Top-down evaluation of point source NO_x, SO_2, and CO emissions and comparison to inventories

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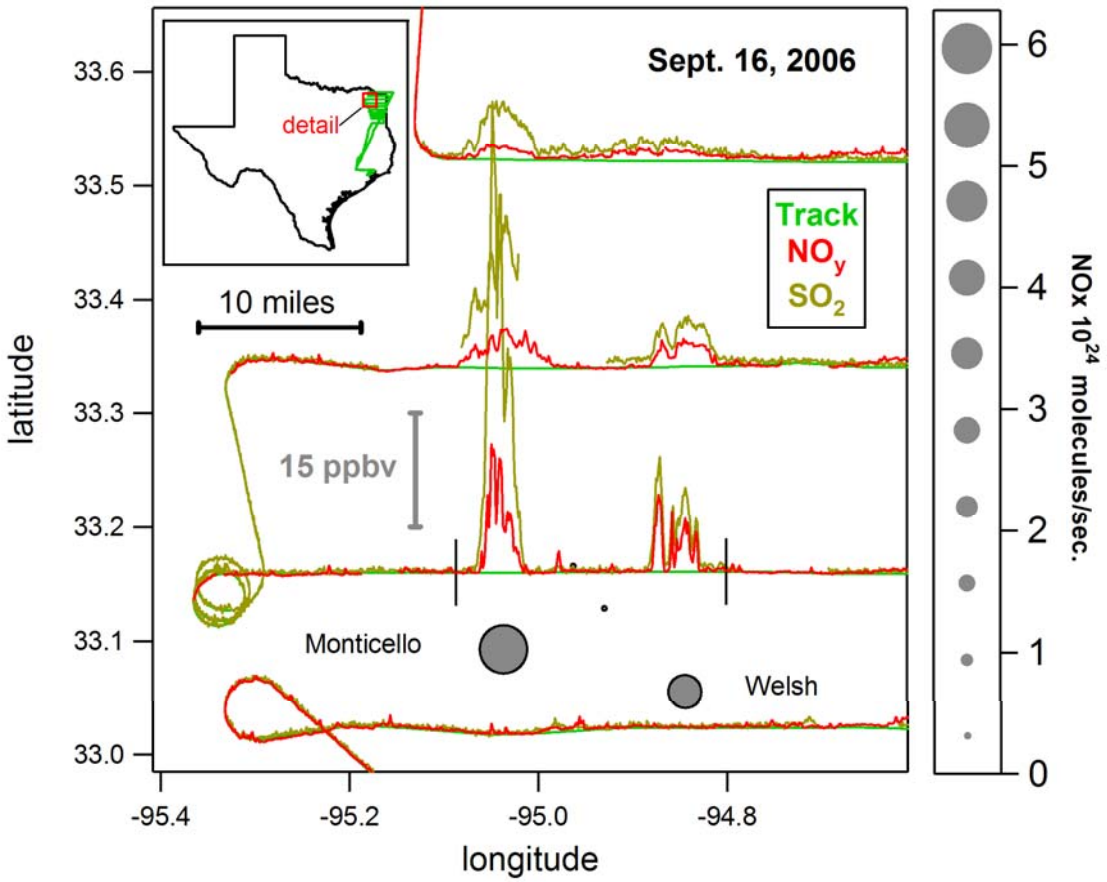
Purpose

- Use aircraft data to calculate emission ratios of NO_x, SO_2, and CO to CO_2 from electric utility power plants.
- Evaluate the ratios calculated from Continuous Emission Monitoring Systems (CEMS) installed at each plant.
- Use aircraft snapshots to independently verify emissions changes over time.

Determining Emission Ratios from Airborne Data



1-second NO_y and SO_2 plotted over 9/16/06 flight track

1-second averages of CO_2, NO_y, SO_2, and CO in cross-wind plume transects

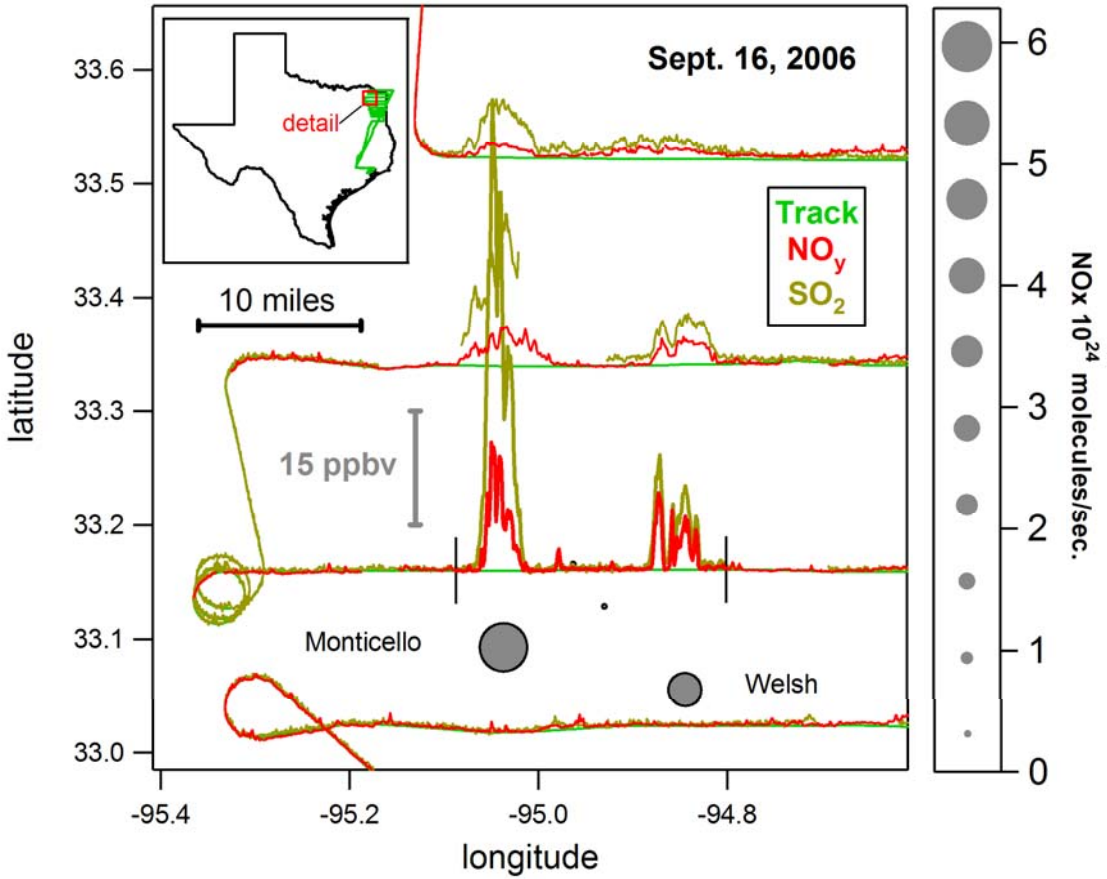
Assumptions:

All NO_x ($NO + NO_2$) emitted from power plants detected downwind as NO_y enhancement

Dilution and mixing affects all species equally

- Emission ratio is conserved during transport

Determining Emission Ratios from Airborne Data



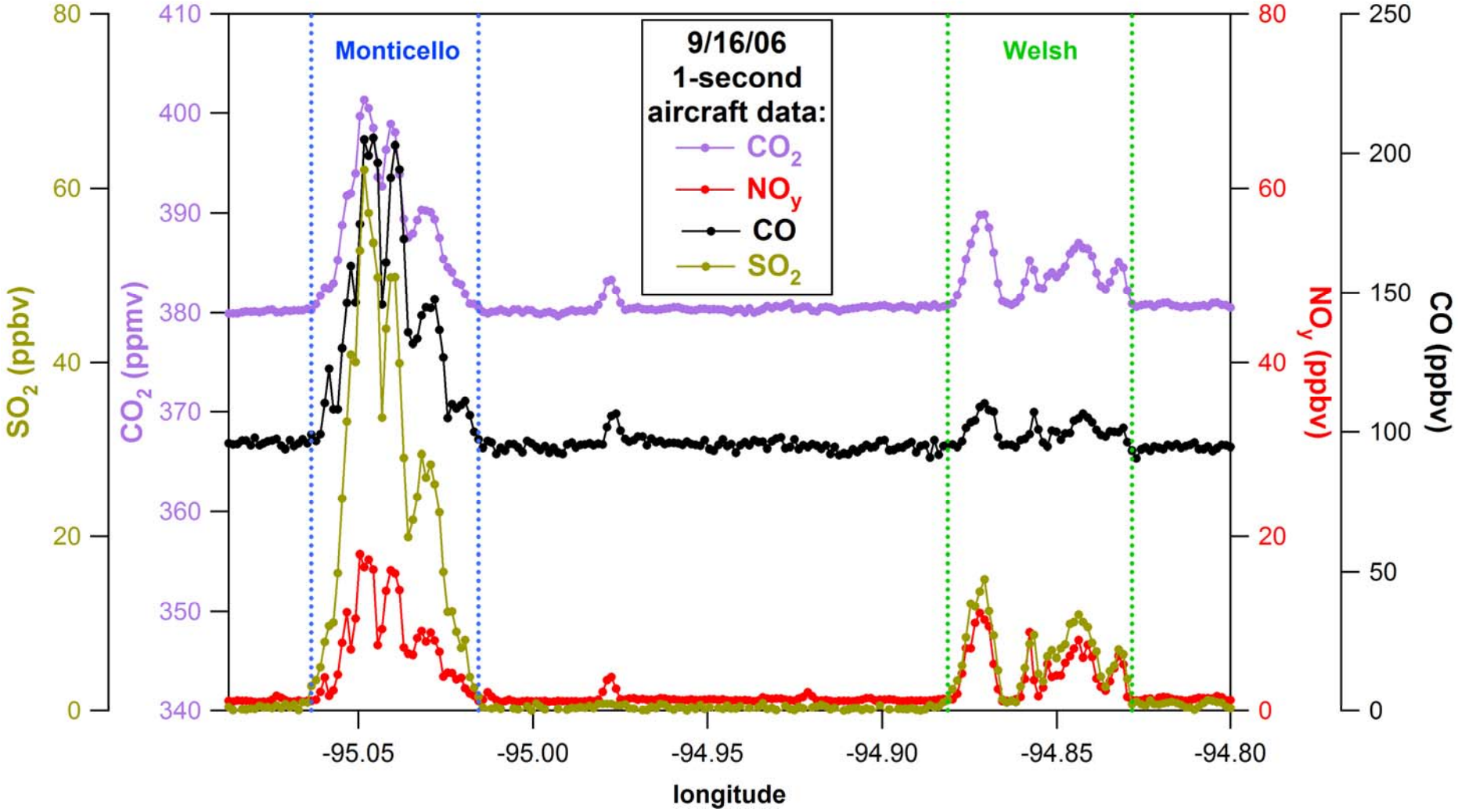
Assumptions:

Using closest transects, differential loss is negligible

- short (<1 hour) transport times minimize loss of reactive species

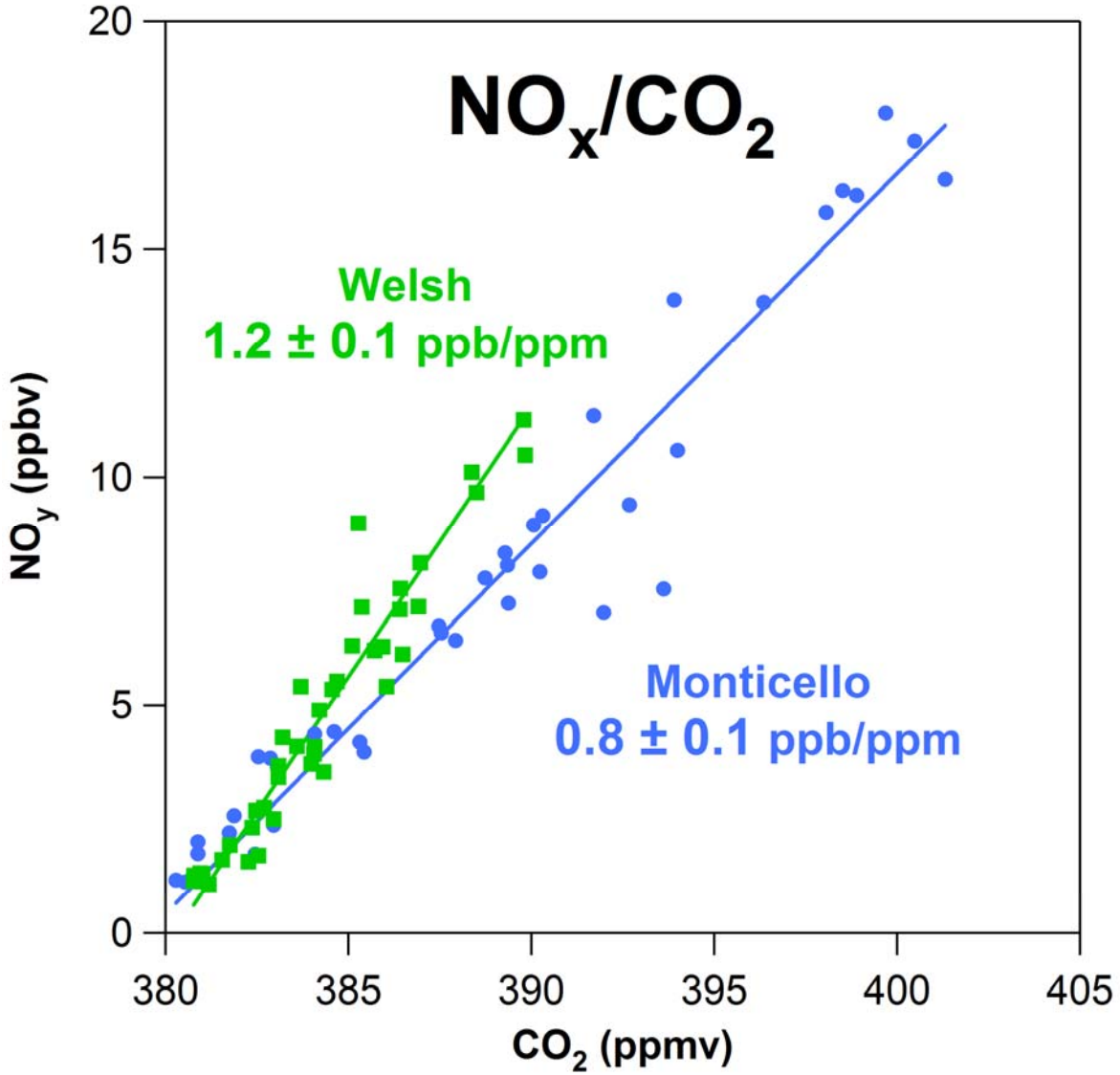
Covariance in measured species give a direct measure of the point source emission ratio

Determining Emission Ratios from Airborne Data



Enhancement in species defines plumes

Calculated NO_x emission ratios



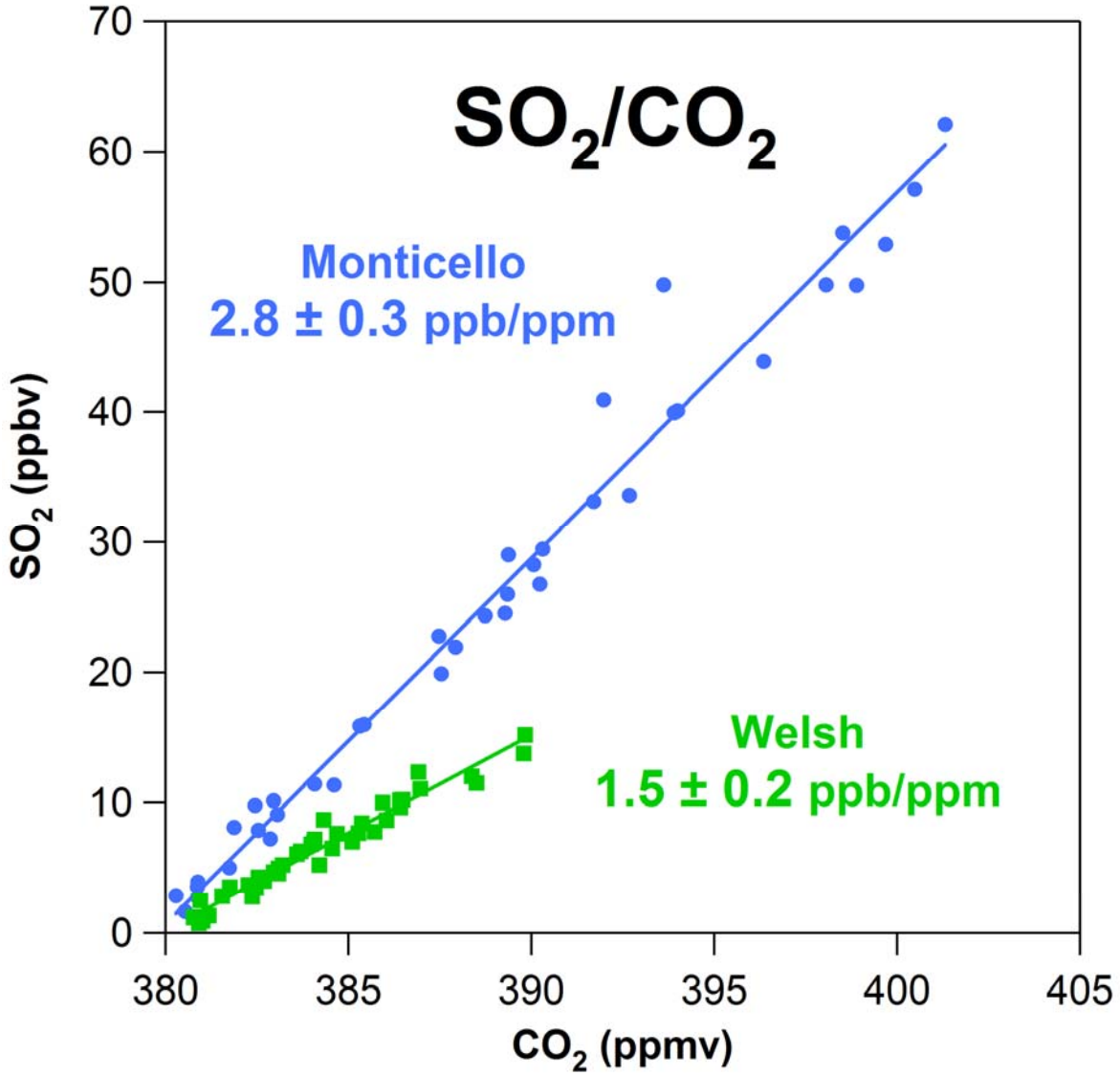
Slopes give estimate of emission ratio in molecules NO_x/ molecules CO_2

2-sided fits are weighted by aircraft measurement uncertainties:

CO_2: < 0.4 ppmv

NO_y: 0.1–0.5 ppbv ± 12%

Calculated SO_2 emission ratios



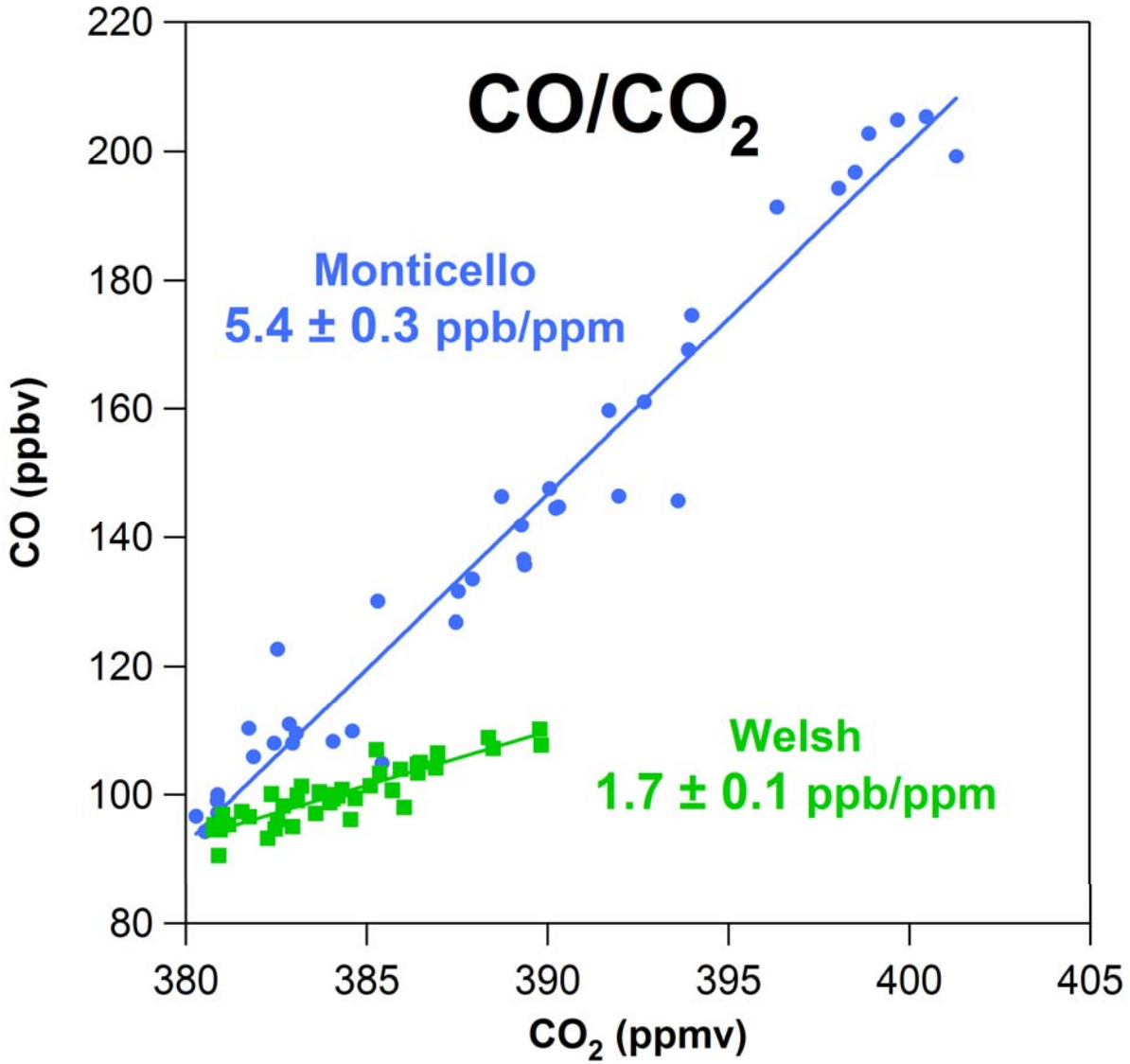
Slopes give estimate of emission ratio in molecules SO_2/ molecules CO_2

2-sided fits are weighted by aircraft measurement uncertainties:

CO_2: < 0.4 ppmv

SO_2: 0.3 ppbv ± 12%

Calculated CO emission ratios



Slopes give estimate of emission ratio in molecules CO/ molecules CO_2

2-sided fits are weighted by aircraft measurement uncertainties:

CO_2: < 0.4 ppmv

CO: 1 ppbv ± 5%

Comparison with hourly CEMS

- Use average wind speed and distance from source to calculate an estimated time of emission from that source.
- Use hourly CEMS data to calculate an emission ratio.

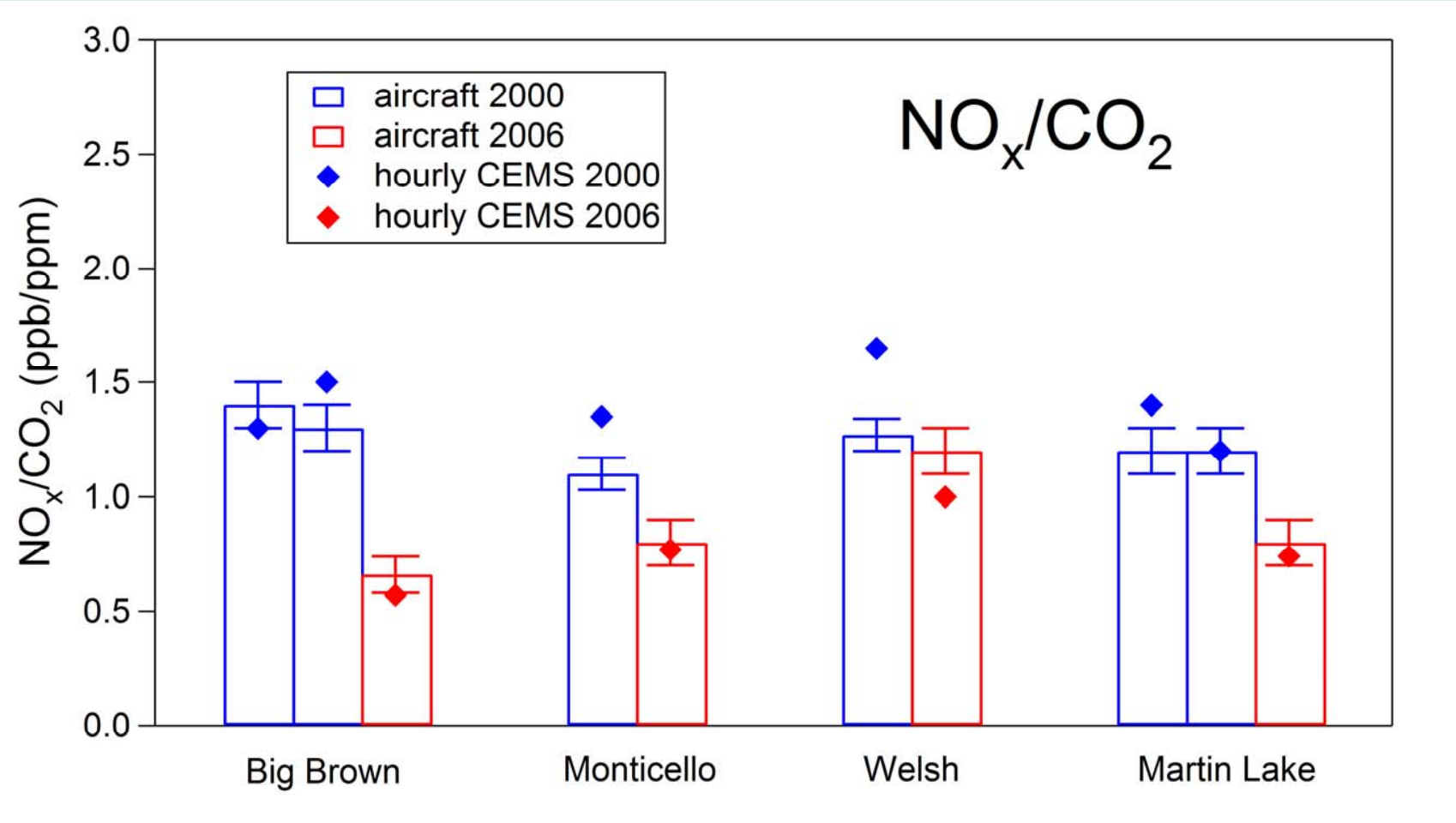
Comparison with hourly CEMS

emission ratio		NO_x/CO_2	SO_2/CO_2	CO/CO_2
Monticello	aircraft	0.8 ± 0.1	2.8 ± 0.3	5.4 ± 0.3
	hourly CEMS	0.8	2.8	…
Welsh	aircraft	1.2 ± 0.1	1.5 ± 0.2	1.7 ± 0.1
	hourly CEMS	1.0	1.7	…

Emission ratios calculated from aircraft data and hourly CEMS data are in quantitative agreement.

Aircraft data includes uncertainties, which are necessary for scientific evaluation.

NO_x reductions between 2000 and 2006



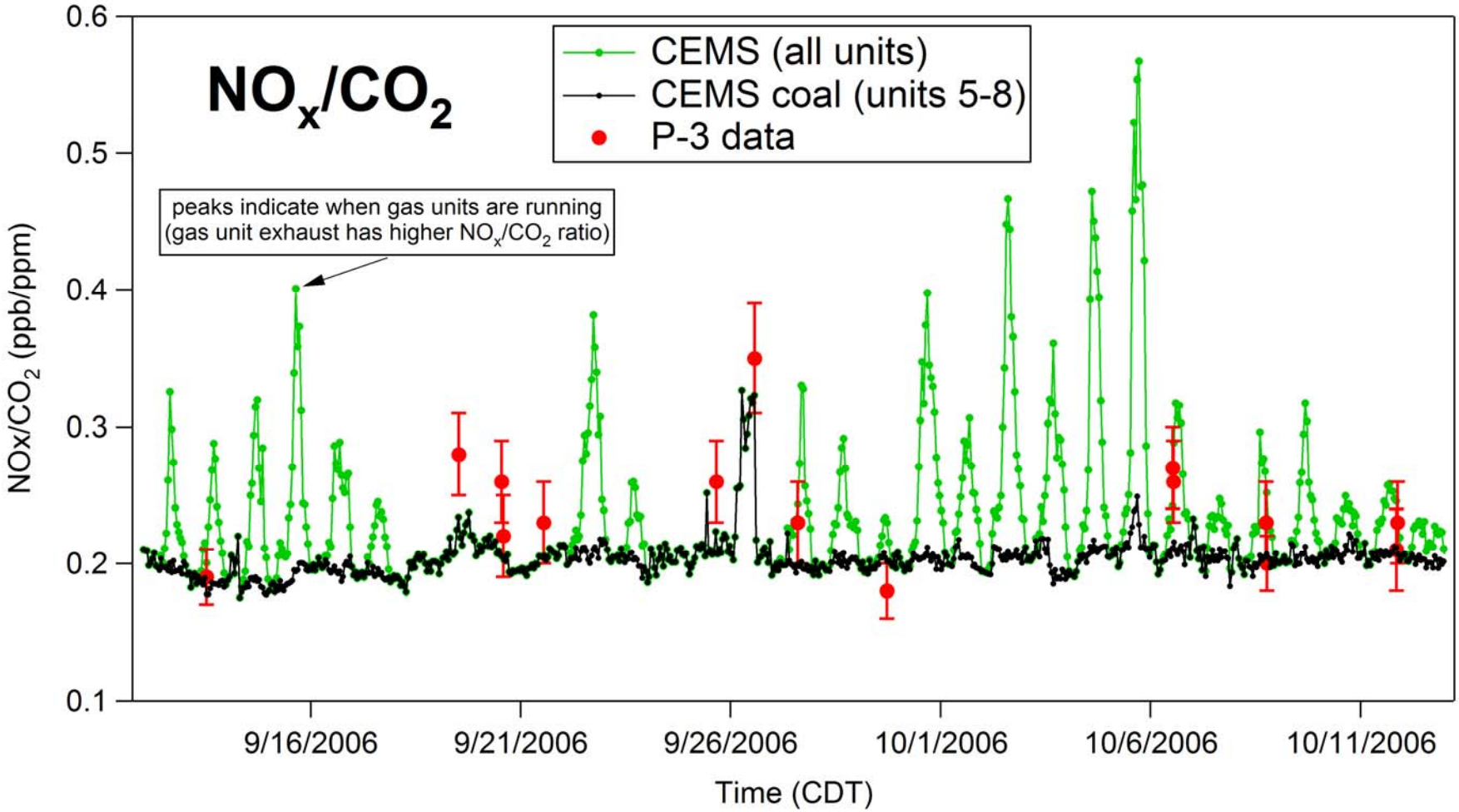
Aircraft data confirm substantial NO_x reductions have occurred.

NO_x reductions between 2000 and 2006

NO_x/CO_2	aircraft	hourly CEMS	annual CEMS
Big Brown	-51%	-59%	-64%
Monticello	-27%	-43%	-42%
Welsh	-6%	-39%	-44%
Martin Lake	-33%	-43%	-46%

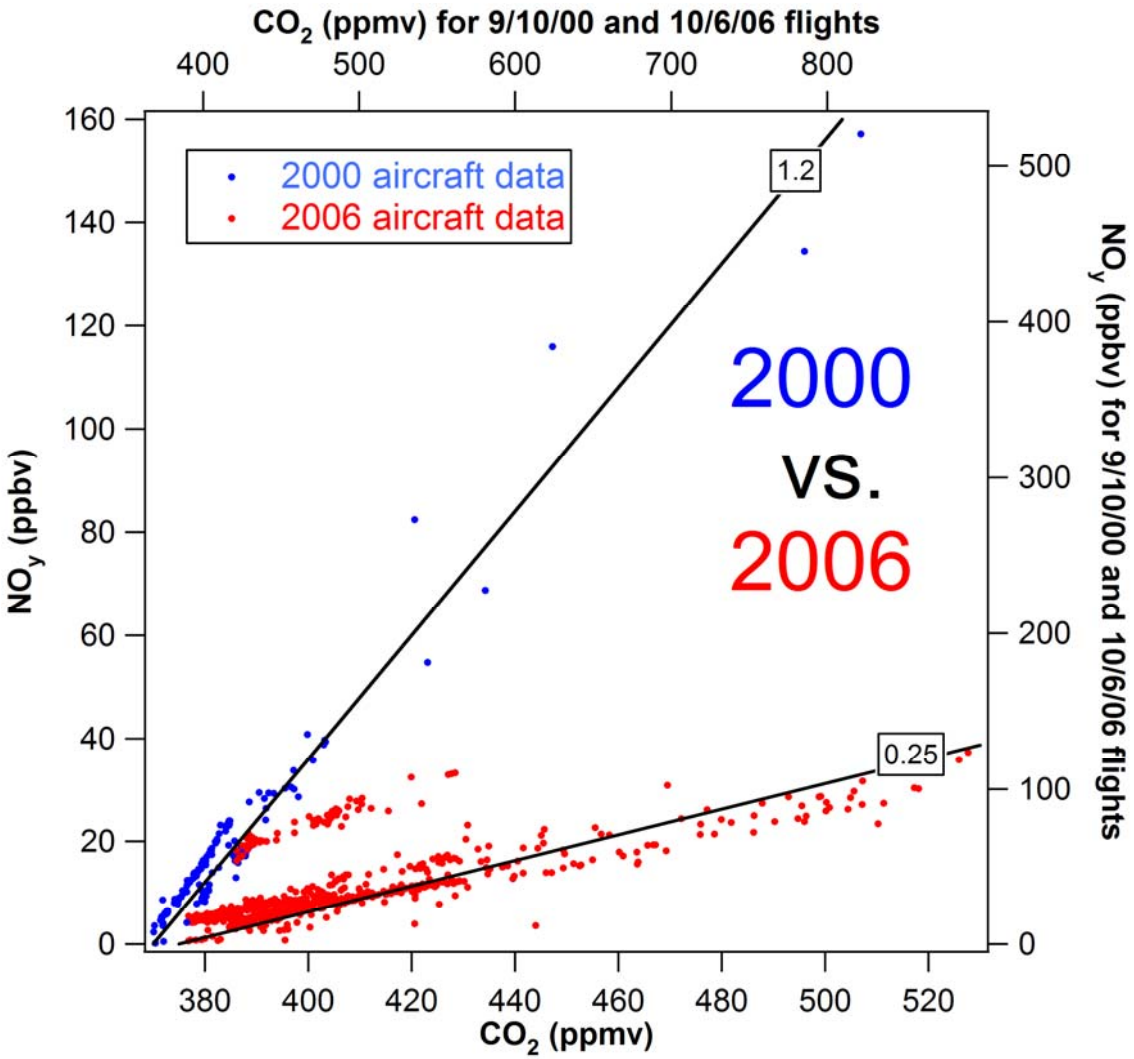
Aircraft data show substantial NO_x reductions have occurred and confirm control strategies have made an impact on NO_x pollution emitted into the atmosphere.

Calculations of W. A. Parish NO_x/CO_2 ratios by aircraft and hourly CEMS are in good agreement



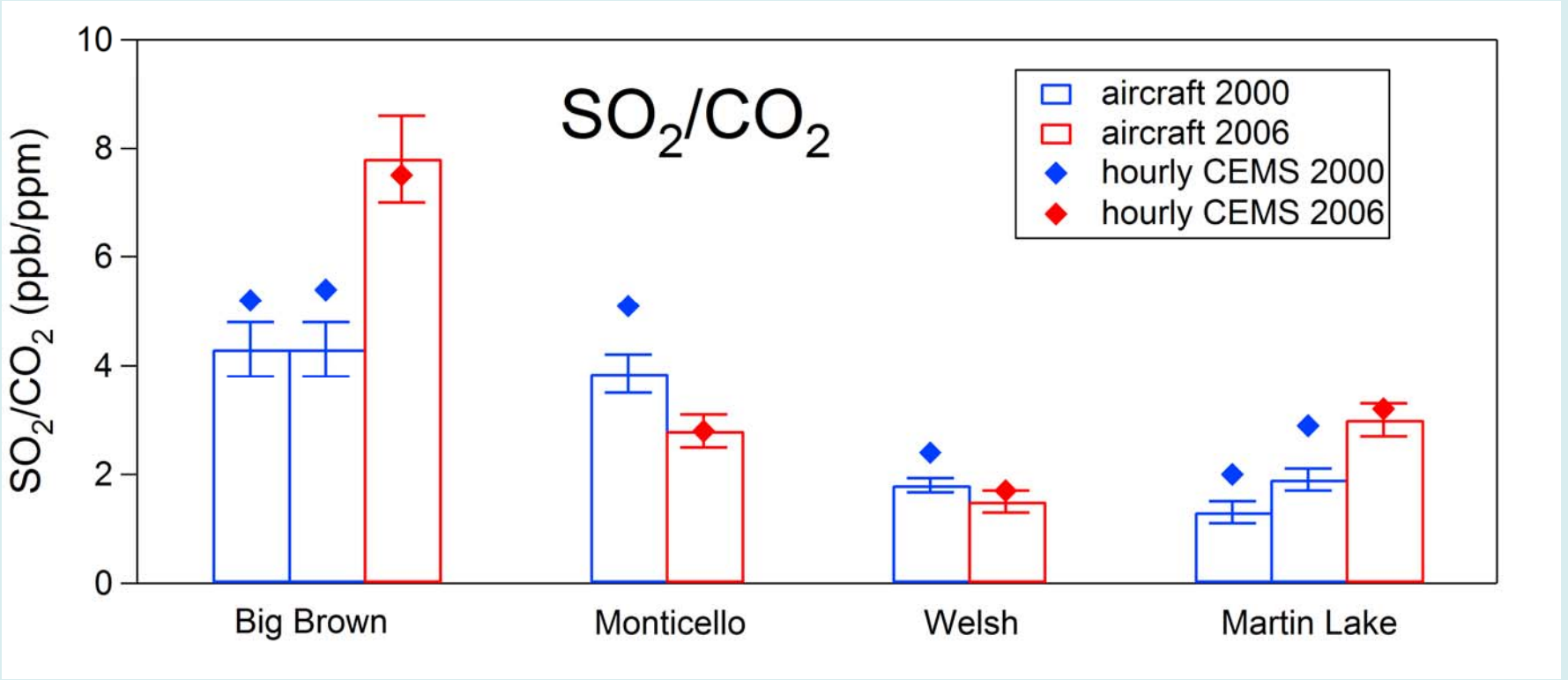
- Shown above are 16 passes the NOAA aircraft made downwind of Parish power plant throughout the 2006 field campaign.

W. A. Parish NO_x/CO_2 reductions



- 2000: 4 aircraft transects average **1.2** ppb/ppm
- 2006: 16 aircraft transects average **0.25** ppb/ppm
- NO_x reduction measured by aircraft: **79%**
- **These three numbers are <u>identical</u> to annual CEMS data**

SO_2 emissions changes from 2000 to 2006



Aircraft data show a dramatic increase in Big Brown and Martin Lake SO_2 emissions.

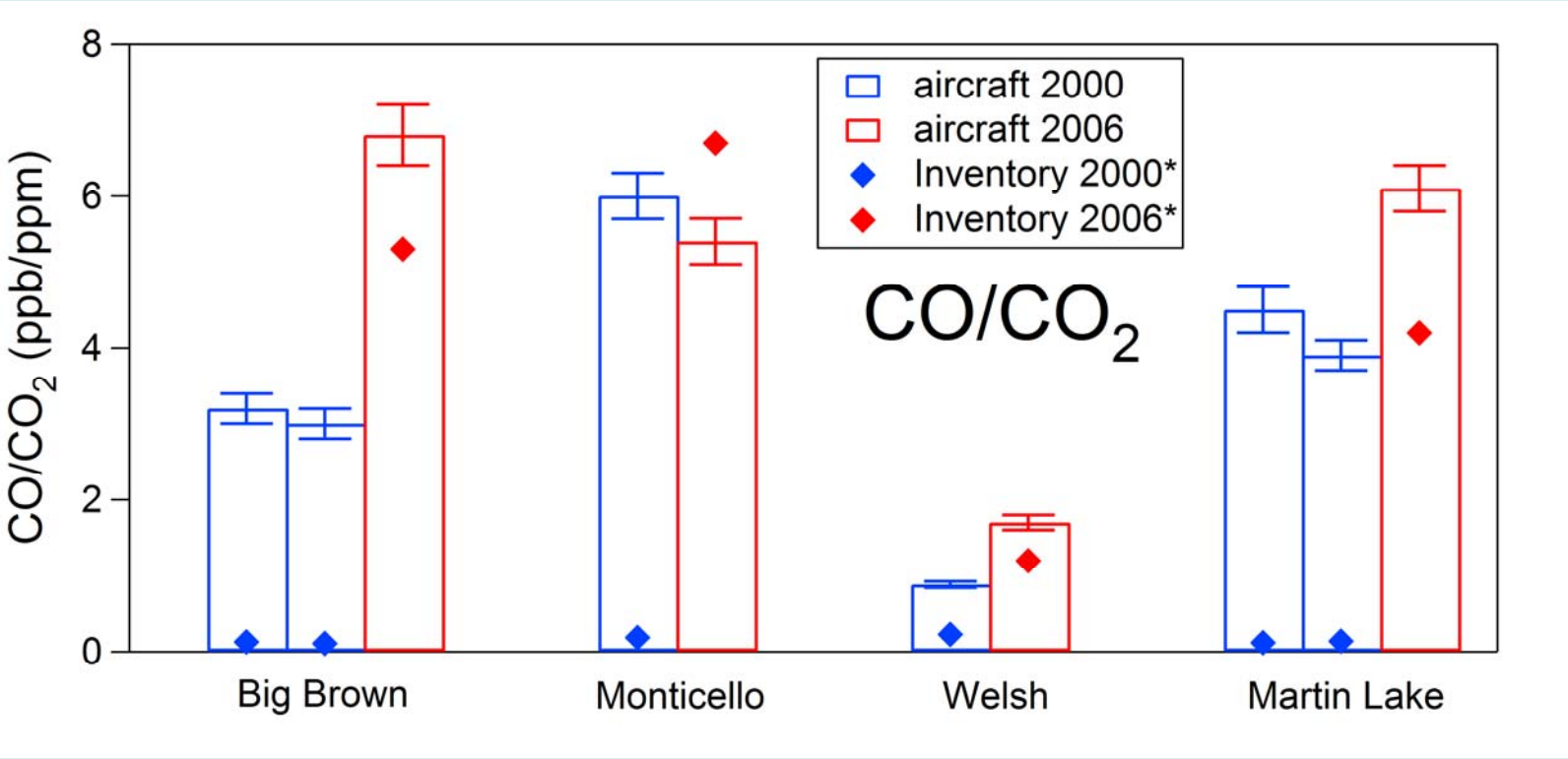
Aircraft and CEMS ratios calculated from 2006 data are in excellent agreement (i.e. to within their respective uncertainties).

SO_2 emission changes from 2000 to 2006

SO_2/CO_2	P-3	hourly CEMS	annual CEMS
Big Brown	+81%	+42%	+11%
Monticello	-27%	-45%	-28%
Welsh	-17%	-29%	-18%
Martin Lake	+88%	+31%	+25%

- Percentage changes differ due to systematic differences between aircraft and CEMS data from 2000.

CO emissions inventories more realistic



* Inventory numbers were calculated by multiplying 1999 and 2004 TCEQ point source emissions inventory CO/NO_x ratios by 2000 and 2006 hourly CEMS NO_x/CO_2 ratios

- CO emission calculations in 1999 grossly understated actual emissions
- By 2004, inventories confirmed substantial CO emissions from electric utility power plants

Conclusions

- In 2006, emission ratios from aircraft and hourly CEMS agree to within an average of ±10%.
- Aircraft and CEMS data show NO_x emissions from several electric utility power plants have decreased substantially (25-80%) since 2000.
- Aircraft and CEMS data show significant increases in SO_2 emissions from Big Brown and Martin Lake.
- Large and apparently continuous CO emissions from the Big Brown, Monticello, and Martin Lake plants have been observed on each of the four study days in 2000 and 2006.

Implications

- Annually averaged CEMS data are used as input to gridded national inventories; latest is NEI 2005, still being updated in 2008.
- Significant point source NO_x reductions continue to occur during the period between successive NEI versions.
- Separate treatment of CEMS sources within the NEI will allow for more frequent updates and therefore increase the effectiveness of air quality modeling efforts.