Part 1 Questions & Answers Session

Please type your questions in the Question Box. We will try our best to get to all your questions. If we don't, feel free to email Melanie Follette-Cook (melanie.cook@nasa.gov) or Andrew Thorpe (andrew.k.thorpe@jpl.nasa.gov).

Question 1: How are new point sources discovered? Does one work from area sources down to point sources or does one use other databases, such as gas pipelines, to nominate candidates?
Answer 1: Great question. In some cases we use satellite instruments like TROPOMI, etc., to understand where there are interesting global gradients that can be followed up with EMIT. More typically, we have a team of scientists looking through the EMIT results to identify methane plume candidates and then we use additional information to provide additional context, including high-resolution true color imagery and infrastructure databases.

Question 2: How are different types of sectors identified and attributed in the same small area?
Answer 2: Slide 32 is a nice illustration of this. If we see multiple plumes that come from distinct sources, we can then identify the emission source and the associated emission sector. The example above shows methane emissions that span landfill, energy (power plant, pipeline), and wastewater treatment sources.

Question 3: At what point in the end-to-end tasking, collecting, detection pipeline is wind data taken into account (either modeled or realtime wind data)? For example, is tasking suspended in higher wind periods or is wind incorporated in a post-processing stage?
Answer 3: Winds are taken into account when EMIT methane concentrations are used to calculate an emissions rate, which helps many stakeholders who need more quantification of emissions. Wind conditions don't affect the way the instrument collects data, but they can introduce uncertainty in emissions estimates. Because NASA and the EMIT team are very careful about providing only the highest quality data, this means that under certain types of wind conditions, emissions estimates might not be available.

In addition, we would expect that higher winds will make detection of emissions more challenging. This can provide an opportunity to assess local wind conditions and how they impact if we are seeing a plume on any given day (i.e., for a oil&gas source, perhaps we struggle to see the plume on a day with high winds, while the plume is very clear on a low wind speed day).

Question 4: How can we Track the 'stubble burning' (India) in real-time scenarios? Can we trace the 'critical zones' via this?
Answer 4: We have not looked at this type of example, but thank you for making me aware of this process. While stubble burning can generate CO_2 and CH_4 emissions, it is likely that these emissions will be below the detection limit of EMIT (typically limited to 100s of kg/hr for CH_4).

Question 5: How can I estimate methane emissions from mud volcanoes using EMIT, EnMAP, and PRISMA?
Answer 5: Some methane sources like mud volcanoes are very small, both in terms of spatial scale and maybe the magnitude of emissions. Satellites like EMIT, EnMAP, and PRISMA may not be able to see these more subtle emissions because they are difficult to distinguish from other sources of natural variability. EMIT and other hyperspectral satellites specialize in detecting large emission events where there is a very big difference between the plume and the background. NASA is working on developing new techniques that are better able to observe more subtle sources of methane and some of these we demonstrate first in our AVIRIS airborne work.

Question 6: Is there any other data available about plumes besides their shape, density, and persistence? Could isotope concentrations and shape be used to attribute to a sector on large scales so that not every plume requires manual attribution?
Answer 6: Unfortunately, we cannot measure isotopic differences with EMIT or AVIRIS-3.

Question 7: What was the time frame for the Kansas pipeline detection between the detection and EPA being notified?

Answer 7: We typically can share methane plume imagery with stakeholders (like the EPA) within a few days of the EMIT observation. Sharing these results quickly is a priority because it provides the potential for mitigation.

Question 8: Is there a plan to address the missing area in Northern latitudes? Particularly to observe the CH_4 emissions from the thawing permafrost? Can you provide some general information on anticipated methane releases from melting permafrost? Has it been detected yet? Will it be visible only as area flux increases, or will there be point sources?

Answer 8: This is a great question! Because of the International Space Station's orbit, it can't see the Northern high latitudes. In addition, because permafrost emissions may be more subtle and spatially distributed, EMIT may struggle to observe them and differentiate from the background methane concentrations. NASA and other space agencies are working to address these gaps in different ways. First, in some data sparse regions we fill gaps with airborne observations and field campaigns. Germany's space agency is also working on a new instrument called MERLIN, which uses a new technique called LiDAR to measure methane concentrations in high latitudes. Because LiDARs carry their own light sources, they are particularly well suited to seeing high latitude regions, which lack sunlight for large parts of the year.

Question 9: Are there undetected plumes? Could you talk about how to find them?

Answer 9: Given EMIT has a detection limit on the order of 100s of kg/hr, there is certainly going to be a distribution of emissions that will not be observed with EMIT. Airborne instruments like AVIRIS-3 have a lower detection limit, on the order of 10s of kg/hr, so one option is to use airborne instruments to detect smaller emissions.

Question 10: Would it be possible to detect an underground crude oil leak using remotely sensed methane data?

Answer 10: If there are significant methane emissions associated with the crude oil leak, it would be possible to do so. The examples that I shared in the presentation were from natural gas pipelines.

Question 11: Is it reliable to rely solely on satellite data in studies of methane emissions, air quality, or dust, and can such data be considered valid in research without verification from on-the-ground measurements?

Answer 11: Over the last 10 years, the research community has published many studies that included in situ validation (i.e., controlled methane release experiments, ground-based measurements like thermal cameras, and direct sampling of the atmosphere). On-the-ground measurements are always helpful, but not always required (there have been many studies using satellite instruments for CH_4 that do not include ground based measurements).

Question 12: Is EMIT or another satellite sensor able to retrieve CH_4 and CO_2 emissions from wildfires? Have any results been demonstrated?
Answer 12: We have always been interested in this potential, but it will be very challenging given the fact that CH_4 and CO_2 fluxes will likely be below the detection limit of EMIT. These emissions are also more diffuse and less like point source. There are other instruments that measure emissions from wildfires, like TROPOMI (https://doi.org/10.1038/s41586-024-07878-z).

Question 13: It was a bit strange to see that CH_4 contribution to heat imbalance has been relatively constant of ~ 0.4 w/m. Can you comment?
Answer 13: I am not familiar with the number that is being cited here. There are many studies (Nisbett et al., 2023, https://doi.org/10.1029/2023GB007875; Feng et al., 2023, https://doi.org/10.5194/acp-23-4863-2023, etc.) that indicate increases in atmospheric concentrations of methane and the associated radiative forcing from this potent greenhouse gas.

Question 14: When a dam is storing water, does the submerged vegetation generate significant CH_4?
Answer 14: It is possible that submerged vegetation can actually provide a pathway for CH_4 from the subsurface. I am aware of this in Arctic environments and this may also be true in other wetland environments.

Question 15: Are there other satellites with sensors and orbital paths that allow for the detection of methane plumes at high latitudes? Or is this mostly achieved via in situ measurements?
Answer 15: Yes, there are instruments that have orbits that extend to higher latitudes than EMIT that have detected regional methane enhancements (for example TROPOMI; https://doi.org/10.3390/rs16162979). Other instruments have detected point source at high latitudes

(https://www.esa.int/Applications/Observing_the_Earth/Copernicus/Trio_of_Sentinel_satellites_map_methane_super-emitters).

Question 16: What is the spectral resolution of EMIT?
Answer 16: EMIT has a spectral sampling of 7.4 nm. More information can be found here: https://earth.jpl.nasa.gov/emit/instrument/specifications/

Question 17: What are some of the key challenges in distinguishing anthropogenic methane emissions from natural sources using satellite data, and how are these addressed?
Answer 17: Natural methane emissions are typically smaller in magnitude and more diffuse as compared to anthropogenic emissions, which are typically larger and more point source like in nature. Given this, point source instruments typically struggle to observe emissions from natural emissions.
We have used airborne instruments like AVIRIS and AVIRIS-NG to identify natural methane seeps (Thorpe et al., 2014, https://doi.org/10.5194/amt-7-491-2014) and methane from permafrost (Elder et al., 2021, https://doi.org/10.1029/2020GB006922). The high spatial resolution is key because it allows for the emission location to be identified on the ground.

Question 18: Can you comment about the concentration unit of CH_4, being ppm/m?
Answer 18: Units are ppmm enhancement, which is defined as the mixing ratio length in units of ppmm (parts per million meter), representing the thickness and concentration within a volume of equivalent absorption (Thorpe et al., 2022, https://doi.org/10.1126/sciadv.adh239; Thompson et al., 2016, https://doi.org/10.5194/amt-8-4383-2015). As described in these publications, this unit can be converted to mass units that can be used to generate emission estimates.

Question 19: What methodologies are used for calibrating the algorithms that convert raw radiance data into methane concentration estimates, and how are systematic biases minimized across different satellite missions?
Answer 19: This is a great question. By making all EMIT radiance data, methane data products, and the code used to generate these data products publicly available (see links in the presentation), the goal is to have other research teams be able to reproduce and improve upon our results. The EMIT team is increasingly working with other

research teams using additional instruments to improve retrieval algorithms and emission quantification approaches.

Question 20: Can one distinguish smaller plumes from larger plumes with knowledge of local geography, construction techniques, or operator maintenance records?
Answer 20: Local knowledge, like high resolution base map imagery, infrastructure datasets, etc. can certainly be helpful when it comes to identifying methane plumes. This is particularly true of smaller plumes (i.e. just a few EMIT pixels in extent) which are harder to identify.

Question 21: I feel like question 9 was referring to the identification of plumes that were within the detection limit of EMIT but potentially passed over by the current screening method. Is there a possibility that quantified emissions haven't been flagged by the current system? Is there an opportunity to assist with finding these unflagged emissions?
Answer 21: This is a great question. We perform a careful review of all plume candidates and only high confidence examples are published to the US GHG Center and the LP DAAC. This means that there certainly could be credible plumes that our current system has not identified. Because we make full scene methane results publicly available, anyone can examine these results and perform their own assessment.

Question 22: Can you please say a few words about CH_4 point source detection with cameras?
Answer 22: There are a number of hand held camera systems that are designed for identifying methane plumes, including from companies like FLIR and SENSIA.