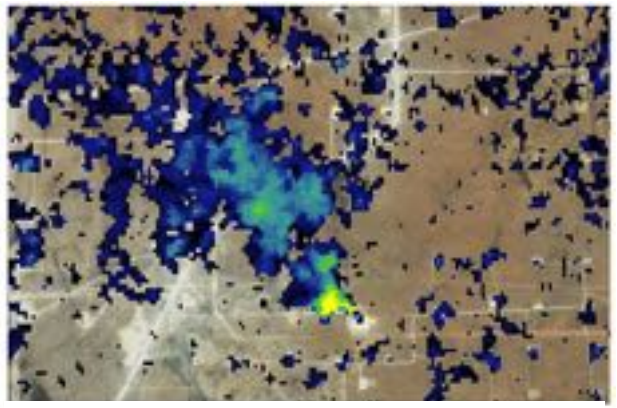
- Maps of ΔXCH4 (methane concentration enhancement) are derived using a data-driven method (matched-filter principle) applied to the 2100-2450 nm window
- Plume identification through visual inspection
- Flux rates (Q, in kg-CH4/h) estimated using the Integrated Methane Enhancement (IME) method
- Sensitivity ~[500-1500] kg/h, depending on surface type and wind speed



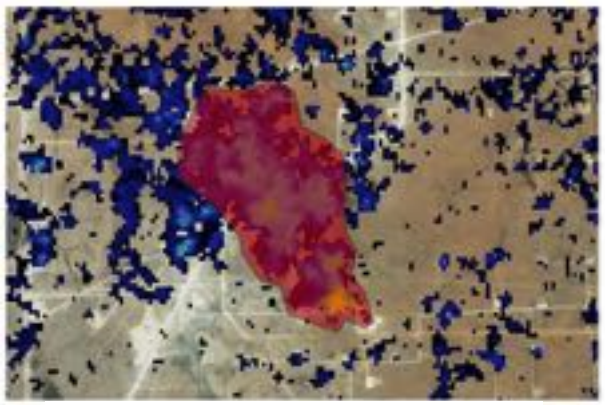
Processing flow



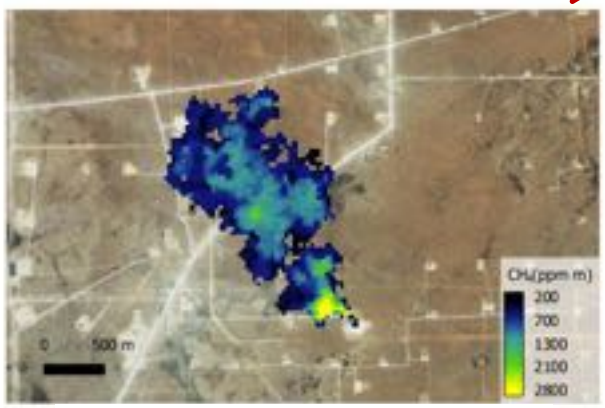
Methane concentration enhancement



Methane map + threshold



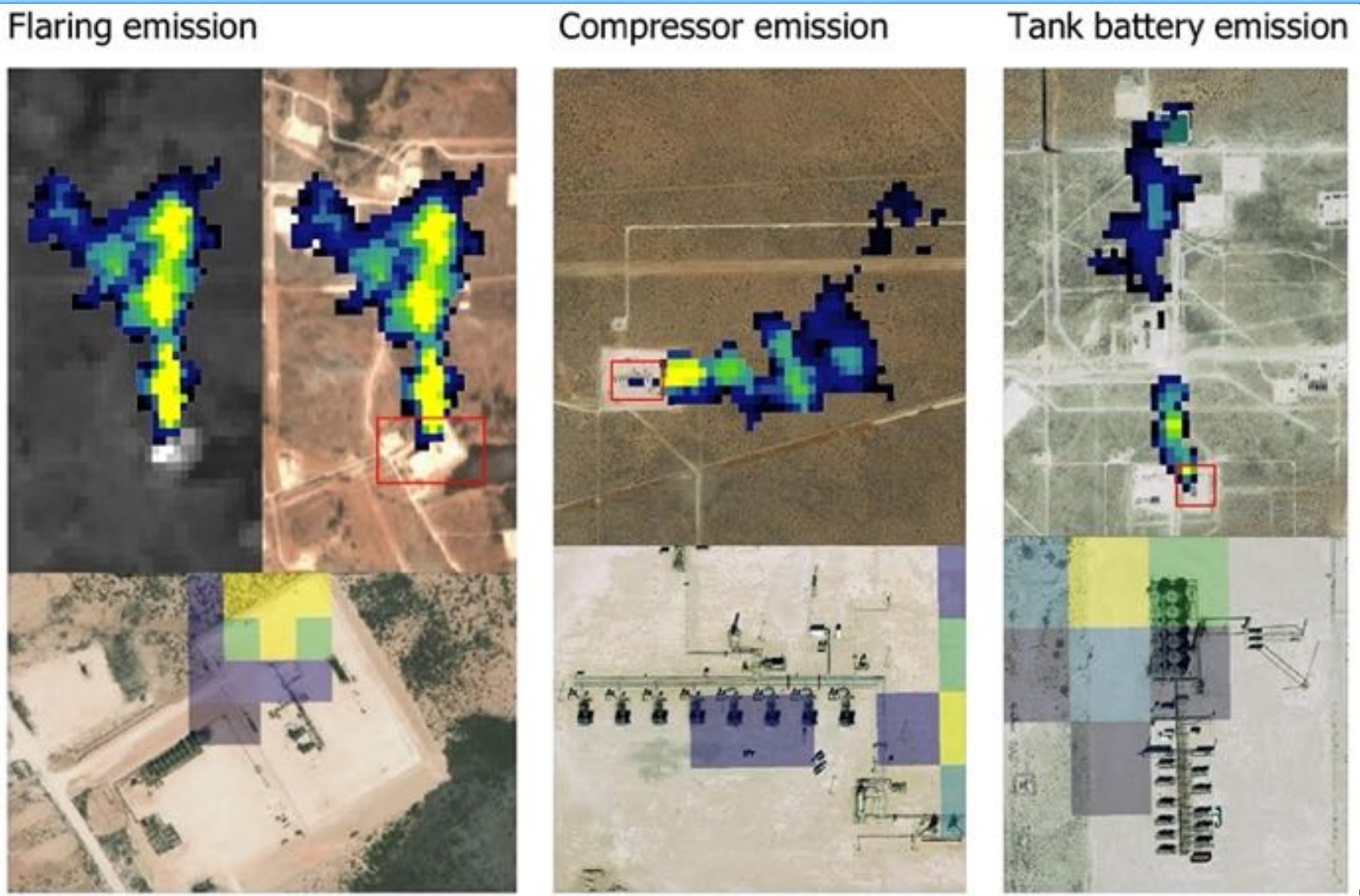
Manual plume mask



Final plume

Attributing plumes to sources

30-m spatial resolution generally allows the attribution of methane plumes to sources

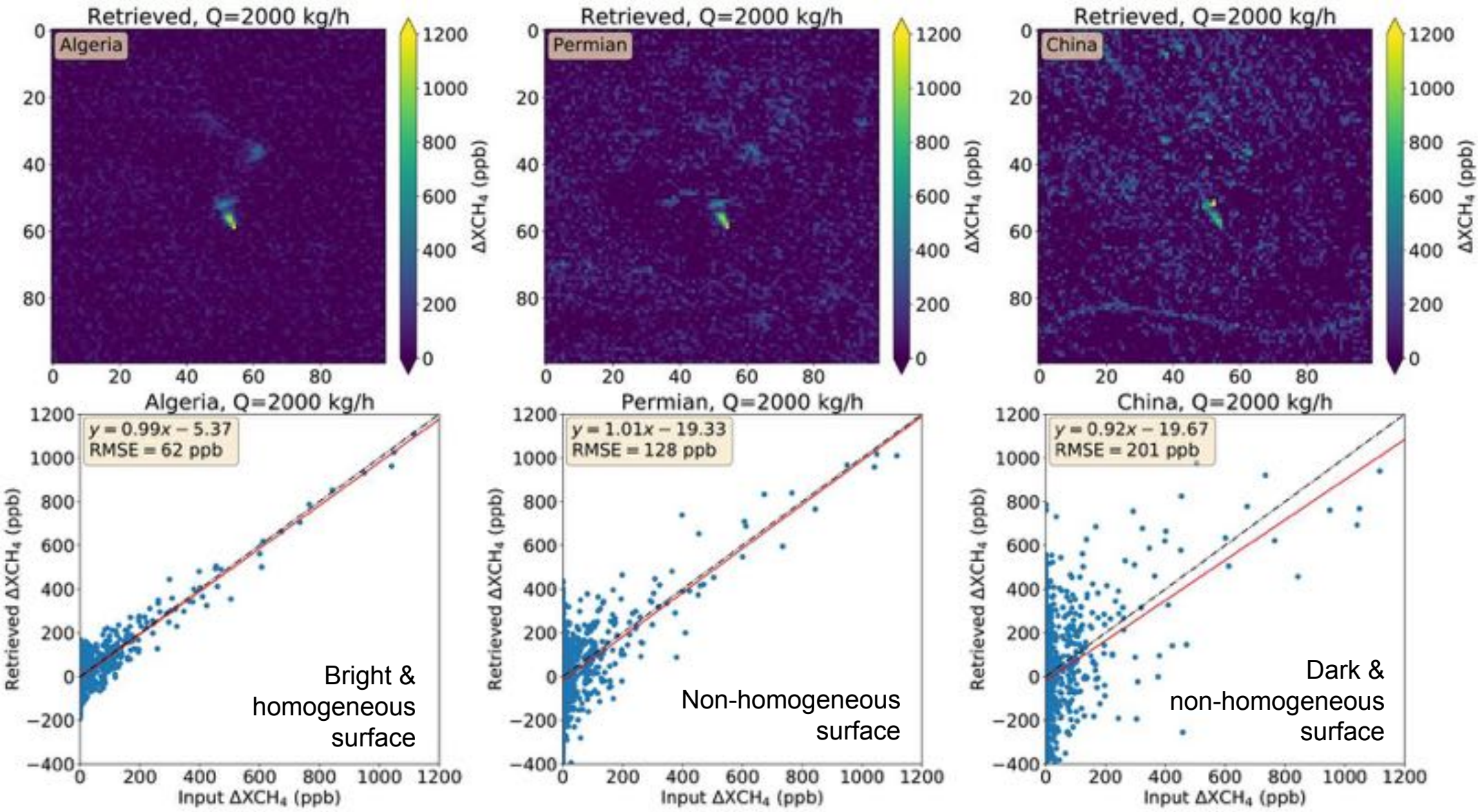


Irakulis-Loitxate, Guanter et al., Science Advances (2021)

Results from end-to-end simulations for PRISMA

Retrieval not biased, but strong sensitivity to the surface type

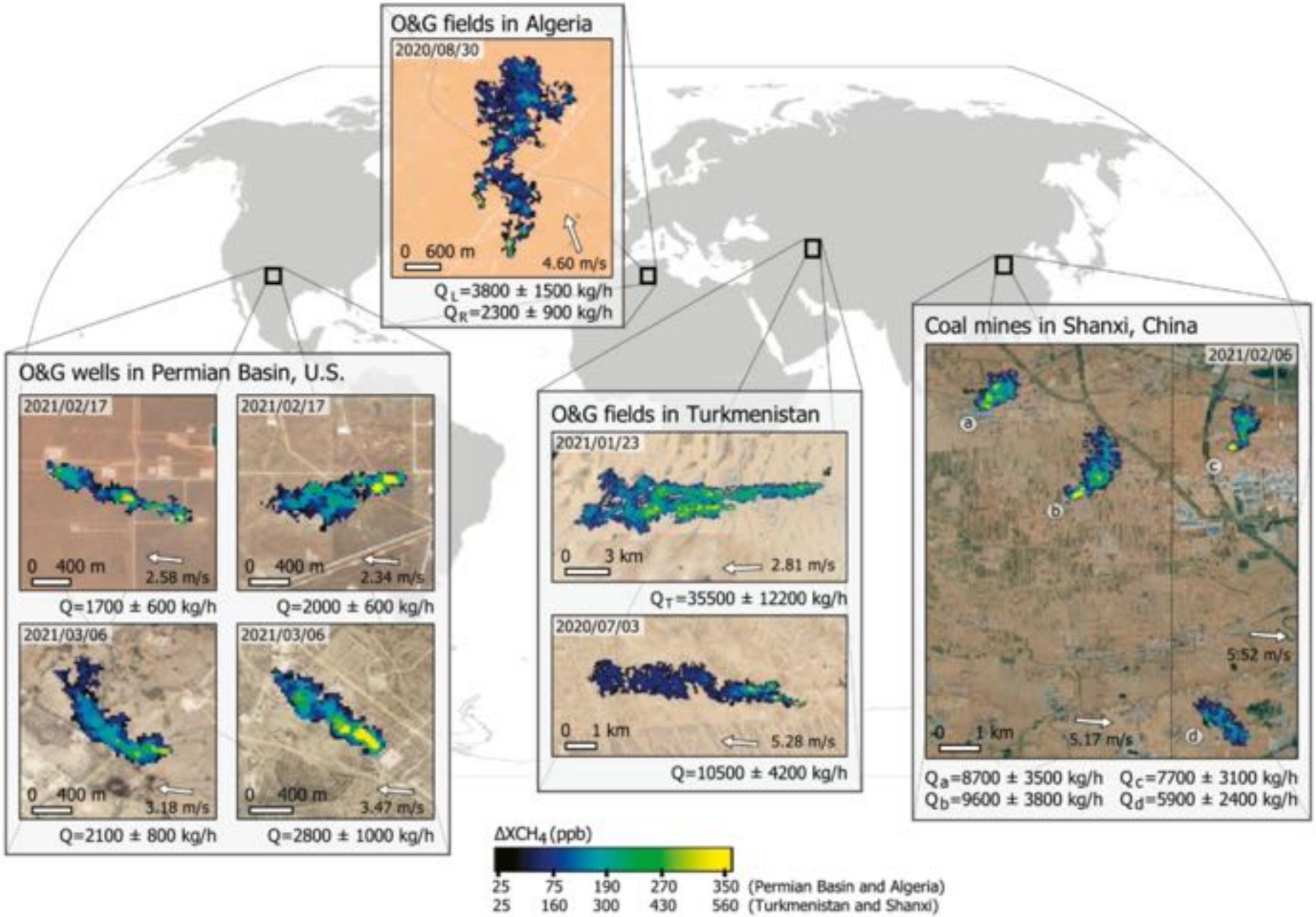
Methods to reduce surface impact under development



Guanter et al., RSE, 2021

Examples of methane plumes from point sources

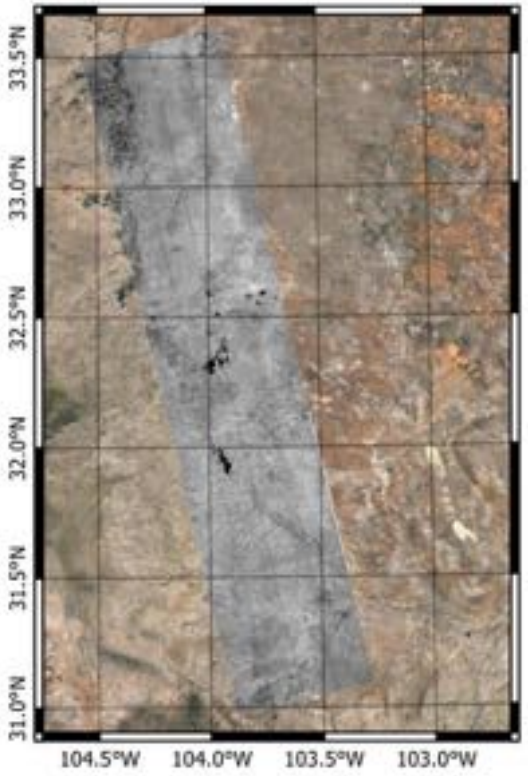
PRISMA data currently used in a number of methane emission surveys around the world

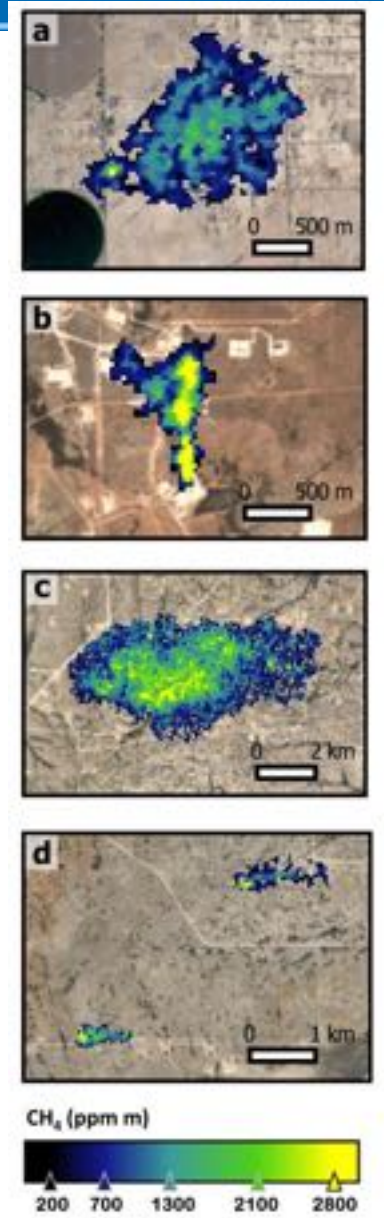


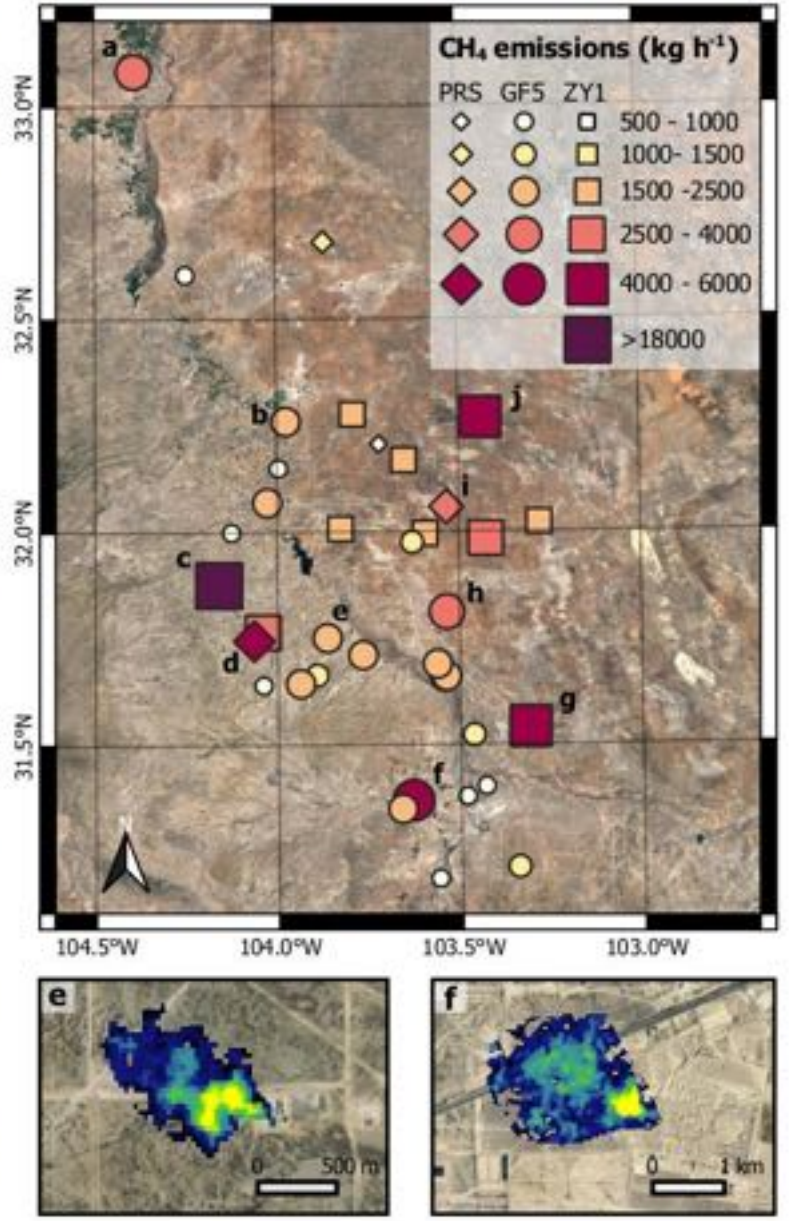
Guanter et al., RSE, 2021

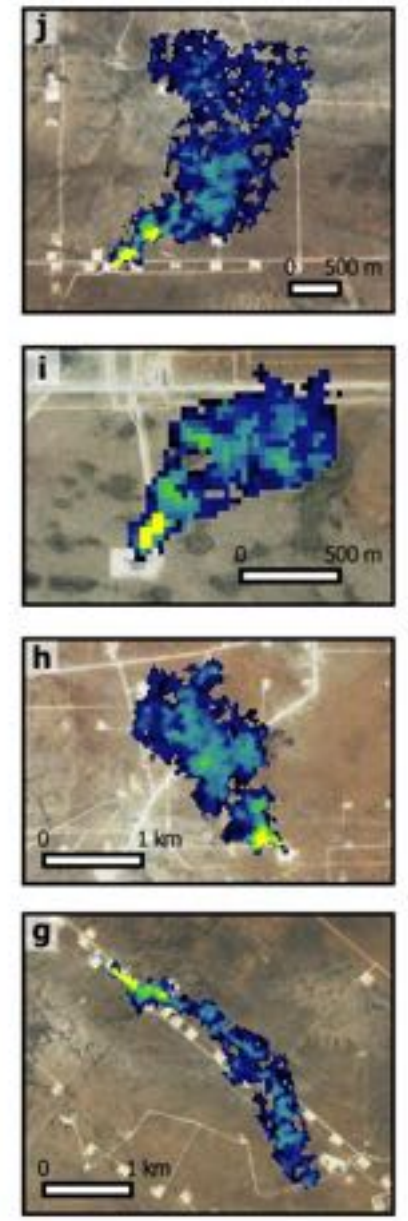
Survey of methane point emissions in the Permian Basin

- ~30 hyperspectral satellite images processed to methane concentration enhancement maps
- 19 plumes with Q>500 kg/h found from one single overpass of the GF-5 AHSI mission





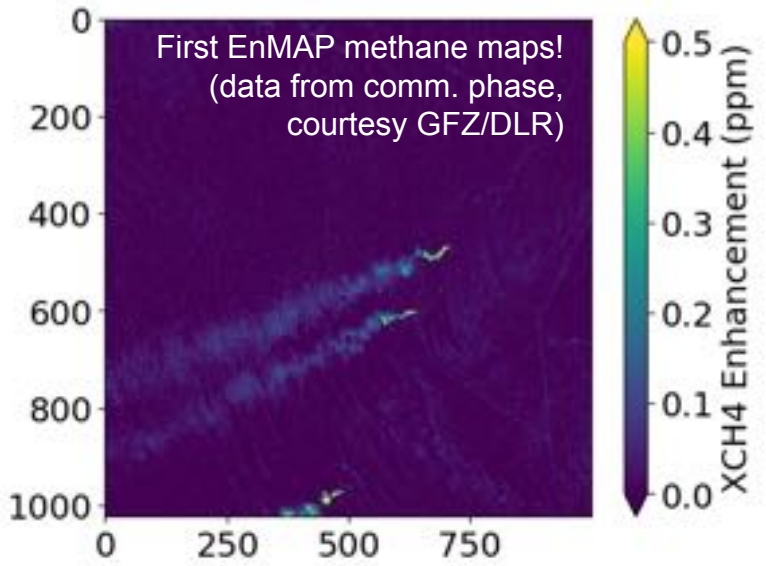




Irakulis-Loitxate, Guanter et al., Science Advances (2021)

Summary and Outlook

1. Methods for the detection and quantification of methane plumes with satellite imaging spectrometers (PRISMA, AHSI, EnMAP, EMIT) are mature
2. New retrieval approaches to reduce sensitivity to the background and for offshore mapping under development
3. Satellite imaging spectroscopy missions already in use for UNEP's International Methane Emissions Observatory (IMEO)
   - Purpose: to guide methane mitigation efforts through the detection of methane point sources around the world
   - Based on synergies between different classes of methane-sensitive satellites
   - Role of imaging spectroscopy missions: targeted observations for individual source detection



Thank you for your attention