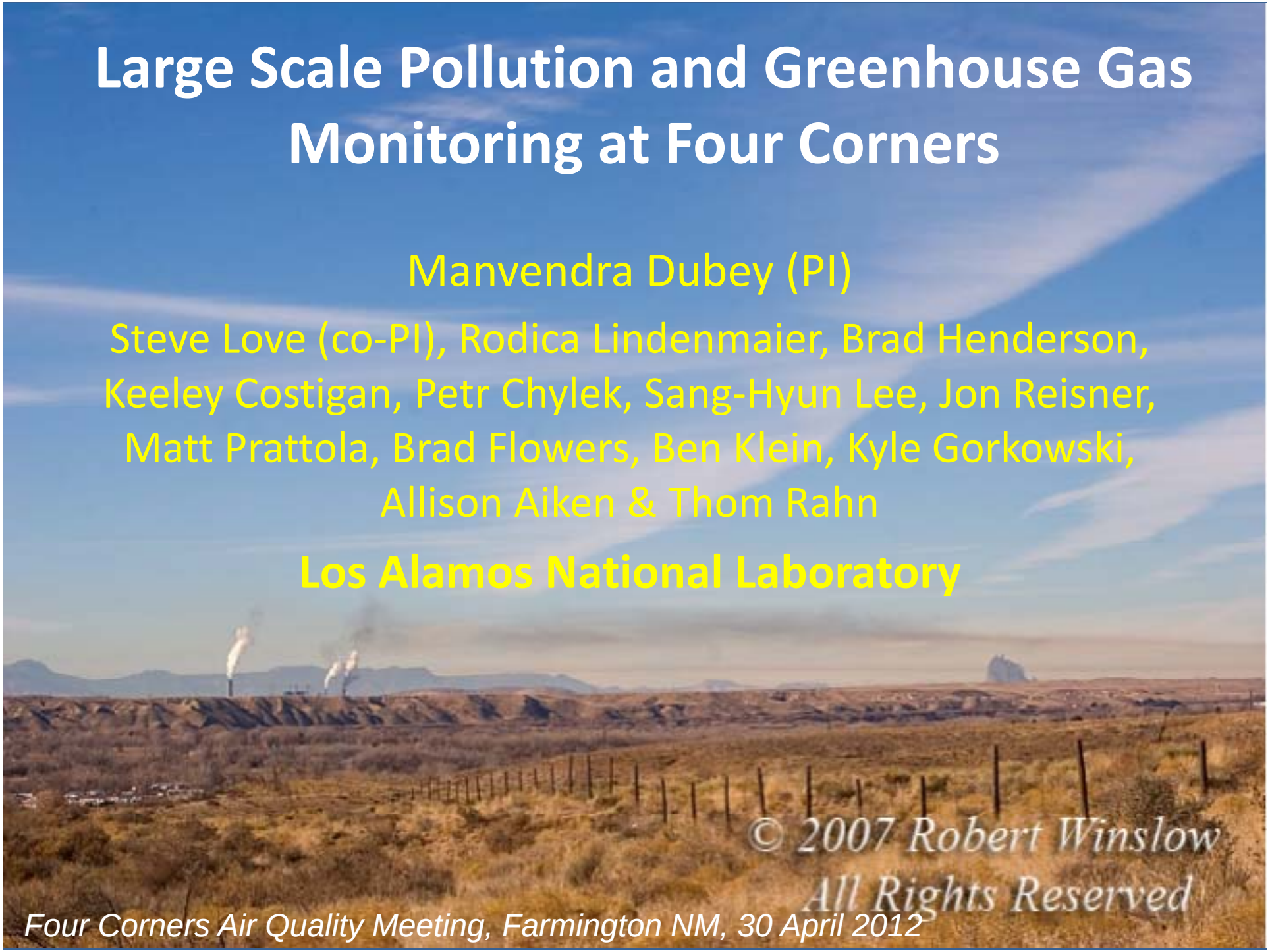
Large Scale Pollution and Greenhouse Gas Monitoring at Four Corners

Manvendra Dubey (PI)

Steve Love (co-PI), Rodica Lindenmaier, Brad Henderson, Keeley Costigan, Petr Chylek, Sang-Hyun Lee, Jon Reisner, Matt Prattola, Brad Flowers, Ben Klein, Kyle Gorkowski, Allison Aiken & Thom Rahn

Los Alamos National Laboratory



Four Corners Air Quality Meeting, Farmington NM, 30 April 2012

US Regulates Pollutants to Protect Human Health (NOx, PM, SO_2, CO, Hydrocarbons)

NOx + HCs + (time (distance, flow)) => O_3

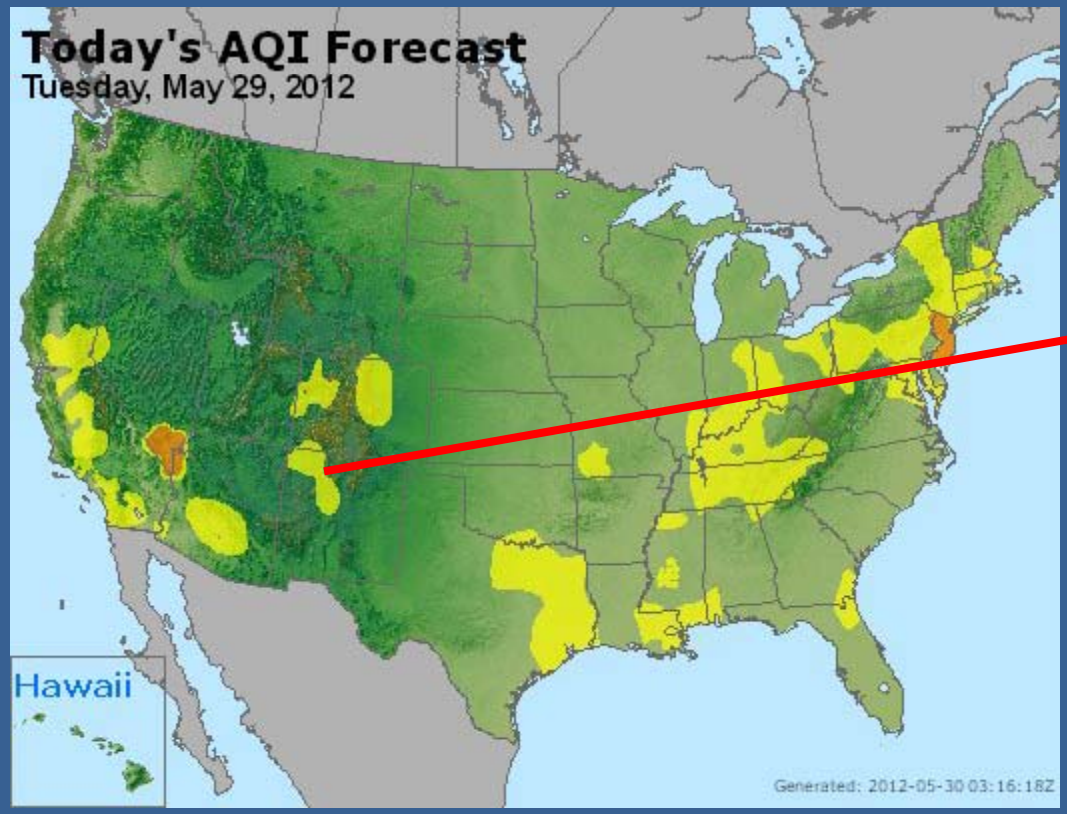
- Reporting Emissions
- Monitoring Emissions
- Verifying Emissions
- Monitoring Air Quality (Trends-Long Term)
- Forecasting Air Quality
- Verifying Air Quality
- Point to Local to Regional Scales

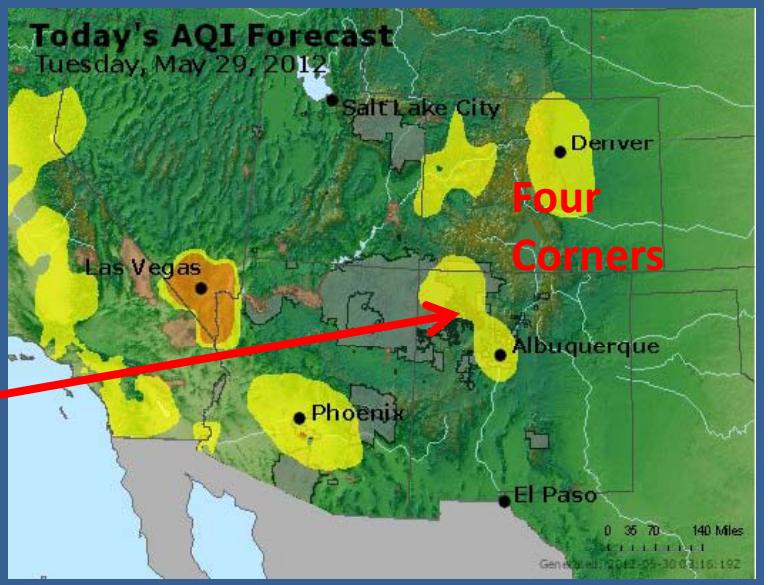
US Considering Permitting Greenhouse Gases (CO_2, CH_4, N_2O)

Objectives: Source to Regional Scale

- To monitor air quality (O_3, NO_x, SO_2, etc.)
- To observe changes in the concentration of greenhouse gases (GHG = CO_2, CH_4, N_2O.)
- To trace GHG fluxes with co-emitted pollutant signatures and attribute them to sources
- To verify if the emissions comply with Clean Air Act Requirements.
- To demonstrate that environmental upgrades in power plant are effective

Reporting air quality



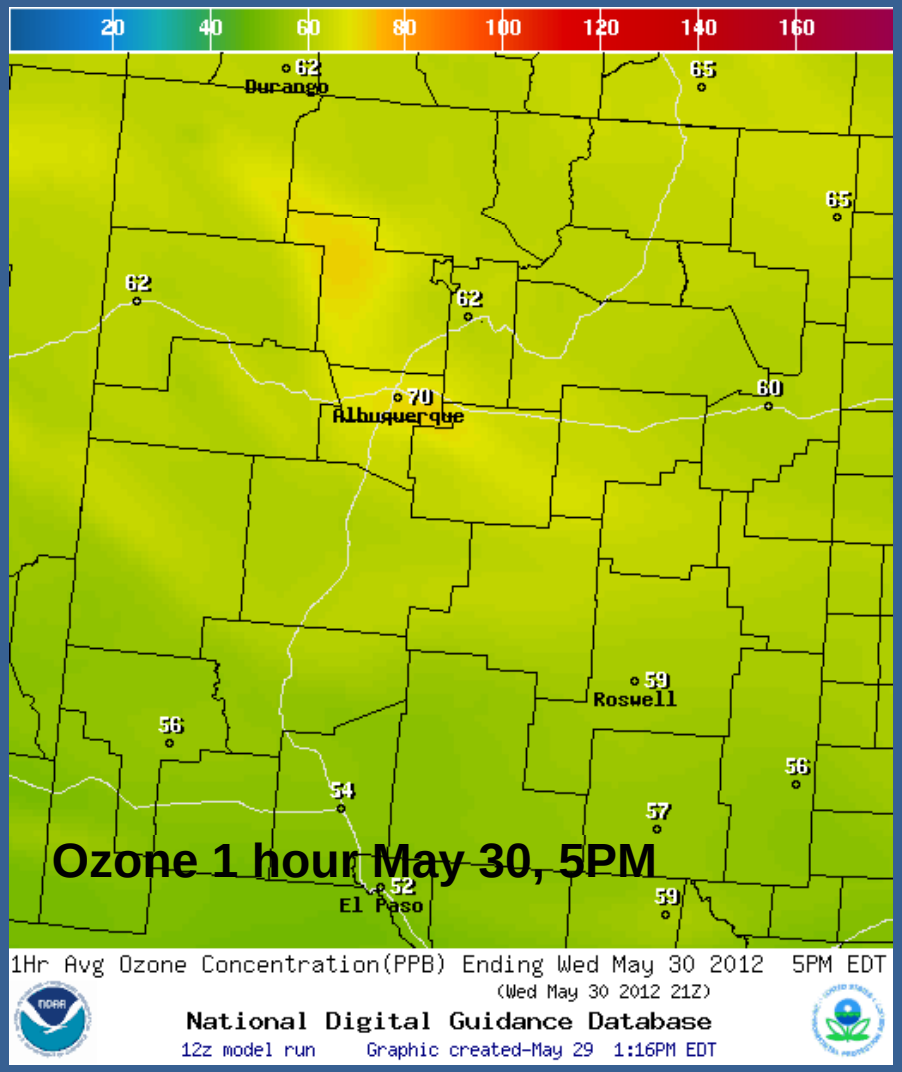


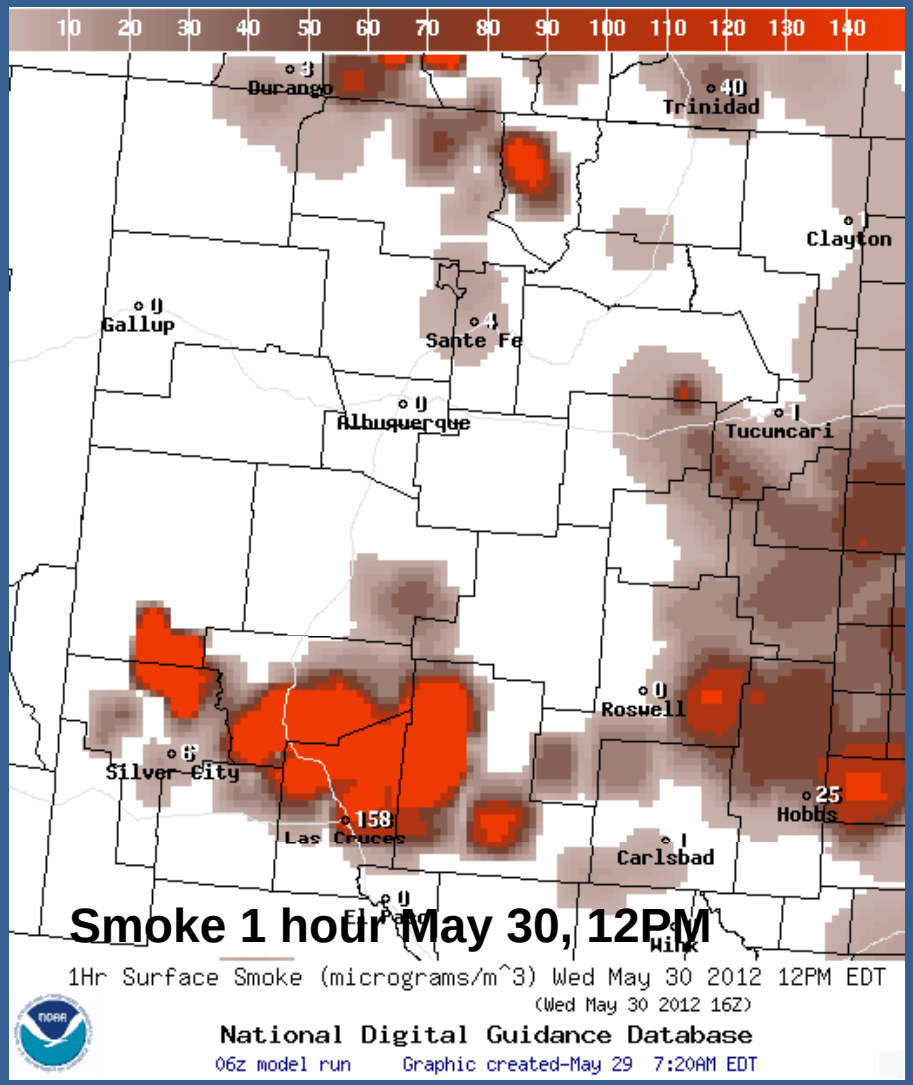
Air Quality Index (AQI) Values	Levels of Health Concern	Colors
When the AQI is in this range:	*..air quality conditions are:*	*...as symbolized by this color:*
0-50	Good	Green
51-100	Moderate	Yellow
101-150	Unhealthy for Sensitive Groups	Orange
151 to 200	Unhealthy	Red
201 to 300	Very Unhealthy	Purple
301 to 500	Hazardous	Maroon

$$I = \frac{I_{high} - I_{low}}{C_{high} - C_{low}}(C - C_{low}) + I_{low}$$

http://www.airnow.gov/

Forecasting air quality





http://airquality.weather.gov/

Approach and Methods: 4 Corners Test-bed

4-Corners, $\Delta(NOx)/\Delta CO_2) = 3 \times 10^{-3}$

San Juan, $\Delta(NOx)/\Delta CO_2) = 1.4 \times 10^{-3}$

- **Ideal site in our back-yard with 2 large power plants of distinctively different emissions profiles in an isolated semi-arid locale with a feeble natural carbon cycle and real time stack emissions.**
- **Multi-scale observations (*in situ*, ground, satellite) and modeling (forward and inverse) with uncertainty quantification.**
- **Verification evaluation at calibrated site**

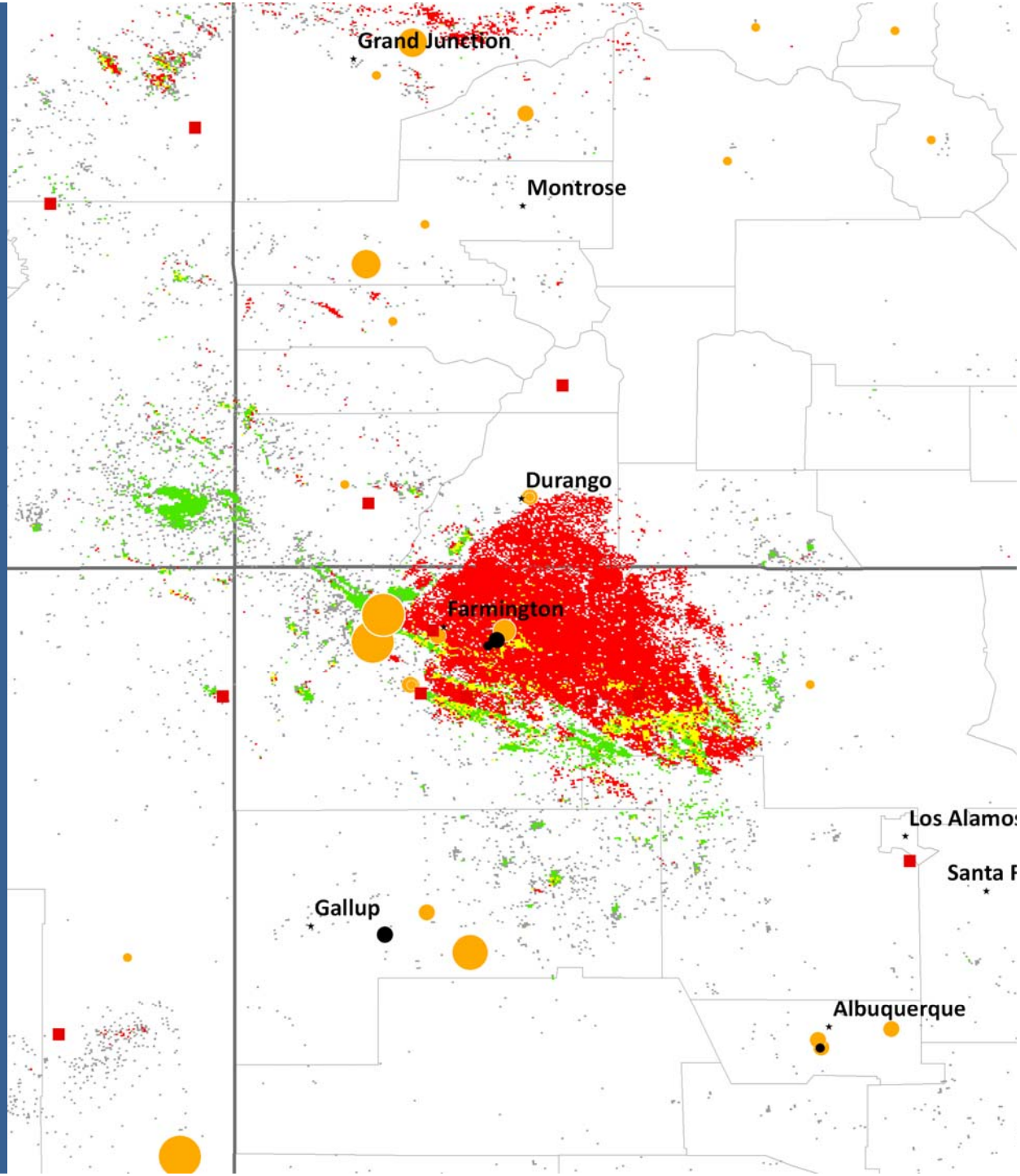
CO_2 (29 Mtons/year, 0.1 Mtons/day)
NO_x (79 Ktons/year, 0.2 Ktons/day)

Anthropogenic Sources (Local)

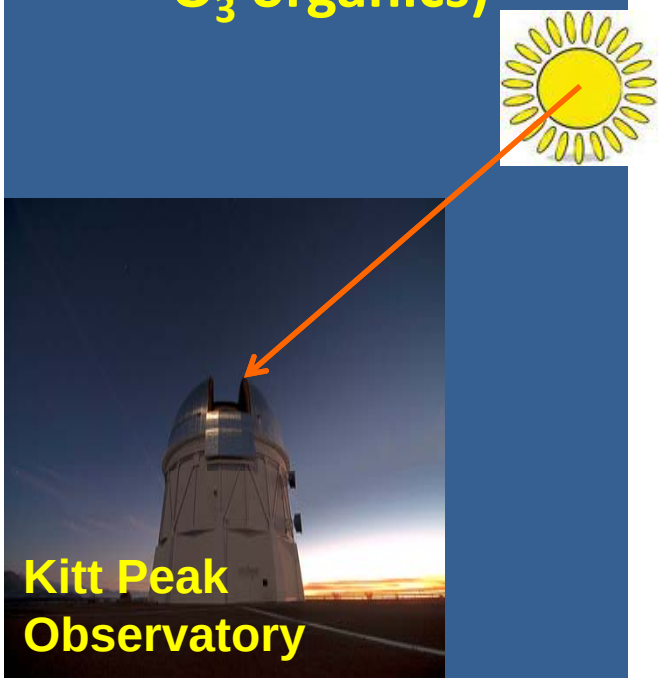
NOx (Power, Transport)

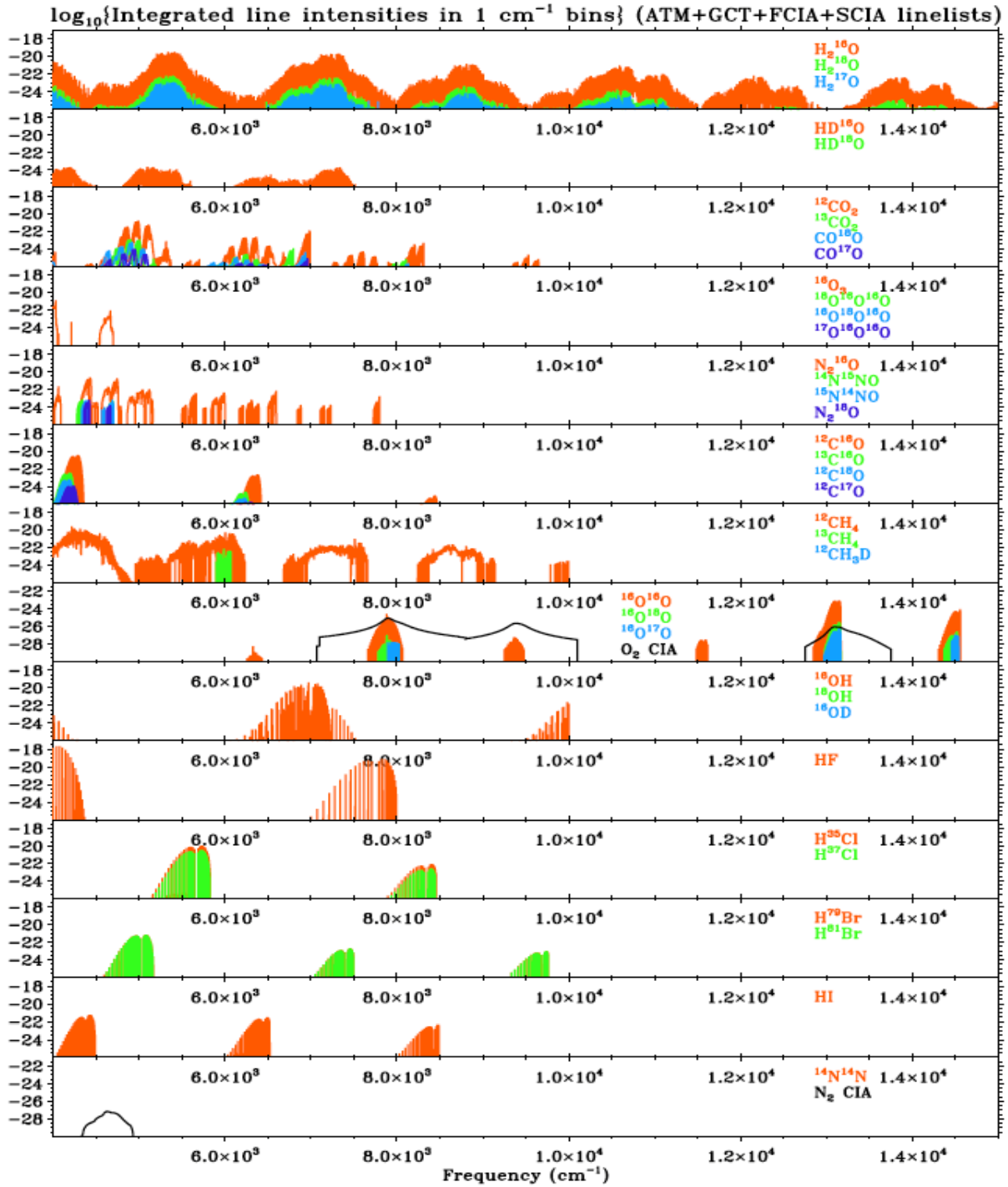
SOx (Power)

Organics (Trans, **Gas Wells/Fields**, Fires)



High resolution solar absorption spectra have fingerprints that can be used to retrieve column H_2O, CO_2, CO, CH_4, N_2O, O_2, their isotopomers, pollutants (NOx, SO_2, O_3 organics)





First Solar FTS to Monitor Power Plant Operational San Juan NM

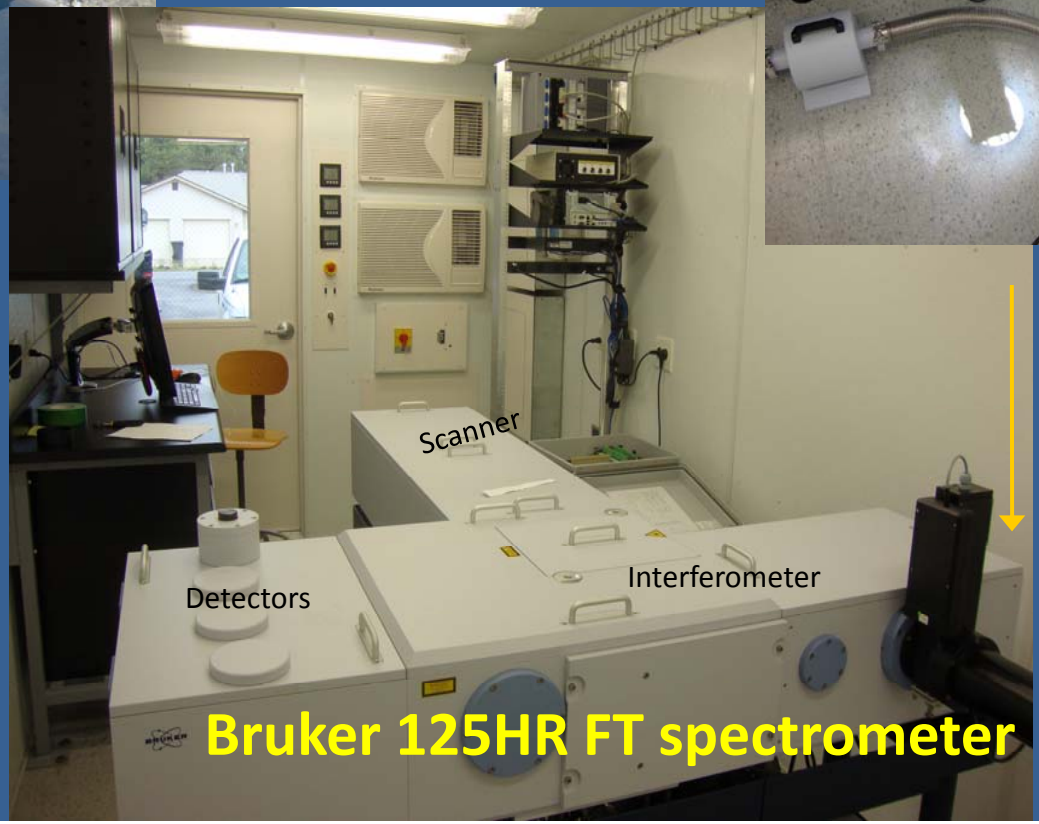
Goal: Separate CO_2 contributions fro high NOx and low NOx PPs using FTS data

https://tccon-wiki.caltech.edu/Sites/Four_Corners

Four Corners PP
High NOx/CO_2

San Juan PP
Low NOx/CO_2

LANL Solar Fourier Transform Spectrometer (Vis-UV-NIR-MIR) for CO_2, NO_2, SO_2, CH_4, N_2O, CO, C_2H_6…



Solar
Beam

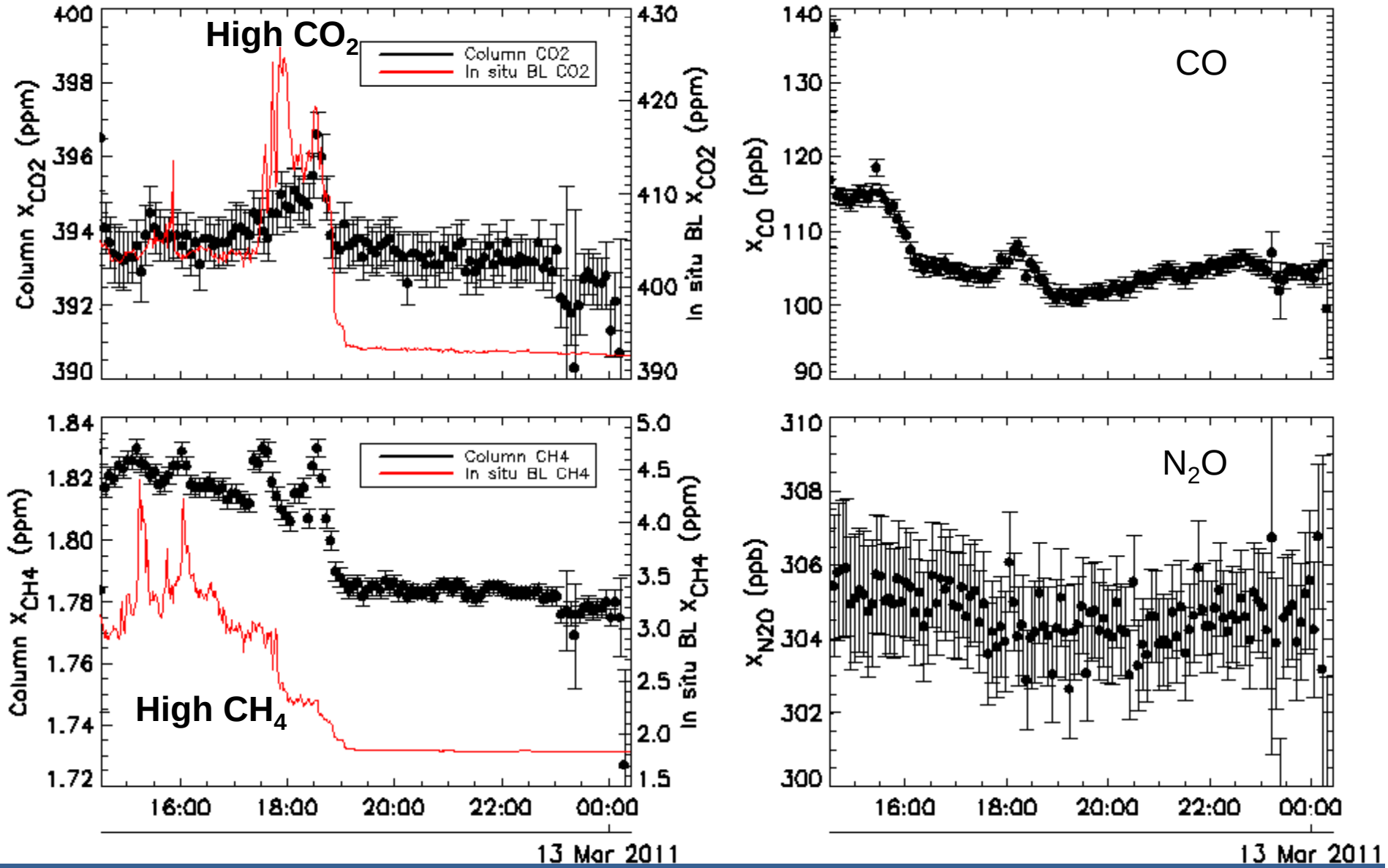
AUTOMATED REMOTE
SOLAR OBSERVATORY

Picarro Analyzers: In Situ Composition

- Very sensitive in situ gas analyzers able to detect traces at parts per million to billion levels
- Do not require frequent calibration and can be operated remotely

•CO_2, CH_4, CO, H_2O
•CO_2 Isotopes
•Water isotopes
•CH_4 isotopes

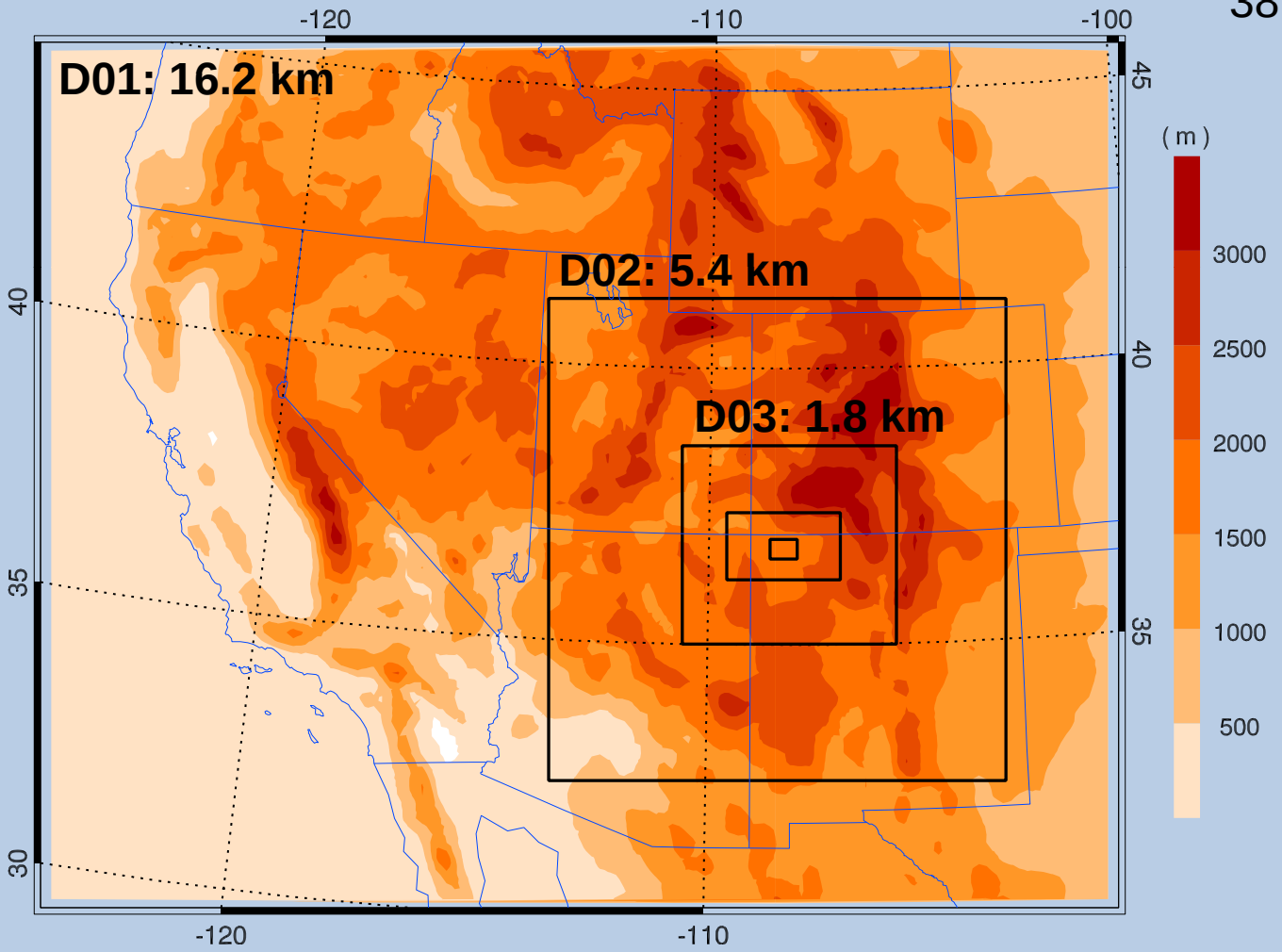
CO_2 2-3 ppm column increase from power plant, 10-30 ppm rise in BL
CH_4 0.05 ppm column increase from coal mining (?), 3 ppm rise in BL



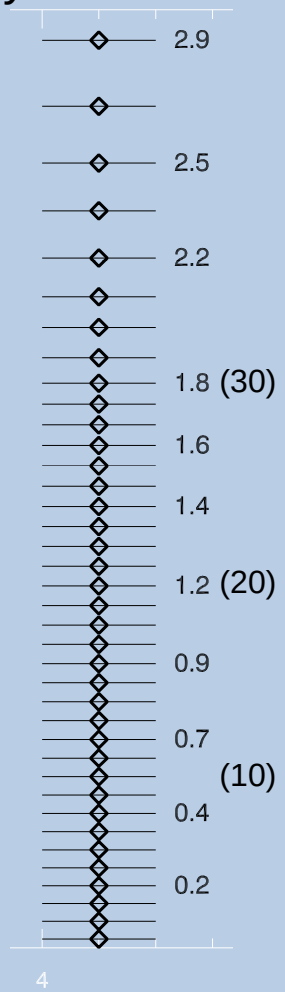
12 March 2011

Nested 5 domain WRF Chem. Modeling of 4-Corners

16.2 km → 5.4 km → 1.8 km → 0.6 km → 0.2 km → 67 m

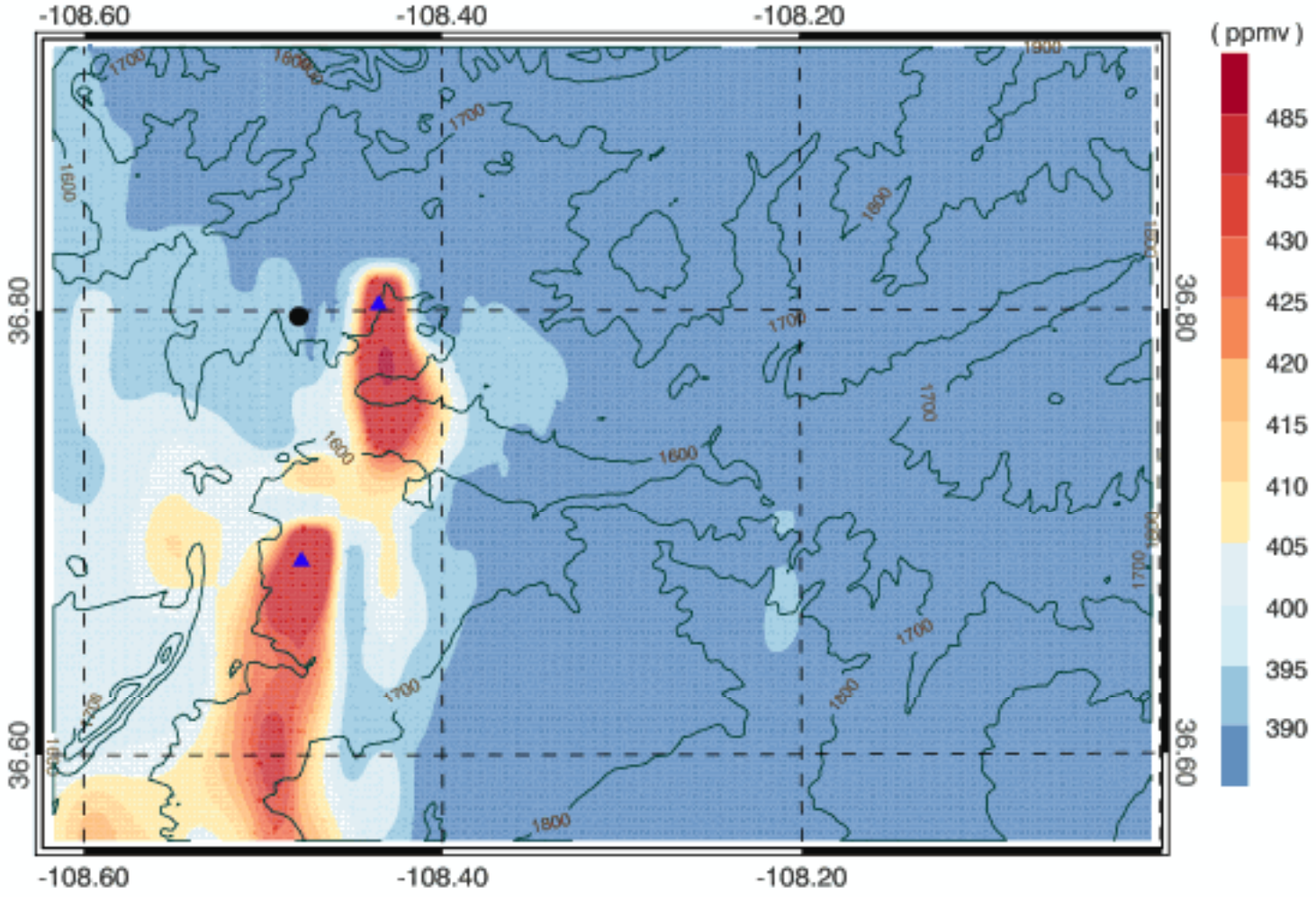


38 layers below 3 km

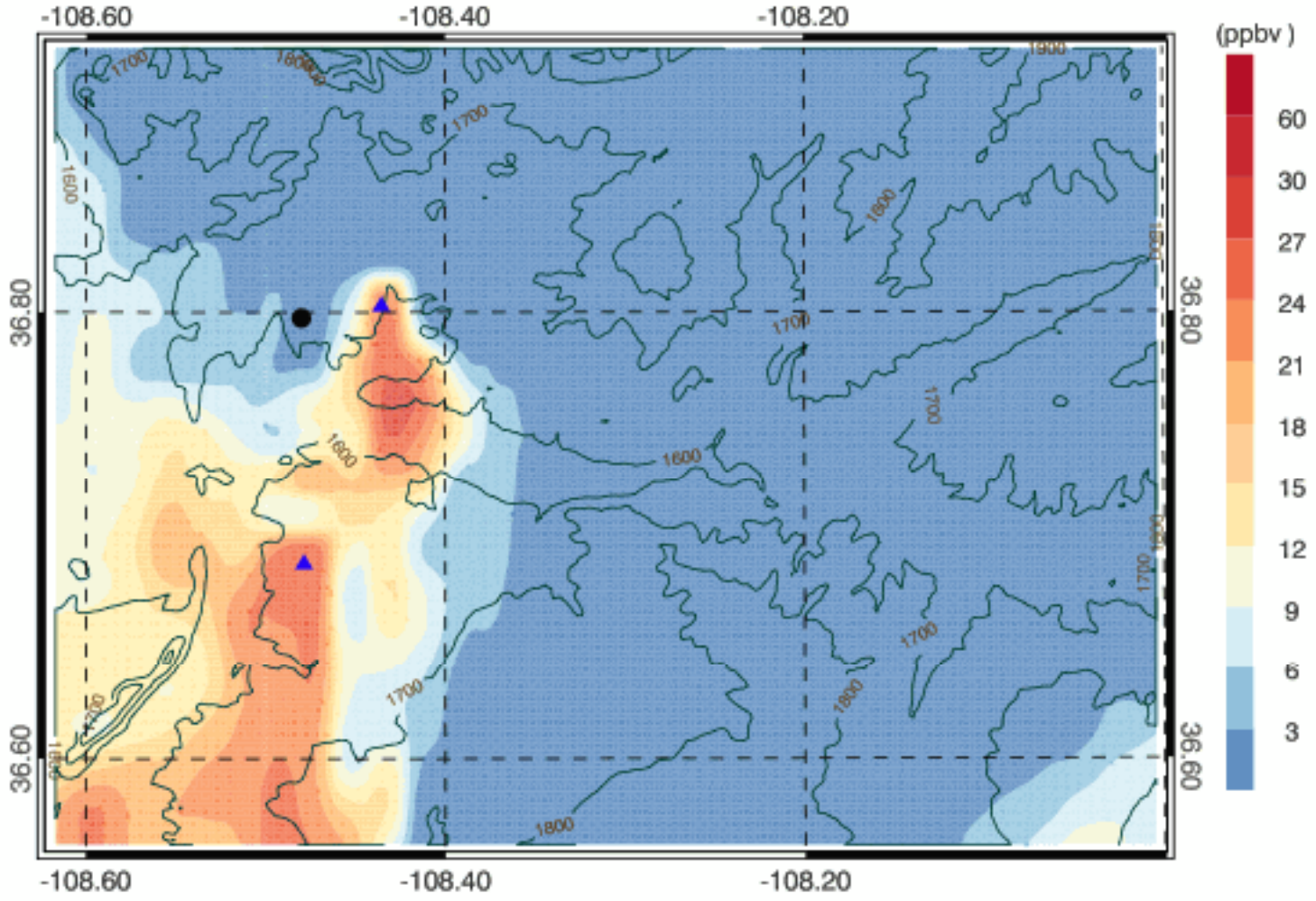


First half sigma: ~28m, Top: 20 hPa (~20km)

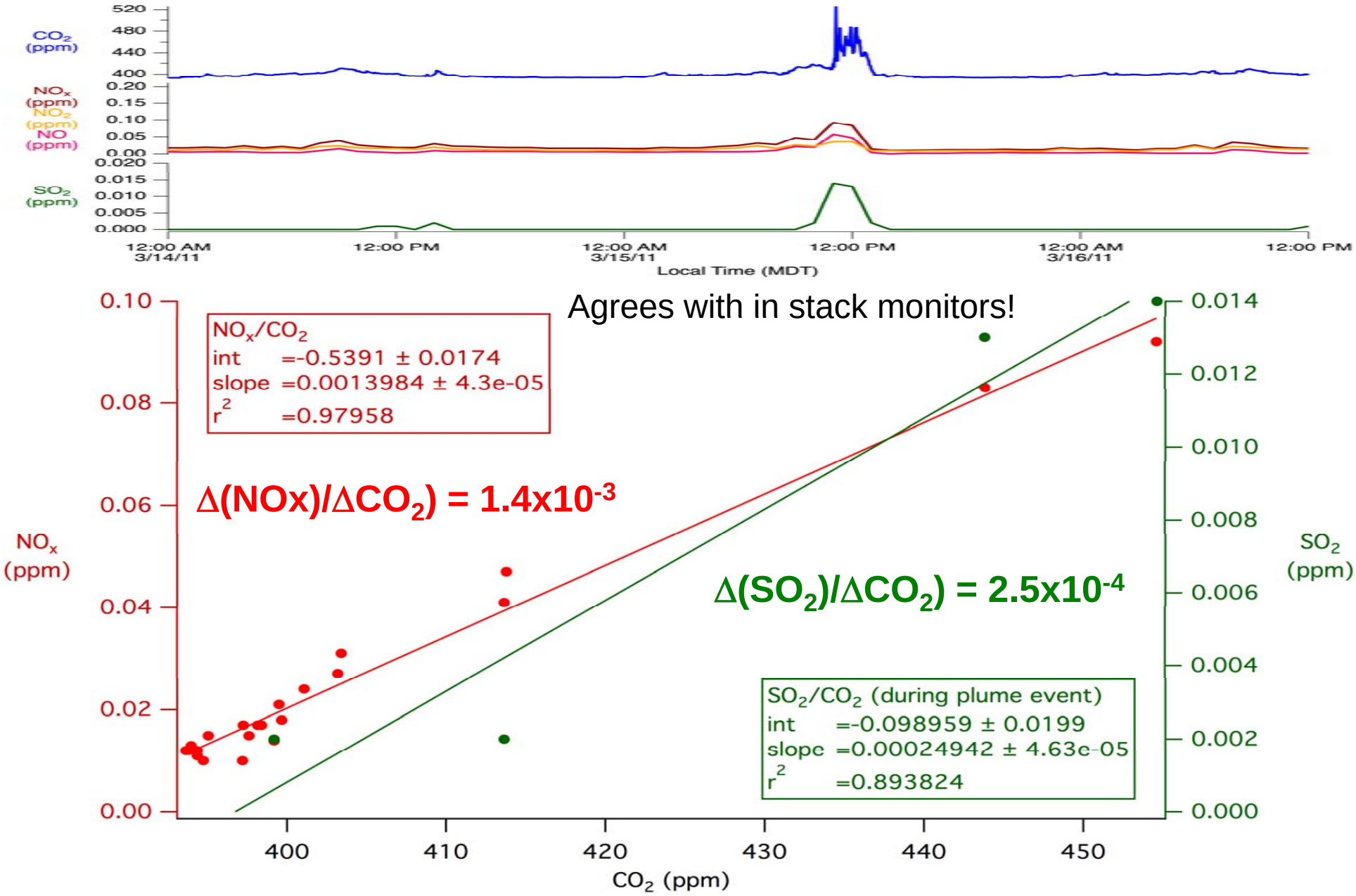
00 UTC 03/15/2011:XCO2 (Max= 488.6 ppmv



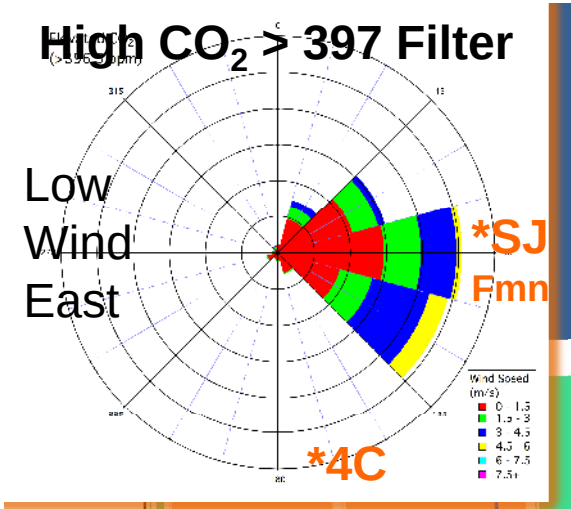
00 UTC 03/15/2011:XNO2 (Max= 28.3 ppbv)

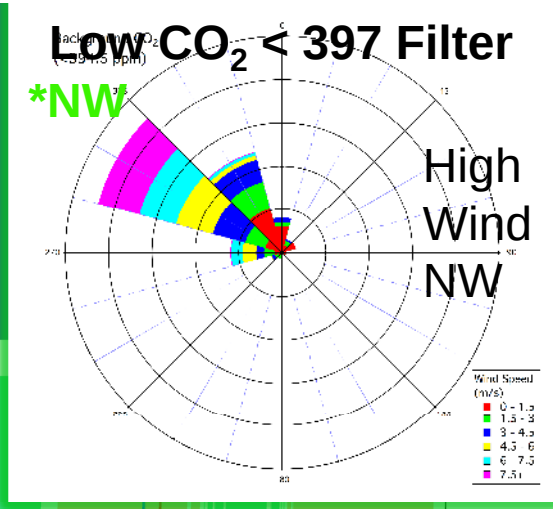


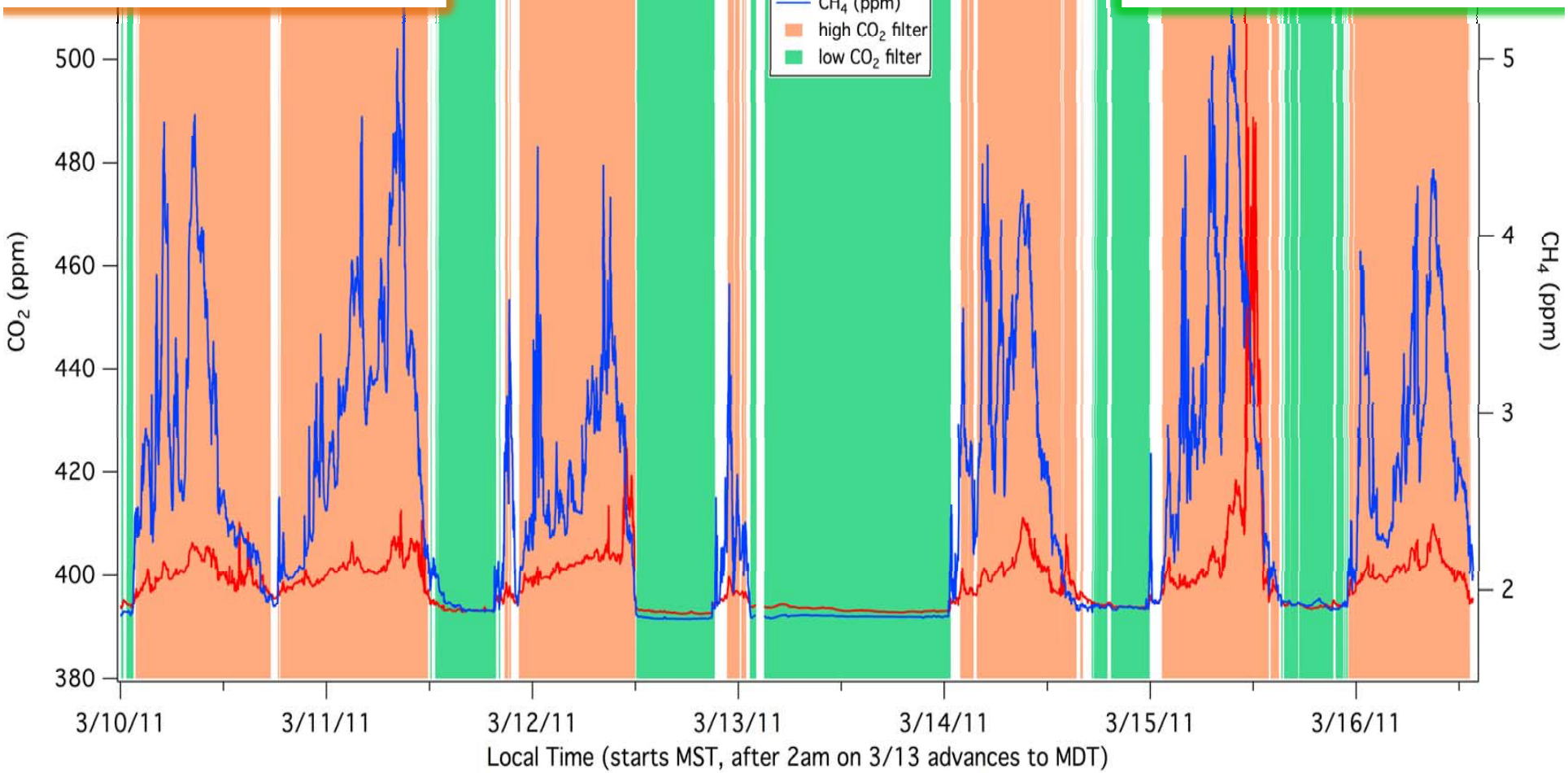
In Situ NO_2, CO_2, SO_2 *San Juan* Power Plume at site 3/15/11



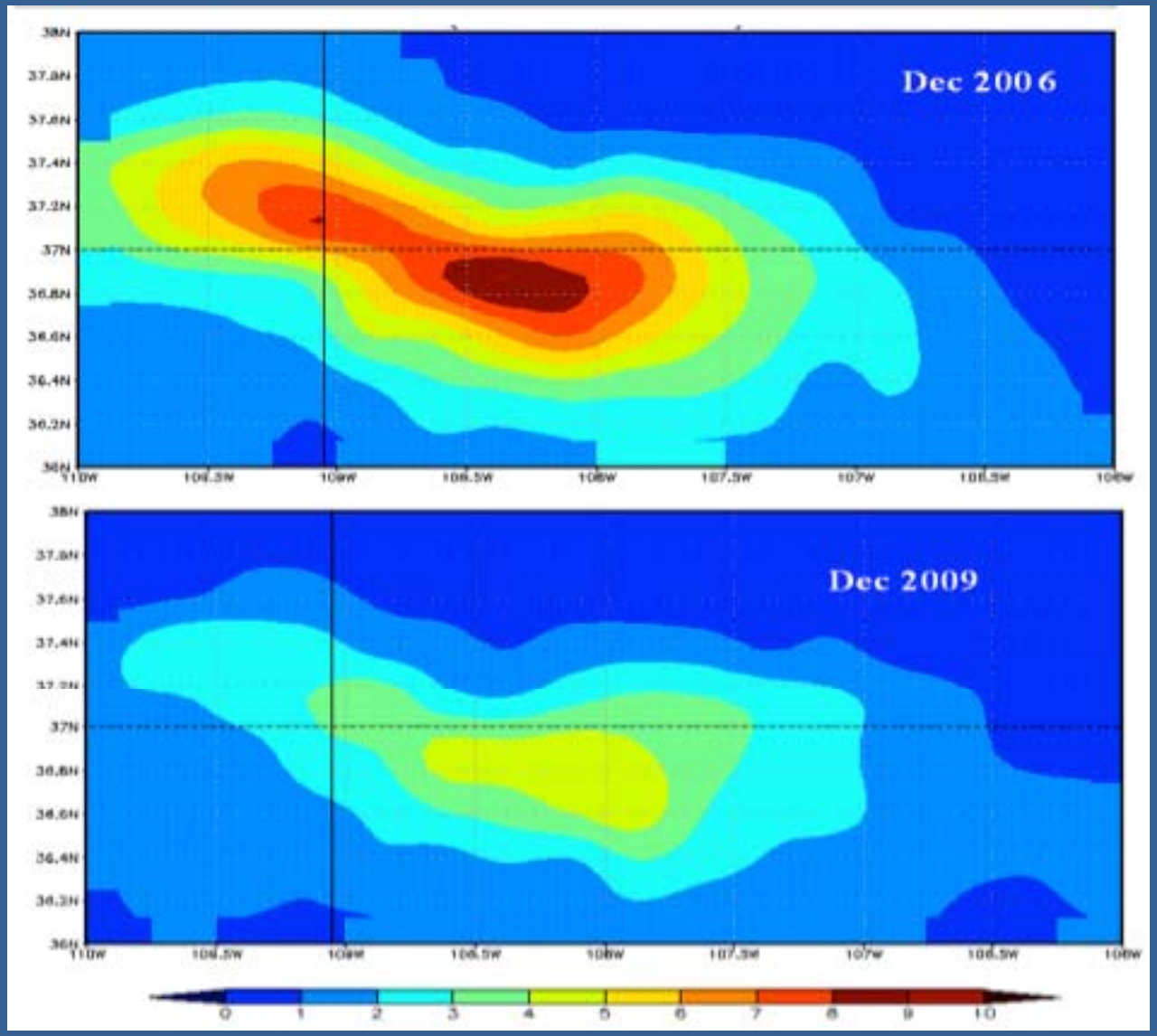
In Situ CO_2/CH_4 and wind direction/speed







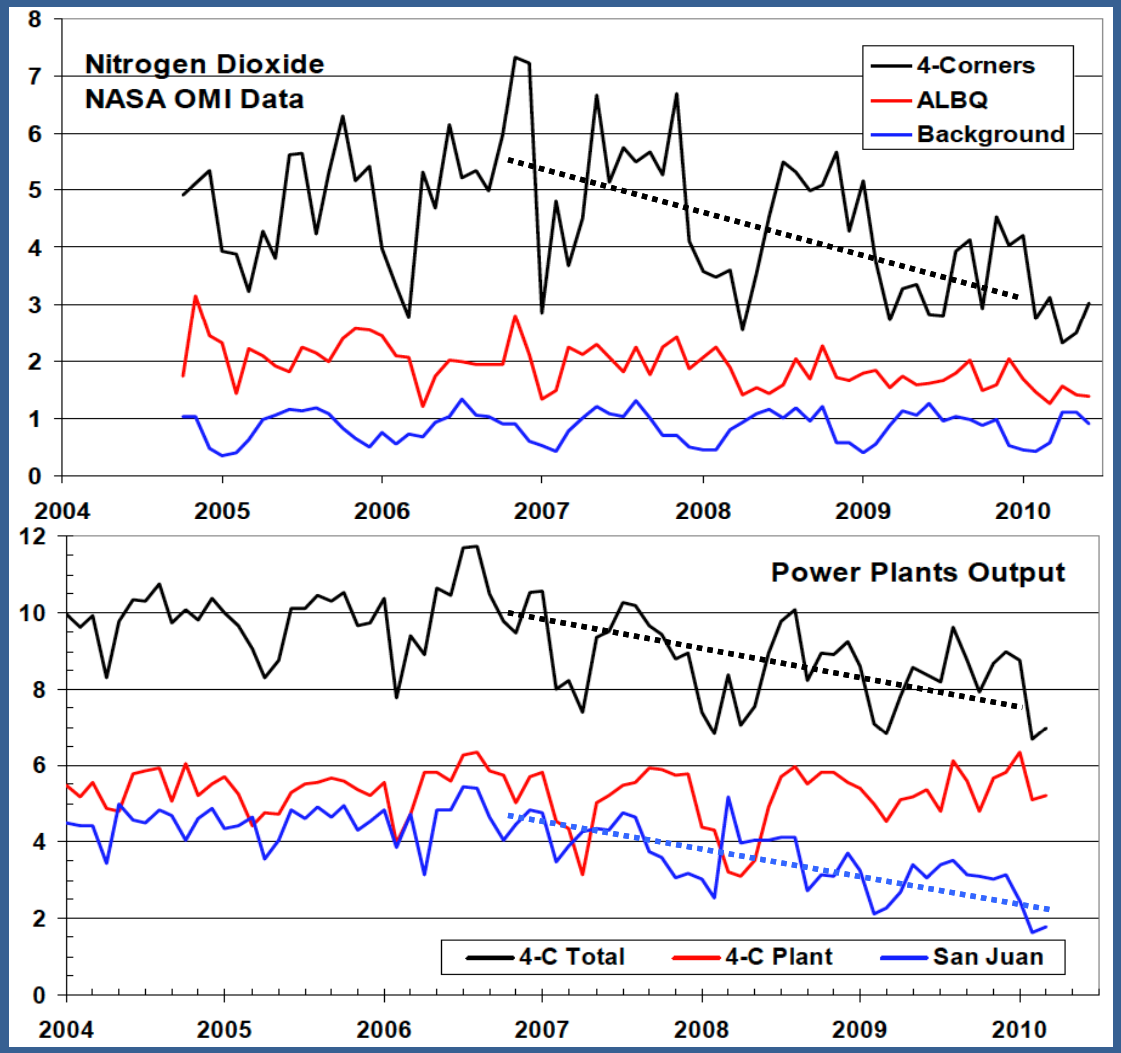
Four Corners NO_2 column trends from OMI



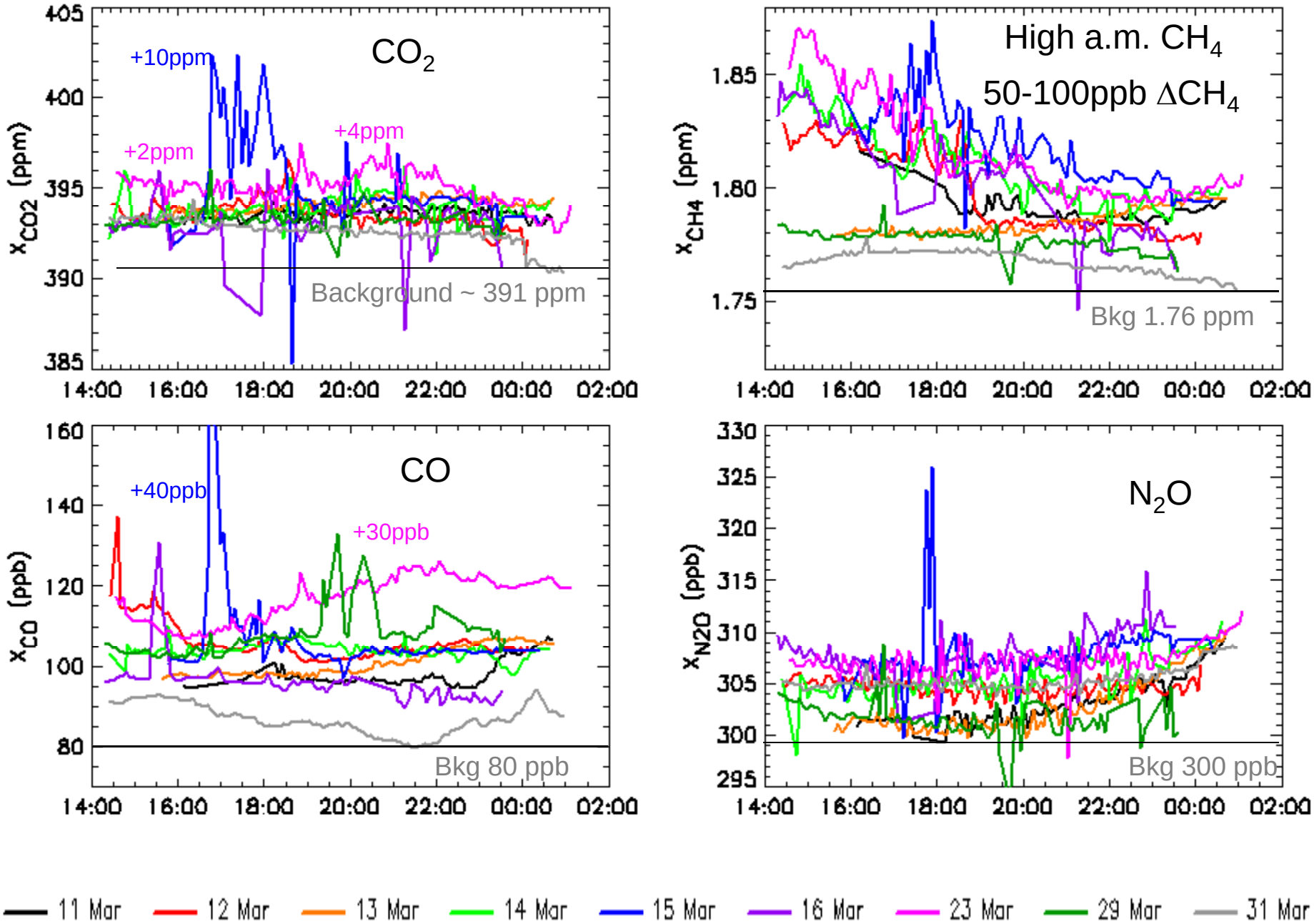
NO_2 decline from Boiler Environmental Upgrade 2006-2009 ($300M investment at San Juan Plant)

OMI
Top Down

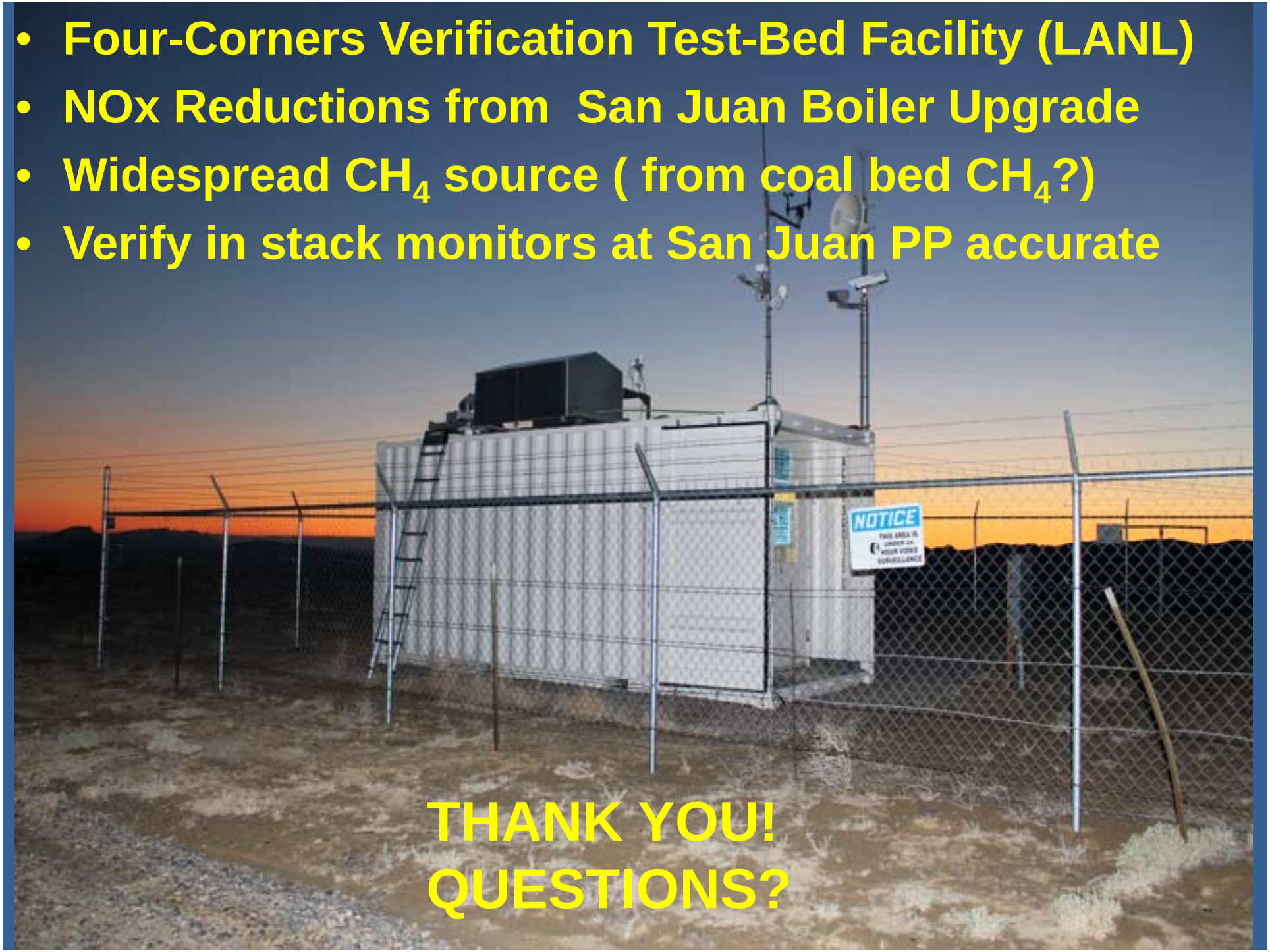
CEMS
Bottom Up



Column CO_2 background 393ppm, 2-10ppm power plant signal



- Four-Corners Verification Test-Bed Facility (LANL)
- NOx Reductions from San Juan Boiler Upgrade
- Widespread CH_4 source (from coal bed CH_4?)
- Verify in stack monitors at San Juan PP accurate



THANK YOU!
QUESTIONS?