NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY
U.S. DEPARTMENT OF COMMERCE

Consensus Standards for Methane Measurements: Plume Scale Data

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For May 2024 IWGGMS

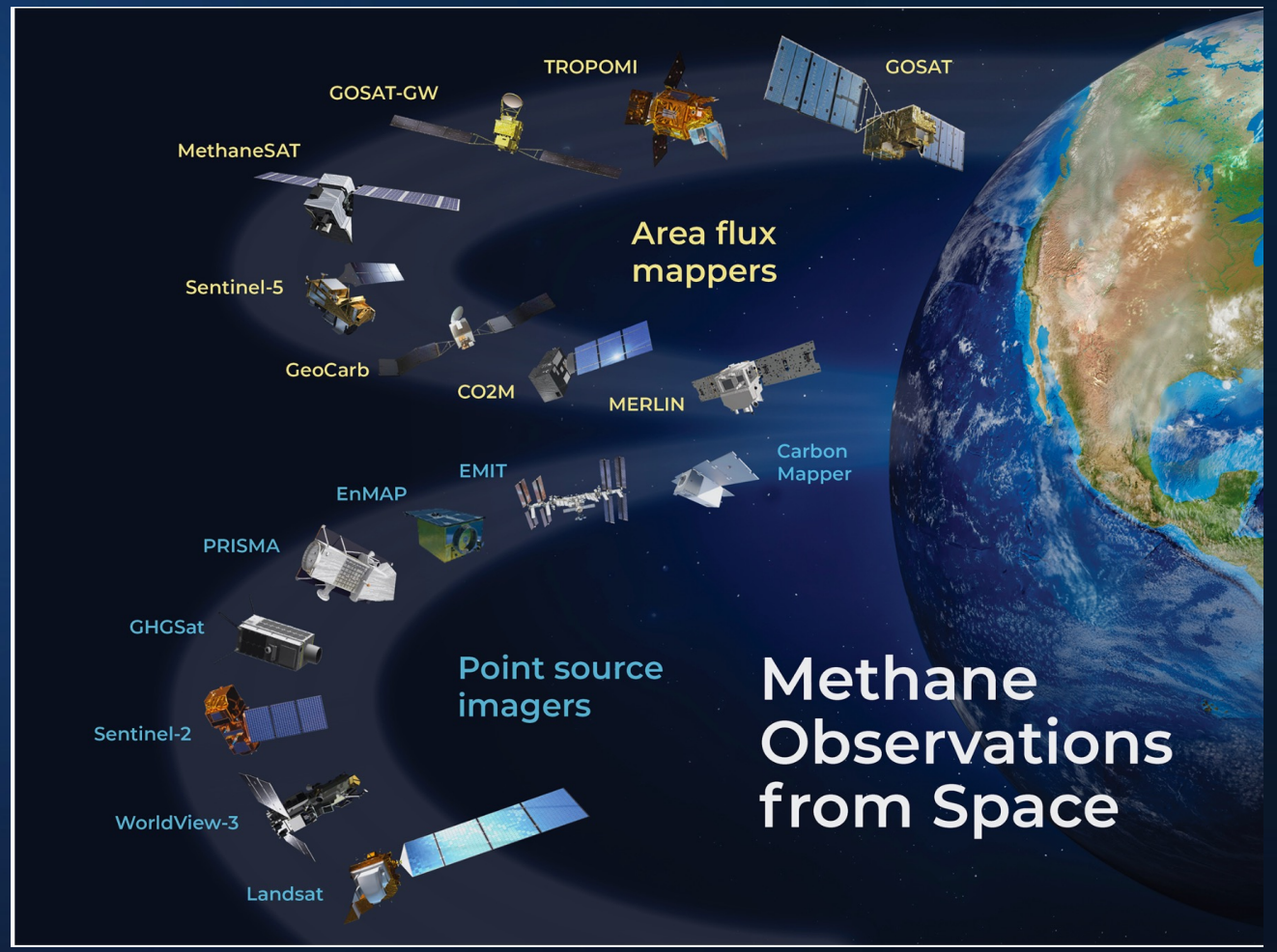
May 29, 2024

Exciting times!!

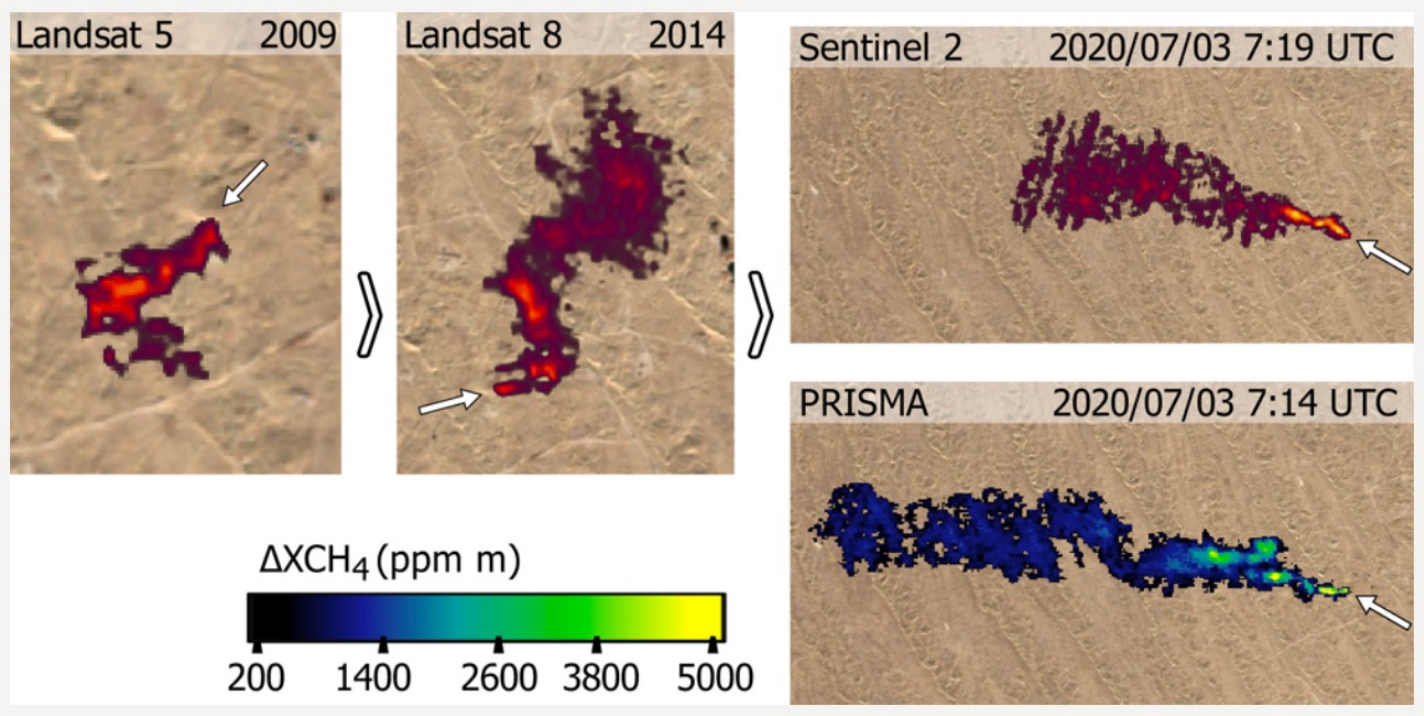
Many missions underway and about to come on line

Aircraft capabilities as well

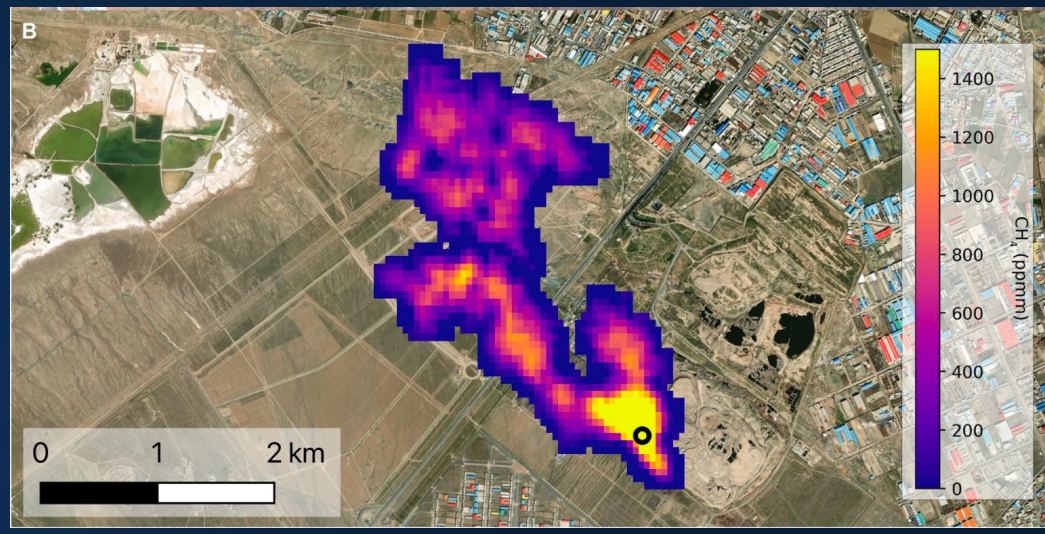
Figure from Jacobs et al., ACP, 2022



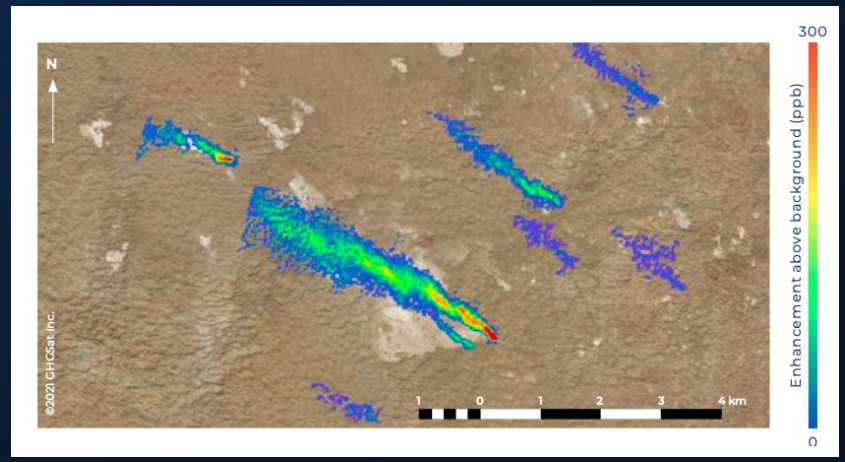
Plume observations abound!



Irakulis-Loitxate et al 2022



EMIT, from Thorpe et al 2023



GHGSat, from Aramier et al 2023

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By Nichola Groom and Valerie Volcovici

December 2, 2023 12:56 PM EST · Updated 6 months ago

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2 minute read · May 9, 2023 7:57 AM EDT · Last Updated 5 days ago

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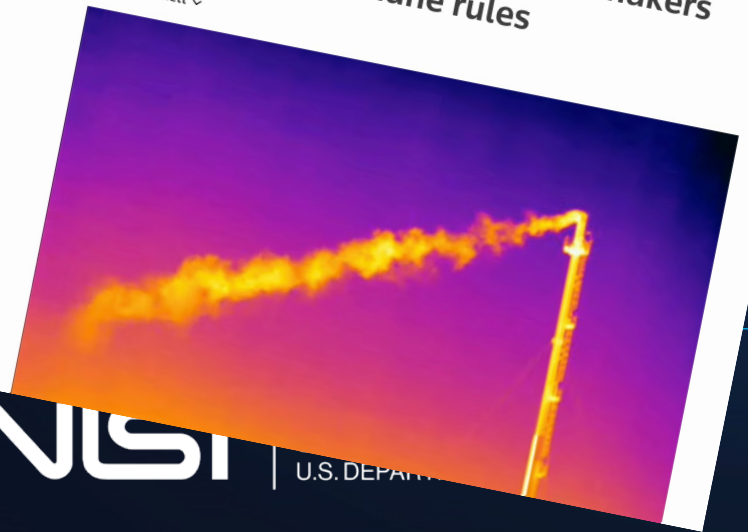
By Kate Abnett



cnn.com/2023/04/17/us/methane-oil-and-gas-epa-climate/index.html

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The oil and gas industry is emitting way more of this potent, planet-warming gas than the EPA has estimated, study shows

By Ella Nilsen, CNN

Published 3:00 PM EDT, Mon April 17, 2023

A Methane Mixed Bag: EPA Finalizes Methane Rule for New and Existing Oil and Gas Facilities

by: Gary E. Steinbauer, Christina M. Puhnaty of Babst, Calland, Clements & Zomnir, P.C. - *Articles, Alerts & Perspectives*

Posted On Wednesday, December 13, 2023

On December 2, 2023, the U.S. Environmental Protection Agency (EPA) released a **pre-publication version** of its final *Standards of Performance for New, Reconstructed, and Modified Sources and Emissions Guidelines for Existing Sources: Oil and Natural Gas Sector Climate Review* (Final Rule). The Final Rule comes more than two

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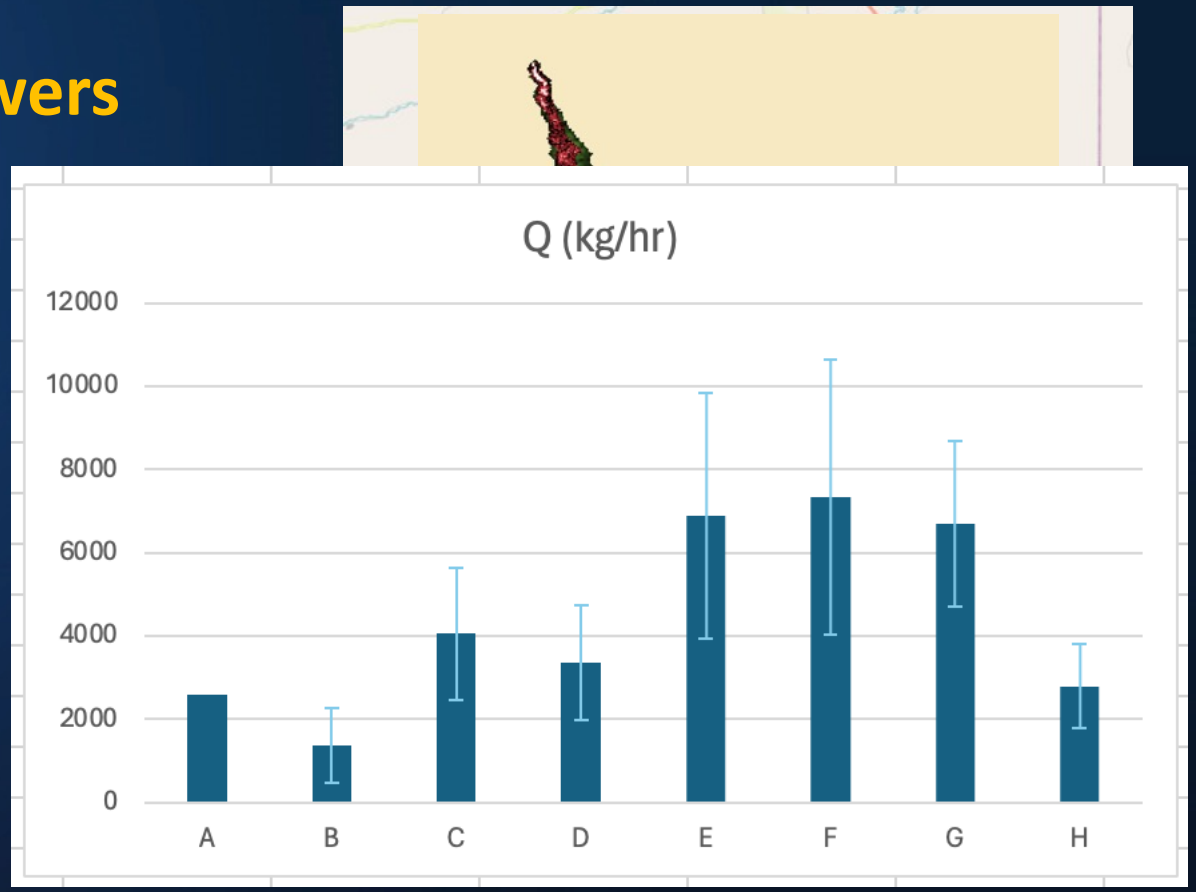
That's great, but....

- **There is a lot of variation in the answers**
  - Where is the plume
  - Location of the source of the plume
  - Estimate of total emissions



Strategy

- **Three key aspects of methane plume data that will improve reliability and trust are:**

1. Methodological consistency (observational strategies, data analysis and quality control).

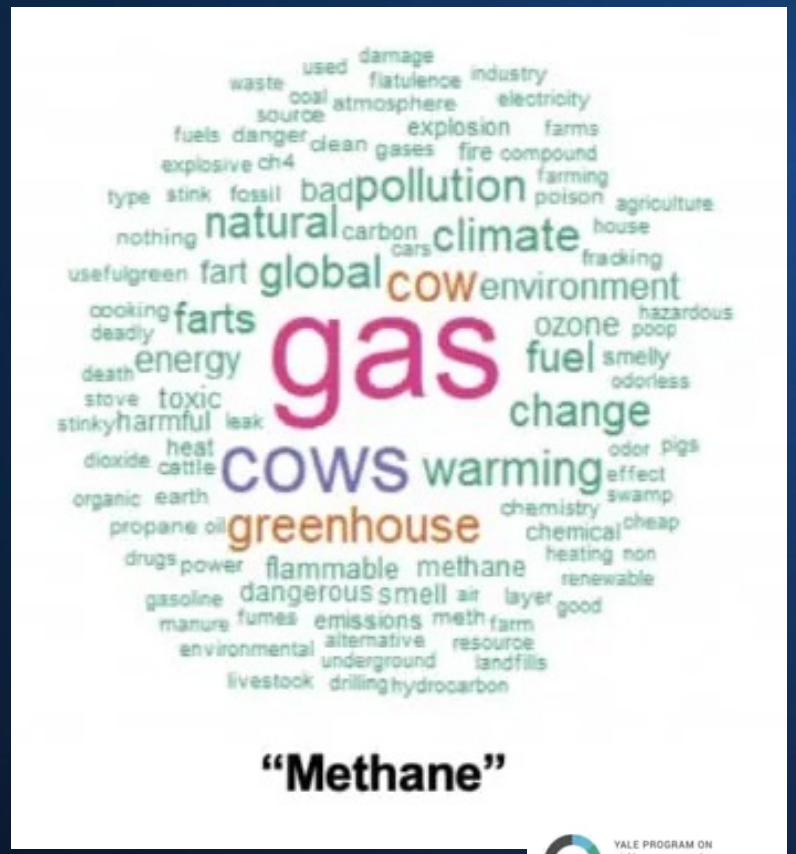
2. Independent evaluation (controlled release testing and other ground-truthing).

3. Enhanced transparency (enabling further intercomparison and repeatability).

NIST Coordinated Activities

- Bring together key communities to discuss consensus standards, terms, and taxonomy. Terminology includes plumes, enhancement, plume origin, attribution, and 90% probability of detection.
- Begin to develop documentary standards, including data level definitions and organization of documentation to increase transparency
- Document the current practices of data analysis
- Facilitate intercomparisons and analysis of intermediate products as well as plume quantification
- Explore how we can assist with coordination of controlled releases
- Explore collaboration with US GHG Center to host exemplar datasets, and to centralize documentation such as ATBDS and quality control protocols

Accomplishments to date

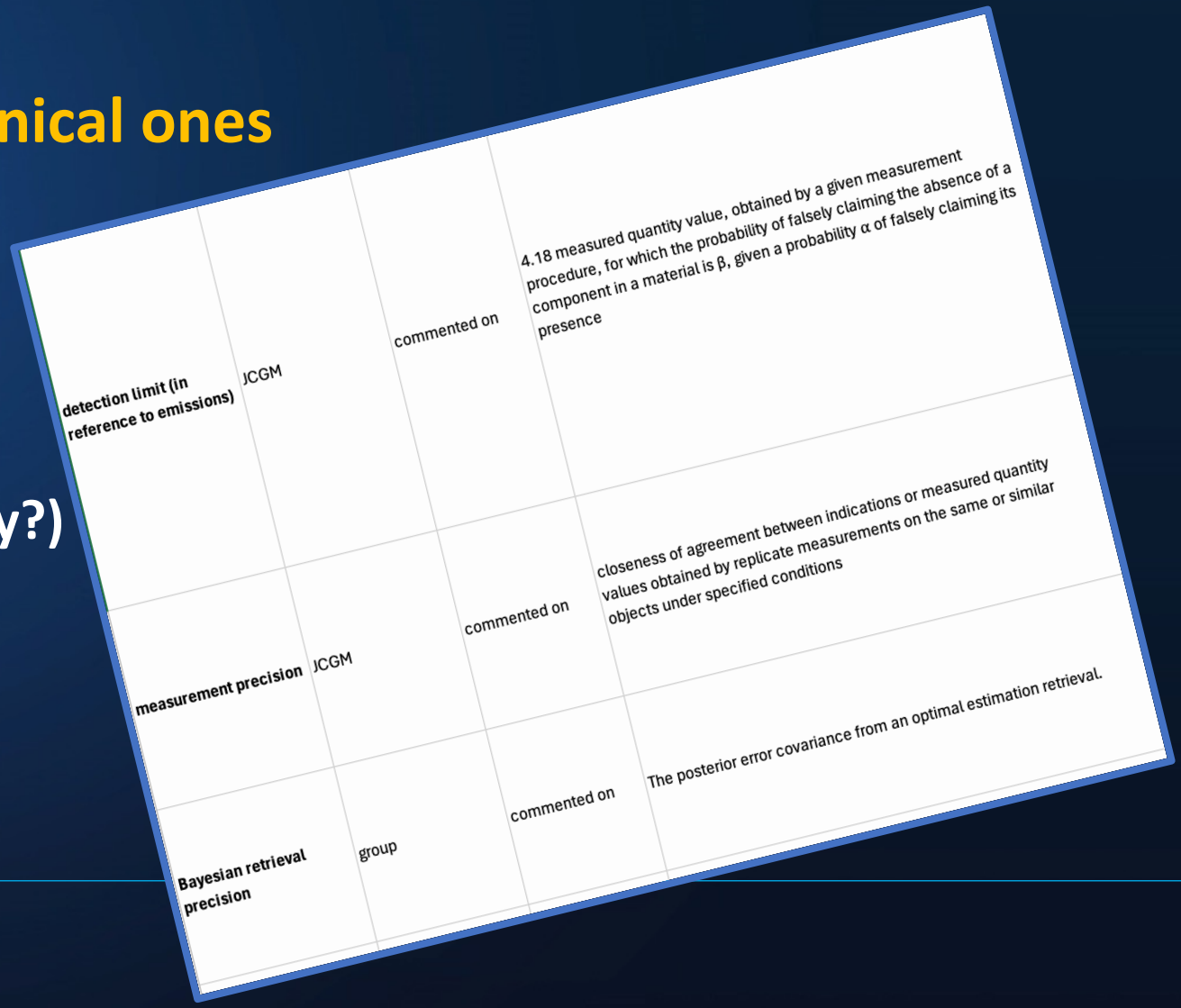


- Held workshop in Jan 2024
- Held a series of meetings with smaller groups over the spring
  - Definitions
  - Workshop report
  - Current workflows
  - Connection to other efforts (CEOS, NPL, EPA, +)
- Second workshop in May 2024

https://earth.org/data_visualization/natural-gas-or-methane-the-term-you-use-matters/

Definitions

- **Have agreement on more technical ones**
  - Precision
  - Probability of detection
  - etc
- **Others not at consensus yet**
  - Plume (depends on sensitivity?)
  - origin
- **Next steps**



detection limit (in reference to emissions)	JCGM	commented on	4.18 measured quantity value, obtained by a given measurement procedure, for which the probability of falsely claiming the absence of a component in a material is β, given a probability α of falsely claiming its presence
measurement precision	JCGM	commented on	closeness of agreement between indications or measured quantity values obtained by replicate measurements on the same or similar objects under specified conditions
Bayesian retrieval precision	group	commented on	The posterior error covariance from an optimal estimation retrieval.

Data labeling and format

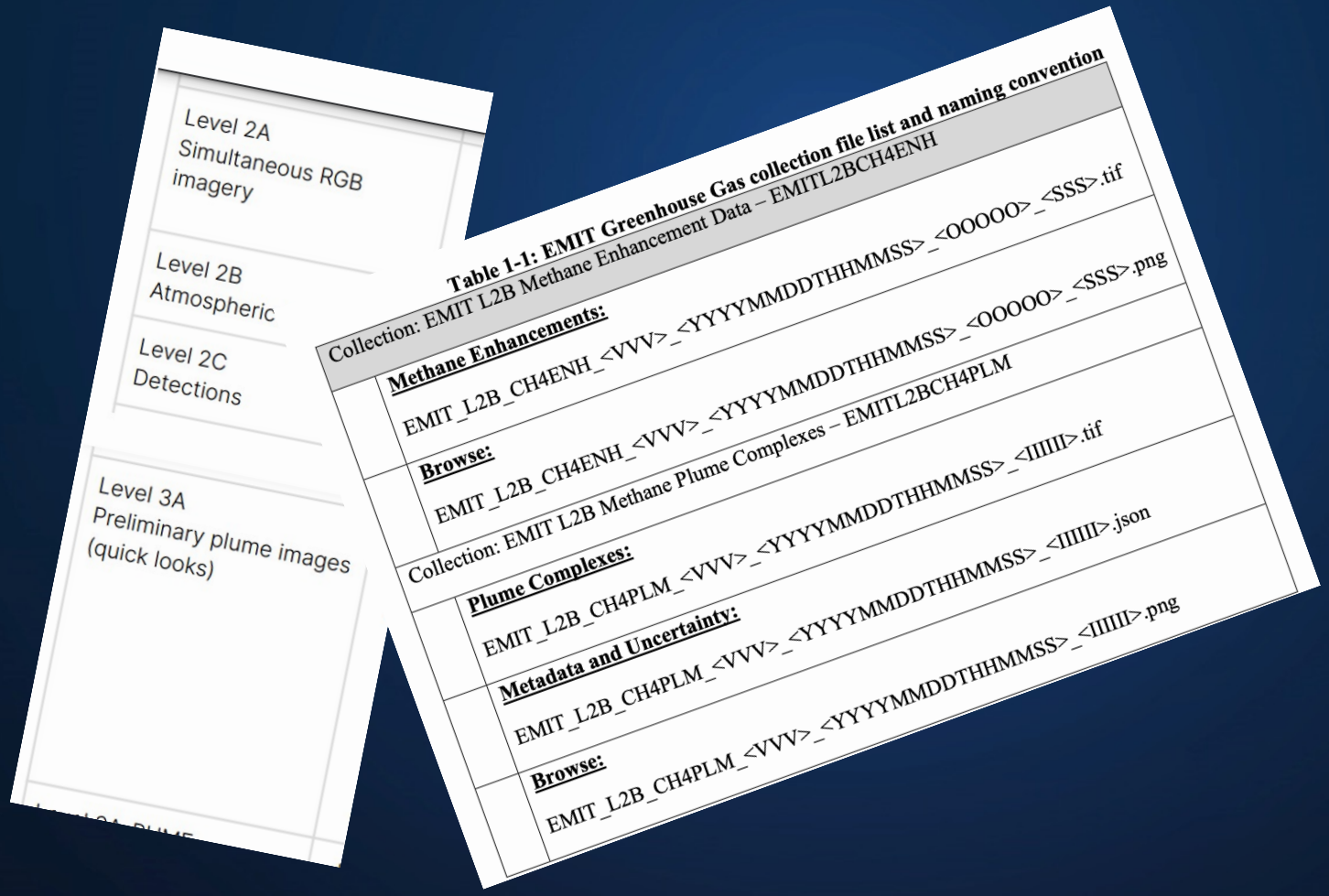


Table 1-1: EMIT Greenhouse Gas collection file list and naming convention

Collection: EMIT L2B Methane Enhancement Data – EMITL2BCH4ENH	
Methane Enhancements:	
EMIT_L2B_CH4ENH_<VVV>_<YYYYMMDDTHHMMSS>_<OOOOO>_<SSS>.tif	
Browse:	
EMIT_L2B_CH4ENH_<VVV>_<YYYYMMDDTHHMMSS>_<OOOOO>_<SSS>.png	
Collection: EMIT L2B Methane Plume Complexes – EMITL2BCH4PLM	
Plume Complexes:	
EMIT_L2B_CH4PLM_<VVV>_<YYYYMMDDTHHMMSS>_<IIIIII>.tif	
Metadata and Uncertainty:	
EMIT_L2B_CH4PLM_<VVV>_<YYYYMMDDTHHMMSS>_<IIIIII>.json	
Browse:	
EMIT_L2B_CH4PLM_<VVV>_<YYYYMMDDTHHMMSS>_<IIIIII>.png	

- There is no consistent definitions of L2/L3/L4 across the teams
- We should also improve consistency of units
- I have some concrete suggestions about ancillary data that should be included with data products

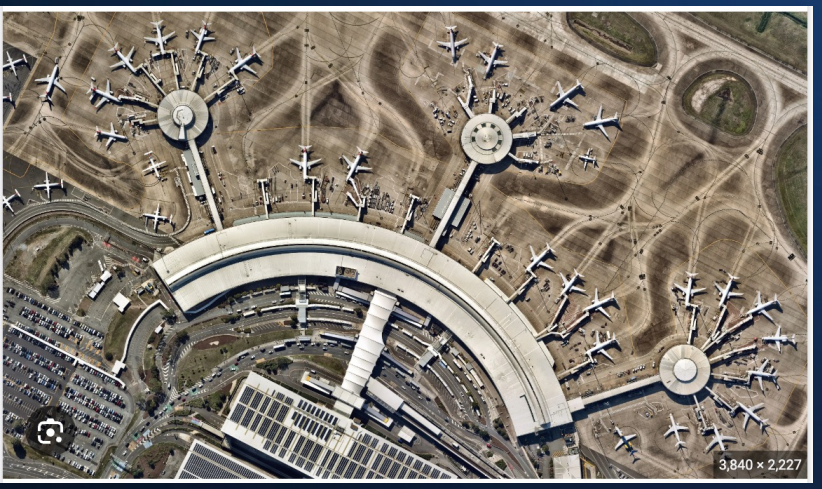
The nature of the beast

- Remote sensing to provide concentration data and beyond involves estimation and inferences!

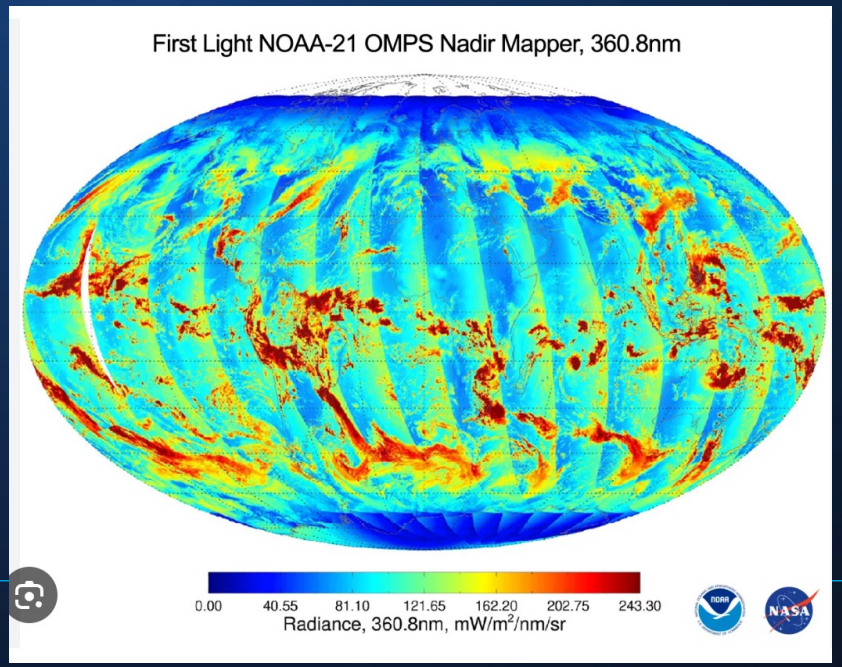
Imaging/radiance, concentration fields, and plume emissions

Each product has more inference and estimates, and becomes harder to validate

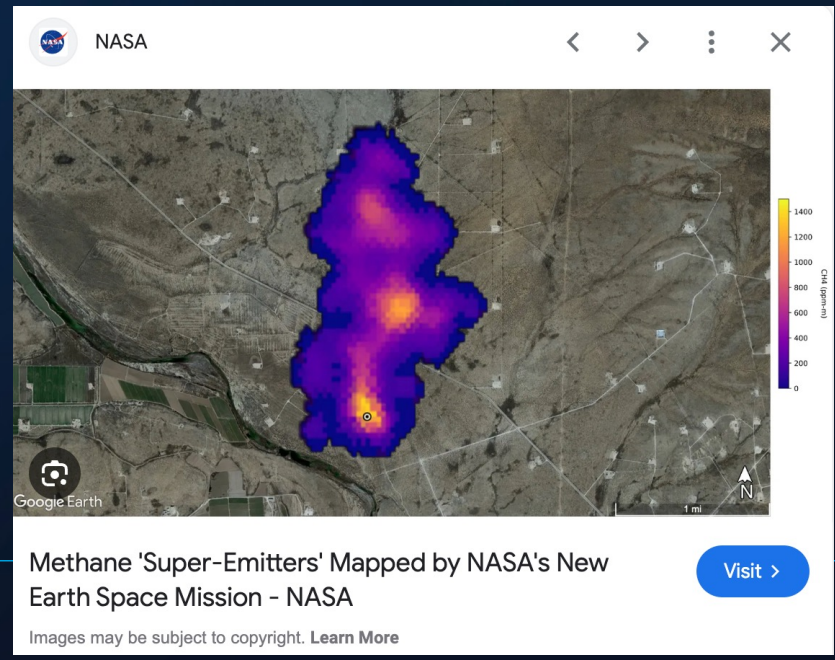
imagery



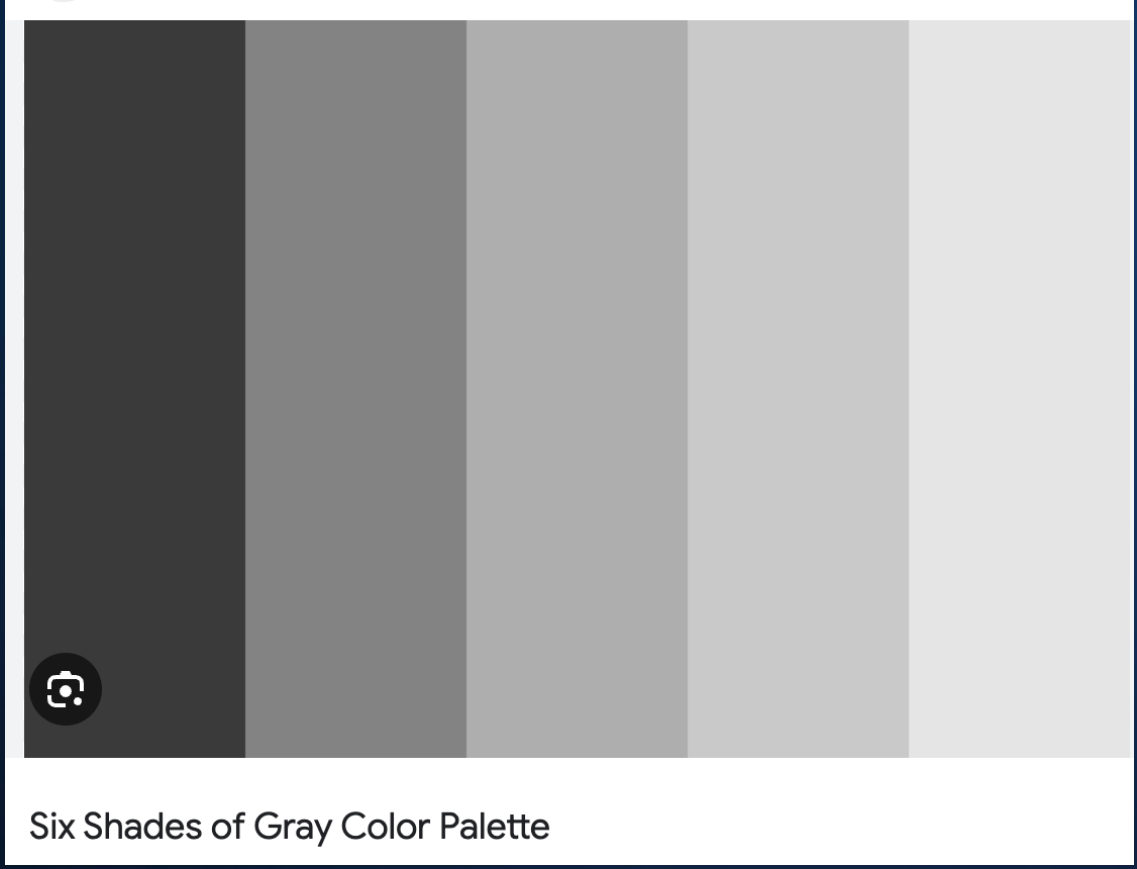
ozone



Plume and emissions



What is the right question to ask?

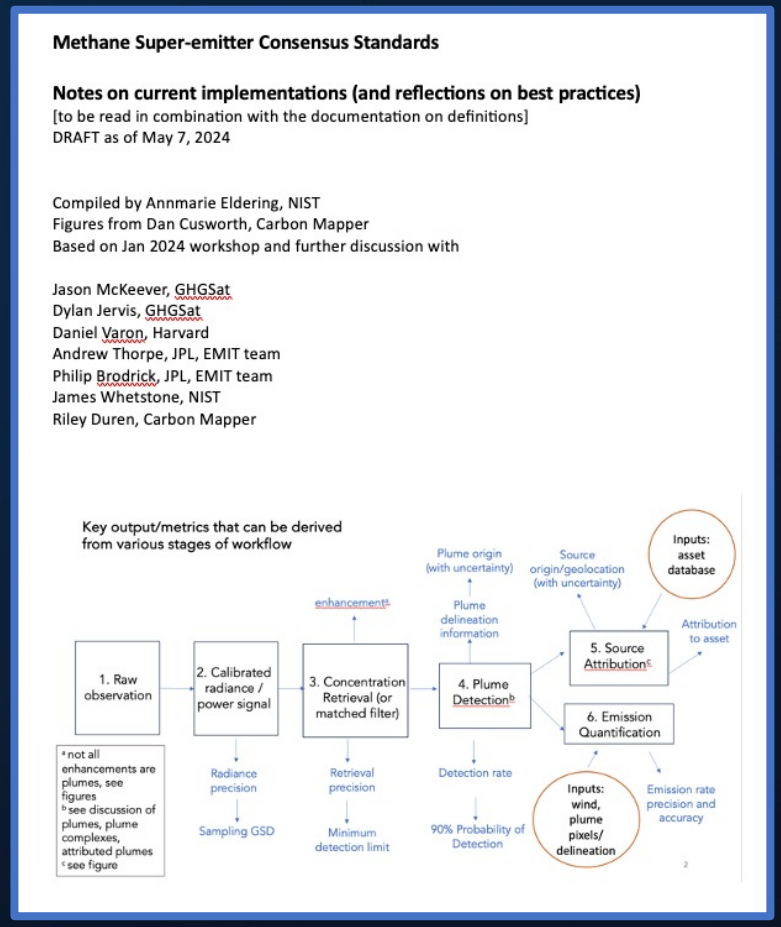


Six Shades of Gray Color Palette

- This remote sensing problem is a difficult technical problem, and not a black and white/ right or wrong situation.
- Perhaps we should ask this: “is the inferred emission rate correct, given the sensitivity and characteristics of the instrument system and atmospheric dynamics?”

Current workflows

- Technical team members participated in series of working meetings
- Draft document of current workflows has been created
  - Captures info about what teams are doing
  - Also has some recommendation from Annmarie on best practices
  - Includes appendices with some content on data format/ancillary data and technical details of implementation
- This work has help us identify area where further investigation is needed to gain insight into sources of difference and uncertainty



Methane Super-emitter Consensus Standards

Notes on current implementations (and reflections on best practices)
[to be read in combination with the documentation on definitions]
DRAFT as of May 7, 2024

Compiled by Annmarie Eldering, NIST
Figures from Dan Cusworth, Carbon Mapper
Based on Jan 2024 workshop and further discussion with

Jason McKeever, GHGSat
Dylan Jervis, GHGSat
Daniel Varon, Harvard
Andrew Thorpe, JPL, EMIT team
Philip Brodrick, JPL, EMIT team
James Whetstone, NIST
Riley Duren, Carbon Mapper

Current workflows

- At a high level, all teams use the same sequence of steps in their workflows
- The details of implementation vary at pretty much every step

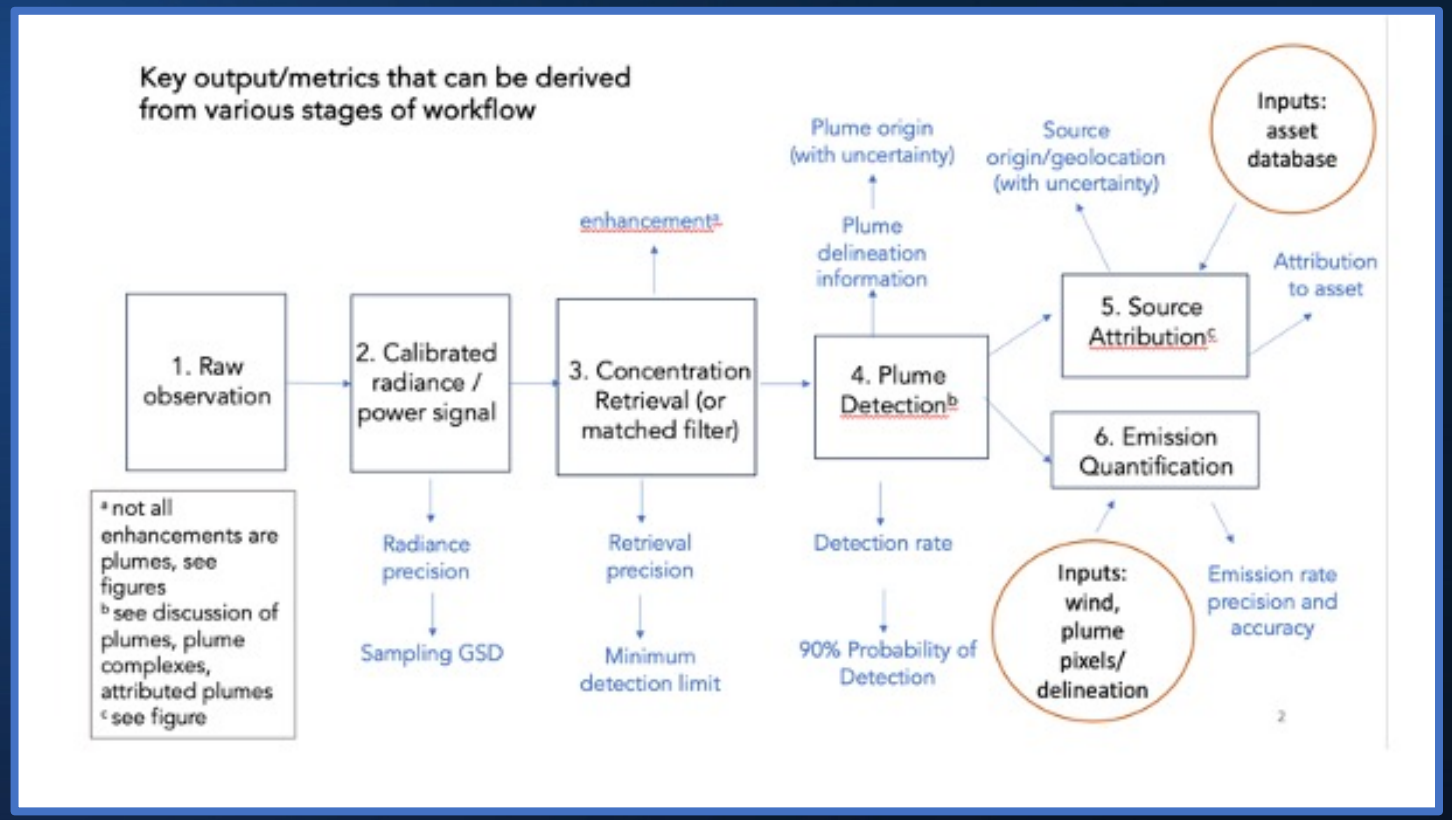


Figure developed by Dan Cusworth

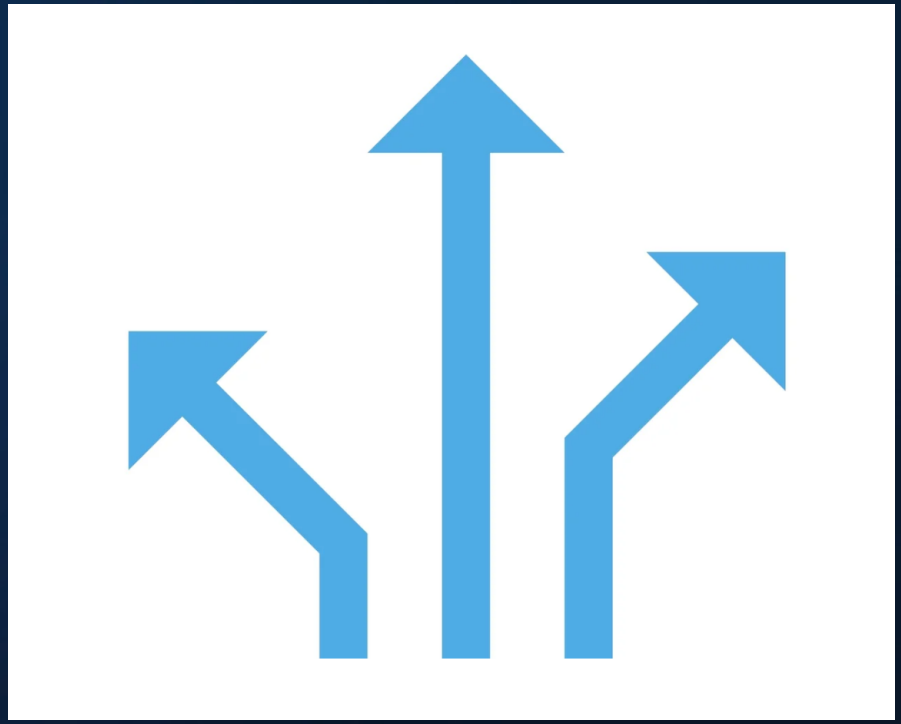
Facilitating intercomparison

- For the May meeting we asked team to participate in an intercomparison
  - Four different EMIT scenes
  - Eight analysis teams
  - Looked at plume masks, wind fields, length of plume, emissions estimate

- Found significant difference in the area included in the plume
- Different sources of wind data varied by a factor of two
- Most emissions estimates were within a factor of 2, but at times different by factors of 3 and 4
- In complex scenes, teams identified different numbers of scenes

Objectives

- Our first objective is documentary standards.
- We may be able to develop some consensus on best practices and common language
- Gain insight into source of differences
- Communicate to the broader community the reasons behind the variations in results



Controlled releases

- Independent checks will also help quantify intercomparability of data, potentially increase trust and utility of data
- Controlled releases are a critical tool for providing this independent check on measurement systems
- Controlled release capabilities are also rapidly evolving and we need to maximize the utility of these experiments
- Can we coordinate the information sharing about controlled release experiments while respecting constraints and safety concerns?

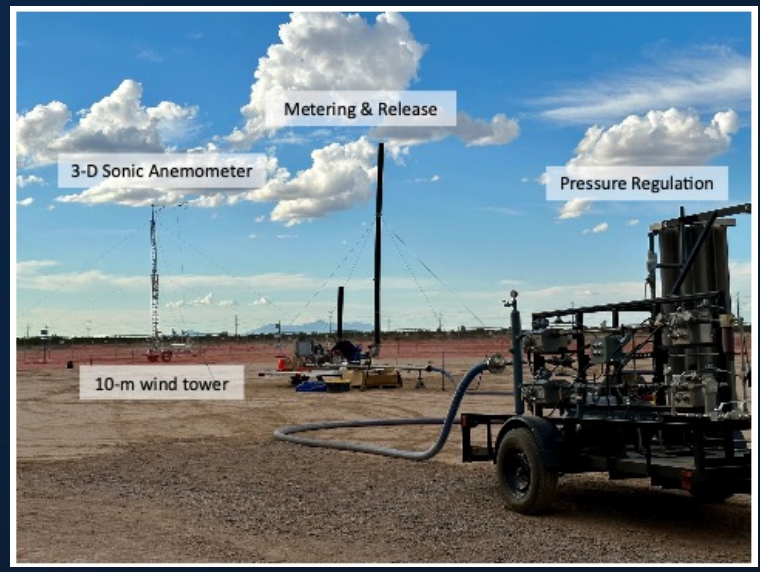
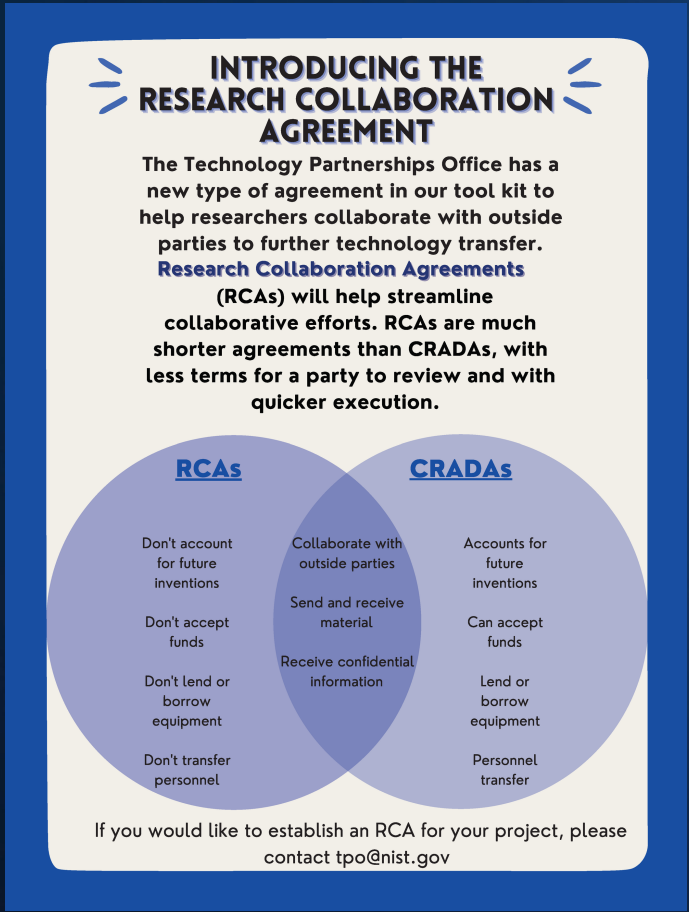


Figure courtesy of Adam Brandt

NIST mechanisms



- Collaboration agreement at NIST (there are two types)
- Permits research between NIST and companies, universities, state/local governments, other Federal labs, and non-profit organizations
- Allows for confidential info

- Host data and working information while analysis is underway (this include hosting calls and meetings if desired)
- Assist as needed while papers are being written with results
- When papers are published, transfer final dataset to the intercomparison portal as US GHG Center
- Can invite new groups to participate in this and future intercomparisons

The concept of an enhanced transparency portal

- Public repository for all remote-sensing data providers able to contribute some or all of the following
  - Algorithm Theoretical Basis Documents (for L1 – L4 product generation)
  - Calibration/Validation documentation
  - Relevant journal papers
  - Quality Control Protocols – for both detection and quantification
  - Exemplar/benchmark data sets to allow science community to reproduce results
    - Representative Leve1-L4 data sets
    - Independent observations once published (e.g., controlled release test results, surface site monitoring)
- Documents that come from the consensus standards workshops
- We have the starting steps, need to add material and increase engagement with other data providers

Where to host this info?

- US GHG Center is an easy option for hosting the enhanced transparency portal
- We are starting to explore the possibilities with the team

In Summary

- Methane plume observations are valuable in a multi-tiered observing system, but there is a lot of variation in results
- We need to build trust and reliability in this data
- NIST is coordinating activities to
  - Create documentary standards
  - Facilitate intercomparison activities
  - Support the community through coordination of controlled release info
  - Develop and enhanced transparency portal to host documentation and example data

Thank you!