San Juan Basin
2015 Ground and Aircraft Data Analysis

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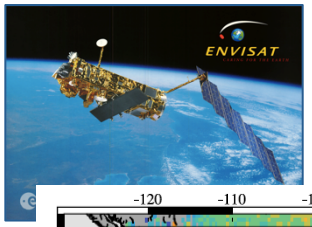
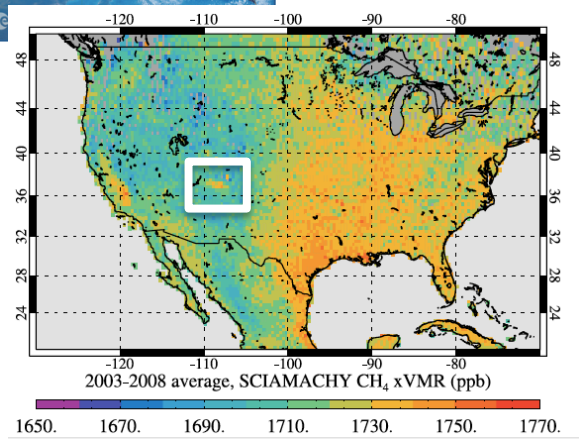
San Juan Basin Methane
"Largest CH_4 Regional Anomaly in US"
[Kort et al., 2014]



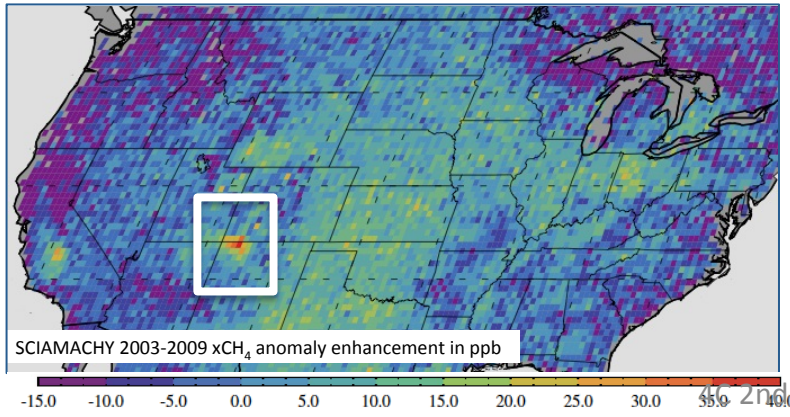


- 7 year average of satellite retrieval [Frankenberg et al., 2011]

➔ to improve signal to noise ratio

- 10 am satellite overpass

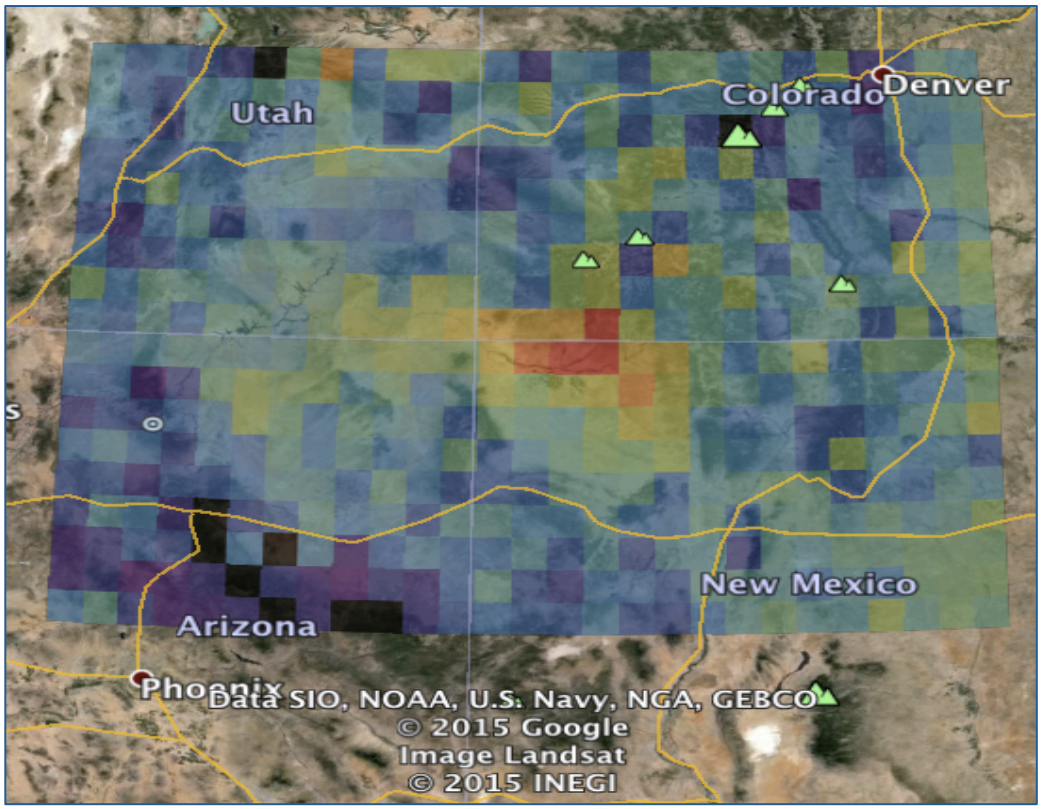
➔ morning atmospheric conditions



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



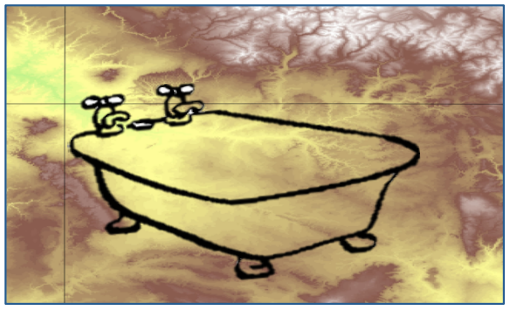
SJB Methane Hotspot :
a persistent and significantly higher methane pollution over portion of the San Juan Basin at 10 am compared to its close surroundings

Plain English definition

What causes a pollution hotspot?

1 Sources

2 Topography



3 Meteorology

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

2015 and 2016 Field campaigns

Funding: NOAA CPO, NASA, BLM, NSF AWG

- April 2015: Coordinated CH_4 Hotspot Study
  - NOAA, U. Colorado, U. Michigan, Scientific Aviation, NASA
  - Airborne (4 airplanes) and Ground measurements
  - Quantification of CH_4 emissions: facility and basin scale

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

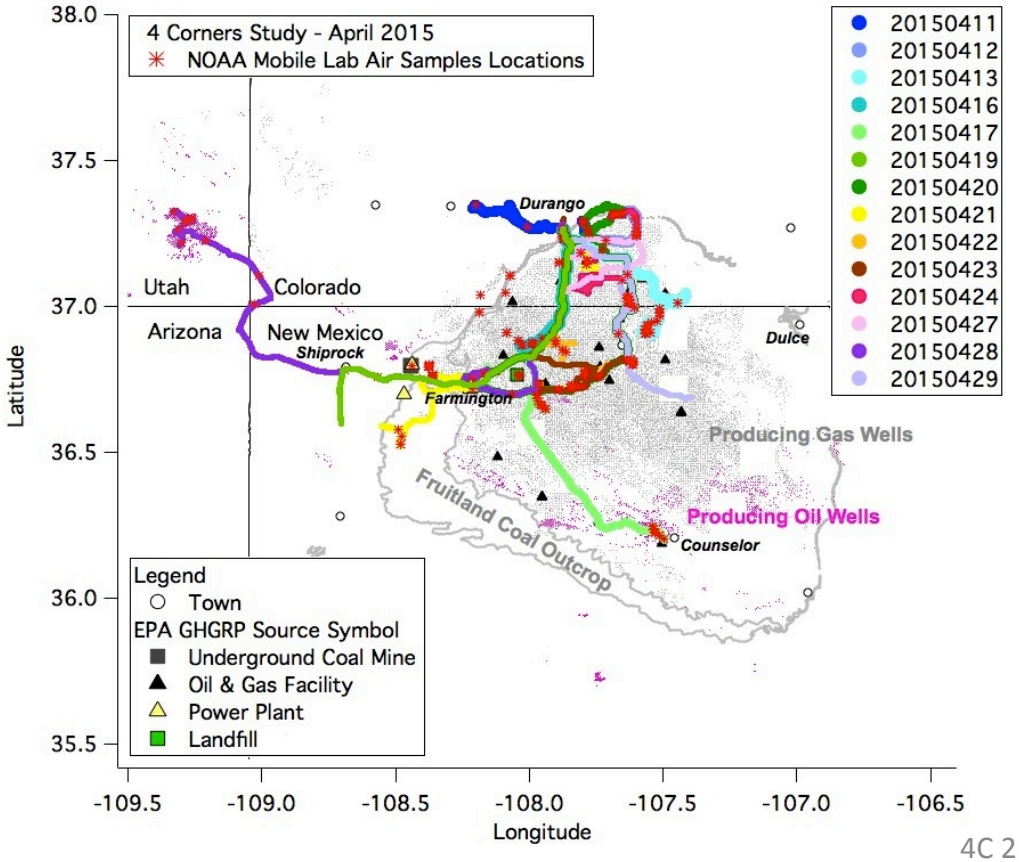
Aircraft Data Analysis

In situ Methane and Ethane

- 5 SA Survey Flights

HOW ELEVATED IS METHANE NEAR THE SURFACE THROUGHOUT THE REGION?

NOAA Mobile Lab Drives



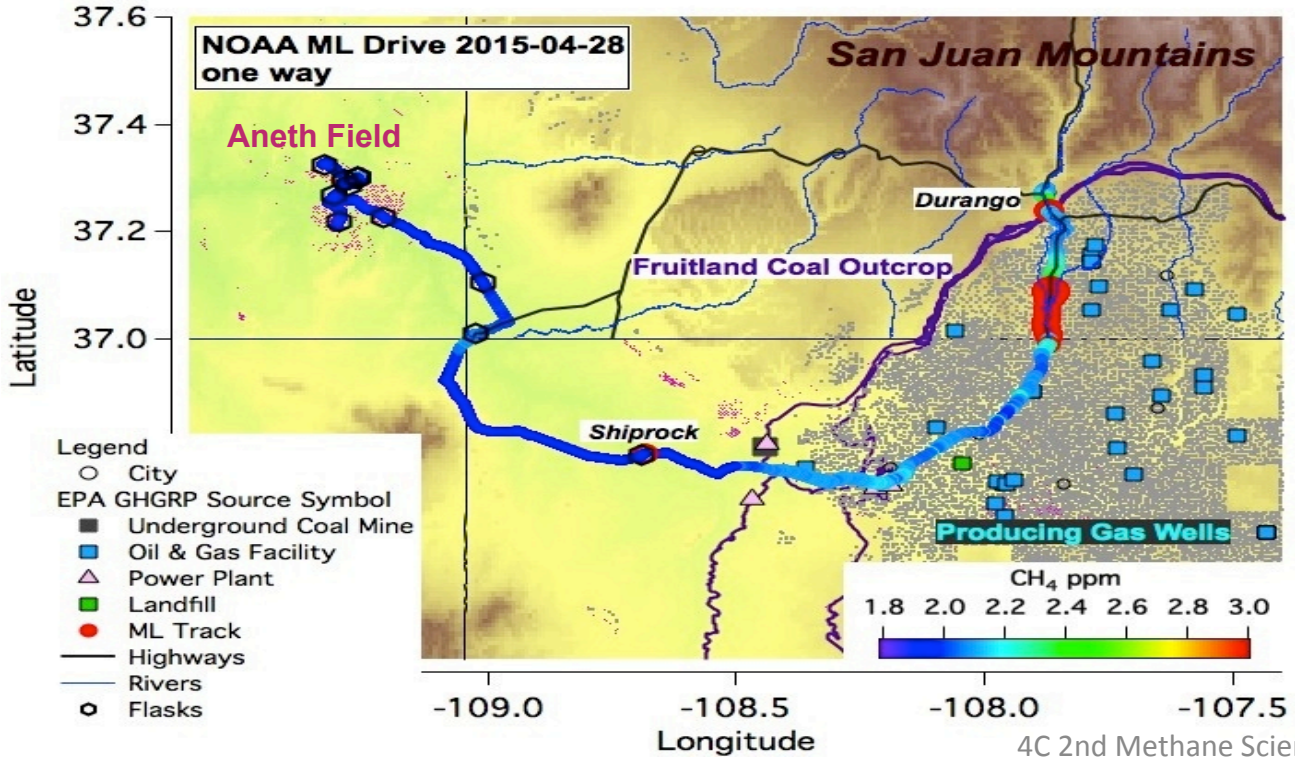
14 drives on public roads or with arranged escort on Tribal Lands.

with Research Assistant Eryka Thorley.

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

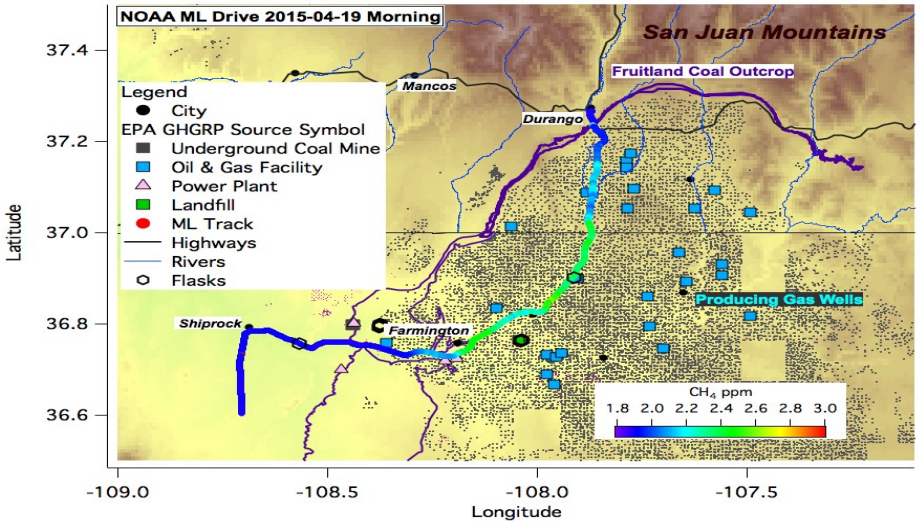


- 7:45am Leaving Durango
- 8:20am Crossing border with NM
- 9:20am Leaving Farmington with Mike King, Navajo EPA

Note: Methane levels drop at W border of gas field

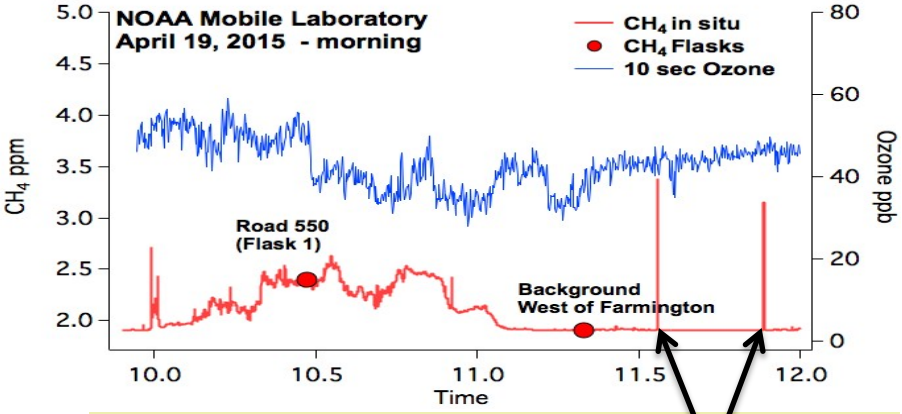
April 19 Durango-Shiprock

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

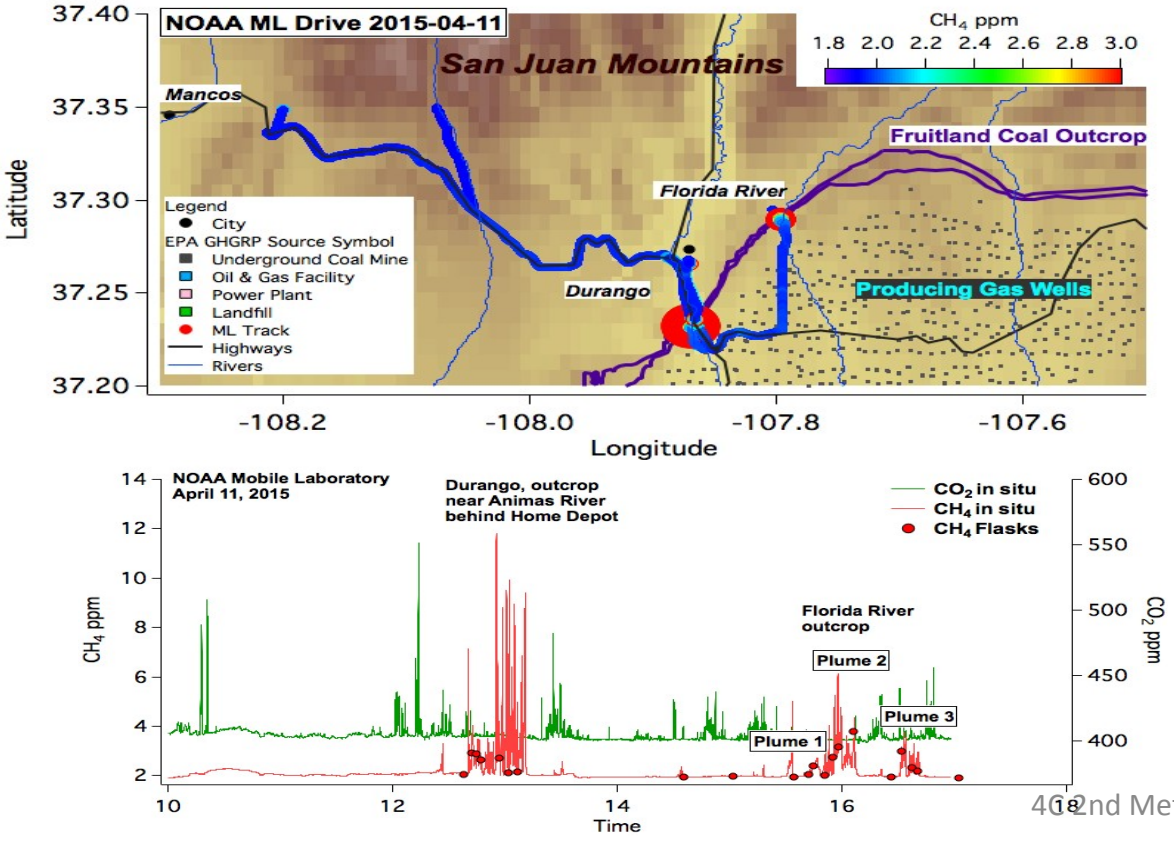


- Two brief CH_4 plumes encountered downwind of compressor station located south of Shiprock

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.

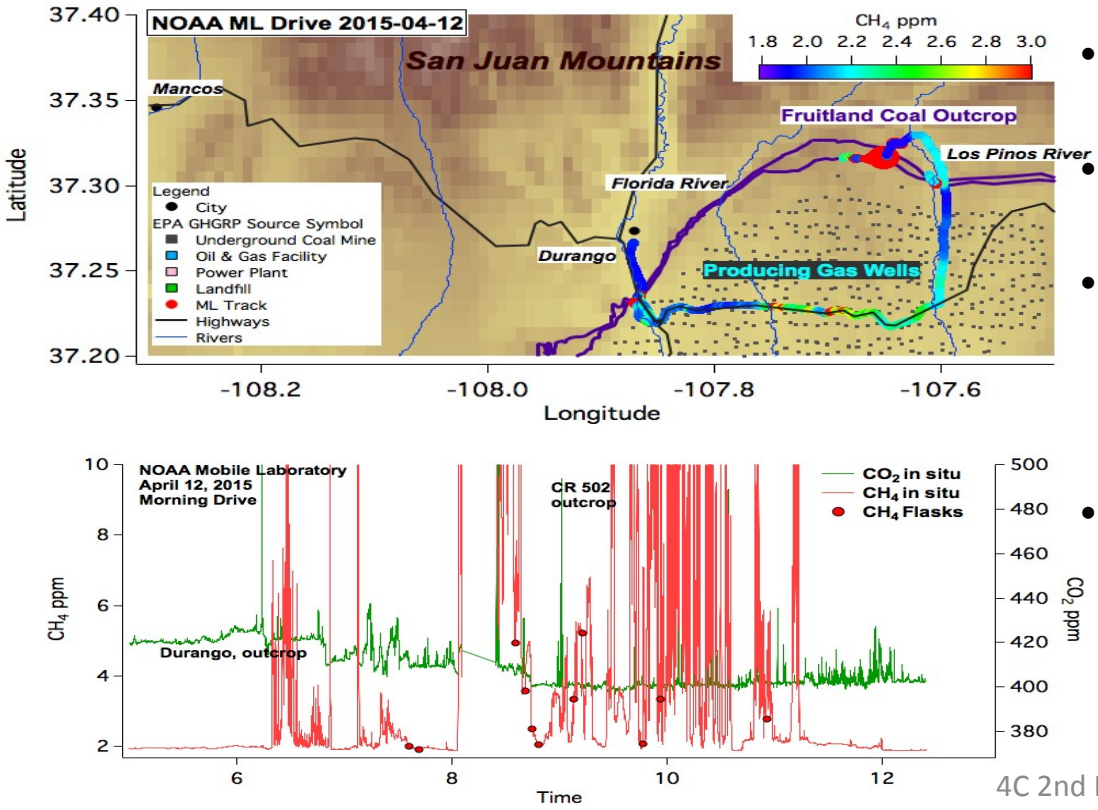
April 11th : outcrop at 2 locations



- 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

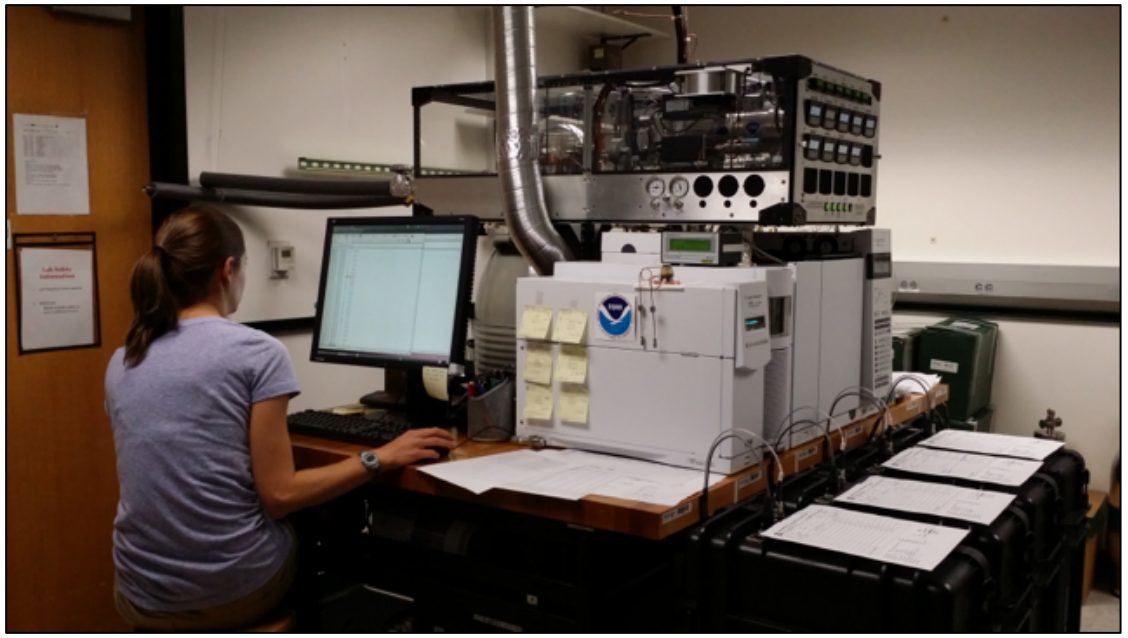
April 12th : outcrop valley location



- 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 progammable flask system

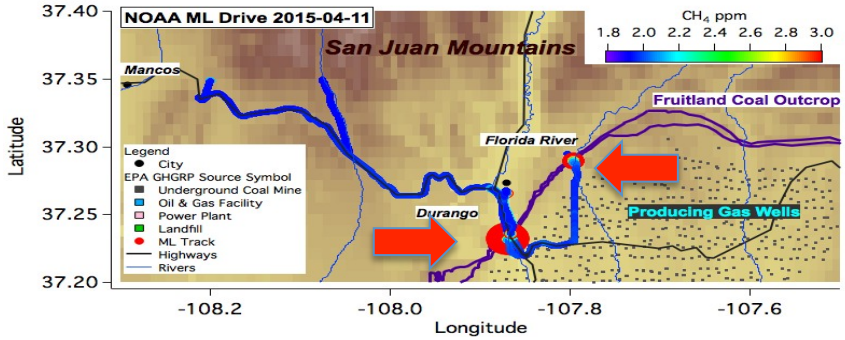
Jon Kofler,
Tower & Mobile Lab engineer



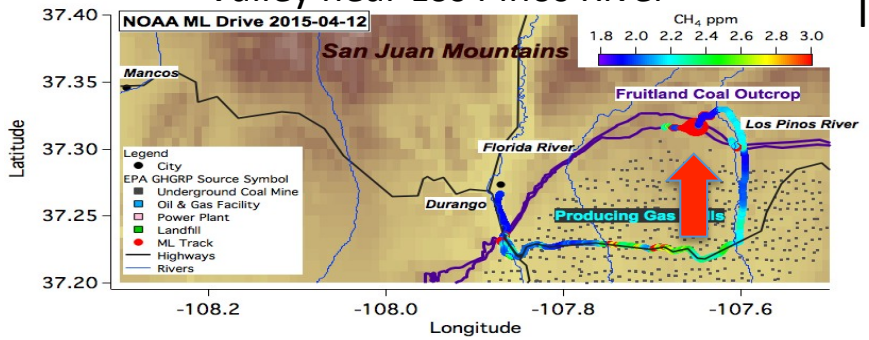
Perseus GC/MS, custom built by Dr. Ben Miller for analysis of > 50 species in flasks from network and campaigns

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

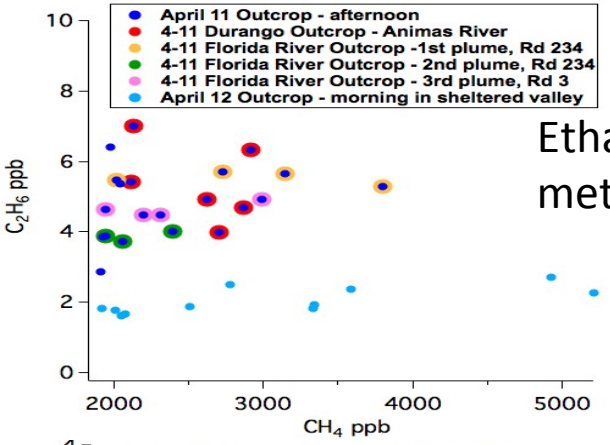
Main sampling locations:
behind Walmart, Durango and Florida River, Rd 234



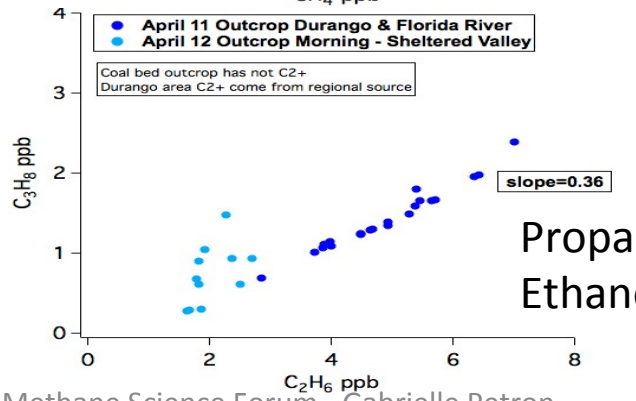
Valley near Los Pinos River



Flask data is color-coded by sampling day and location.



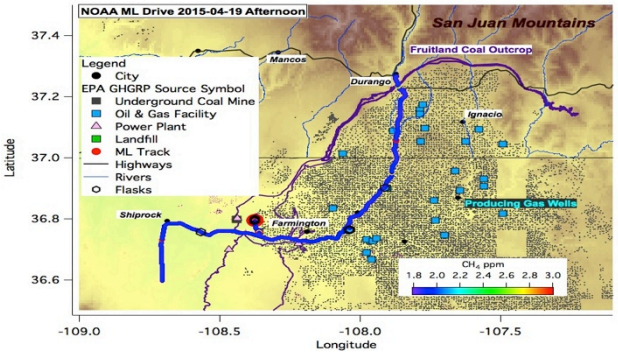
Ethane to methane



Propane to Ethane

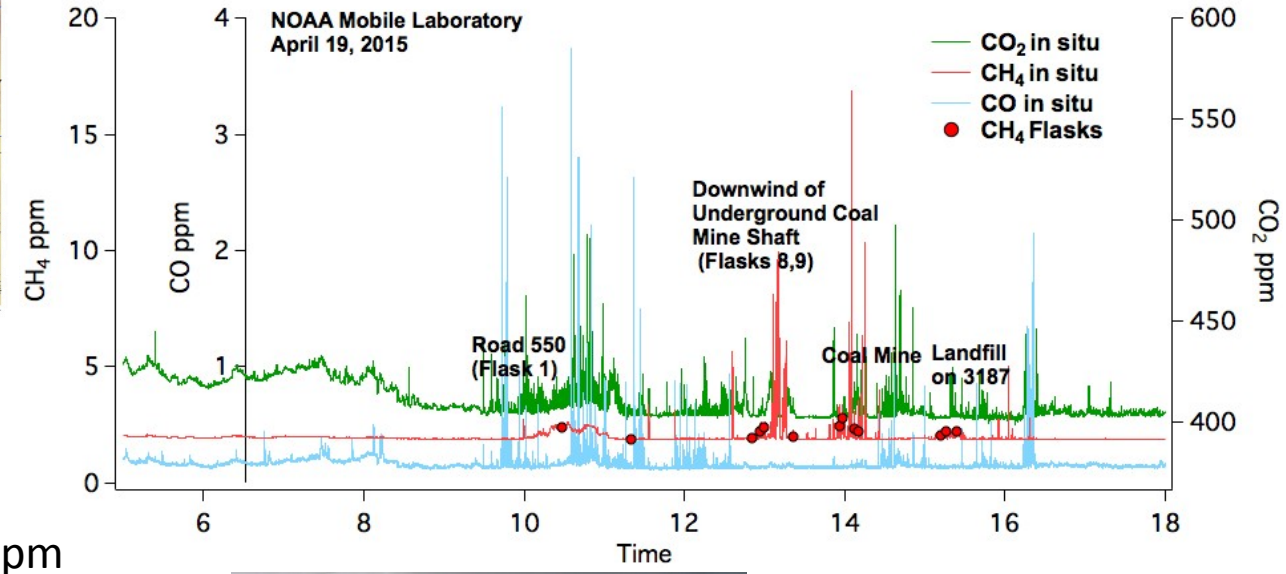
Source sampling drives

Sampling of San Juan underground coal mine air shaft and landfill emissions



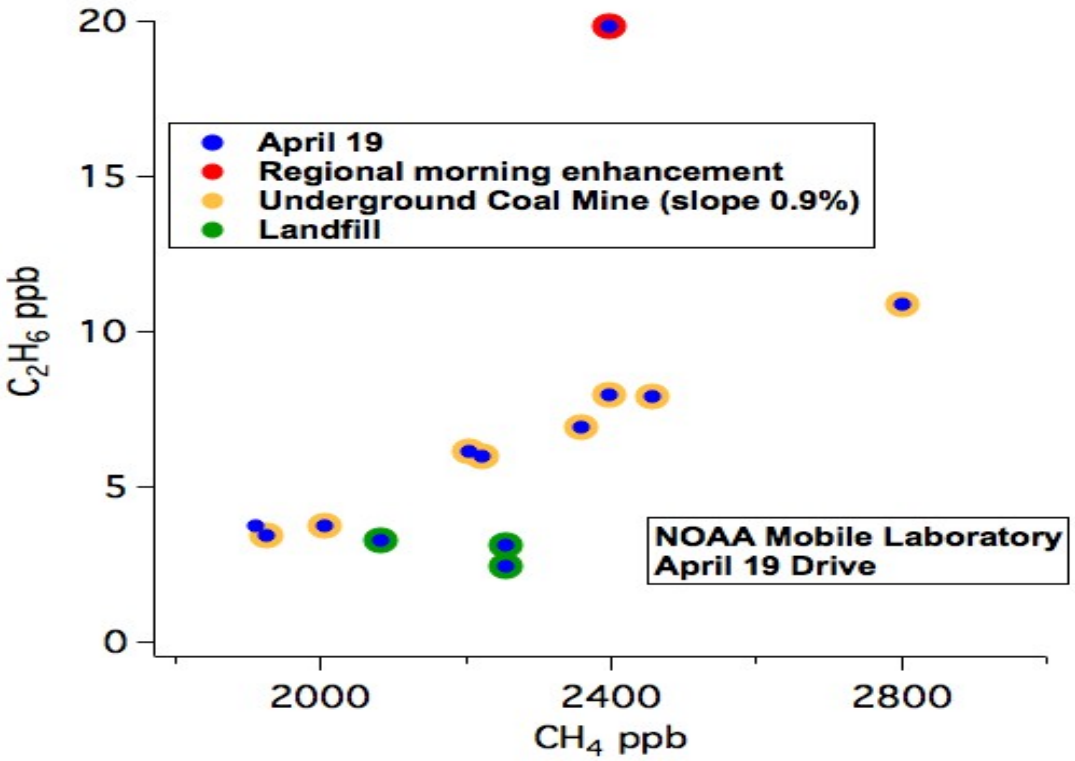
April 19, 2015 –
S of Shiprock to Durango afternoon hours show background CH_4 level ~ 1.9ppm

Coal Mine emissions estimated at ~ 1.4 tonnes CH_4/hr by S. Conley.



ML near San Juan Power Plant, adjacent to coal mine

San Juan Coal Mine and Landfill samples

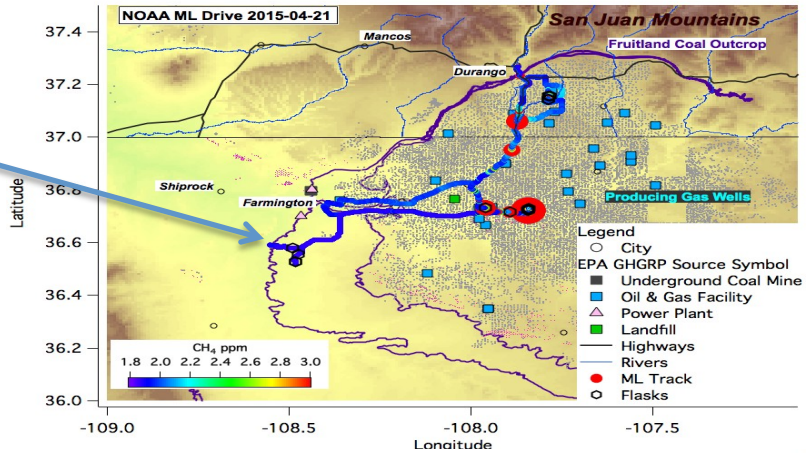


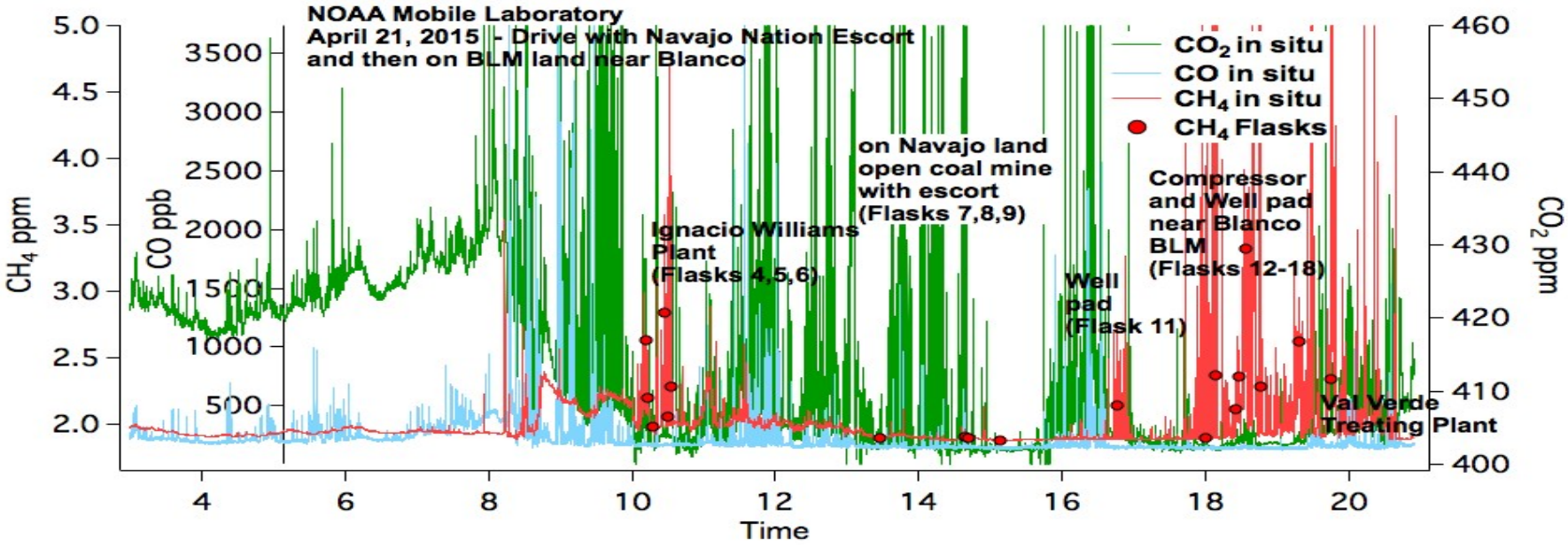
NOAA PFP MAGICC and Perseus Analysis:

- Coal emission plume (orange): 0.9% ethane to methane
- No ethane in landfill emission plume (green)

Surface Coal Mine

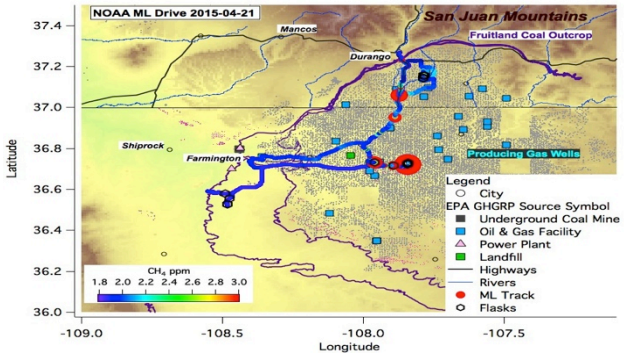
April 21 2015
with Michael King
No elevated CH_4 while driving on Navajo surface coal mine

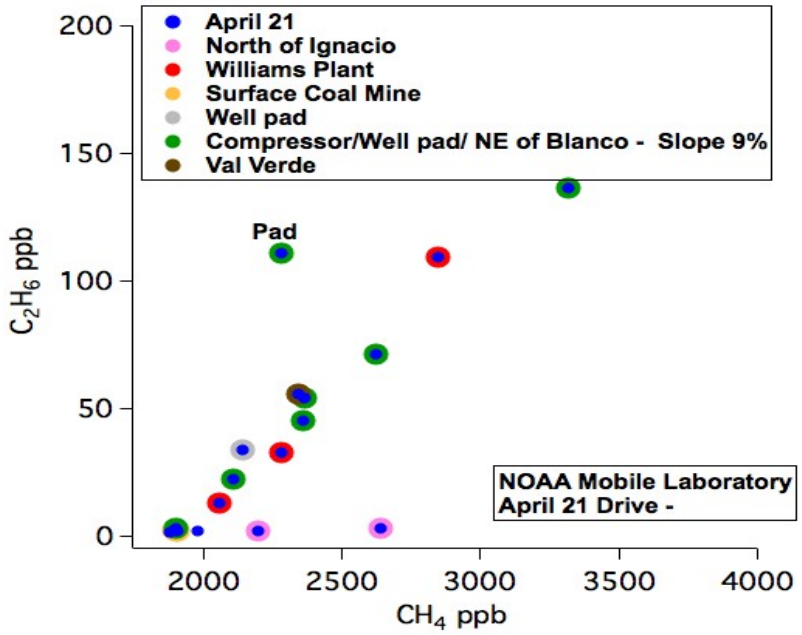


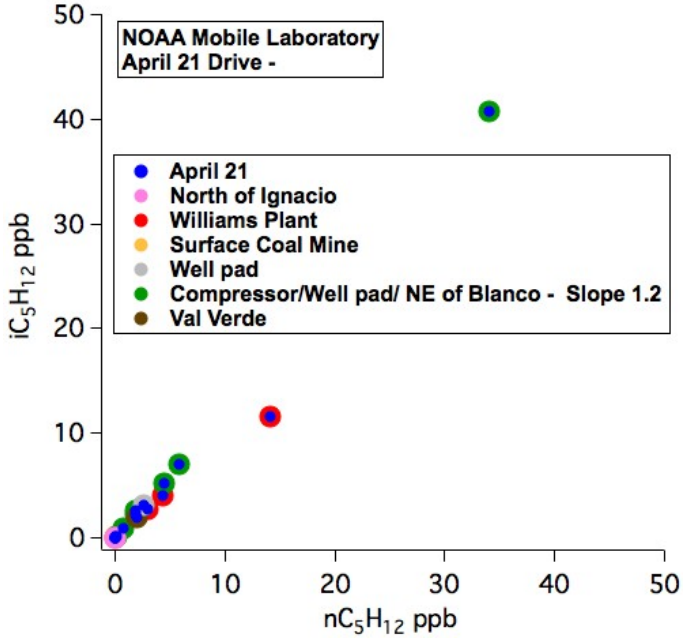


April 21, 2015

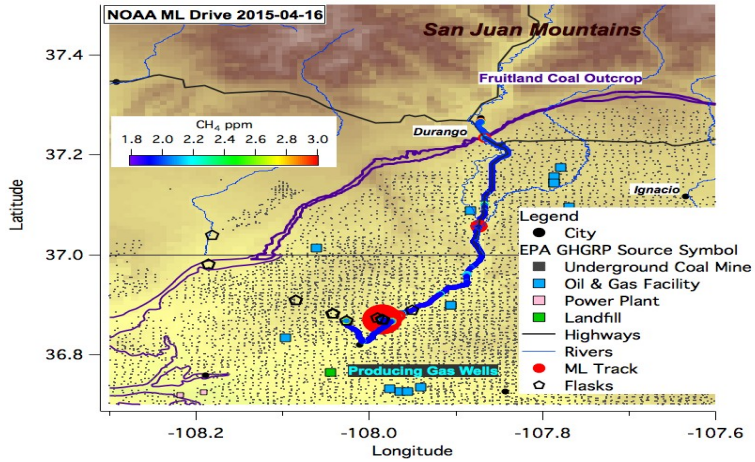
- Several samples have elevated nonmethane hydrocarbons
- NMHC levels are correlated (same sources)



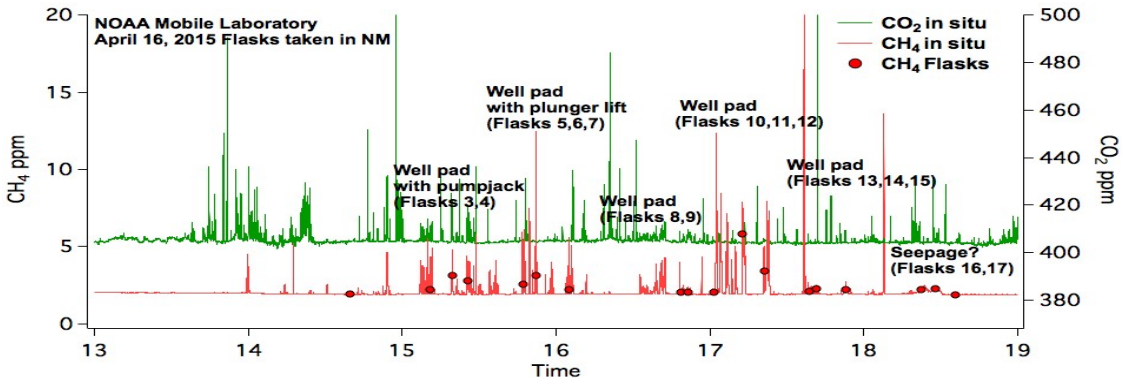


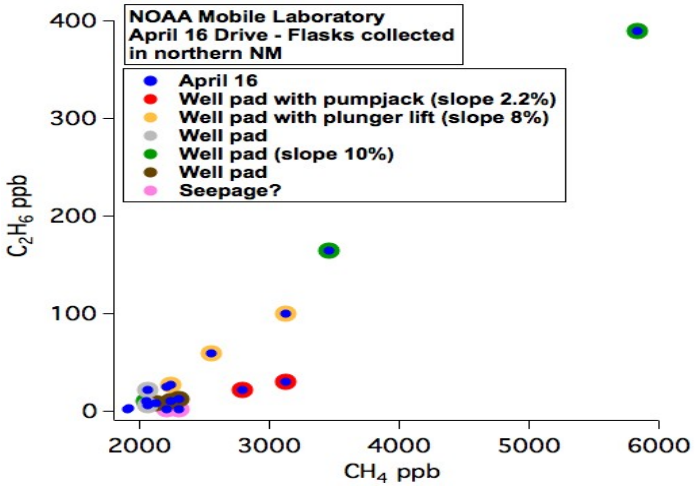


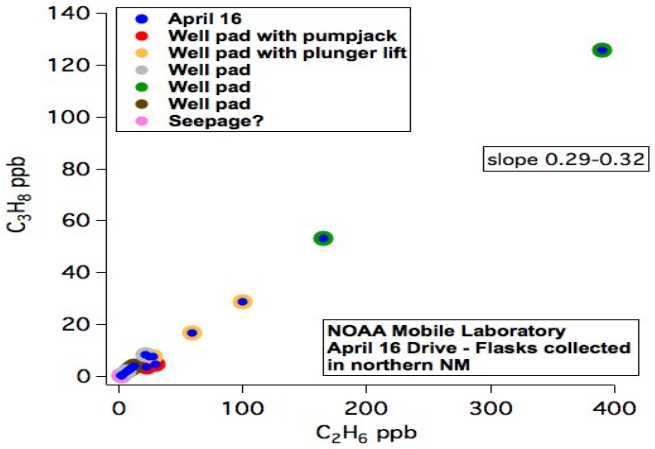
Plumes from well pads



April 16, 2015 Drive







How elevated is methane NEAR the SURFACE throughout the region?

Quick Answer: It depends on day, time of day and location

But

1. Mobile Lab detected many sources of CH_4

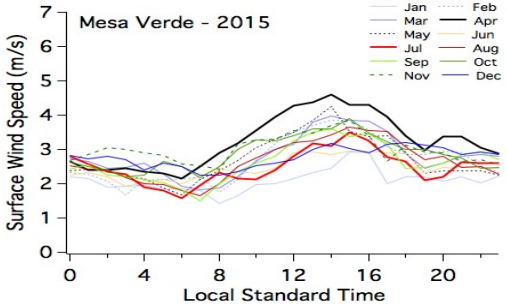
2. At night and in the morning CH_4 (and sometimes NMHC) can be significantly enhanced over large areas

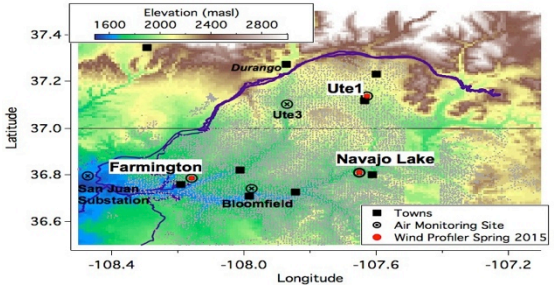
Surface wind speeds typically are much lower at night/early morning in SJB

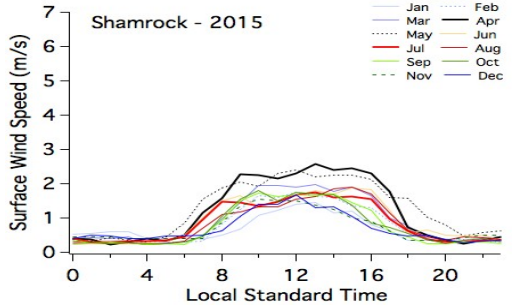
SAMPLING THE NIGHT STAGNANT AIR

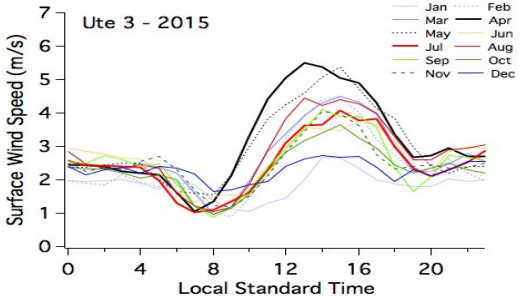
Mean Diurnal Cycle of Horizontal Wind Speed at the Surface

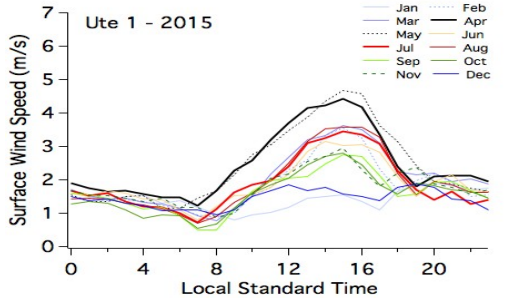
Data from EPA AQS (SUIT, States, NFS, NPS)

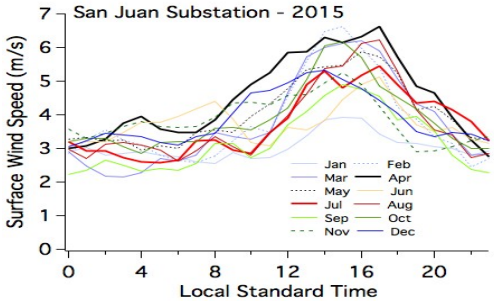


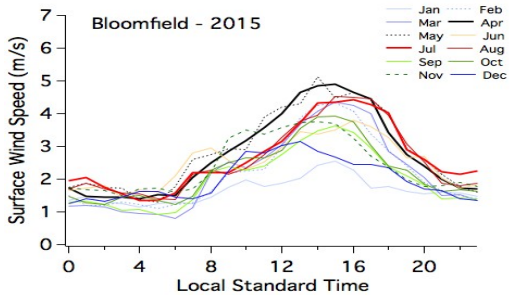


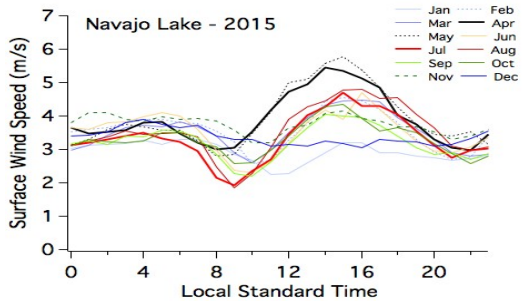


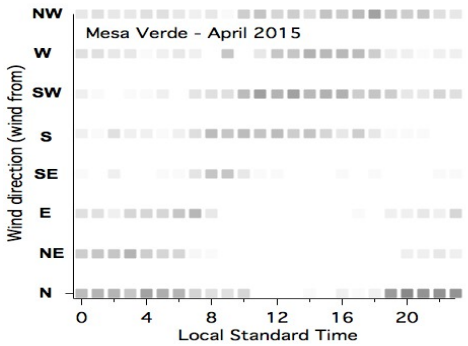


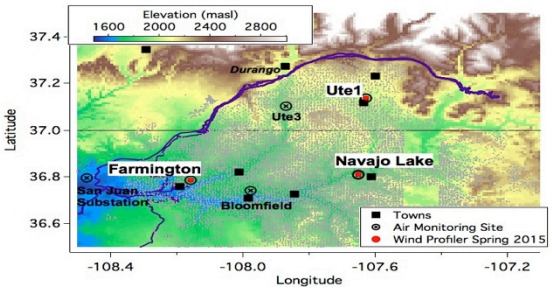


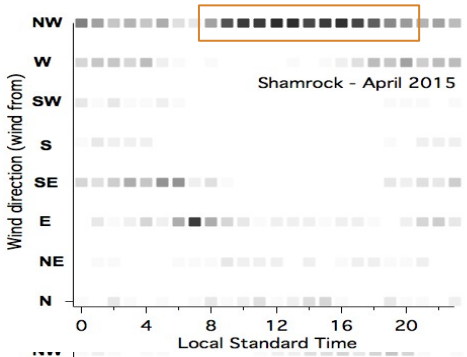






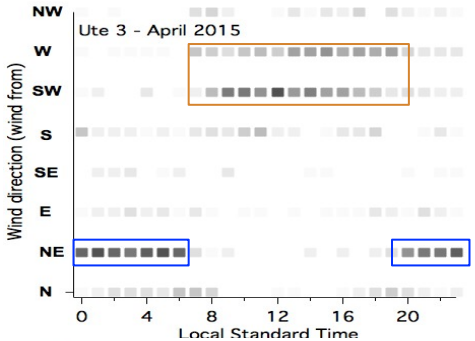


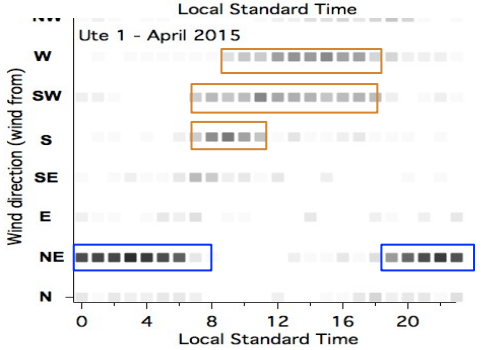


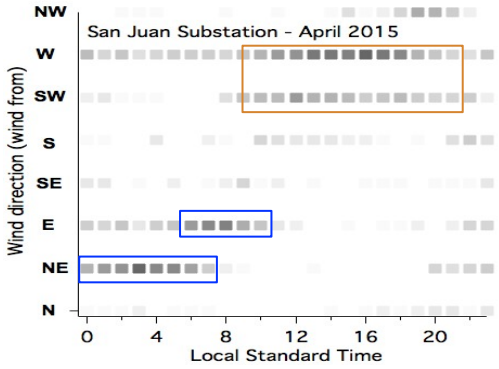


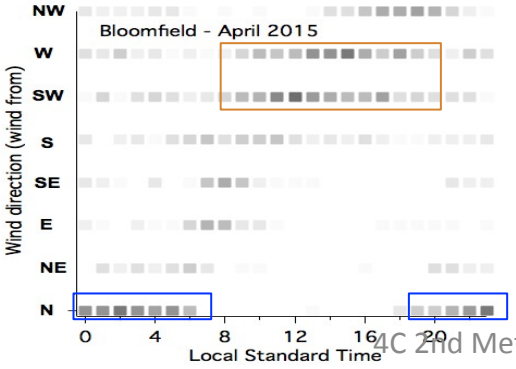
Mean Diurnal Cycle of Horizontal Wind Direction Mean April 2015

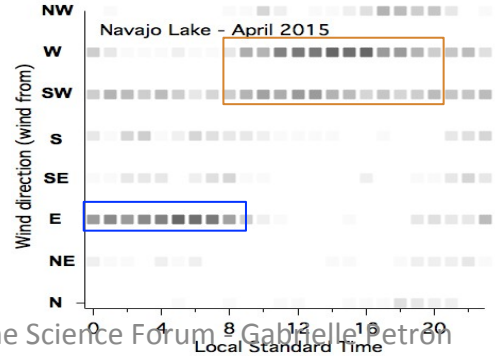
Data from EPA AQS (SUIT, States, NFS, NPS)



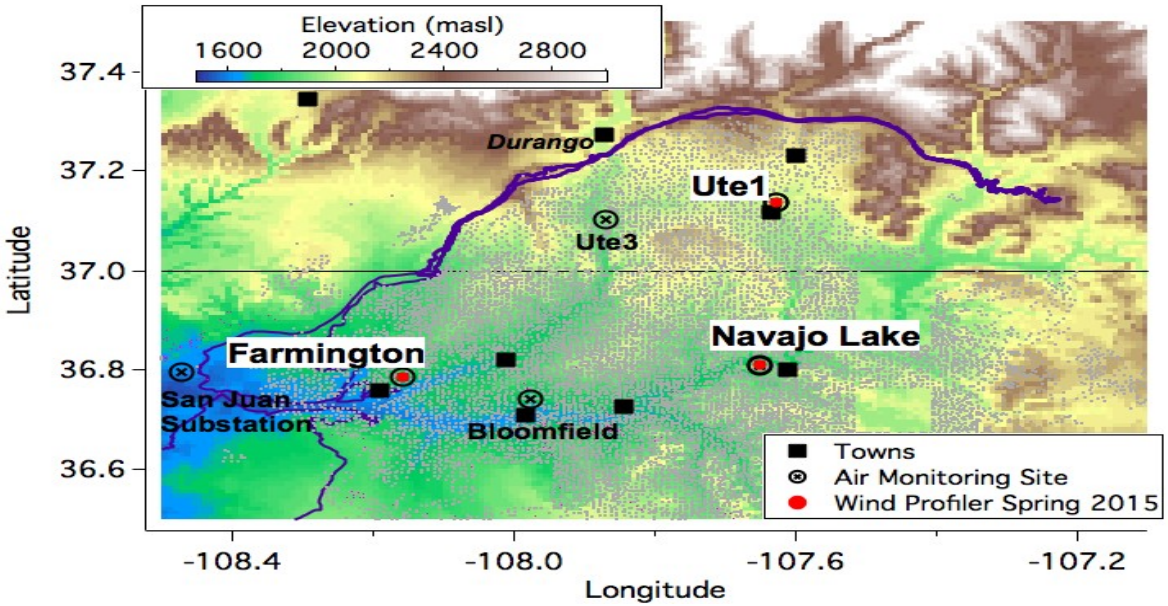








Wind Profiler Deployment:
2 NOAA radars and 1 Leosphere lidar



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)