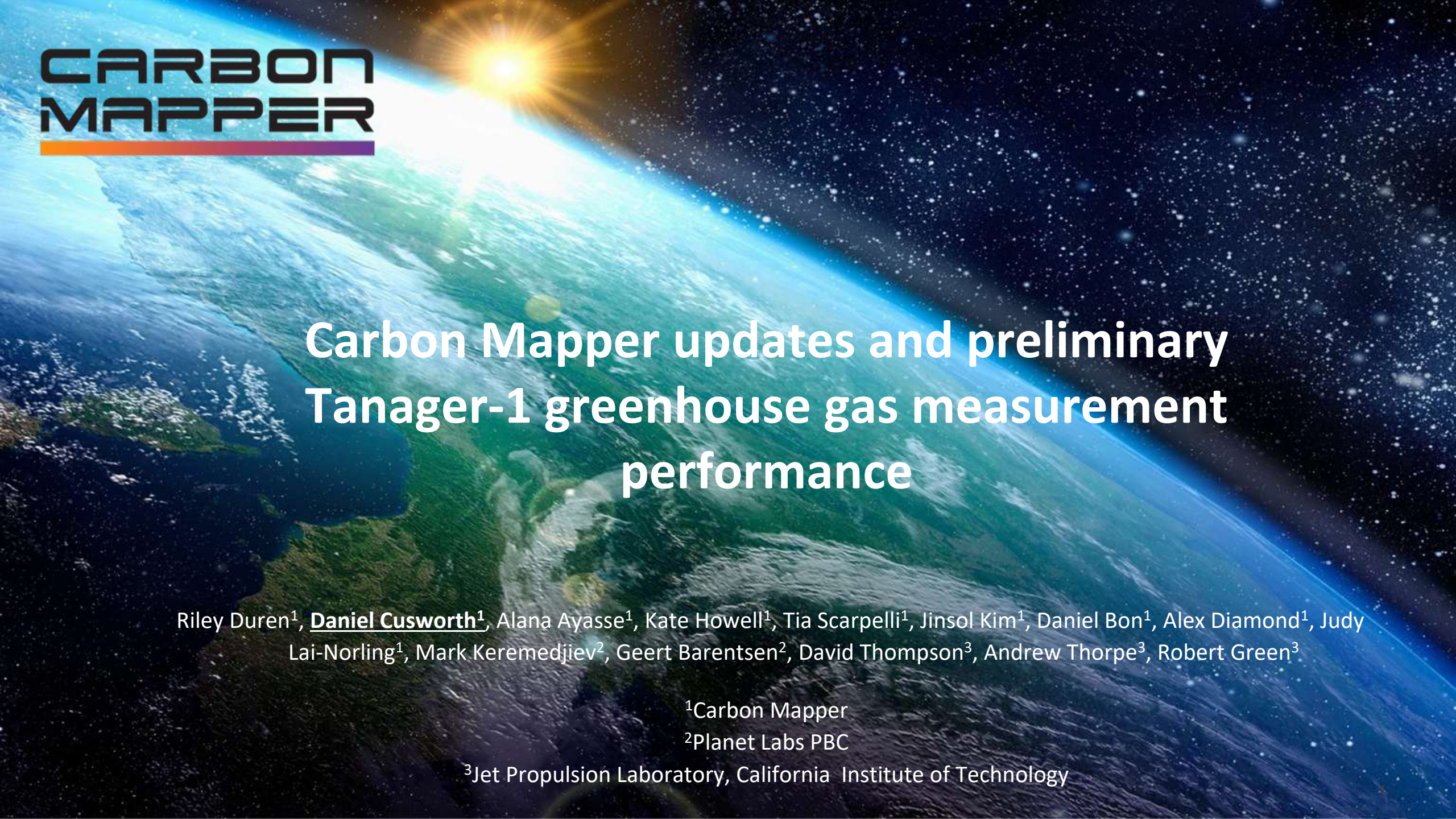


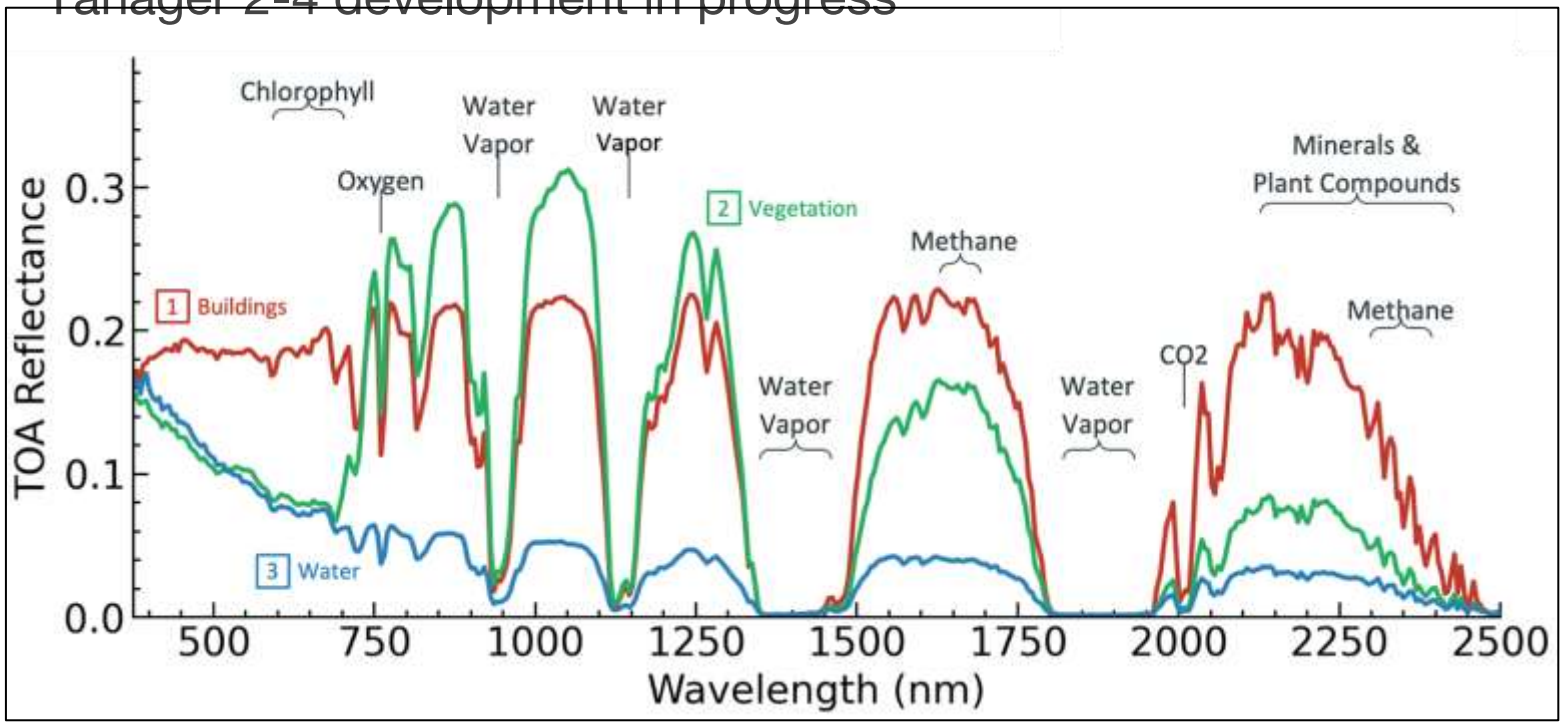
Carbon Mapper updates and preliminary Tanager-1 greenhouse gas measurement performance

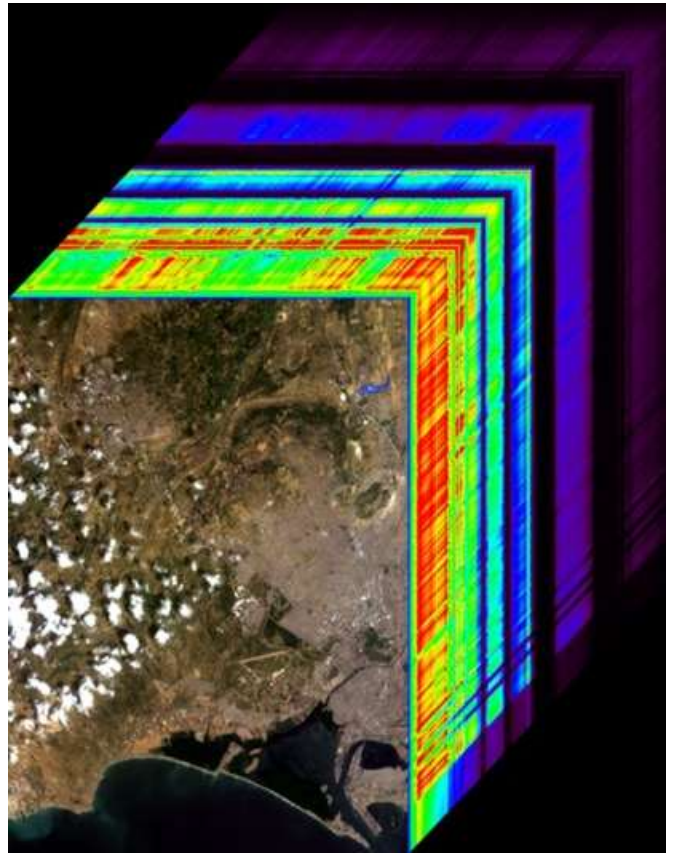
Riley Duren[1], **Daniel Cusworth[1]**, Alana Ayasse[1], Kate Howell[1], Tia Scarpelli[1], Jinsol Kim[1], Daniel Bon[1], Alex Diamond[1], Judy Lai-Norling[1], Mark Keremedjiev[2], Geert Barentsen[2], David Thompson[3], Andrew Thorpe[3], Robert Green[3]

[1]Carbon Mapper
[2]Planet Labs PBC
[3]Jet Propulsion Laboratory, California Institute of Technology

Tanager constellation status

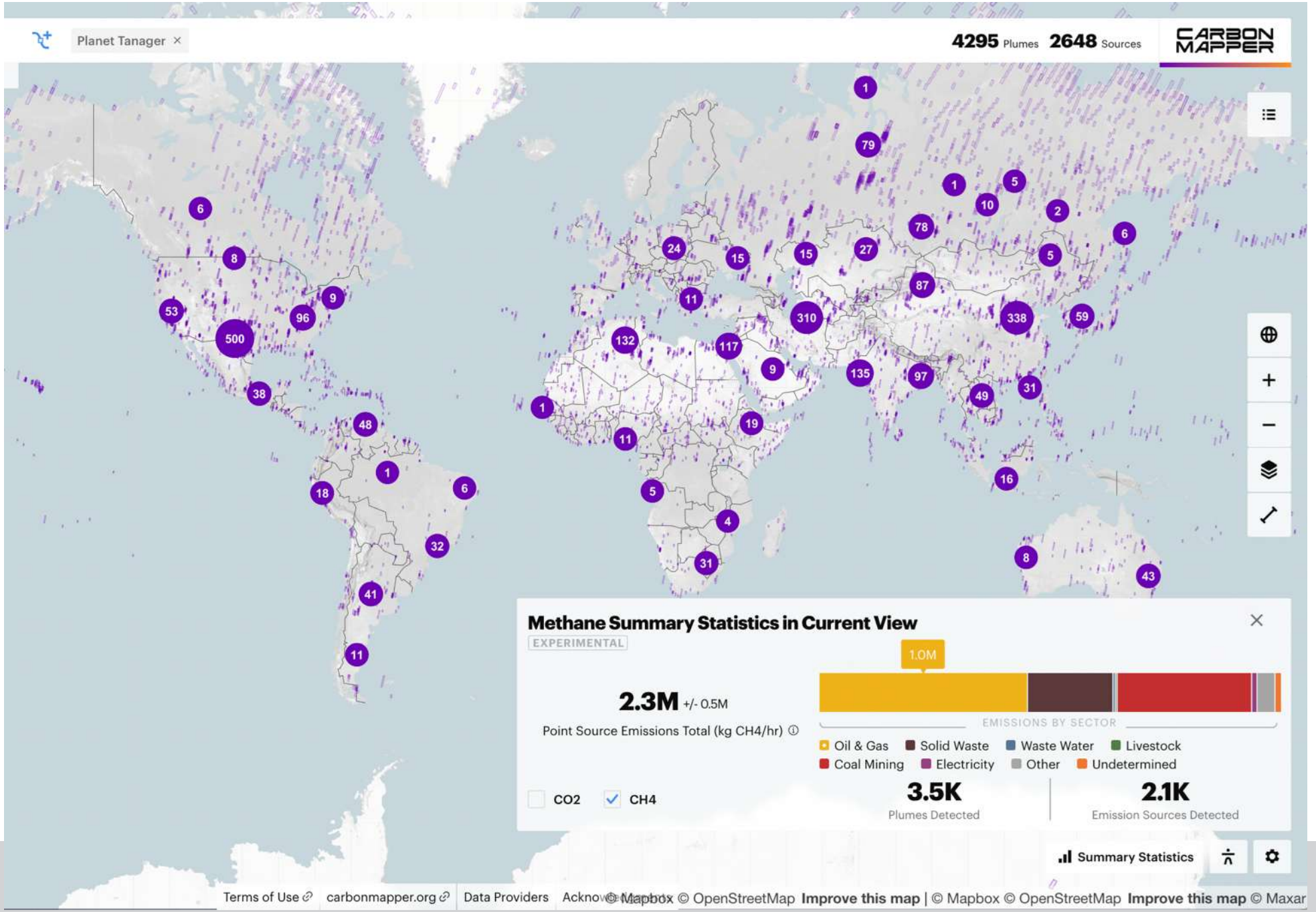
- Tanager-1 commissioning complete
- Orbit lowering complete from initial (500km) to interim altitude (430 km)
- Planet delivering calibrated hyperspectral data to Carbon Mapper with an average latency of about 6 hours
- Tanager 2-4 development in progress



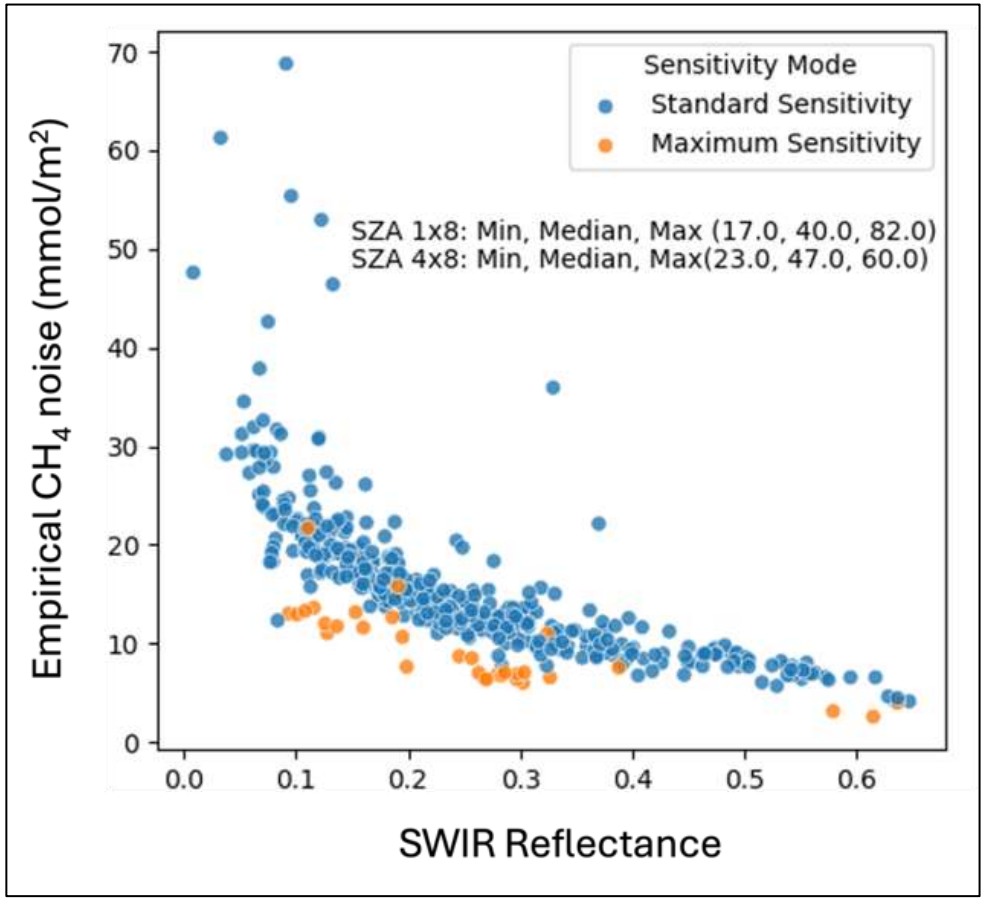


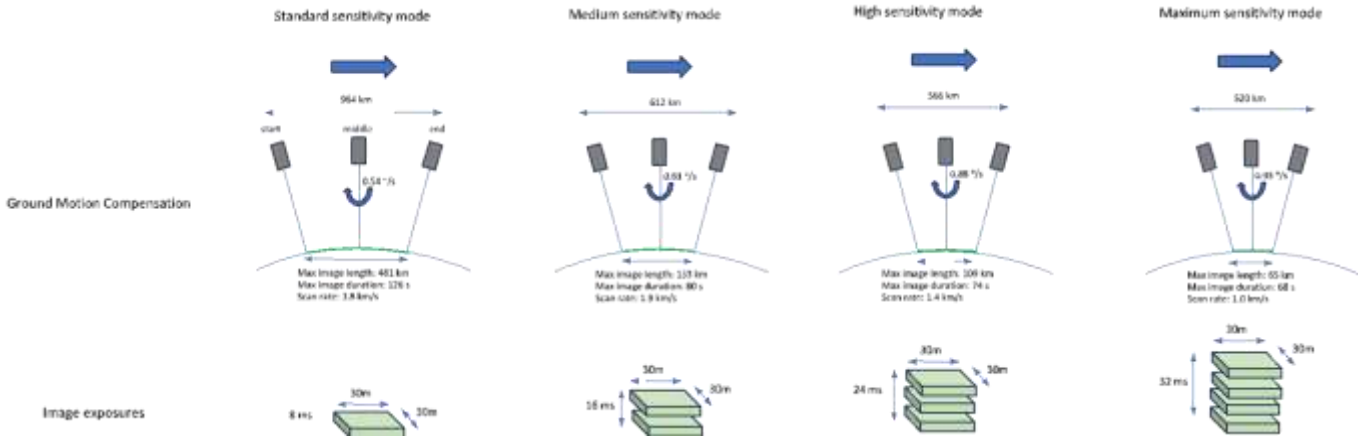
Plots of full VSWIR Top Of Atmosphere (TOA) reflectance from 3 pixels in Karachi scene containing buildings [1], vegetation [2], and water [3] illustrating Tanager's hyperspectral sensitivity to CH_4, CO_2, and multiple other environmental variables.

Tanager-1 is fully operational



Precision and minimum detection limit performance (initial assessment in higher orbit)





Imaging Mode (Sensitivity)	Mean CH_4 Measurement Precision	CH_4 MDL (kg/h)	Mean CO_2 Measurement Precision	CO2 MDL (kg/h)
Maximum (4x8)	0.97%	66	0.30%	10,400
Standard (1x8)	2.12%	144	0.52%	19,600

Single measurement CH_4 precision and MDL for Maximum and Standard imaging modes derived from Tanager on-orbit observations with albedos ranging from 20 to 30% (mean 25%) and solar zenith angles ranging from 40 to 50 degrees (mean 45 degrees). Empirical precision is calculated from the standard deviation of background CH_4 (assuming 650 mmol/m^2 background) and CO_2 (assuming 109,030 mmol/m^2 background) across entire images using the operational CMF retrieval algorithm.

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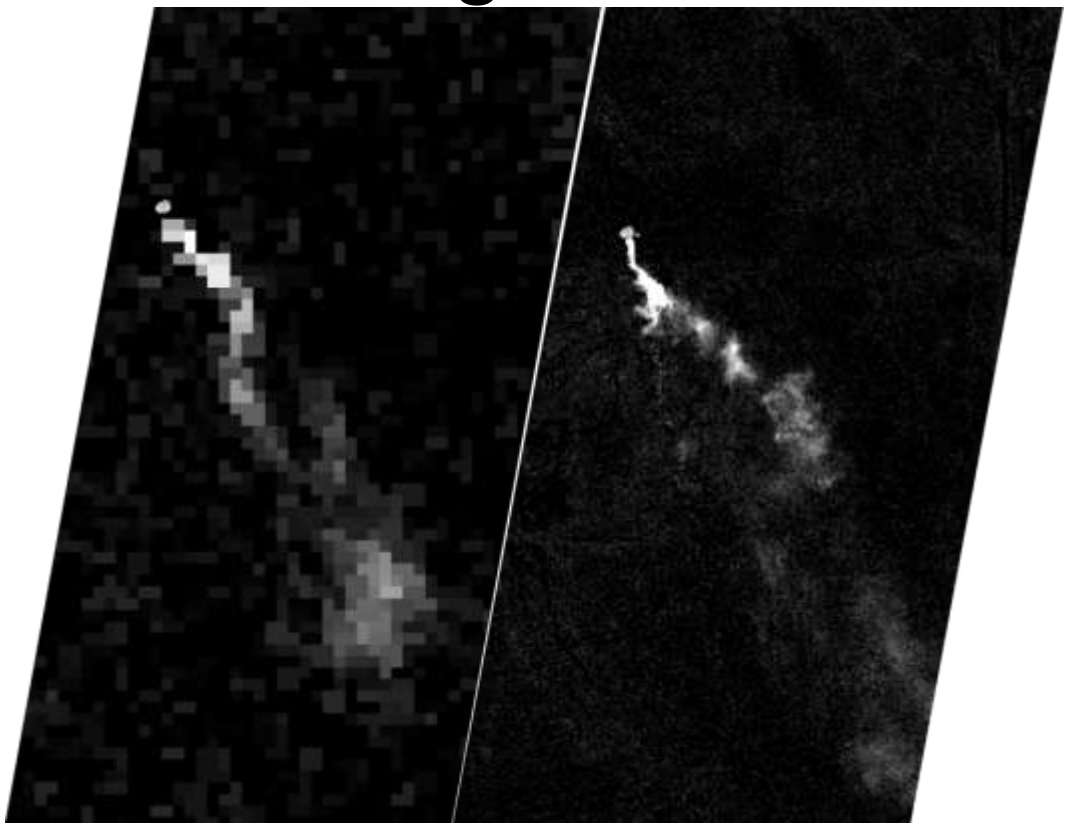
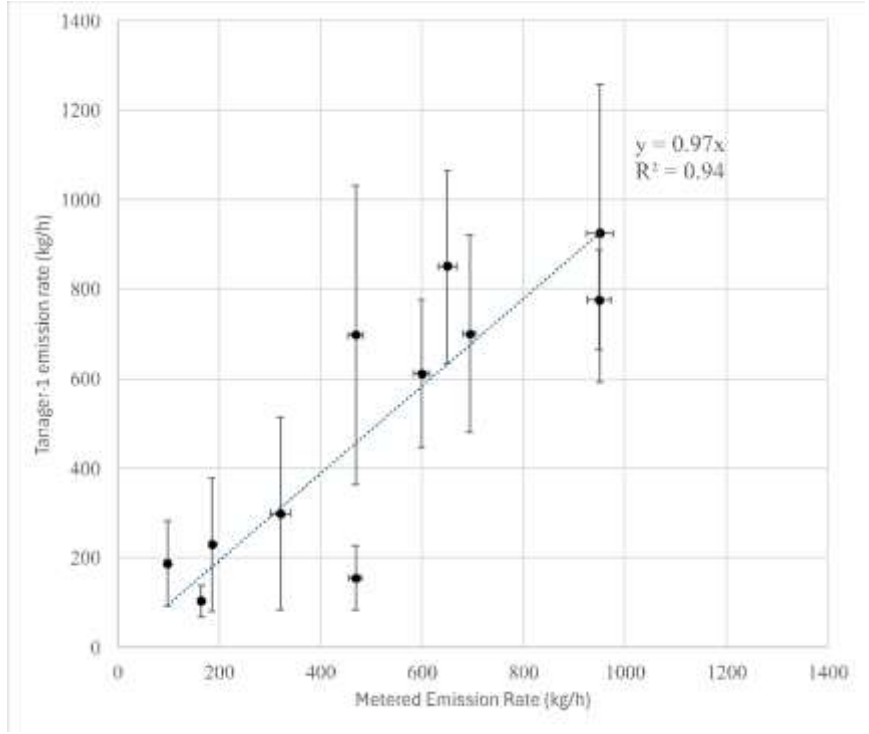
Initial CH4 precision and bias validation: under-flights and controlled release tests

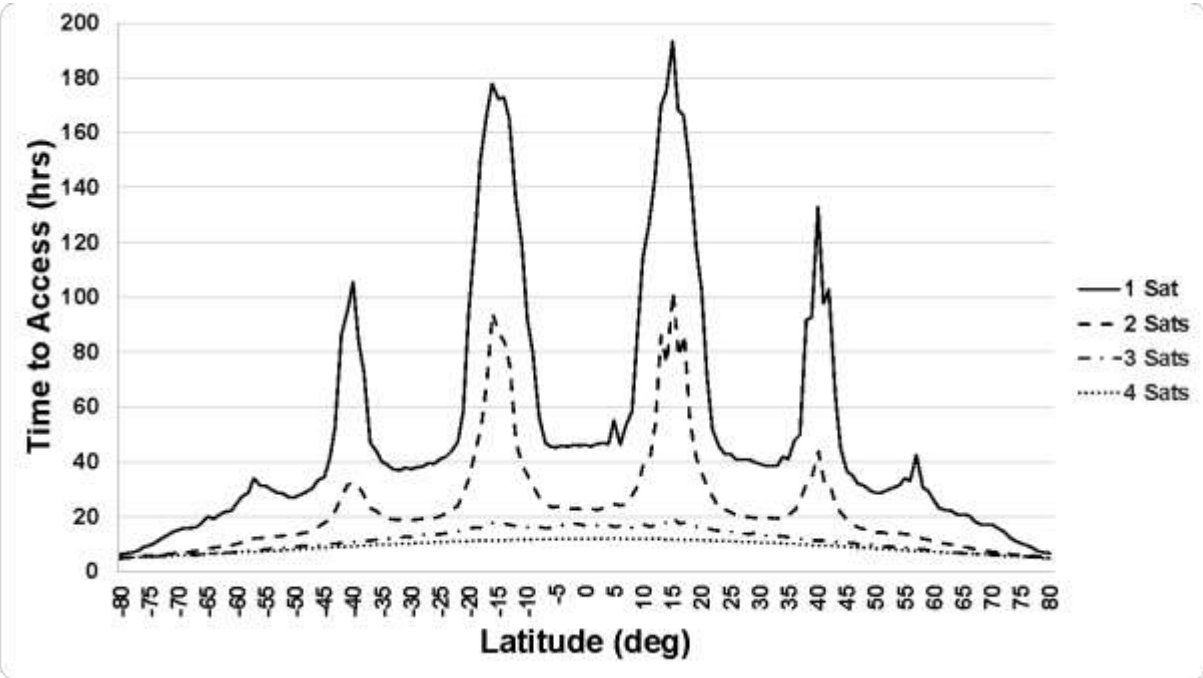


CH_4 retrieval outputs showing plumes detected during near-simultaneous observations of a controlled release test in Arizona on November 4, 2024 with Tanager-1 at an altitude of about 500 km at 18:16:42 UTC (left panel) and AVIRIS-3 at an altitude of 9 km at 18:17:10 UTC (right panel). The geolocation of the methane plume from the two observations agreed to within 20 meters. The emission rate estimate for the single Tanager-1 image was 775 ± 111 $kgCH_4/h$. The mean emission rate from three AVIRIS-3 observations within 10 minutes of the Tanager overpass was 882 ± 133 $kgCH_4/h$. The mean metered emission rate as reported by the controlled release team corresponding to the three AVIRIS-3 observations was 859 ± 49 $kgCH_4/h$.

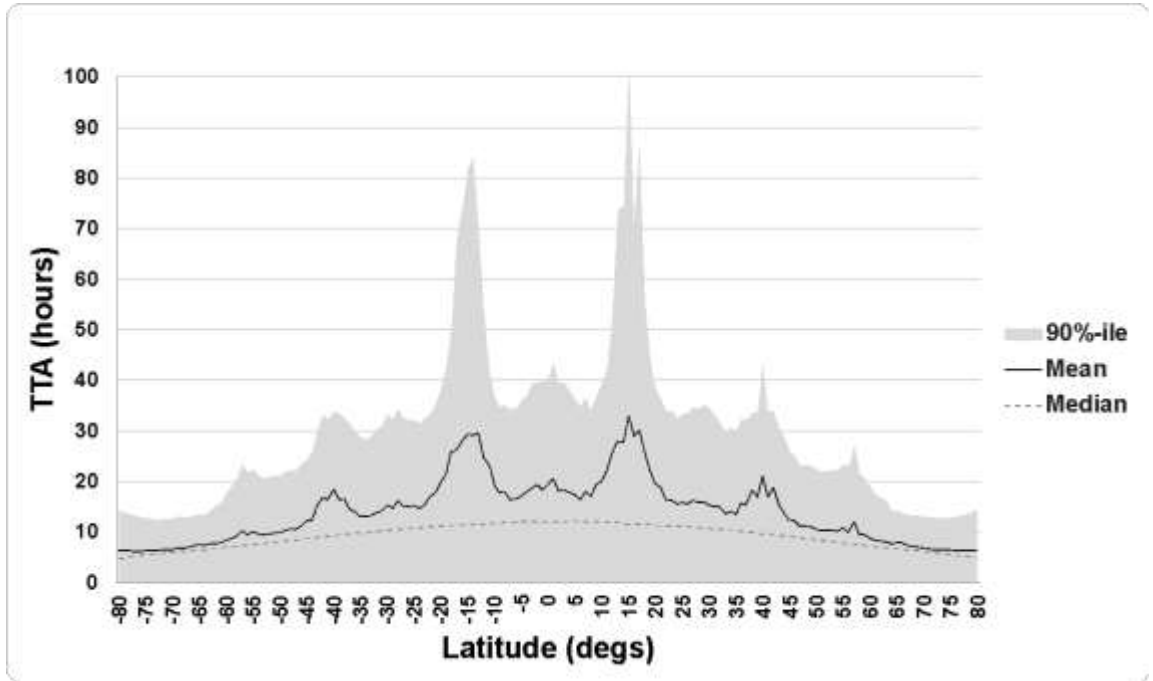


Comparison of Carbon Mapper estimated emission rates and metered emission rates from the Stanford/U. Michigan controlled release team for cooperative (non-blind) testing of Tanager-1 at test sites Arizona and Wyoming. The slope and R^2 for an ordinary least squares fit are shown. The error bars represent 1 standard deviation uncertainties in the Tanager-1 emission estimates and metered emission rates. Most of the observations shown here were using standard sensitivity (1x8) imaging mode and at initial higher orbital altitudes ranging from 430 to 510 km. These initial experiments were designed to provide an initial evaluation of precision and bias rather than probing detection limits and do not represent final sensitivity.

Sample frequency will increase with constellation expansion

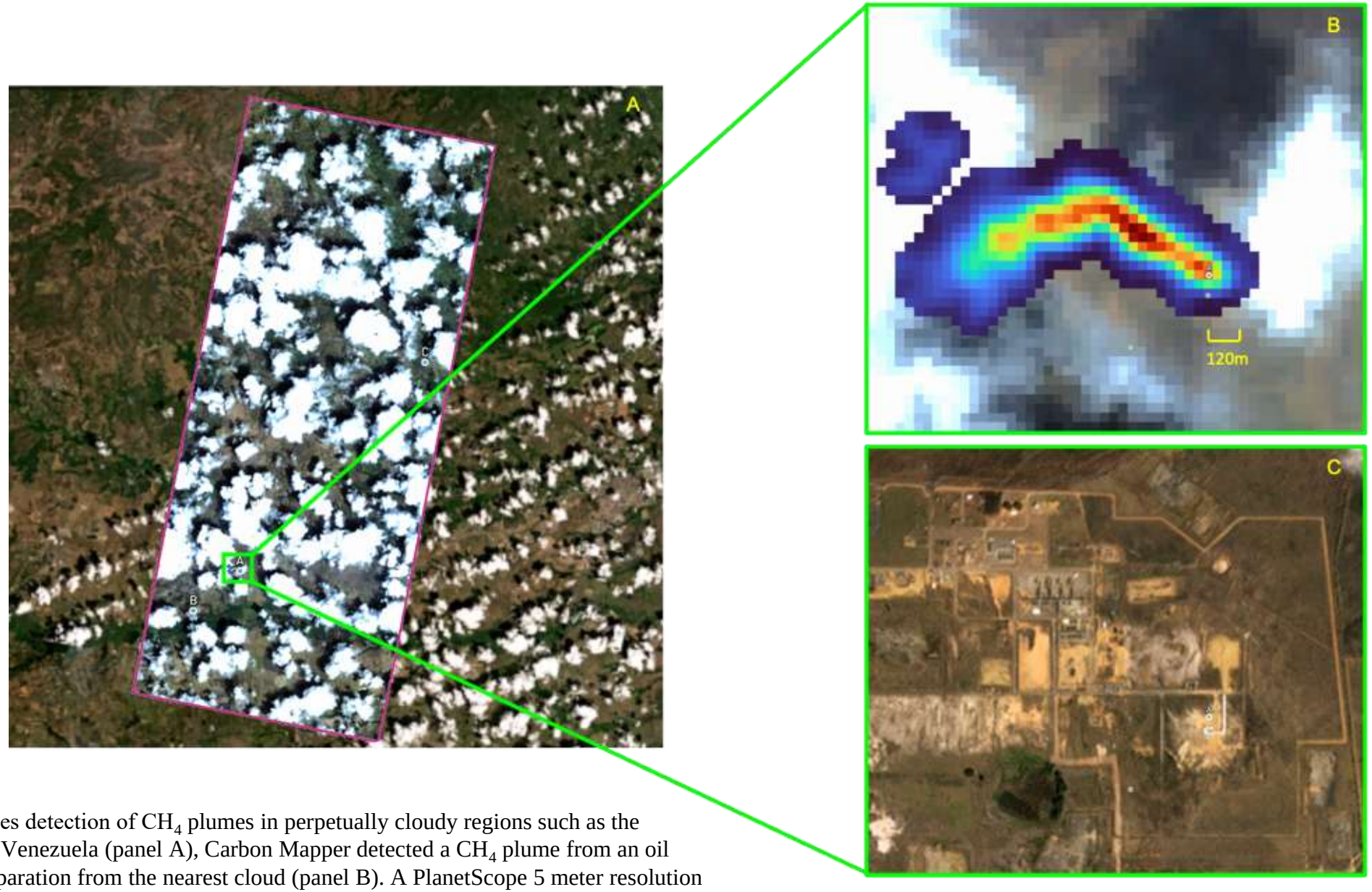


The median Time To Access (TTA) and number of satellites are key factors constraining the revisit intervals for a given observational target at a given latitude. In practice, the achievable revisit interval for mapping large regions depends on TTA and other factors such as cloud cover and the spatial distribution of target areas (e.g., dense collections of images over large regions can result in tasking conflicts which increase the time required to observe them).



The median, mean, and 90 percentile time to access (TTA) for a constellation of four Tanager satellites indicating the ability to provide sub-daily sampling for isolated priority areas at mid latitudes.

Improving point source detection in the tropics



Tanager-1's 30 meter spatial resolution enables detection of CH_4 plumes in perpetually cloudy regions such as the tropics. In this example of a cloudy image of Venezuela (panel A), Carbon Mapper detected a CH_4 plume from an oil and gas facility with a roughly 120 meters separation from the nearest cloud (panel B). A PlanetScope 5 meter resolution visible image of the same area in February 2025 with no clouds clearly shows the oil and gas facility (panel C).

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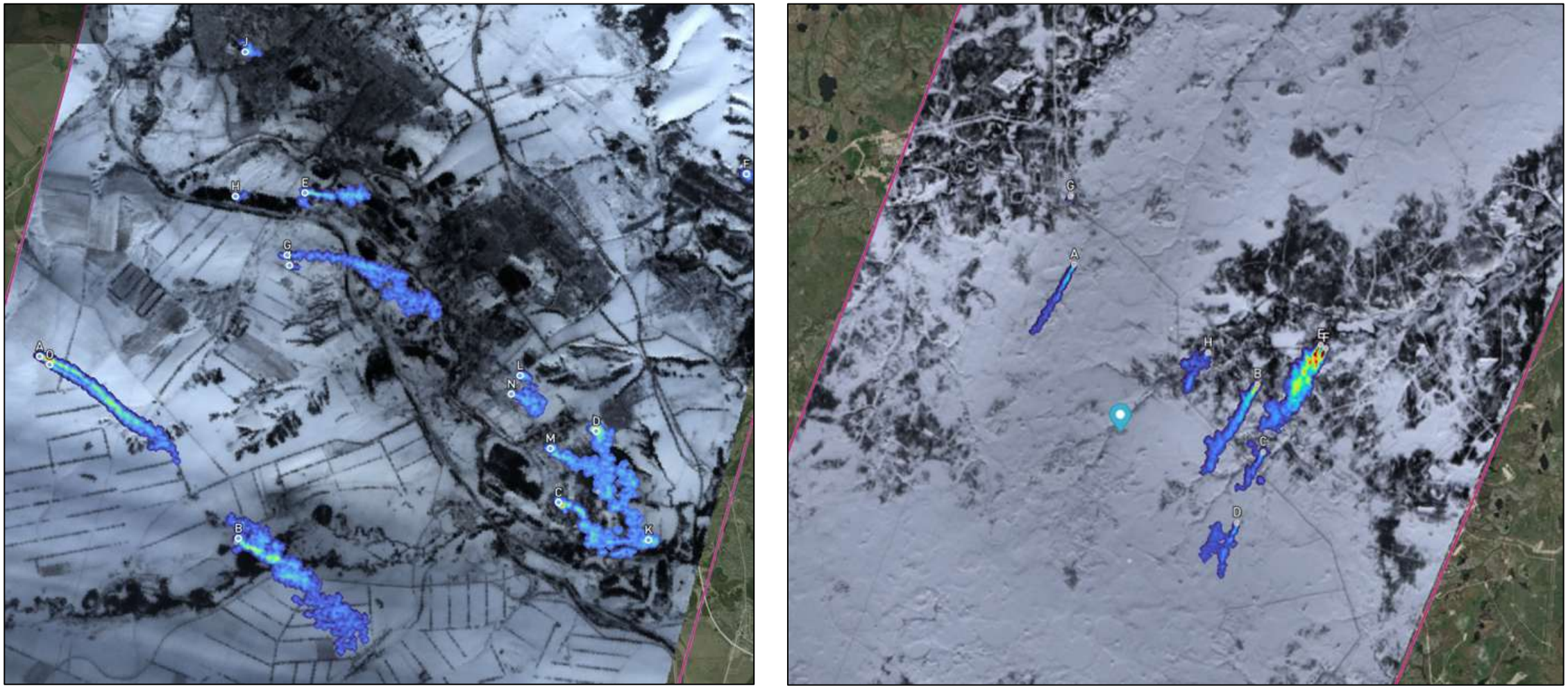
Detecting plumes in high-latitude, snowy scenes



Two examples of Tanager's CH_4 detection capabilities for challenging high latitude winter images in Russia due to large solar zenith angles and low SWIR albedo due to snow covered surfaces. (left) 20 x 20 km^2 subset of a Tanager-1 image at 55 deg N latitude with 13 CH_4 plumes detected on Feb 23, 2025 at 05:51:06 UTC. Emission estimates for the plumes in this image range from about 400 to 2500 $kgCH_4/h$. (right) 24 x 24 km^2 subset of a Tanager-1 image at 66 deg N latitude with 6 CH_4 plumes detected on Feb 26, 2025 at 06:54:41 UTC. Emission estimates for plumes in this image range from about 670 to 5000 $kgCH_4/h$

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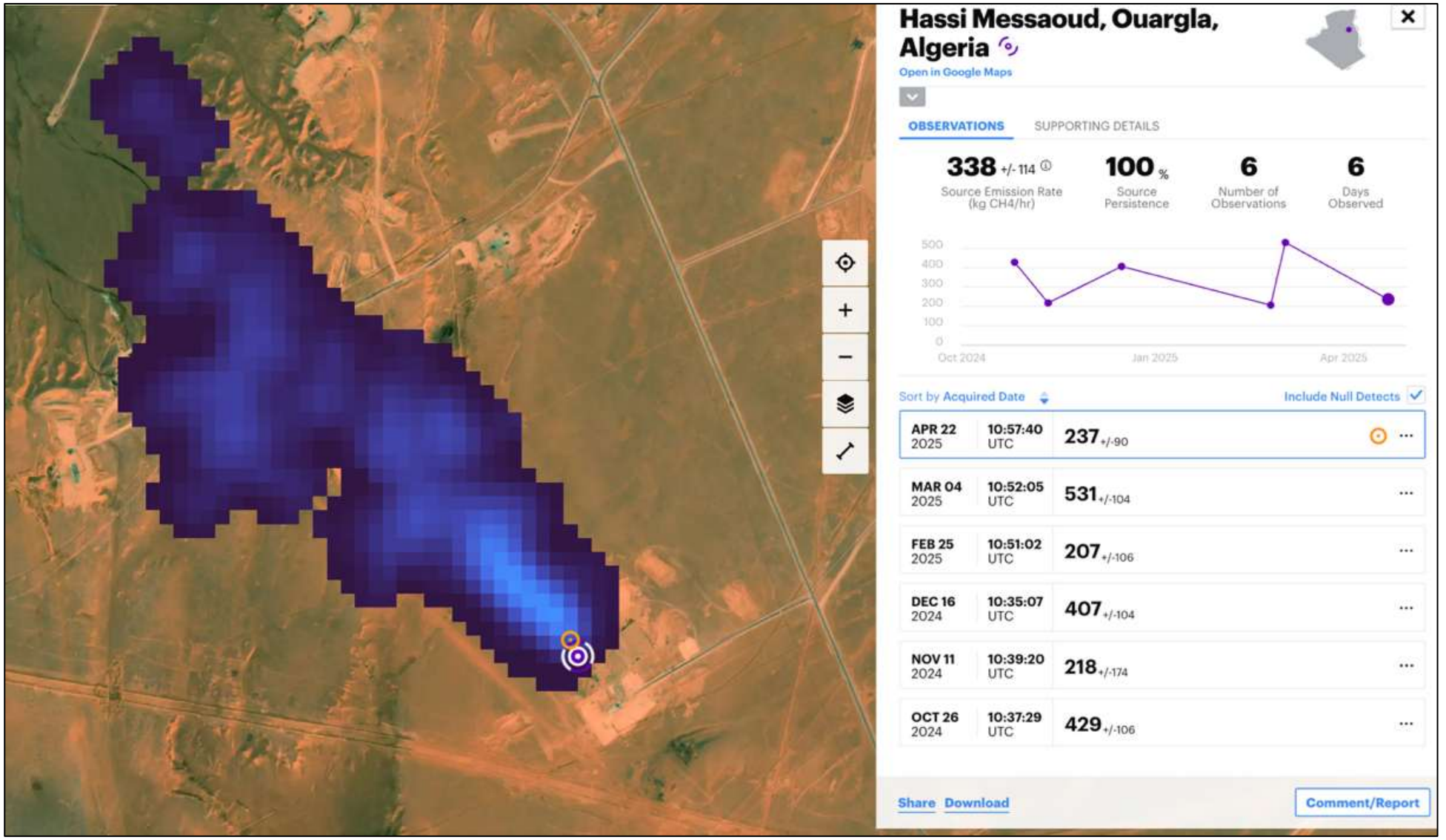
Tracking persistent super-emitters



Screenshot from Carbon Mapper's public data portal showing a time series of CH_4 plumes detected by Tanger-1 at a persistently emitting oil and gas production site in Algeria. Tanager-1 observations of this region occurred on a roughly monthly cadence on average from October 2024 through April 2025.

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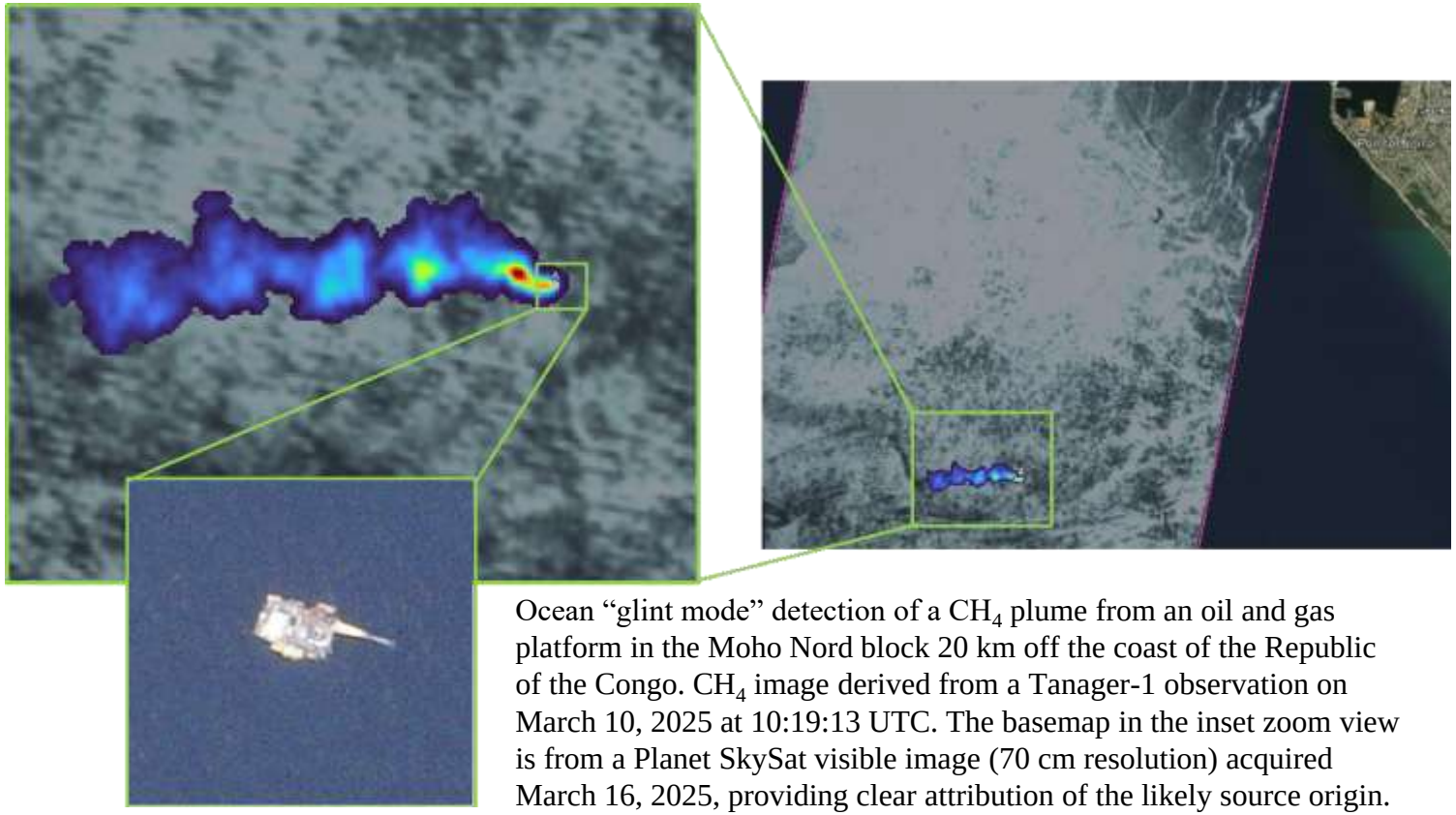
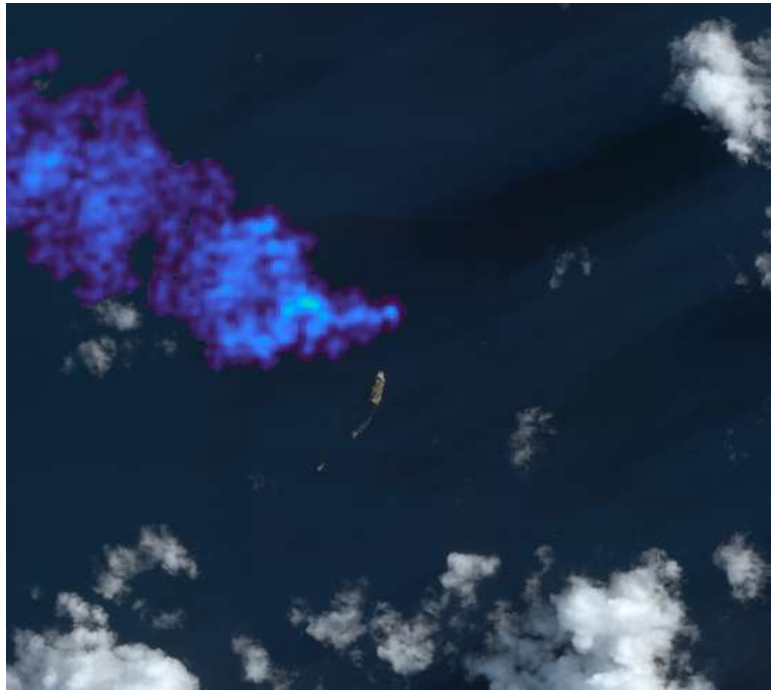
Glint-mode detection of offshore oil & gas emissions



Ocean “glint mode” detection of a CH_4 plume from an oil and gas platform in the Moho Nord block 20 km off the coast of the Republic of the Congo. CH_4 image derived from a Tanager-1 observation on March 10, 2025 at 10:19:13 UTC. The basemap in the inset zoom view is from a Planet SkySat visible image (70 cm resolution) acquired March 16, 2025, providing clear attribution of the likely source origin.



Similar example in Brazilian waters April 23, 2025, with follow-up Planet Skysat tasking revealing drilling ships and tankers

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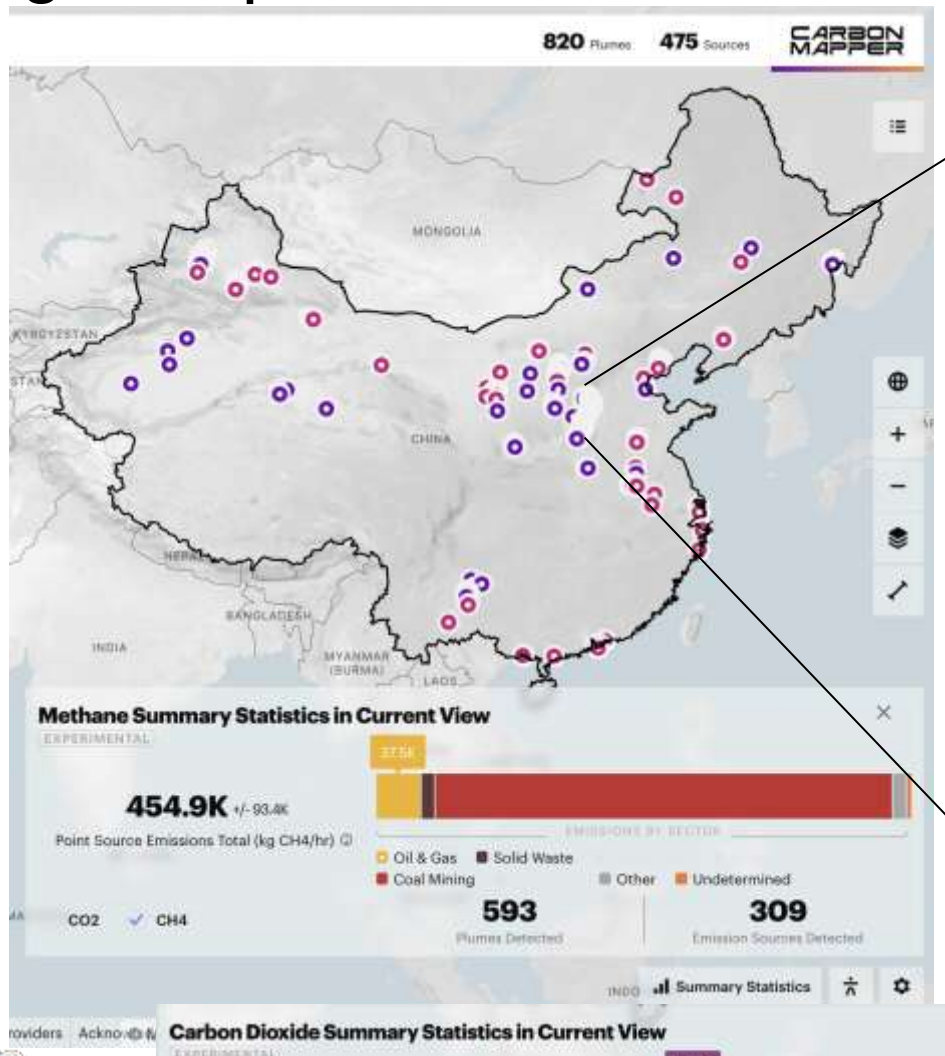
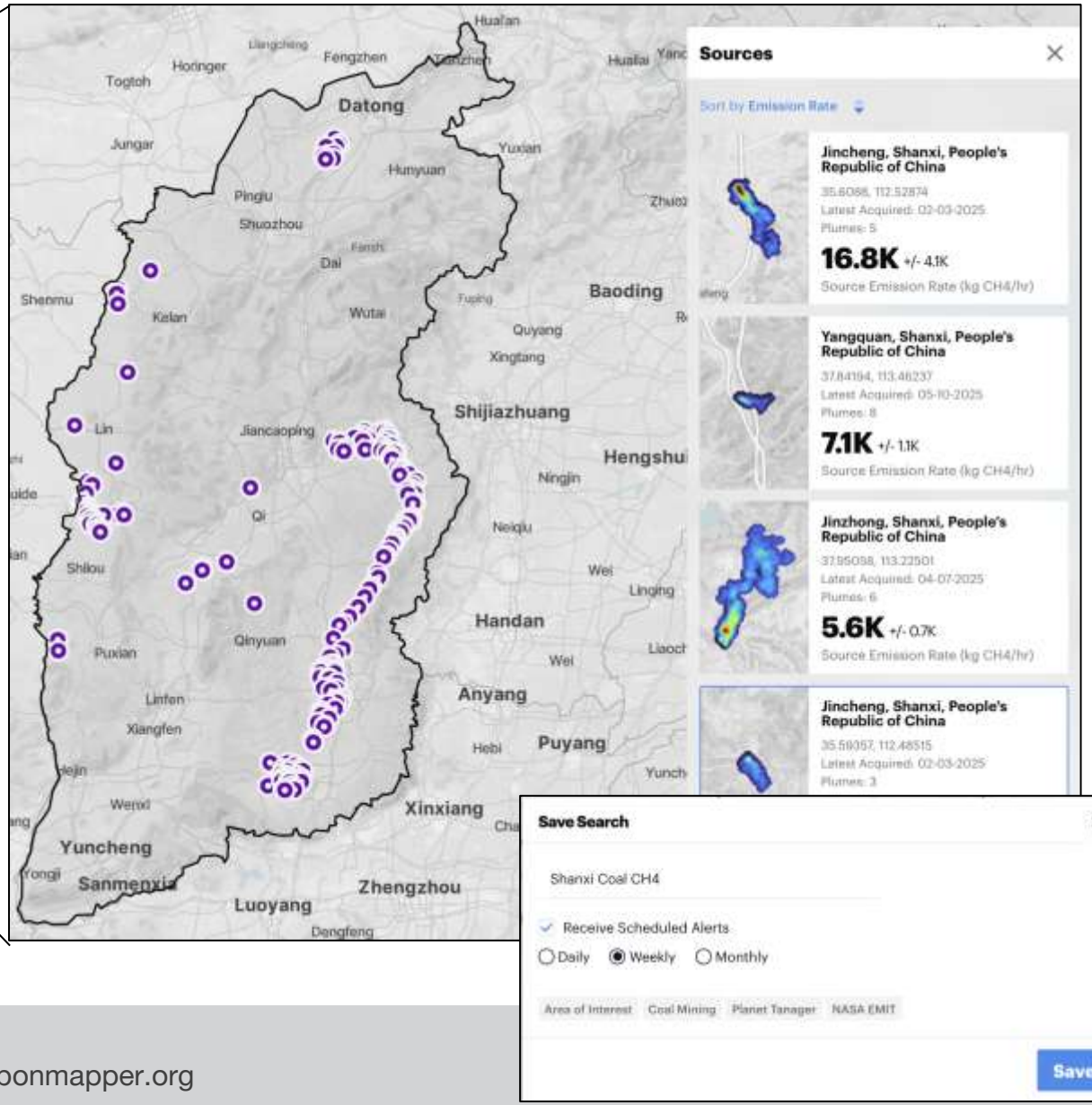
New Carbon Mapper public data portal features:

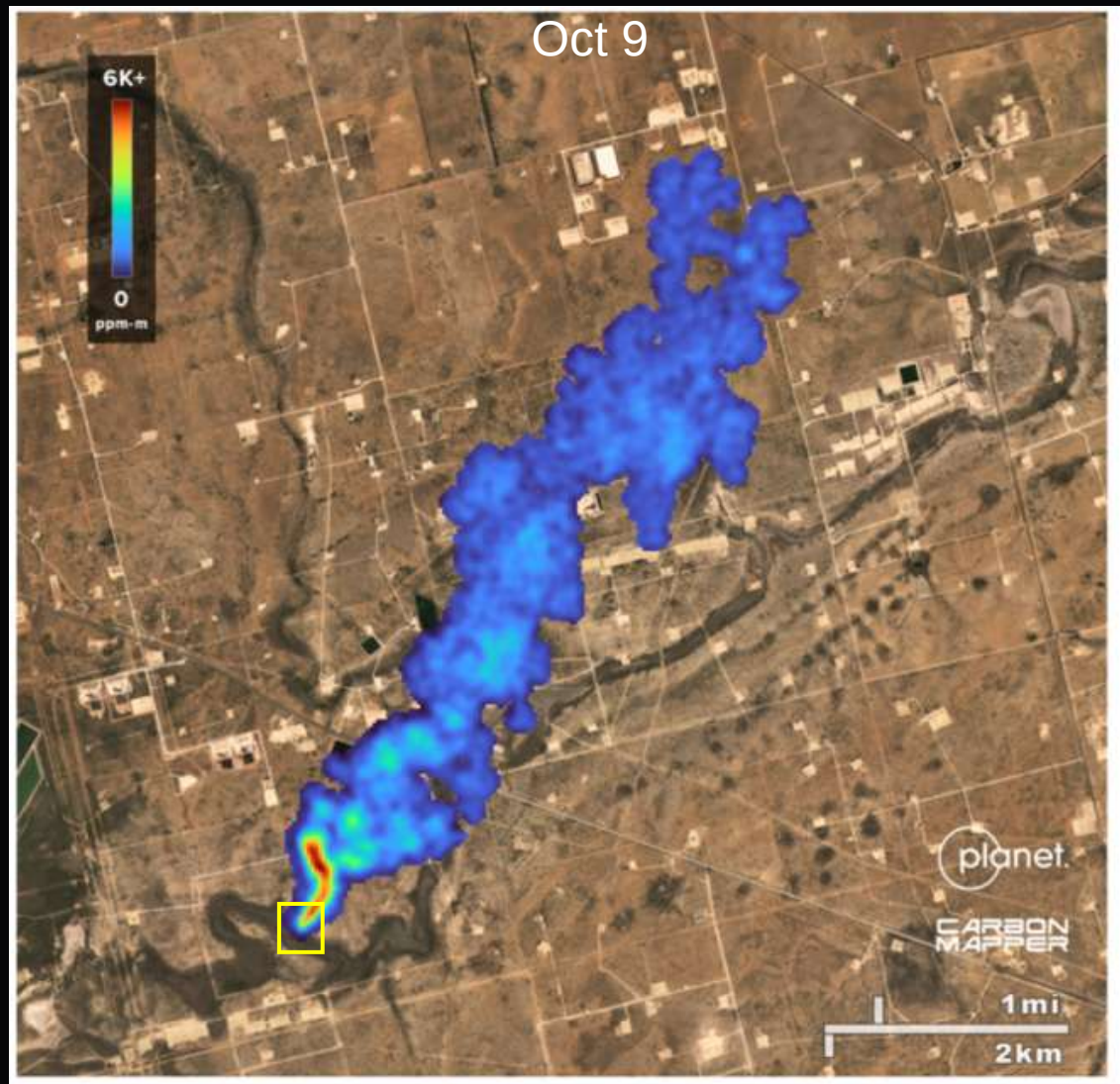
regional point-source statistics, save search, scheduled alerts





Tanager-1: Pipeline leak detection and repair

Permian basin | Detected & reported Oct 9 – repaired Oct 10 –verified Oct 24



Average emission rate over at least 10 days: 4300 +/- 1200 kgCH4/hr

Thank You!

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