Plume Mapping in Four Corners

AVIRIS-NG & HyTES teams
JPL/Caltech, University of Michigan, NOAA, CIRES

Special thanks to David Thompson, Andrew Thorpe
Outline

• Little methane intro

• Introduction into JPL airborne spectrometers capable of methane detection

• The 4-Corners methane background in a nutshell

• The April 2015 airborne flight campaign
Why is methane important (and interesting)?

Figure 8.15 | Bar chart for RF (hatched) and ERF (solid) for the period 1750–2011, where the total ERF is derived from Figure 8.16. Uncertainties (5 to 95% confidence range) are given for RF (dotted lines) and ERF (solid lines).
Recent changes in atmospheric methane
A controlled release experiment in Wyoming
RMOTC — Rocky Mountain Oilfield Testing Center

100's of Parallel Spectrometers

Calibrated Image Cube

Ecosystem Species Map

Detector Array

Spectrometer

Slit

Telescope

Reflectance

Wavelength (nm)

Nitrogen & Chemistry

Leaf Water & Cellular Scattering

Chlorophyll & Ancillary Pigments

Cellulose: Lignin, Sugars

Grassland

Dryland Vegetation

non-Photosynthetic

Conifer

Broadleaf

Santa Barbara

Pacific Ocean 1km

Adenostoma fasciculatum

Quercus agrifolia

Ceanothus megacarpus

Grass

Arctostaphylos spp

Soil
Mapping Methane — AVIRIS-NG

Plume is color-coded

Background is False Color image (similar to how your eye would perceive it)
Global Methane and a look into 4 Corners?
How it all got started

SCIAMACHY Methane Anomalies

Frankenberg et al, JGR, 2011

2003-2008 average, SCIAMACHY CH$_4$ xVMR (ppb)

1690. 1700. 1710. 1720. 1730. 1740. 1750. 1760. 1770. 1780. 1790.

How it all got started | SCIAMACHY Methane Anomalies
How it all got started

SCIAMACHY Methane Anomalies

Kort, Frankenberg et al, GRL, 2014
Kort, Frankenberg et al, GRL, 2014

SCIAMACHY Methane Anomalies

—> Estimated to be about 0.5Tg/yr, almost 10% of US total Oil&Gas

How it all got started  |  SCIAMACHY Methane Anomalies
Potential Sources of CH$_4$ in Four Corners Region

- Total Production rate in San Juan Basin about 1000 billion cubic feet (20Tg/yr)
- 0.5Tg/yr would be about 2.5%
- Largest Coalbed methane production area in US
Potential Sources of CH₄ in Four Corners Region

- Coal bed methane (CBM)
- Tight Sandstone natural gas production
- Active Coal mining
- Geological seeps
- Large Power plants
- Oil production
- Emissions from agricultural sources, waste management facilities and wetlands are small
Campaign Area
Some pictures from the aircraft
Airborne operations

AVIRIS-NG real time methane detection

Real-Time CH$_4$ display

Don’t ask

David Thompson JPL
Native resolution examples
(background is 2.3µm radiance in gray, meter axis)
>200 plumes detected during campaign
Plume distribution — Pareto’s law
Plume distribution — Wellhead
Plume distribution — ???
Methane plume
Plume distribution
Plume distribution — underground storage tank
Methane plume from tank
Plume distribution - Wellhead
Plume distribution — Gusses welcome
Plume distribution — Unclear (multiple sources, maybe well completion?)
Plume distribution —
Gas Processing Facility (temporary plume)
What does the log-normal distribution imply?
Further sources (unknown origin at the time of publication)

Another pipeline (3rd)

Natural Seep
Overall Findings

• We observed more than 200 methane plumes, most of which could be associated with industrial activities (some natural seeps were seen as well)

• Flux rates follow a distribution that implies that the 20% top emitters explain 70-75% of the overall flux

• Estimate of 0.3Tg/yr is not much smaller than total flux estimates, observed plumes explain a large share of area total

• 2 Pipeline leaks were detected and fixed the day after we found them