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

Philip Dennison & Sarang Joshi, University of Utah
Andrew Thorpe & David R. Thompson, NASA Jet Propulsion Lab
Suyash Awate & Parth Kothari, Indian Institute of Technology Bombay
BACKGROUND

- CO₂ and CH₄ 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
- CO₂ and CH₄ 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

**US point source emissions, EPA FLIGHT database**
PREVIOUS EFFORTS

• Matched filter plume detection
  • Fast, simple, but prone to false positives
  • JPL real-time CH₄ 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
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 an 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)
“Indian Strategic Petroleum Reserve”