San Juan Basin
2015 Ground and Aircraft Data Analysis

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San Juan Basin Methane
“Largest CH$_4$ Regional Anomaly in US”
[Kort et al., 2014]

- 7 year average of satellite retrieval [Frankenberg et al., 2011]
  ➔ to improve signal to noise ratio
- 10 am satellite overpass
  ➔ morning atmospheric conditions

Map is a **mozaic of** regional anomalies

➔ different baseline for each tile
Focus of 2015 Campaign was on better understanding San Juan Basin methane pollution

SJB Methane Hotspot:
- a persistent and significantly higher methane pollution over portion of the San Juan Basin at 10 am compared to its close surroundings

Plain English definition
What causes a pollution hotspot?

1. **Sources**
   - Gas and oil operations
   - Seepage at coal outcrop
   - Cows, landfills
   - Coal mining

2. **Topography**
   - Image of a bathtub shape indicating trapping

3. **Meteorology**
   - Image of a person holding a branch, symbolizing wind or air flow

Local emissions of pollutants get trapped by local meteorology (Temp. inversion, low winds) and high surrounding topography leading to pollutant accumulation.

Ex: Mexico City, LA Basin, Salt Lake City, Uinta Basin, Green River Basin

4C 2nd Methane Science Forum - Gabrielle Petron
2015 and 2016 Field campaigns

- April 2015: Coordinated CH₄ Hotspot Study
  - Airborne (4 airplanes) and Ground measurements
  - Quantification of CH₄ emissions: facility and basin scale

Funding: NOAA CPO, NASA, BLM, NSF AWG

Work with Tribal, State, Federal land and air authorities
Campaign Research Guidelines

• How elevated is methane throughout the region?
  – Conduct in-situ calibrated measurements with vans and aircraft

• Where is elevated CH$_4$ coming from?
  – Locate CH$_4$ plumes, identify & quantify emission sources

• Why here?
  – Perfect storm: Emissions, Topography, Wind Patterns

• How persistent is elevated CH$_4$?
  – Conduct measurements at different times of day and study diurnal cycle in atmospheric dispersion

• What else is in the air?
  – Conduct measurements for suite of species with targeted air sampling in flasks and multiple species analysis
Talk Outline

**Ground Data Analysis**
ML In situ Methane and Flask Data and Wind Data from Profilers and long-term Surface Stations
- Survey Drives
- Targeted emission plume sampling

**Aircraft Data Analysis**
In situ Methane and Ethane
- 5 SA Survey Flights
HOW ELEVATED IS METHANE NEAR THE SURFACE THROUGHOUT THE REGION?
NOAA Mobile Lab Drives

14 drives on public roads or with arranged escort on Tribal Lands.

with Research Assistant Eryka Thorley.

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Nighttime or morning drives

• Show some area-wide elevated CH$_4$ at the surface and typically within the basin
April 28 with Mike King, Navajo EPA
Durango to SE Utah and back

- 7:45am Leaving Durango
- 8:20am Crossing border with NM
- 9:20am Leaving Farmington with Mike King, Navajo EPA

Note: Methane levels drop at W border of gas field
April 19 Durango-Shiprock
April 19, 2015 – morning hours show nighttime accumulation

- Mobile Lab track color-coded by in-situ methane mixing ratio measurements.
- Methane 100s ppb enhancements constrained to part of the basin
- Two brief CH₄ plumes encountered downwind of compressor station located south of Shiprock
Outcrop sampling drives

- Show some locally very elevated CH$_4$
- Show ethane and propane levels are variable in Durango and in Florida River area and are correlated.

Carbon Junction

near Los Pinos river, Rd 245
April 11th: outcrop at 2 locations

- Samples of Fruitland Coal outcrop seepage in Colorado from public roads.
- Thank you to LTE for sharing information on where seepage has been documented and where road access was not a problem.

Brief peaks near seeps at 4 to 12 ppm depending on location relati
April 12th: outcrop valley location

- Samples in outcrop in small valley near Los Pinos River
- Known seepage location (LTE)
- Elevated methane along the way and very high levels in valley, some peaks above 50 ppm.
- Several air samples were collected in outcrop plumes on both days and analyzed at NOAA GMD Boulder (red dots on bottom-left figure)
Targeted Sampling with NOAA GMD programmable flask system

Jon Kofler, Tower & Mobile Lab engineer

Perseus GC/MS, custom built by Dr. Ben Miller for analysis of > 50 species in flasks from network and campaigns

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April 11 & 12: Ethane background is variable but there is no ethane in outcrop gas

Main sampling locations:
behind Walmart, Durango and Florida River, Rd 234

Flask data is color-coded by sampling day and location.
Source sampling drives
Sampling of San Juan underground coal mine air shaft and landfill emissions

April 19, 2015 – S of Shiprock to Durango afternoon hours show background CH₄ level ~ 1.9ppm

Coal Mine emissions estimated at ~ 1.4 tonnes CH₄/hr by S. Conley.

ML near San Juan Power Plant, adjacent to coal mine
San Juan Coal Mine and Landfill samples

NOAA PFP MAGICC and Perseus Analysis:
- Coal emission plume (orange): 0.9% ethane to methane
- No ethane in landfill emission plume (green)
Surface Coal Mine

April 21 2015
with Michael King
No elevated CH₄ while driving on Navajo surface coal mine
April 21, 2015

- Several samples have elevated nonmethane hydrocarbons
- NMHC levels are correlated (same sources)
Plumes from well pads

April 16, 2015 Drive
Quick Answer: It depends on day, time of day and location

But

1. Mobile Lab detected many sources of CH$_4$
2. At night and in the morning CH$_4$ (and sometimes NMHC) can be significantly enhanced over large areas
Surface wind speeds typically are much lower at night/early morning in SJB

**SAMPLING THE NIGHT STAGNANT AIR**
Mean Diurnal Cycle of Horizontal Wind Speed at the Surface
Data from EPA AQS (SUIT, States, NFS, NPS)
Mean Diurnal Cycle of Horizontal Wind Direction
Mean April 2015
Data from EPA AQS (SUIT, States, NFS, NPS)
Wind Profiler Deployment:
2 NOAA radars and 1 Leosphere lidar

SUIT Ute 1 AQ monitoring site and Leosphere Windcube

NOAA 915 MHz Wind Profiling Radar at 2 sites: Navajo Lake and near Farmington (photo from another campaign in AR)