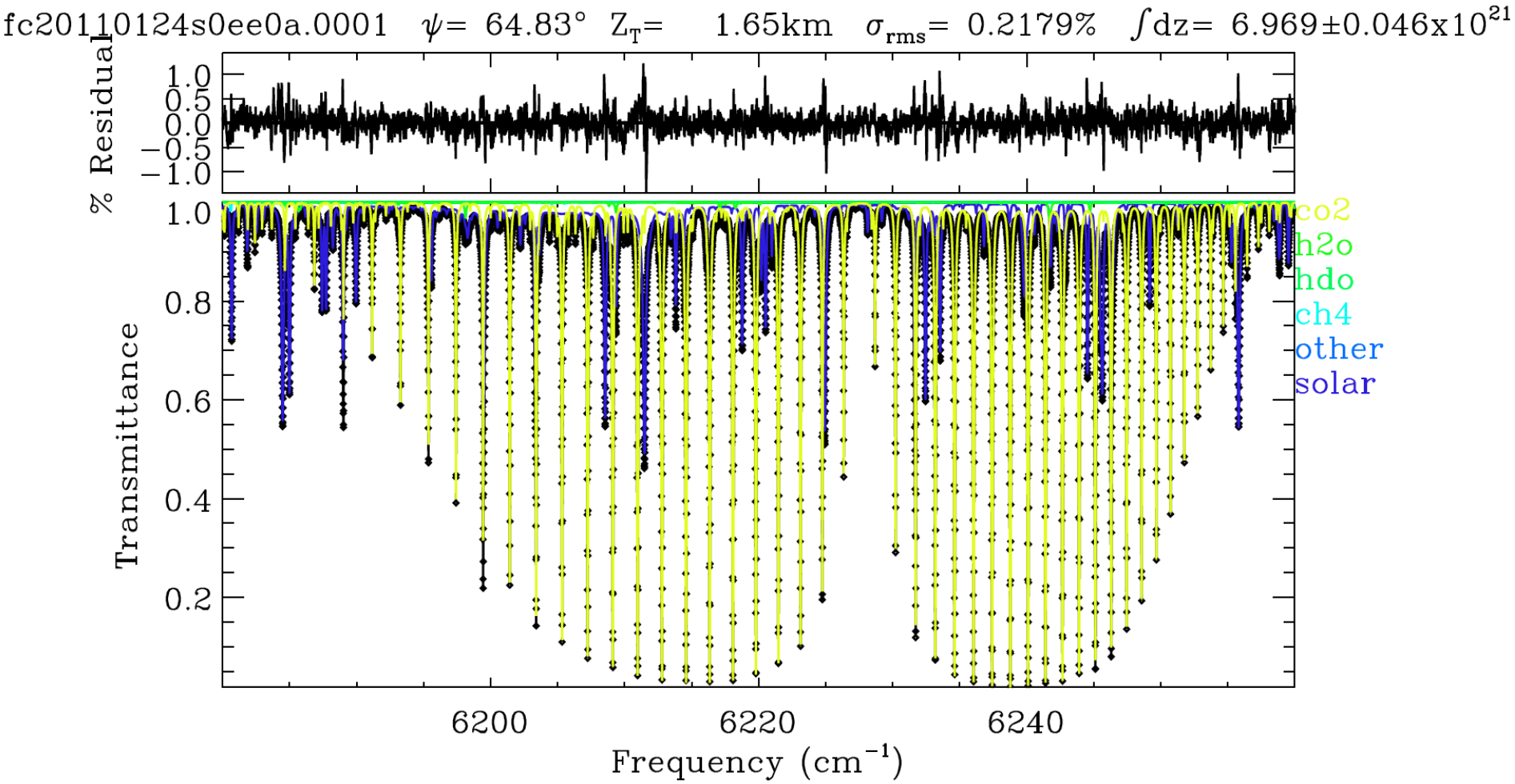
Fit Spectra to Retrieve CO_2: Minimize Residuals

1/24/11 Four Corners, srms = 0.22%

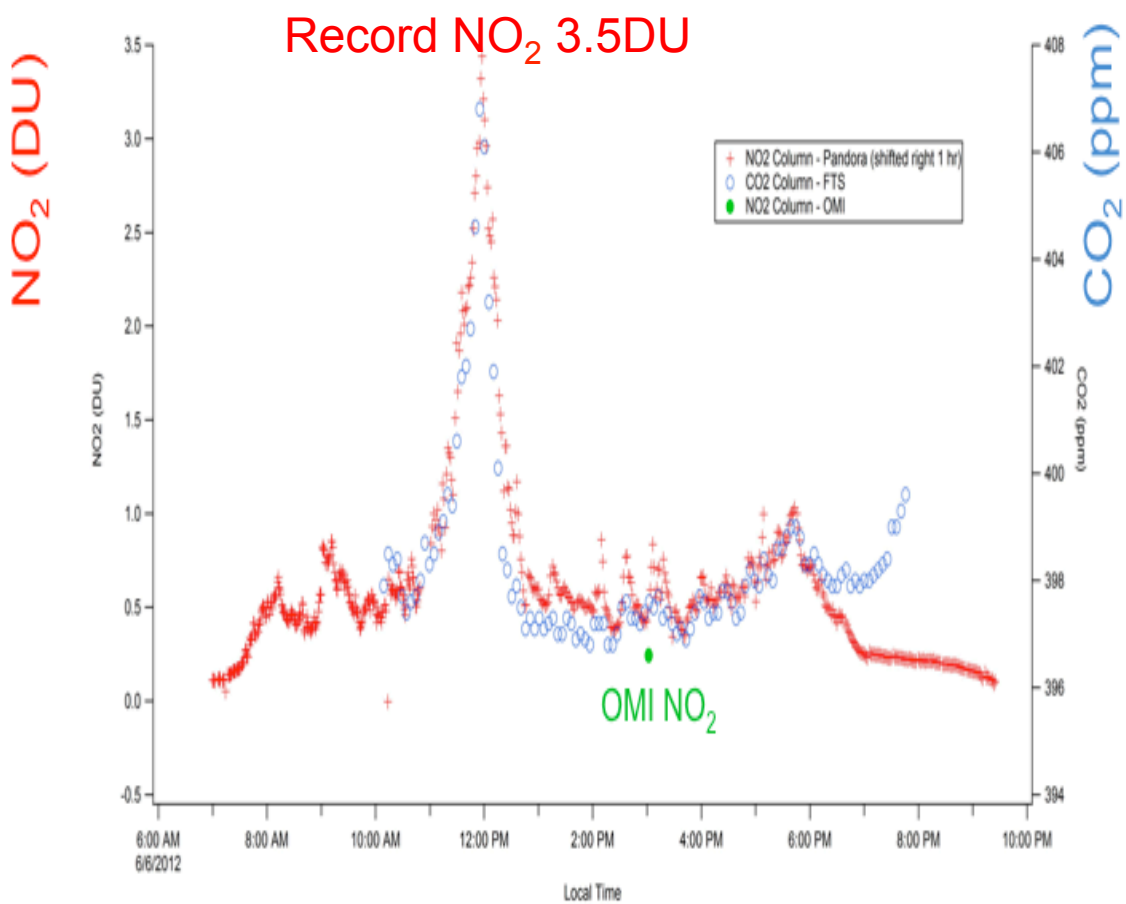


Real time *in situ* trace gas analysis at 4 Corners

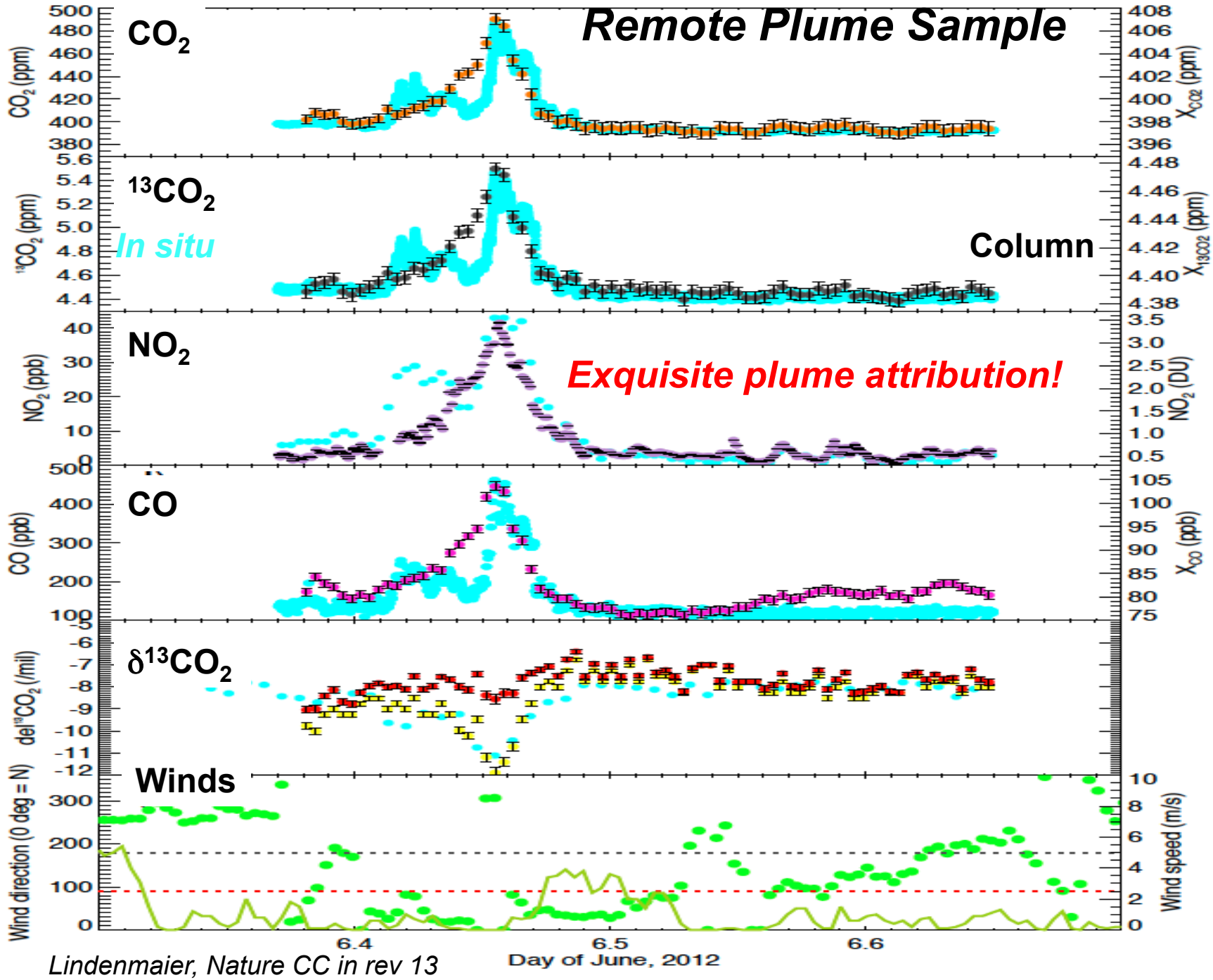
- Ultra-sensitive *in situ* gas analyzers (ppm to ppb)
- Real time, do not require frequent calibration and can be operated remotely

•CO_2, CH_4, CO, H_2O (CRD)
•CO_2 Isotopes (CRD)
•Water isotopes (CRD)
•CH_4 isotopes (CRD)
•NO_x (CL)
•SO_2 (P-UV)
•O_3 (UV_{abs}), PM

Solar UV-Vis mini spectrometer installed 6/5/12 to measure NO_2 (O_3, SO_2)



Measures sun and sky radiance from 270 to 530 nm in 0.5 nm steps with a 1.6° field of view. Products: 1% accuracy and 0.1% precision for NO_2 and O_3.



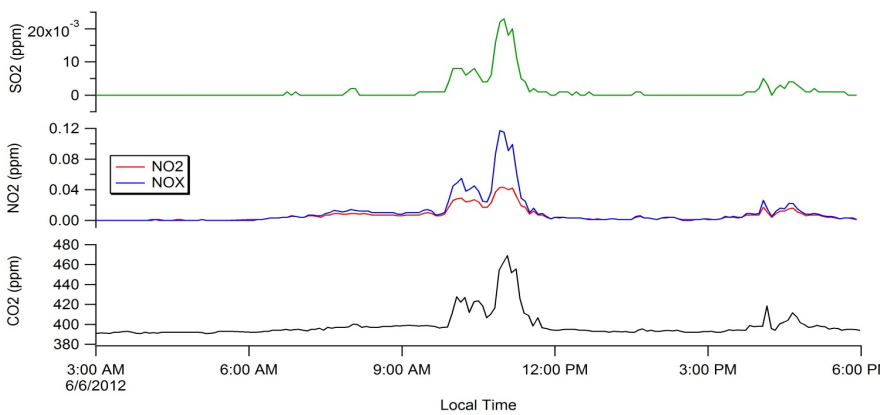
Lindenmaier, Nature CC in rev 13

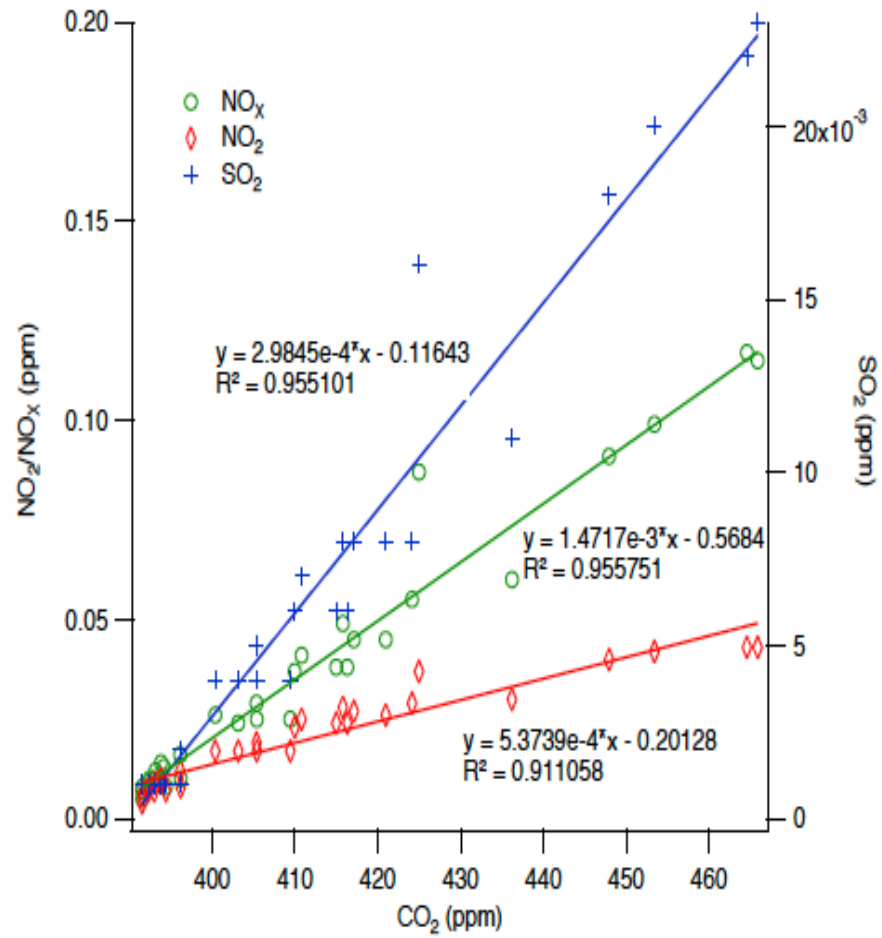
In Situ Emission Ratios: Top Down agree with Bottoms up to <1%

In Stack Meas. ; Top Down Observ.

$\Delta NO_x/\Delta CO_2 = 1.5*10^{-3}; 1.47*10^{-3}$

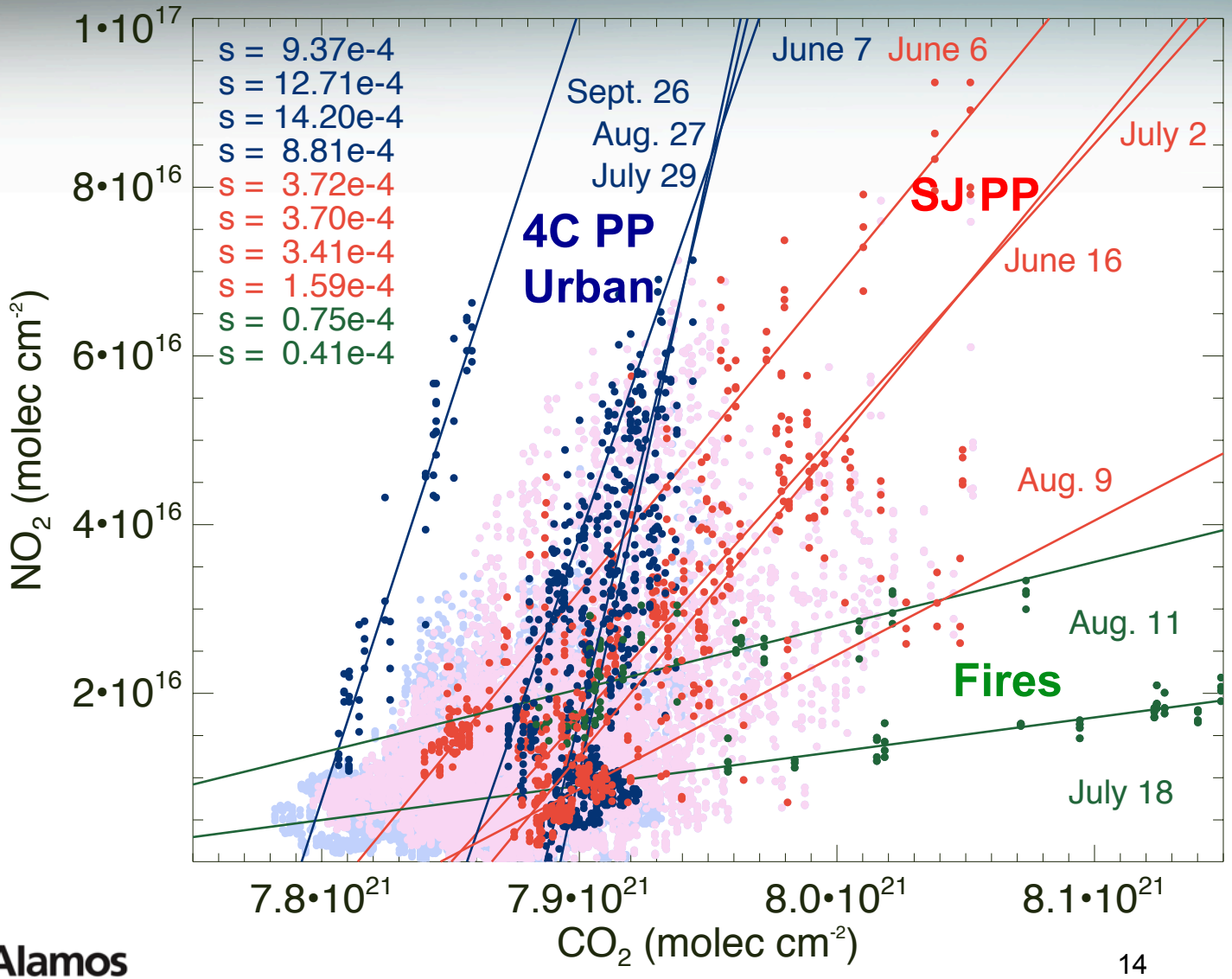
$\Delta SO_2/\Delta CO_2 = 3*10^{-4}; 2.98*10^{-4}$





Remote NO_2/CO_2: Emission Factor Verification

Lindenmaier et al, Nature CC in review 2013



Simulated and Satellite column NO_2 over Four Corners: 15th March 2011

Area-averaged XNO_2

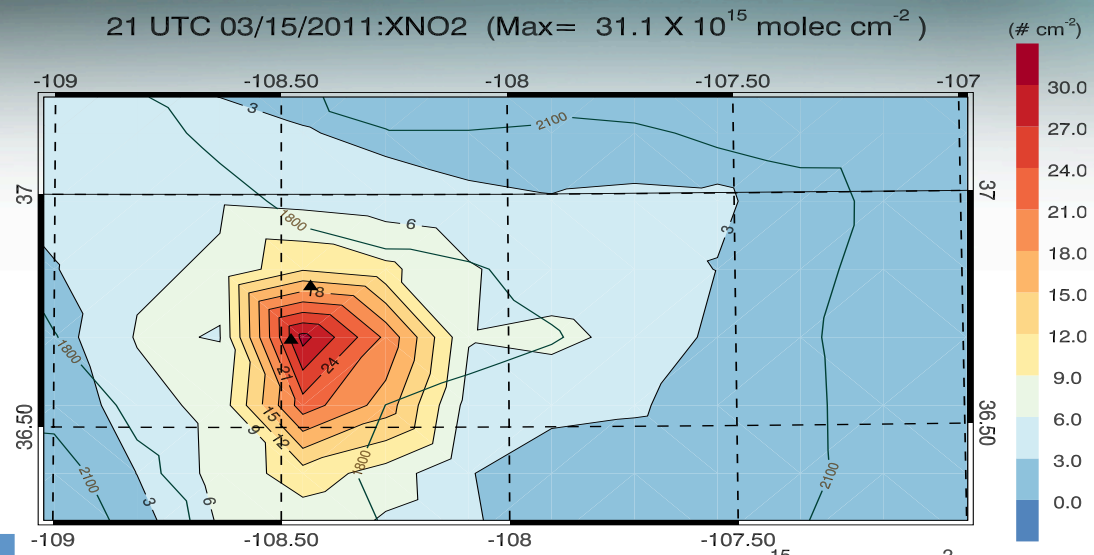
Box
Lon: 108.8-108.0W
Lat: 36.3-37.1N

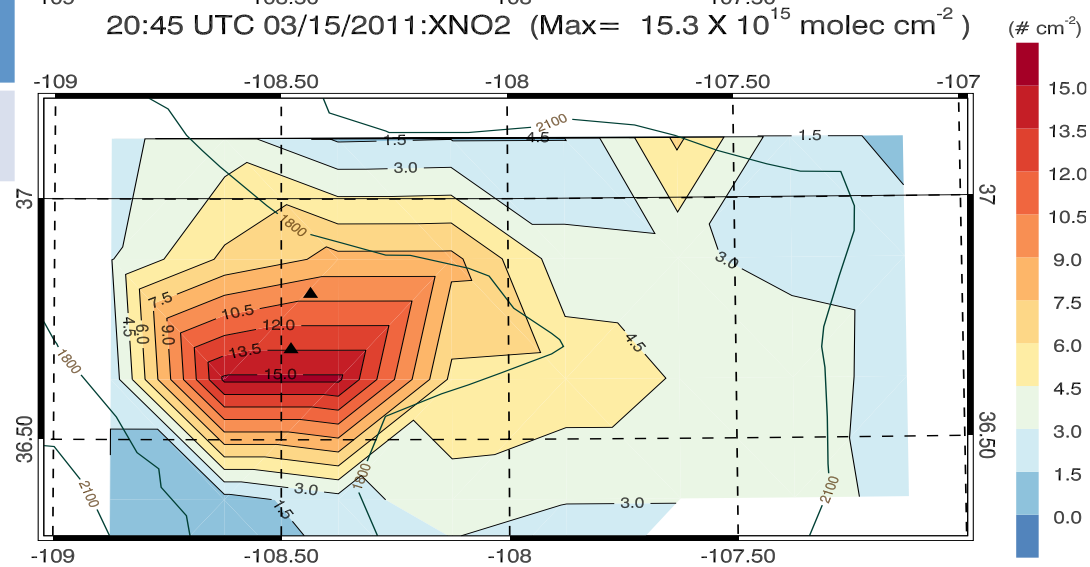
WRF Model

	OMI	WRF
Box	7.28	9.80

WRF 25% > OMI

OMI Satellite

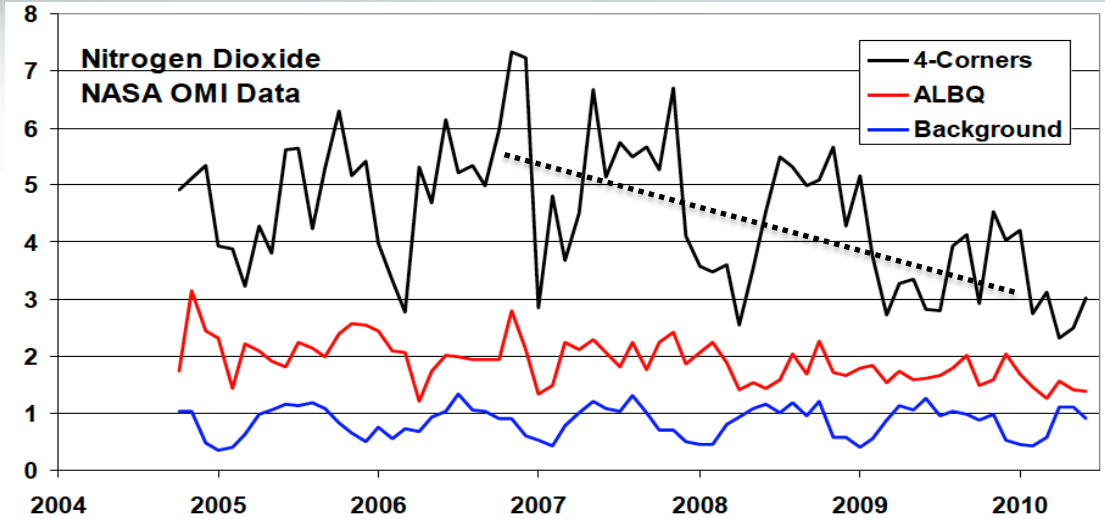




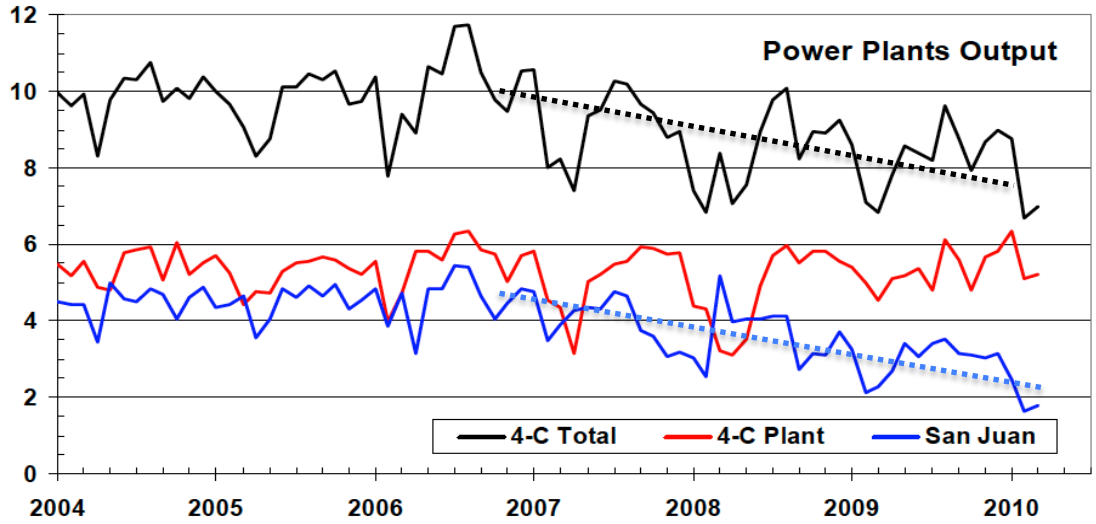
Implies CO_2 may be underreported

Satellite-OMI NO_2 decline from Environmental Boiler Upgrade 2006-2009 ($300M, San Juan PP)

OMI
Top Down



CEMS
Bottom Up



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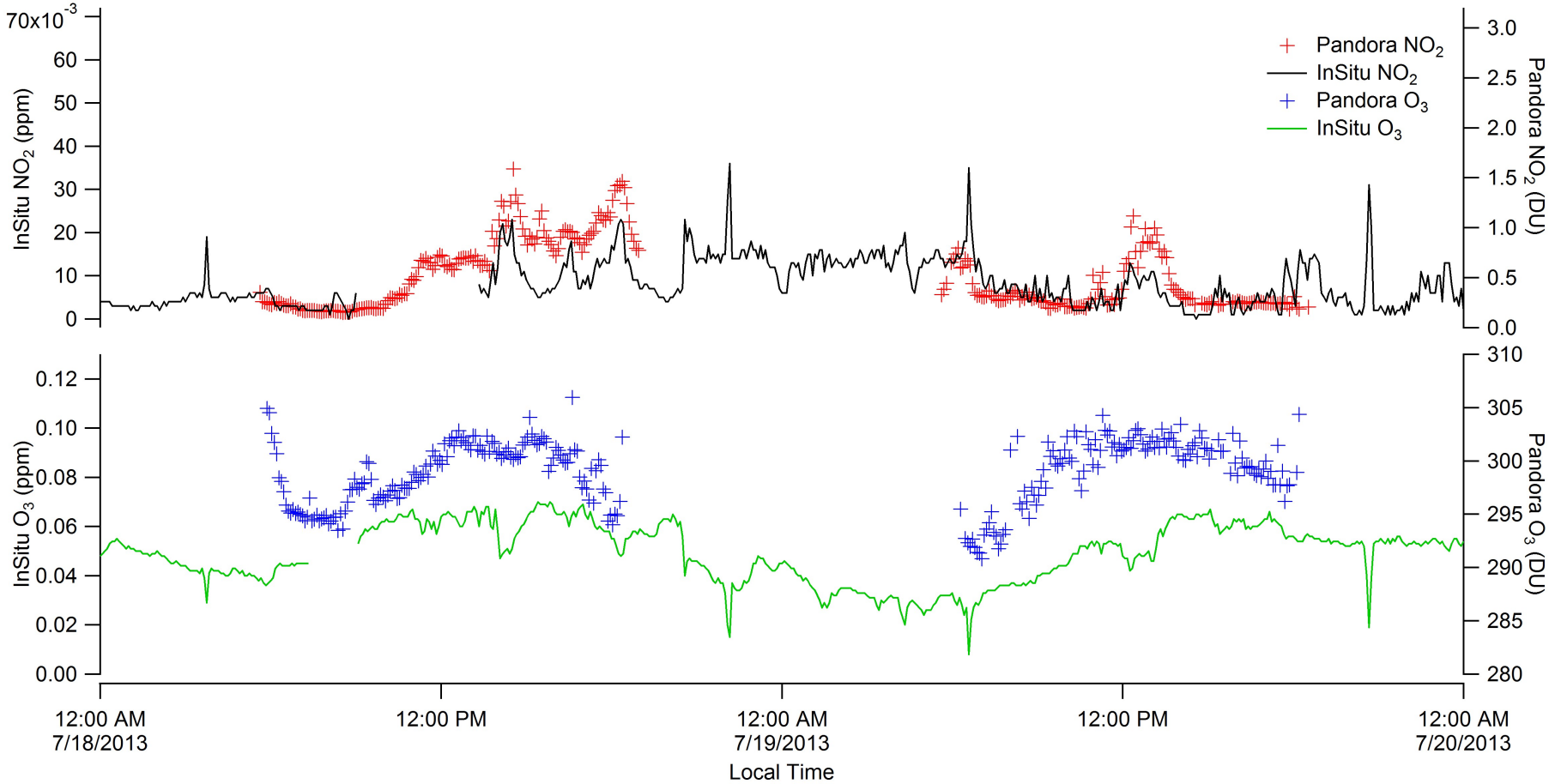
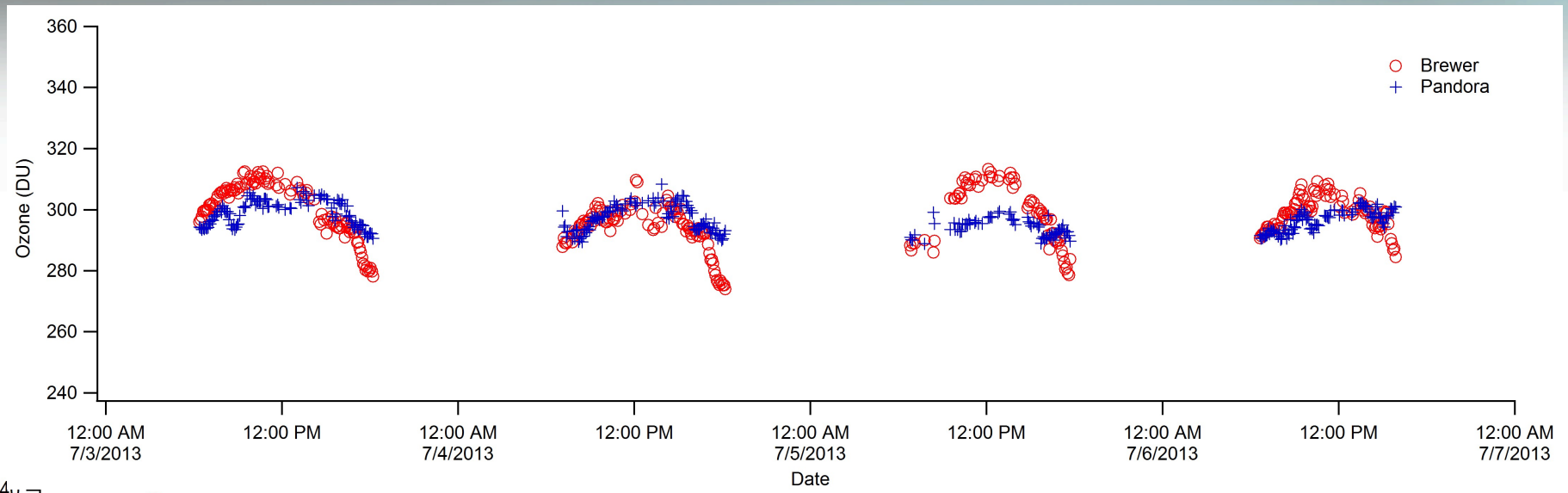
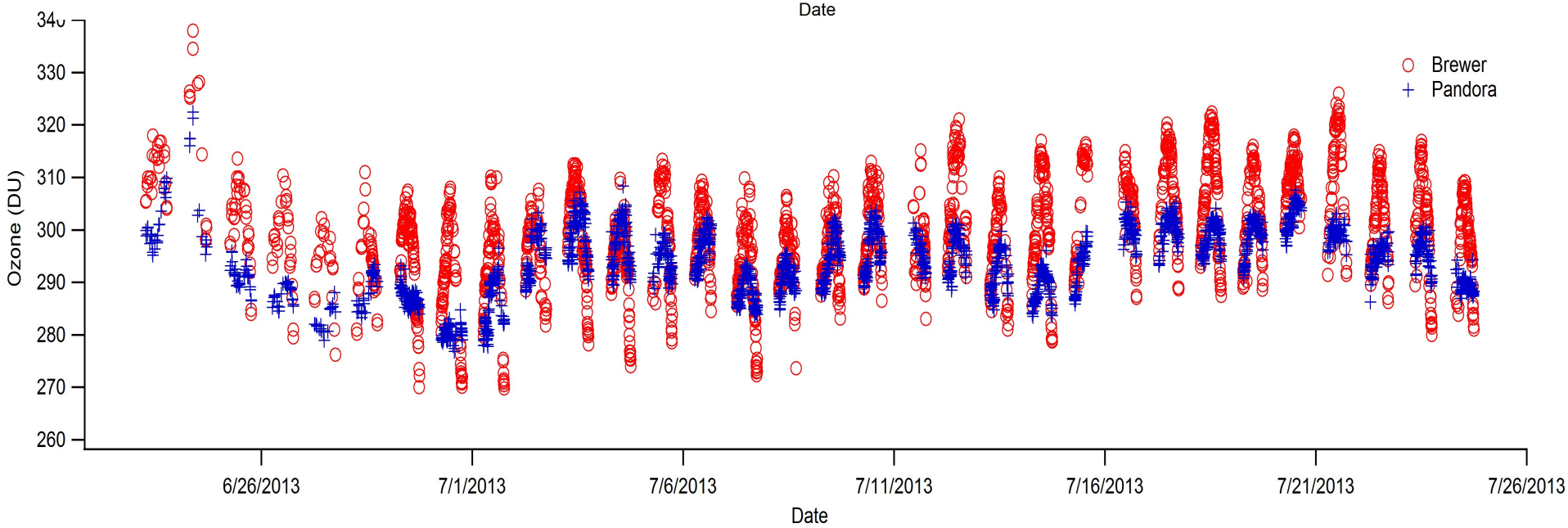
In situ (EPA) and regional remote (Pandora) comparisons of Ozone and NO_2 at San Juan

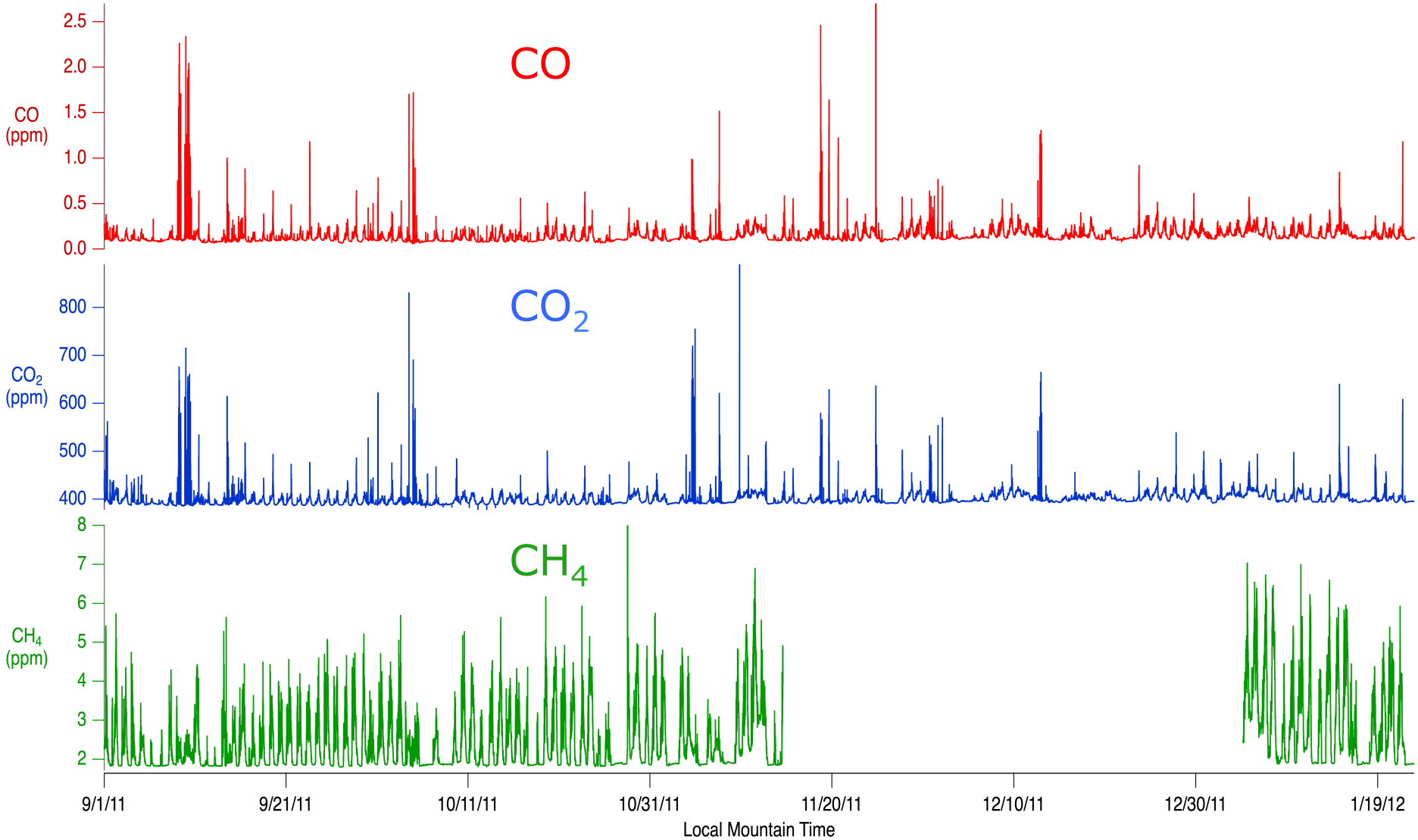


Remote Regional Ozone Monitoring at San Juan Substation: Pandora and Brewer Mark IV



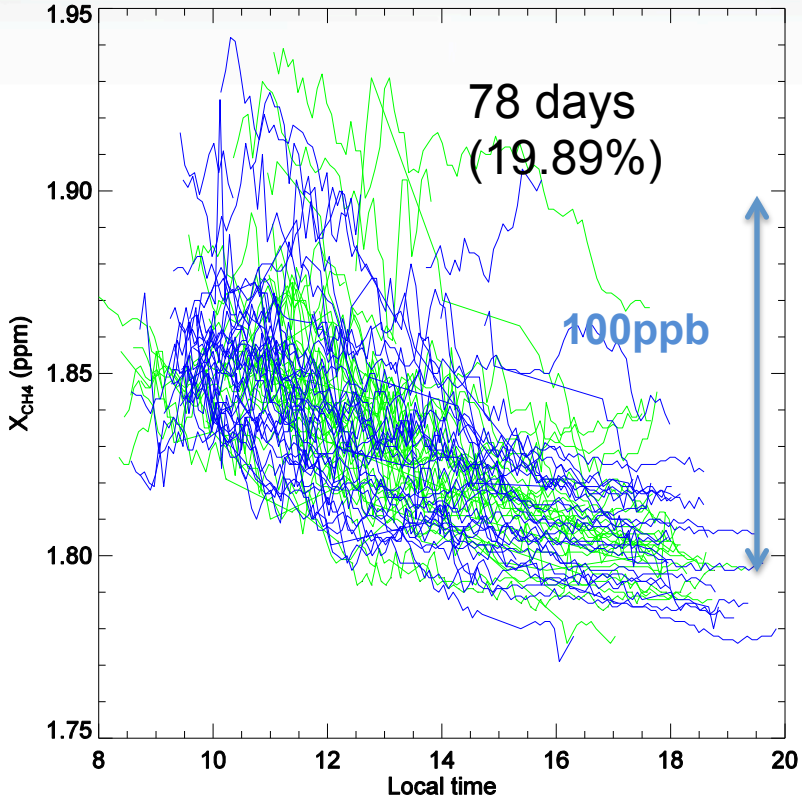


Discovery of Methane (x3) enhancements at 4C

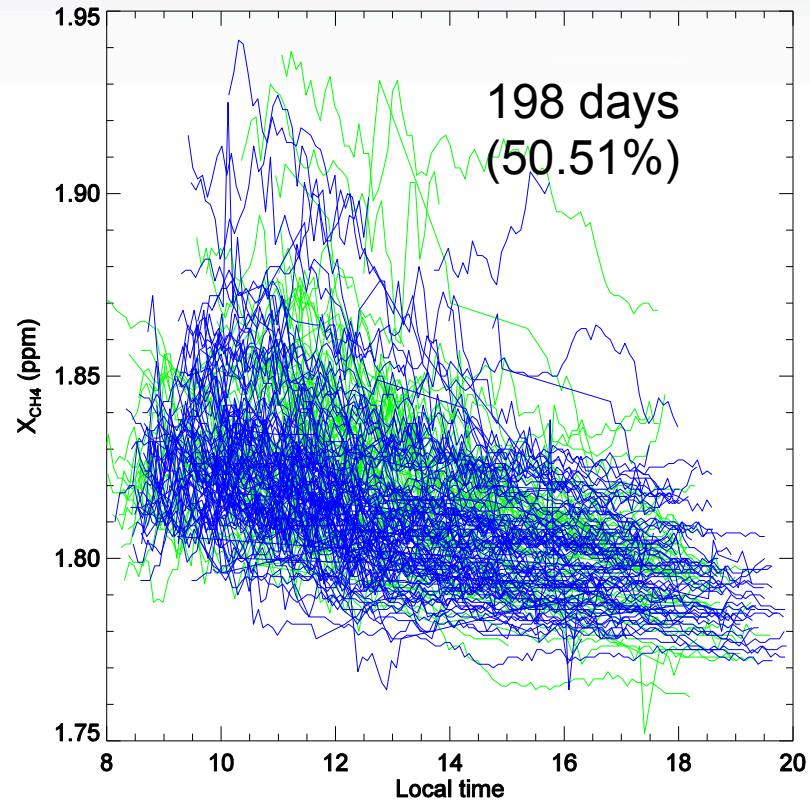


Ubiquitous high CH_4 plumes measured with 4CFTS when winds are low and from SE days

$X_{CH4} \geq 1.85$ ppm



$X_{CH4} \geq 1.82$ ppm



Total measurement days 2011+2012 =392

($X_{CH4} \geq 1.85$ ppm means that at least one value that day reached 1.85 ppm)

Satellite: SCIAMACHY 2003-2009 Hotspot at 4C

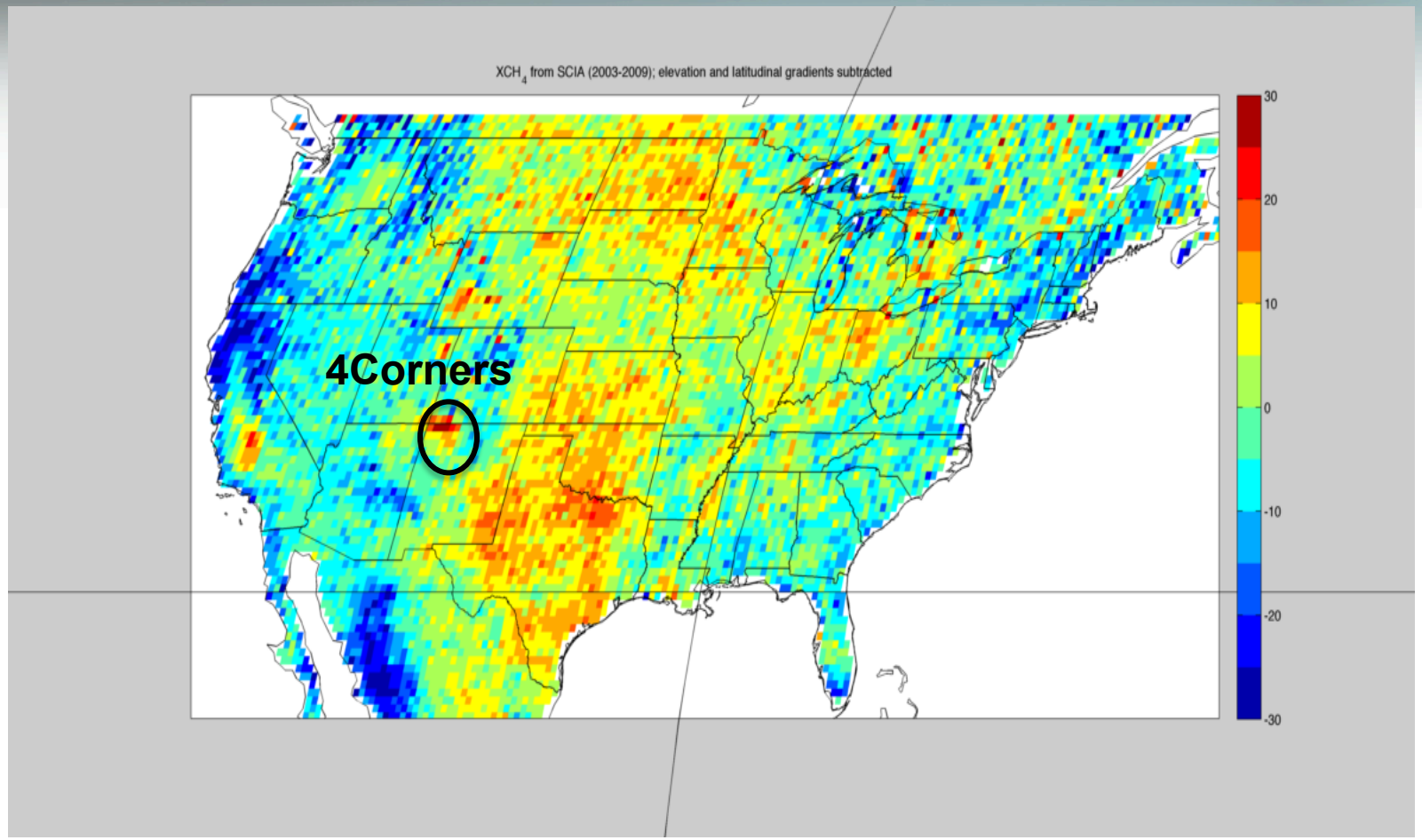
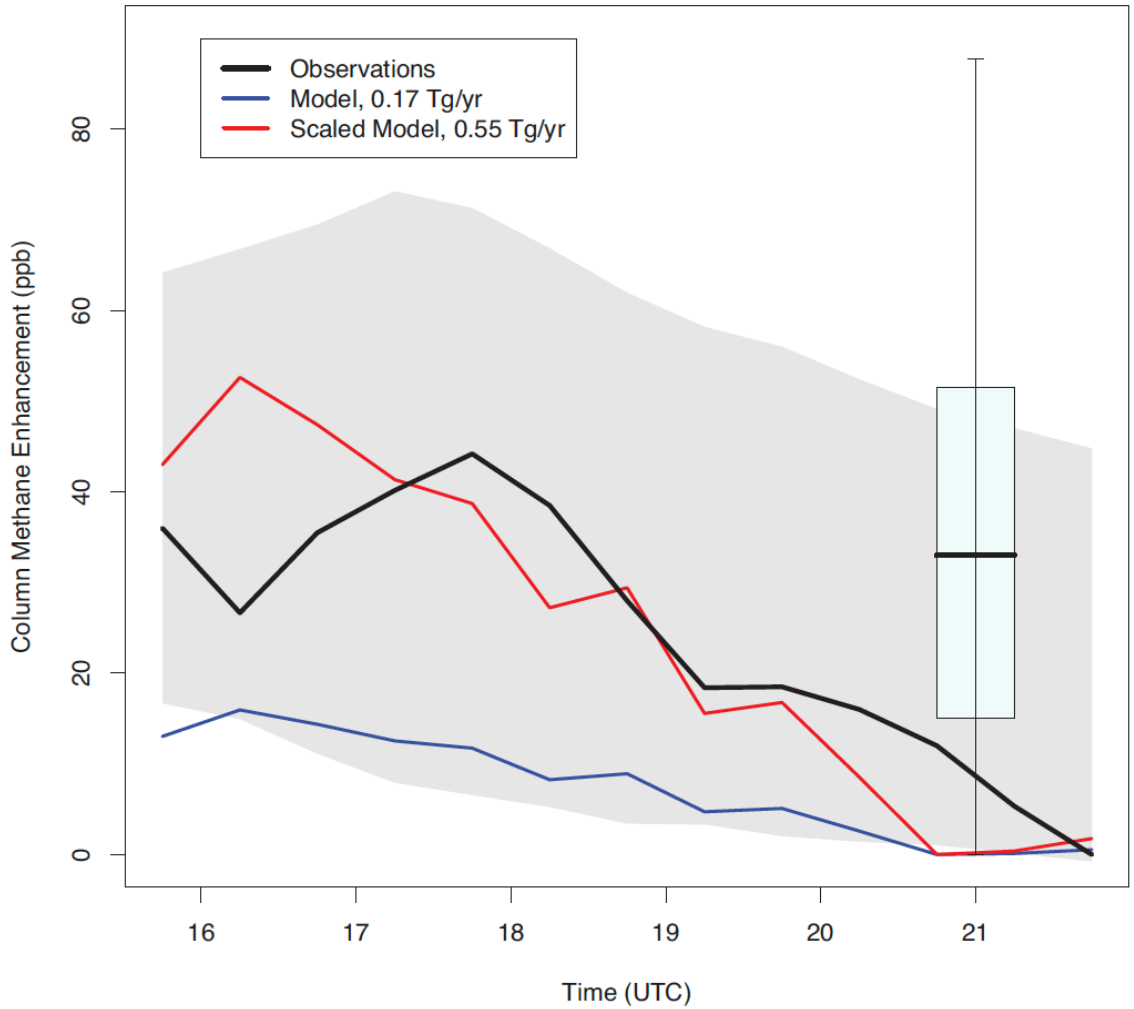
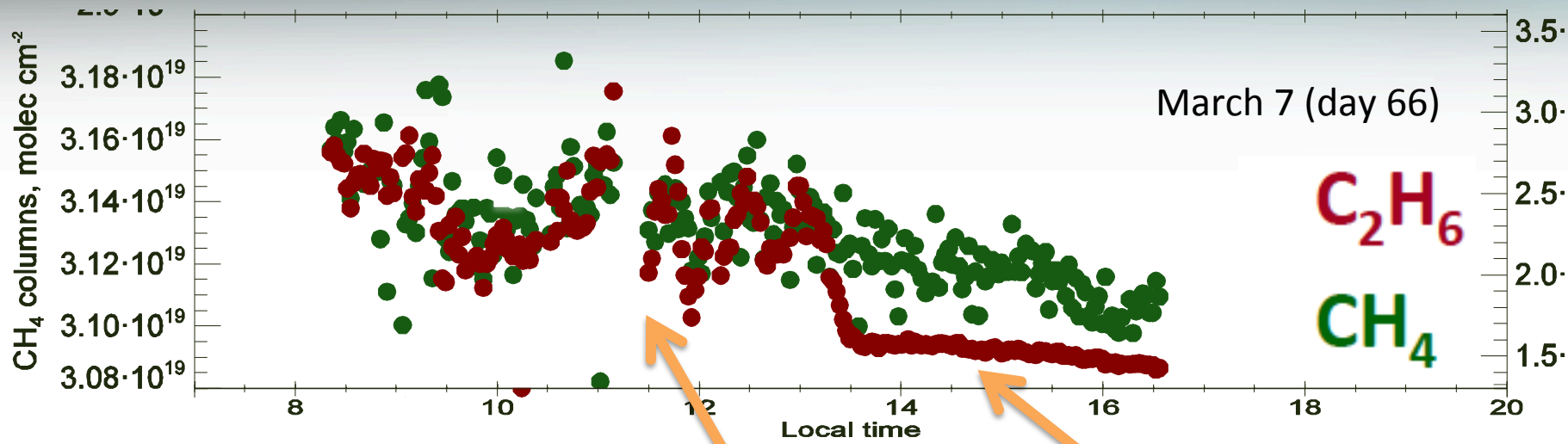


Figure 1: Average methane anomaly as seen by SCIAMACHY from 2003-2009. The four-corners region exhibits the largest regional enhancement in the conterminous US.

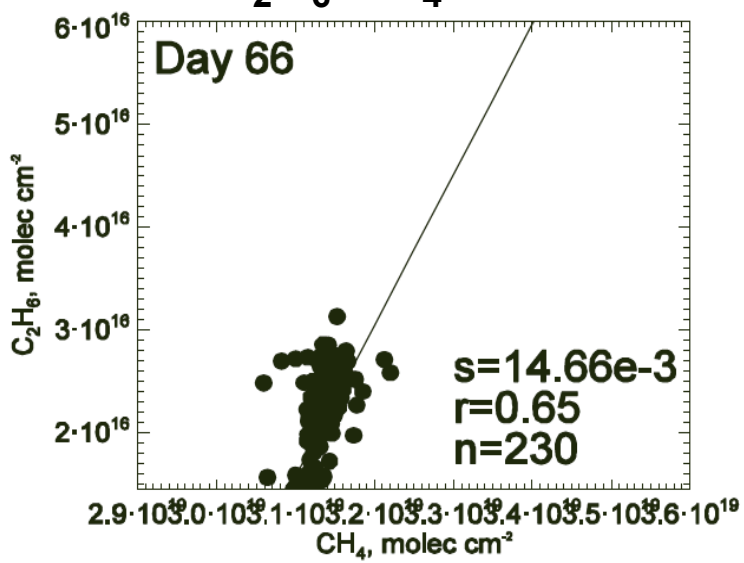
Edgar emissions have to be scaled by x3.3 in WRF model to match 4-Corners FTS observations

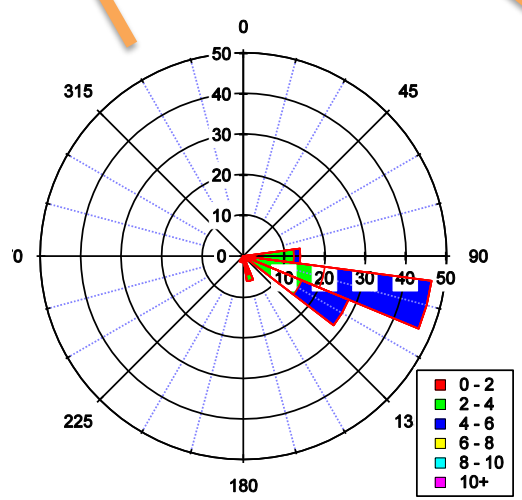


Mid-IR (InSb det) Retrieval of C_2H_6 & CH_4 to attribute thermogenic fugitive leaks

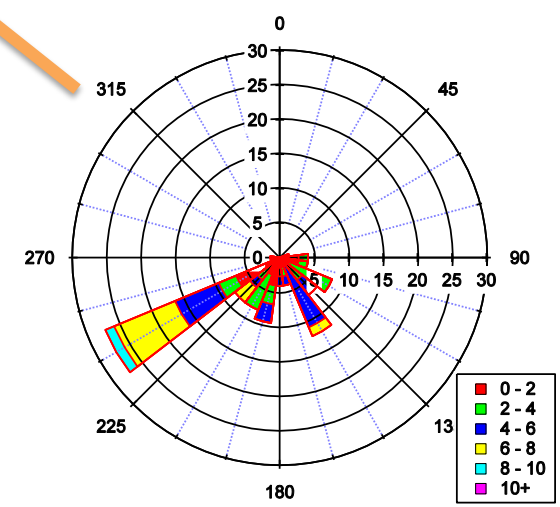


C_2H_6/CH_4 = 1.5%





8 AM – 1 PM



1 PM – 6 PM

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