Improved Trace Gas Plume Detection using Indian and US AVIRIS-NG Data

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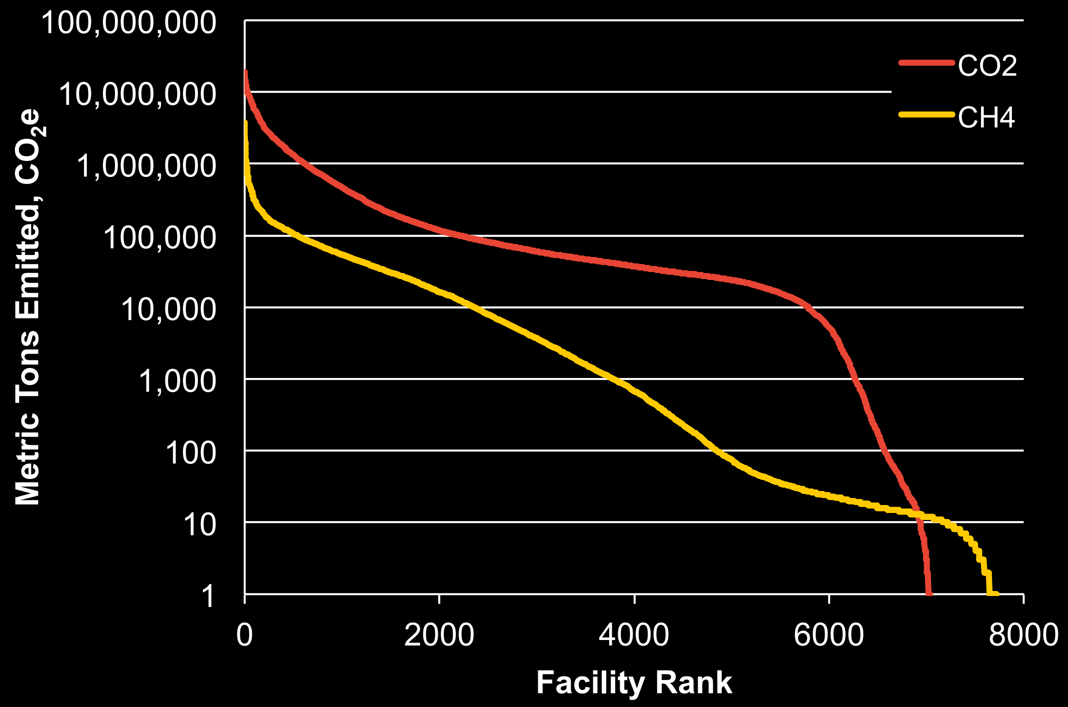
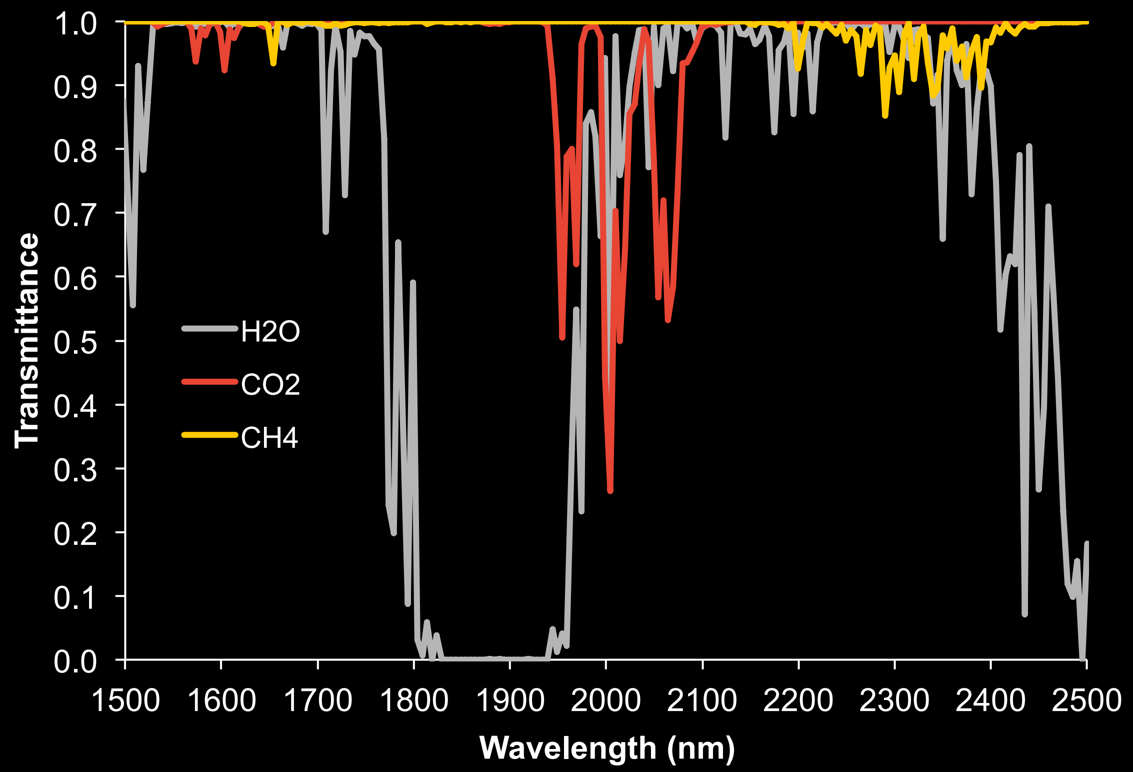
BACKGROUND

- CO_2 and CH_4 are critical greenhouse gases
- Point sources are important targets for reducing anthropogenic emissions
- A small number of facilities are responsible for a large percentage of point source greenhouse gas emissions
  - Only 1.5% of facilities emit ~33% of US point source emissions



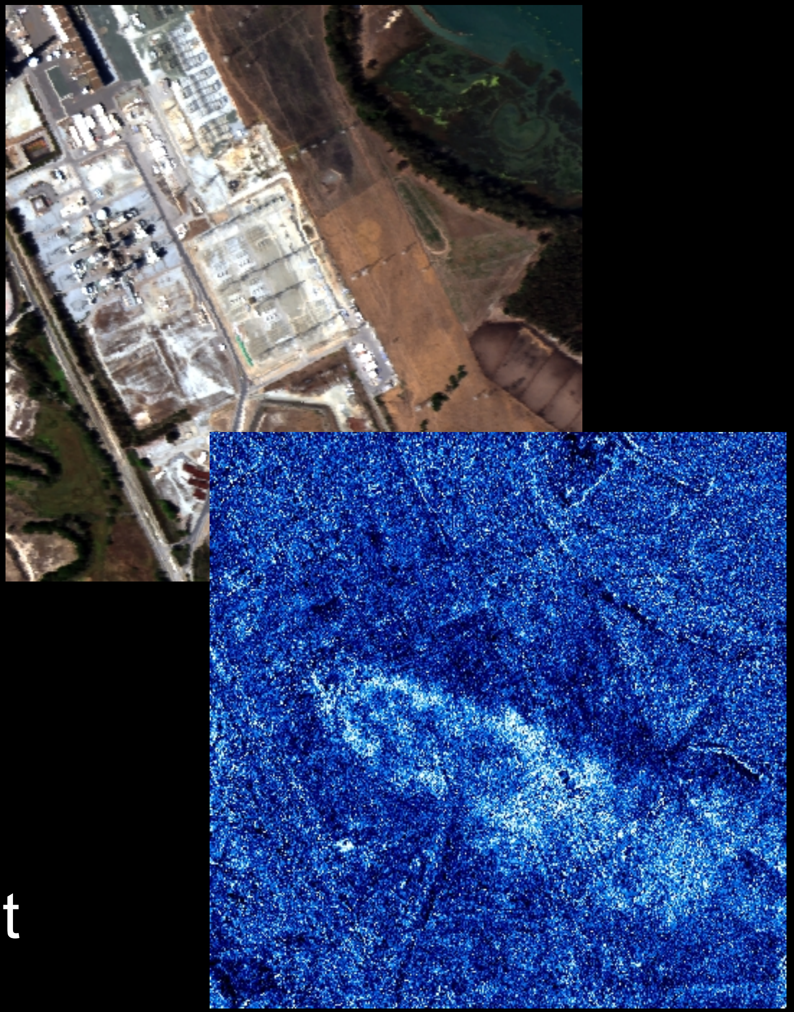
US point source emissions, EPA FLIGHT database

- CO_2 and CH_4 have key absorption features in the shortwave infrared
- The strength of these absorptions in AVIRIS-NG radiance data can be used to detect and measure trace gas plumes



PREVIOUS EFFORTS

- Matched filter plume detection
  - Fast, simple, but prone to false positives
  - JPL real-time CH_4 detection algorithm (Thompson et al., 2015)
- Concentration retrieval
  - Iterative estimate of mixing ratio-length using multiple atmospheric layers
  - Computationally intensive
  - IMAP-DOAS (Frankenberg et al., 2005)
- These methods typically do not take into account the spatial structure of the plume or background reflectance
- We aim to develop a fast trace gas detection method that also takes into account spatial structure



Matched filter detection of CO_2 plume from power plant (Dennison et al., 2013)

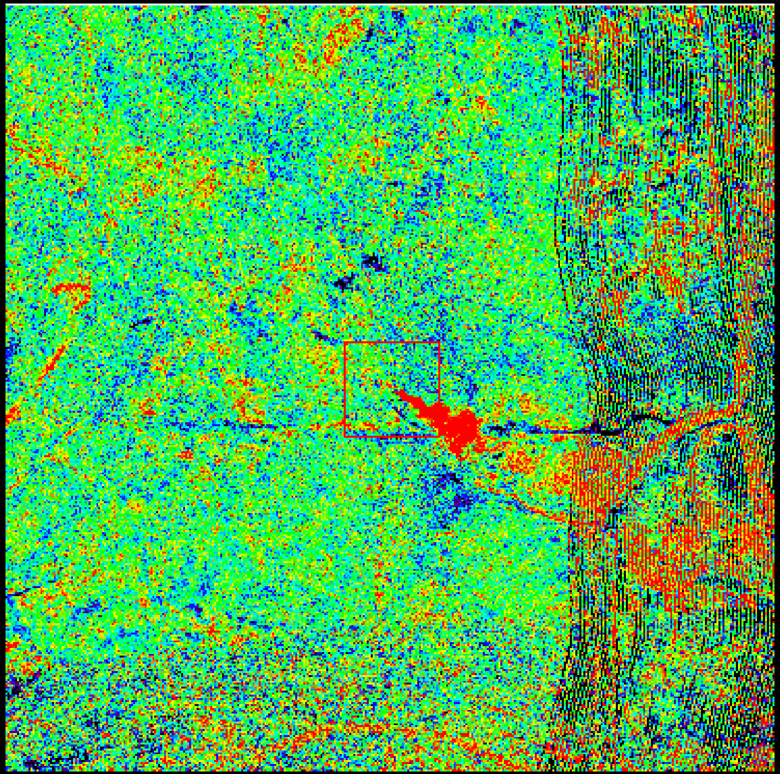
PROJECT GOALS

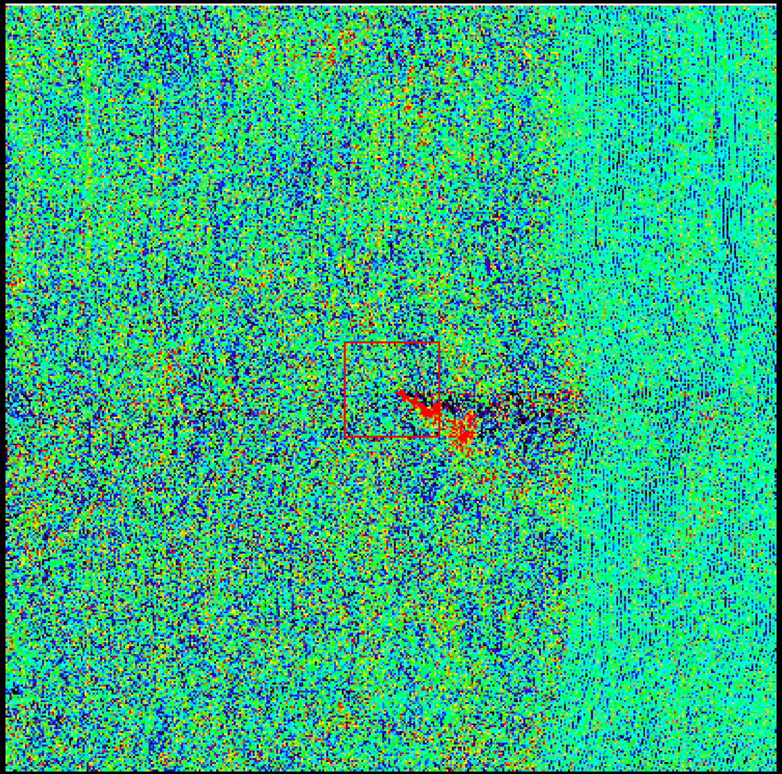
1. Develop new iterative plume detection algorithms based on maximum a posteriori (MAP) parametric estimation and Markov random field modeling
2. Compare the apparent strength and spatial characteristics of CH_4 and CO_2 plumes detected in India and US AVIRIS-NG data
3. Catalyze further algorithm improvements through the creation of a “benchmark” dataset with the best AVIRIS-NG plume examples from the US and India

MAXIMUM A POSTERIORI (MAP) ESTIMATION

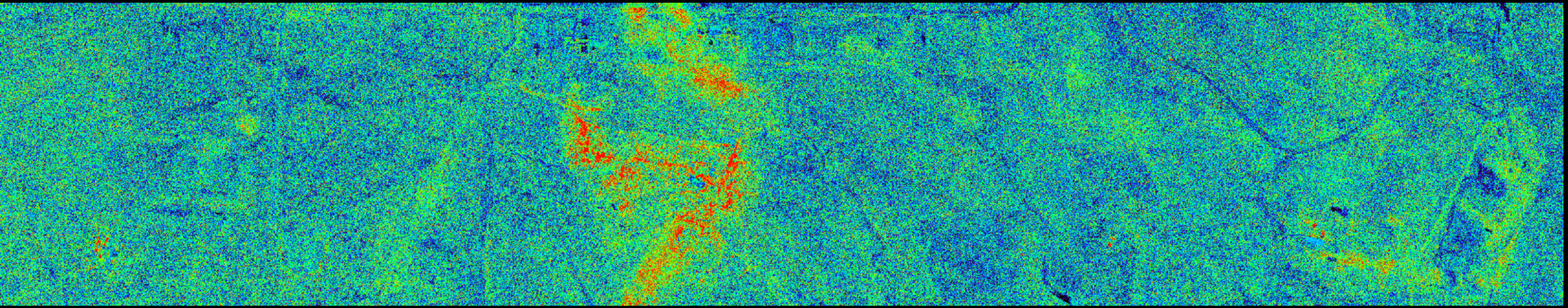
- Bayesian equivalent of a maximum likelihood estimate
- Prior distribution is based on mixing ratio length and spatial correlation
- Likelihood function is optimized using a iterative process to find the optimum mixing ratio length
- Algorithm is easily parallelized and can be implemented on GPU


True color composite, “Four Corners” US AVIRIS-NG data

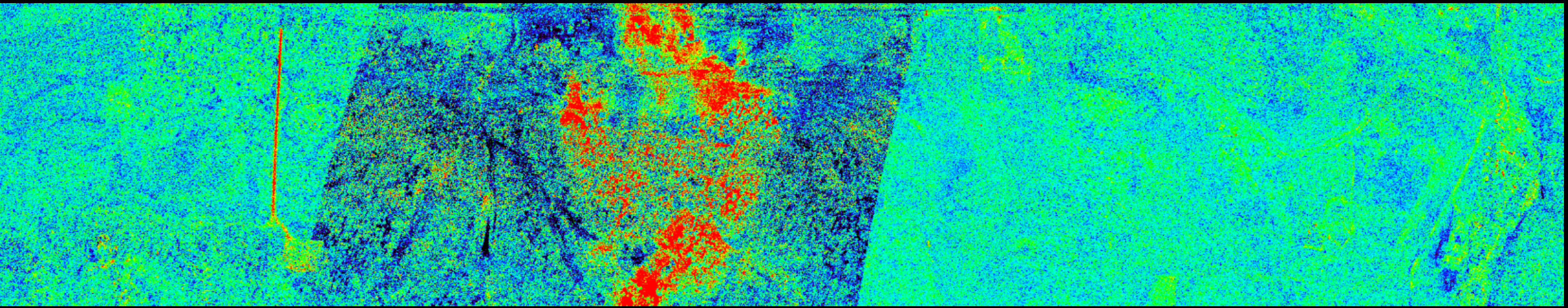

JPL real-time algorithm results


Experimental algorithm: maximum likelihood estimate + weighted covariance matrix (non-iterative)

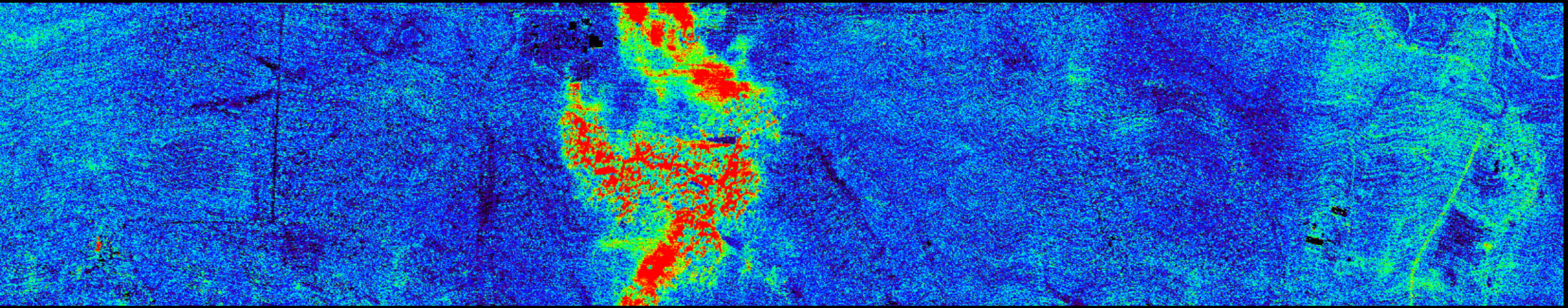
Four Corners
AVIRIS –NG image



Cluster-tuned matched filter



Thompson et al. 2015 real-time mixing ratio length matched filter



IMAP detection algorithm

“Indian Strategic Petroleum Reserve”