Using ambient measurements to critically evaluate the temporal trends of U.S. carbon monoxide emission inventories

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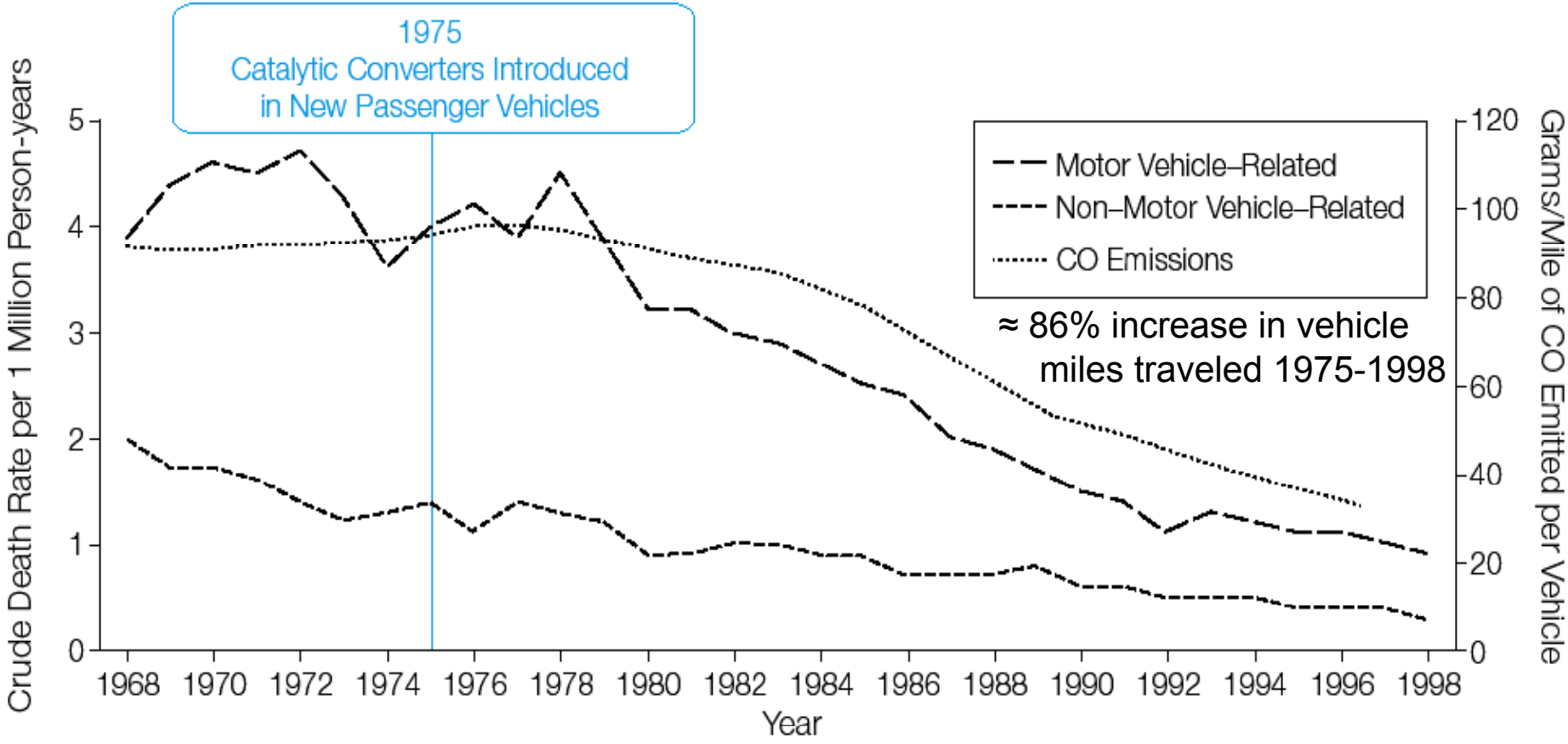
Apology and caveat: I have never been brave enough to attempt to develop an emission inventory, yet I criticize.

Today:

- Review "common knowledge" of CO emissions.
- Review history of U.S. CO emission inventories.
- Challenging emission inventories with ambient measurements.
- Conclusions and Recommendations.

“Everyone knows” that CO emissions have decreased dramatically over the last couple of decades …



“National Vehicle Emissions Policies and Practices and Declining US Carbon Monoxide-Related Mortality”, J.A. Mott et al., *J. Amer. Med. Assoc., 288*, 988-995, 2002. ≈ 12,000 deaths avoided.

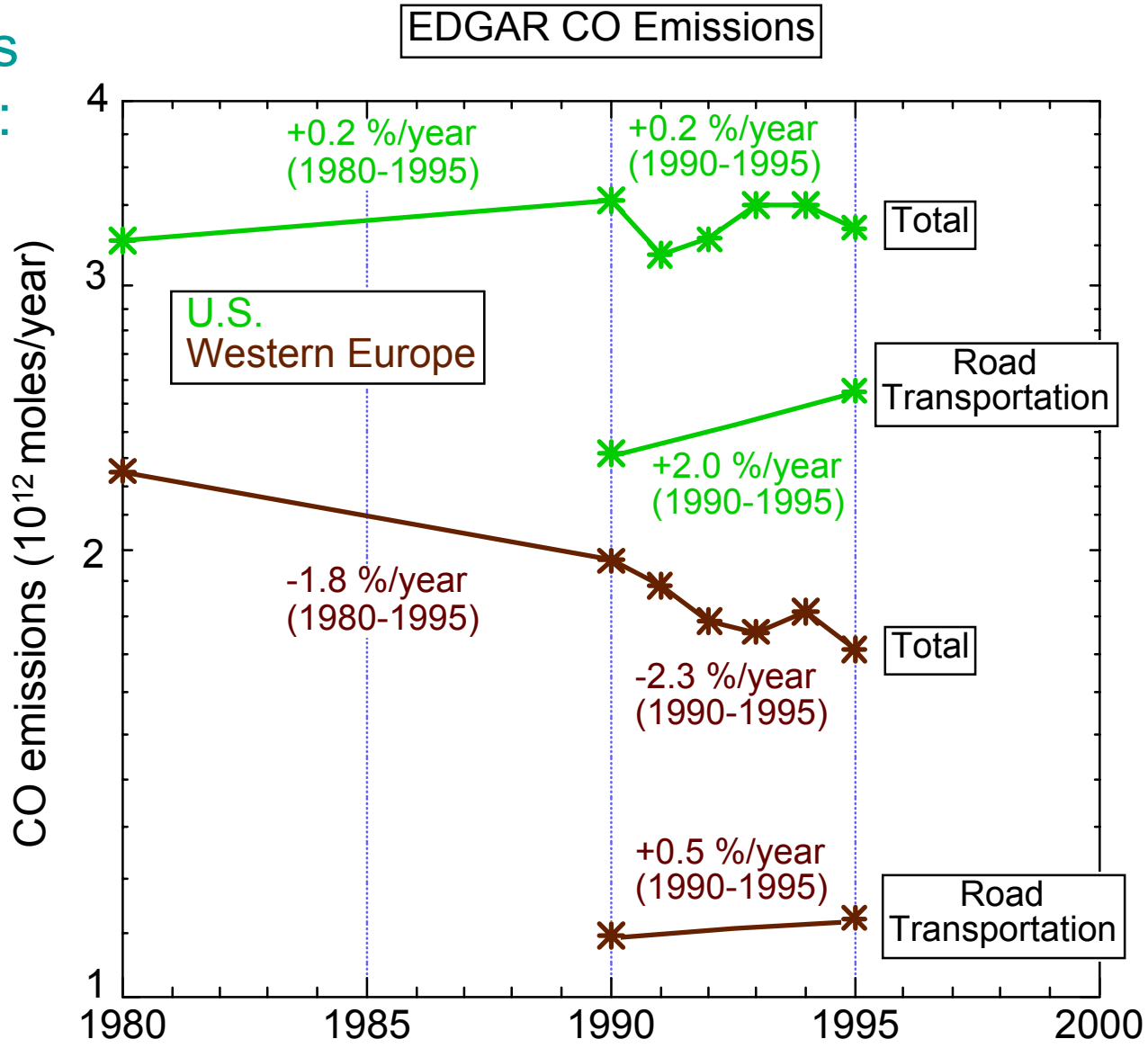
… except global emission inventory community ...

Global CO Emissions Inventory Enigmas:

Compared to U.S., Western Europe emits factor of 2 less with 40% more population. Lifestyle!

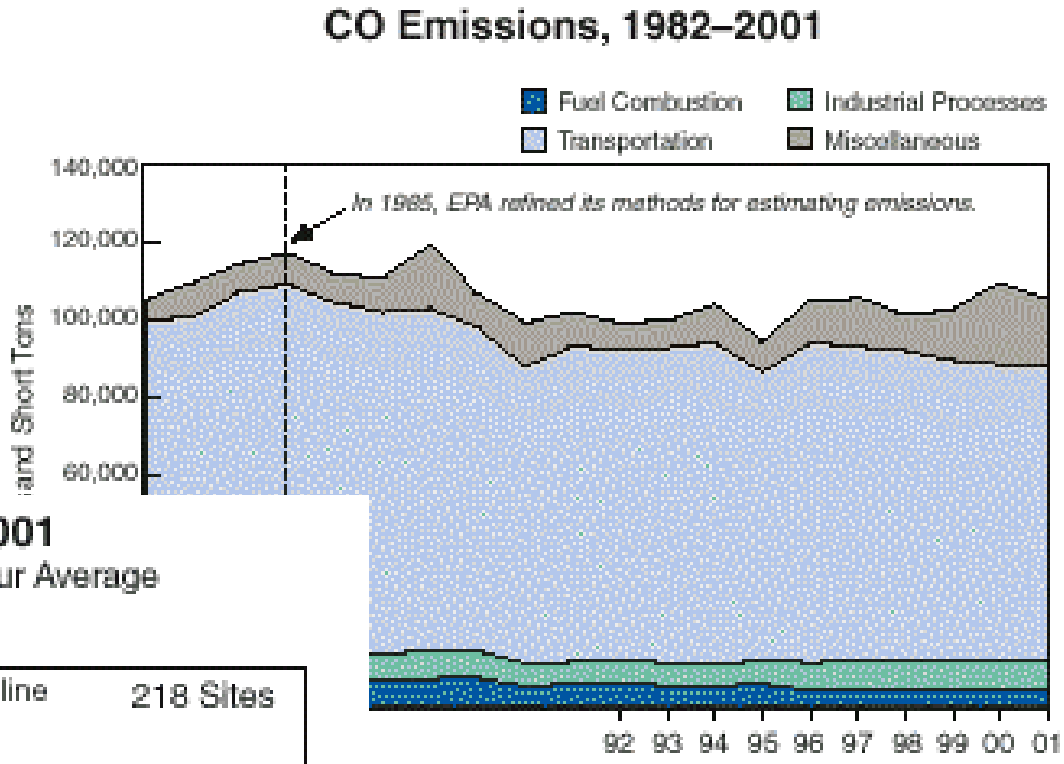
Western Europe emissions decreasing significantly while U.S. emissions nearly constant.

Road transportation emissions increasing?

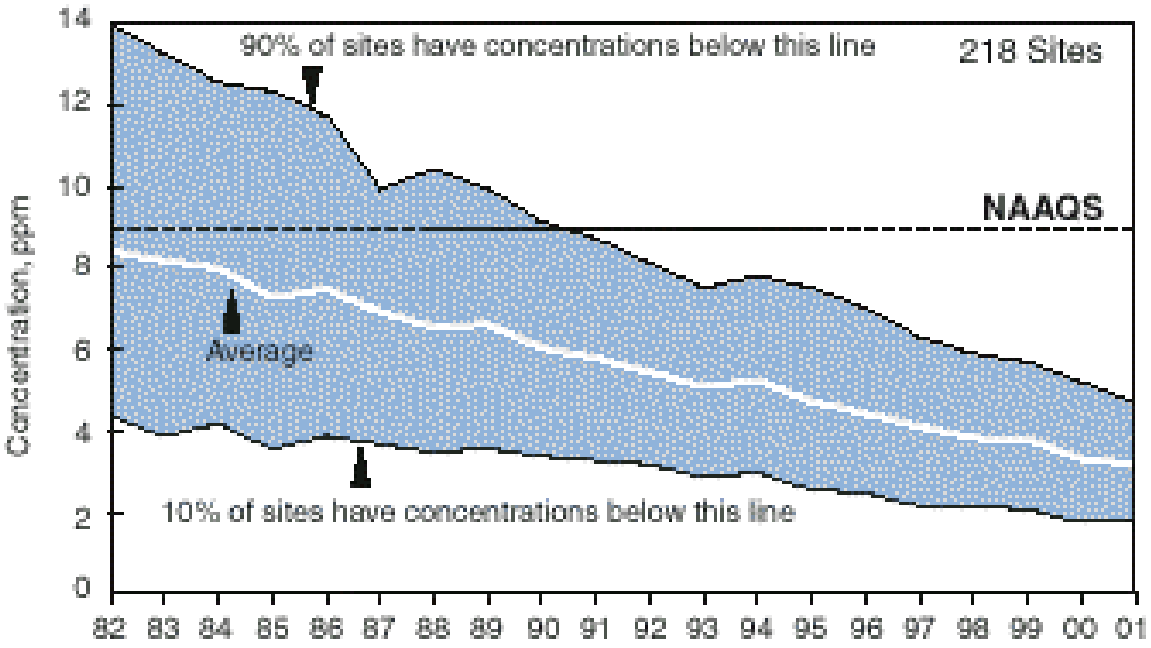


… and part of EPA.

National CO Emissions Inventory Enigmas:



1982–01: 0% change
1992–01: 6% increase

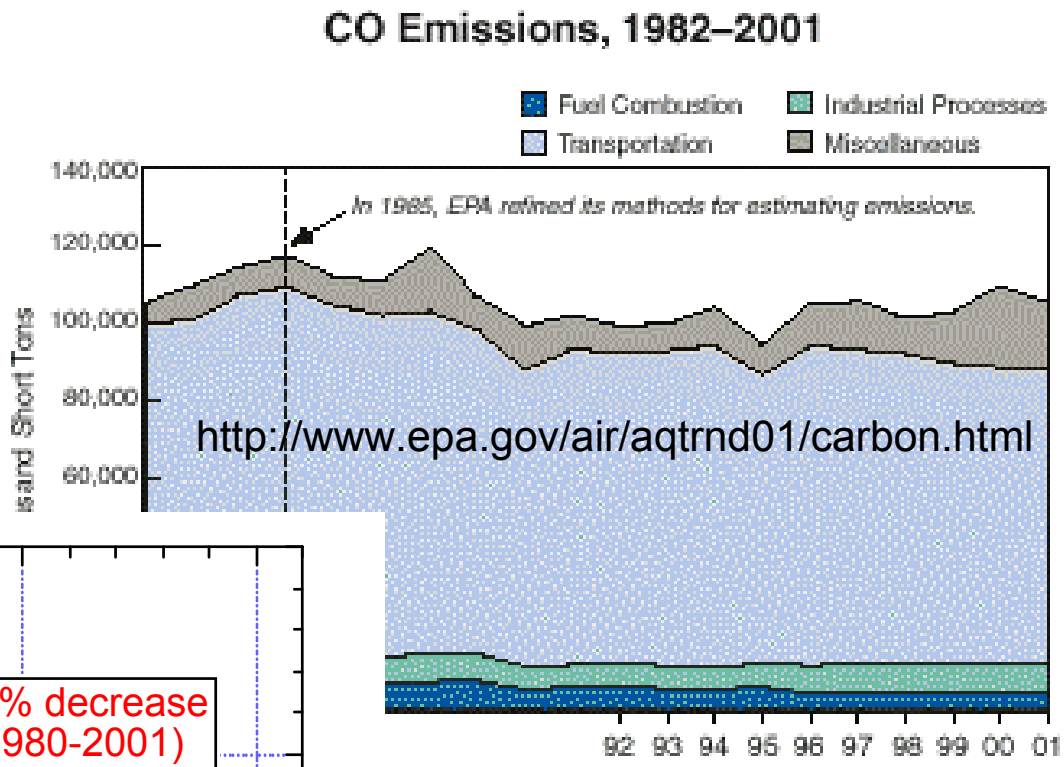


1982–01: 62% decrease
1992–01: 38% decrease

Over last 20 years:
Emissions constant, but ambient levels decreased by factor of 2.6? Can't be!!

http://www.epa.gov/air/aqtrnd01/carbon.html

National CO Emissions Inventory Enigmas:



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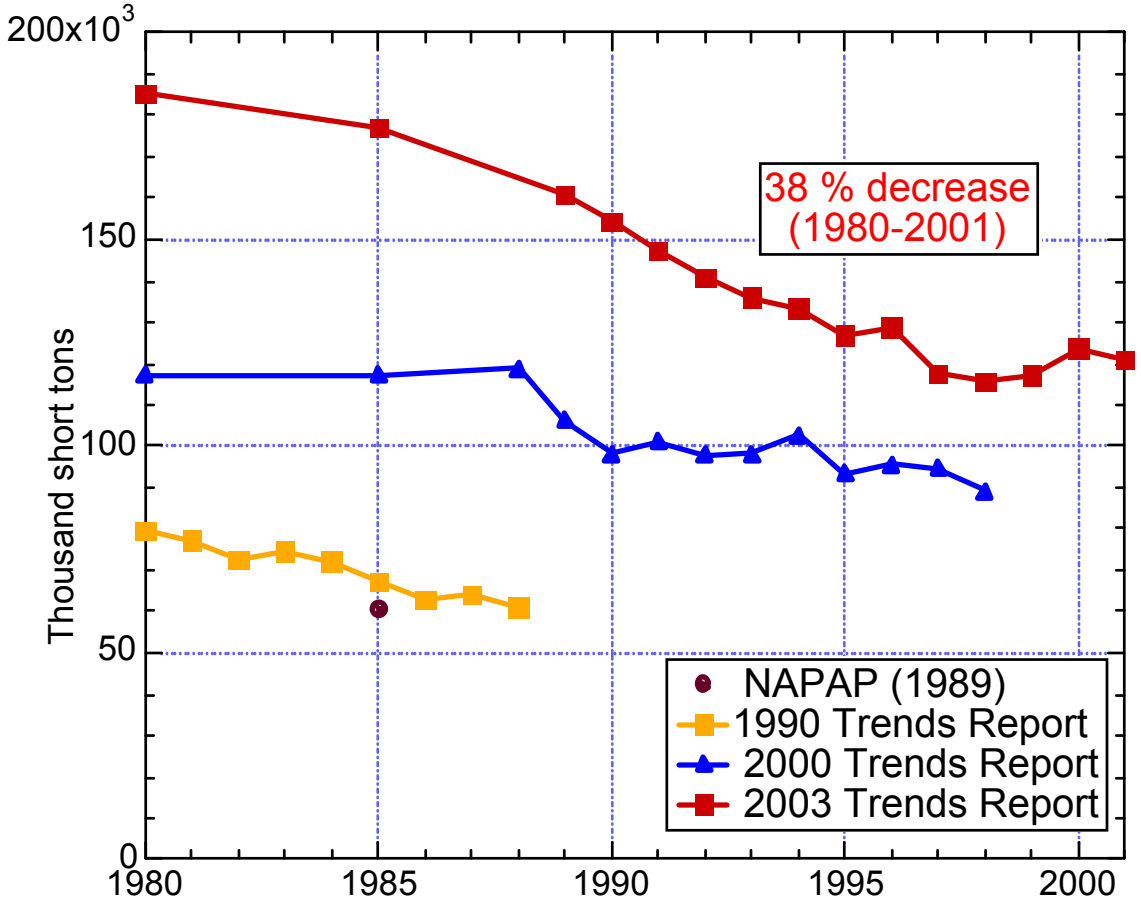


Current EPA emissions information is self-contradictory.

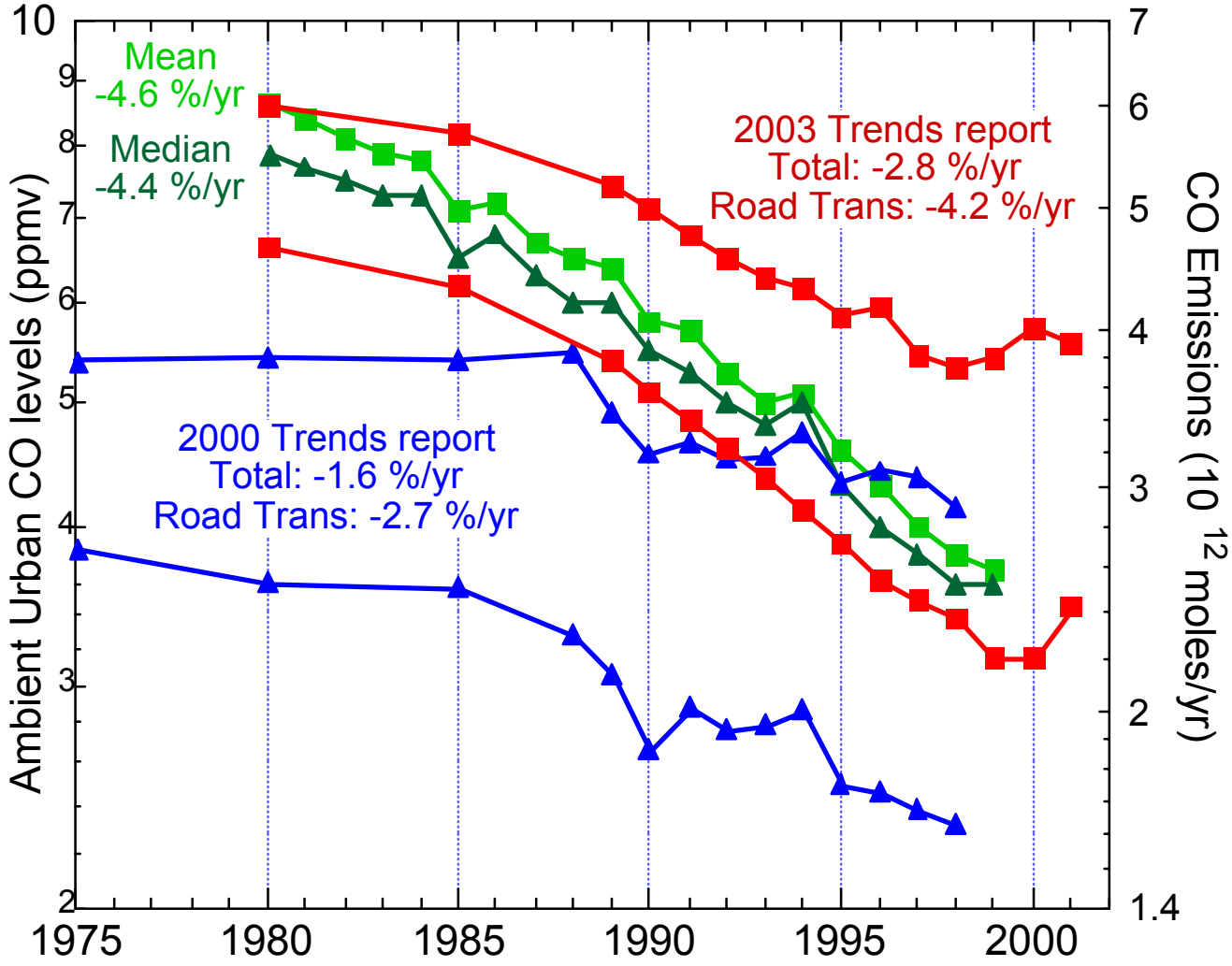
EPA emissions estimates have changed drastically. Danger Sign!!

What can ambient CO measurements tell us?
Compare trends in 2nd highest annual maximum 8 hour average for about 350 stations in U.S. - 1980-1999

Maximum ambient urban CO levels are likely dominated by road transport sources.

2003 Trends Report (but not 2000 Report) captures decrease in maximum urban CO levels.

(No information regarding absolute emission levels.)



Rural U.S. levels also decreasing at ≈ 3%: Hallock-Waters et al., *Geophys. Res. Lett.*, *26*, 2861-2864, 1999..

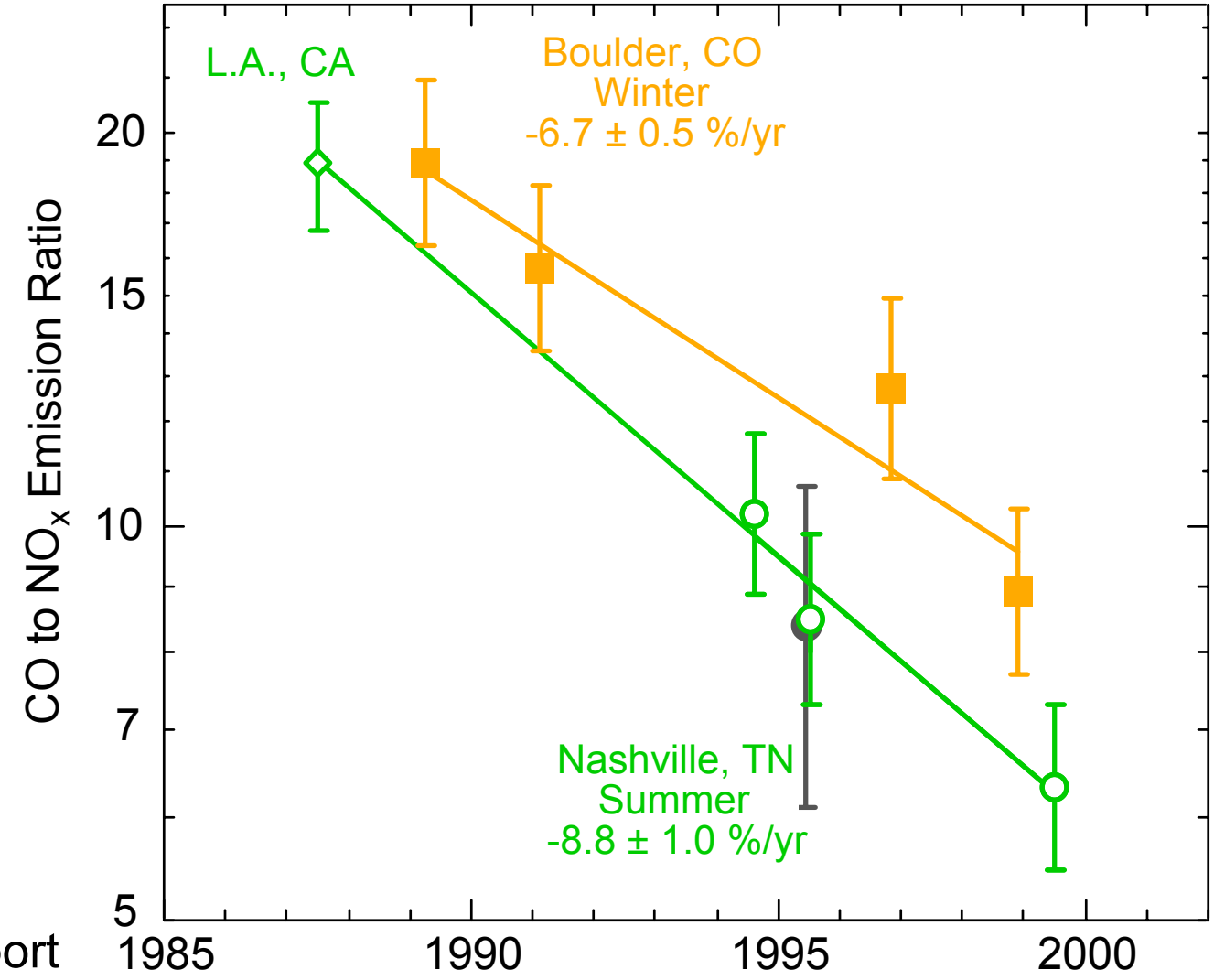
What can ambient CO measurements tell us?
Compare trends in CO to NO_x ratios in 3 U.S. urban areas.

Select isolated urban sites

Morning rush hour urban CO/NO_x ratios are dominated by road transport sources.

Very strong decrease observed

L.A. - Nashville trend is our best guess for national, road transport emission trend.



Parrish et al., *J. Geophys. Res., 107 (D12)*, 4140, doi:10.1029/2001JD000720, 2002.

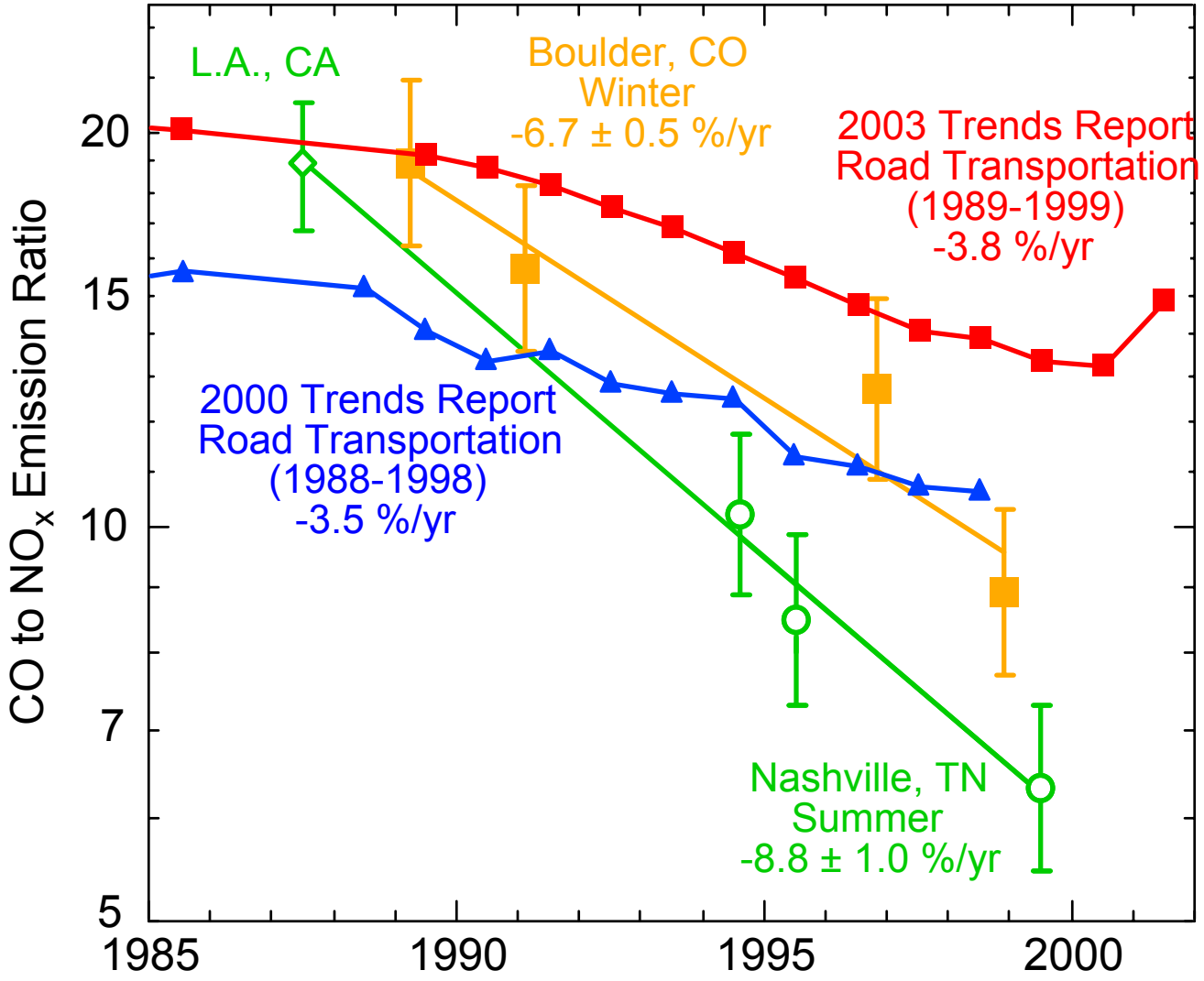
What can ambient CO measurements tell us?
Compare trends in CO to NO_x ratios in 3 U.S. urban areas.

Morning rush hour urban CO/NO_x ratios are likely dominated by road transport sources.

Neither Trends Report captures decrease in CO/NO_x ratios.

Neither Trends Report matches recent low observed CO/NO_x ratios, and 2003 is worse than 2000.

Implies problems in NO_x emissions!



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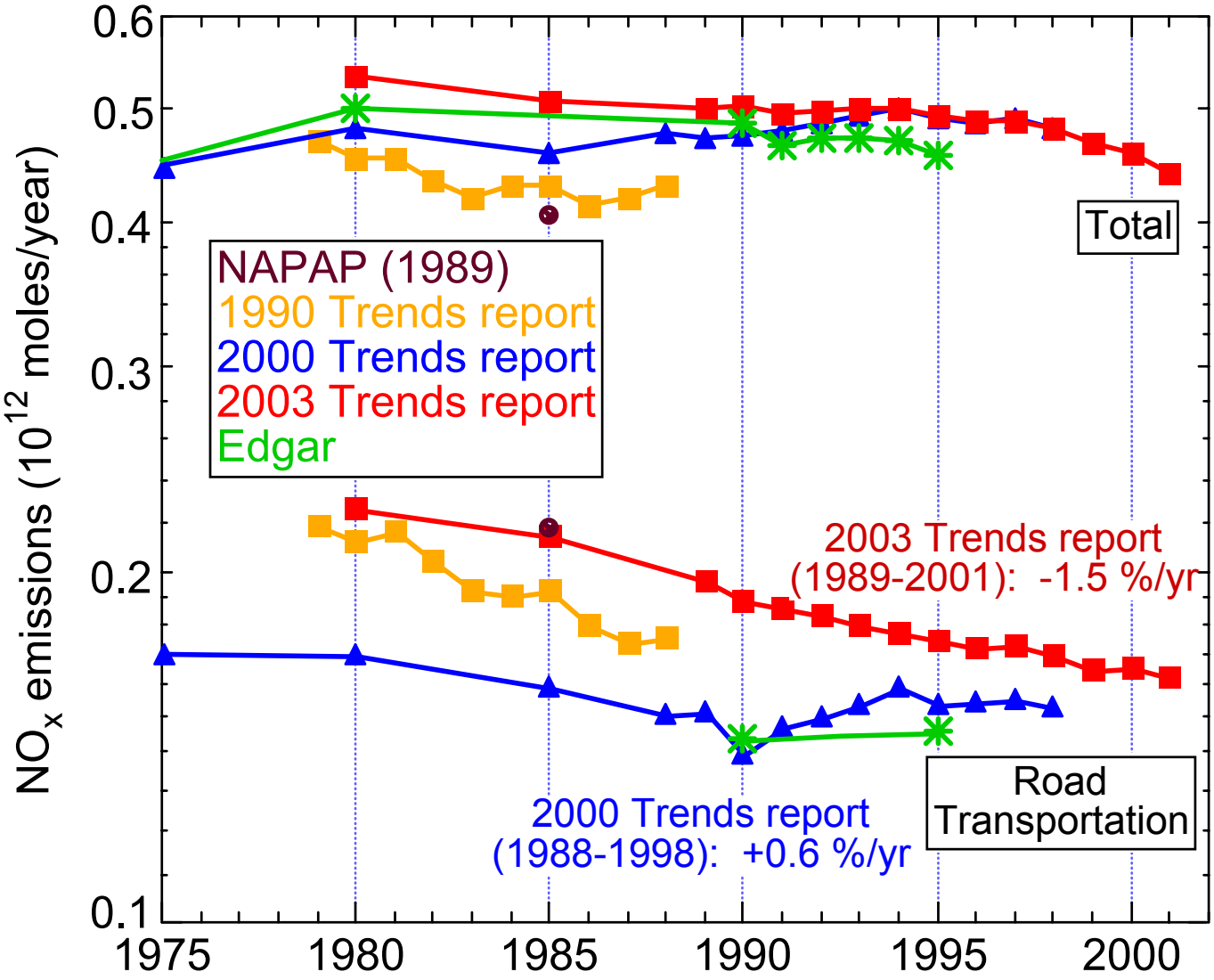
National NO_x Emissions Inventory History:

Estimates of total emissions have changed relatively little

Fraction assigned to road transport has changed to a greater extent (but now back to 1989 estimate)

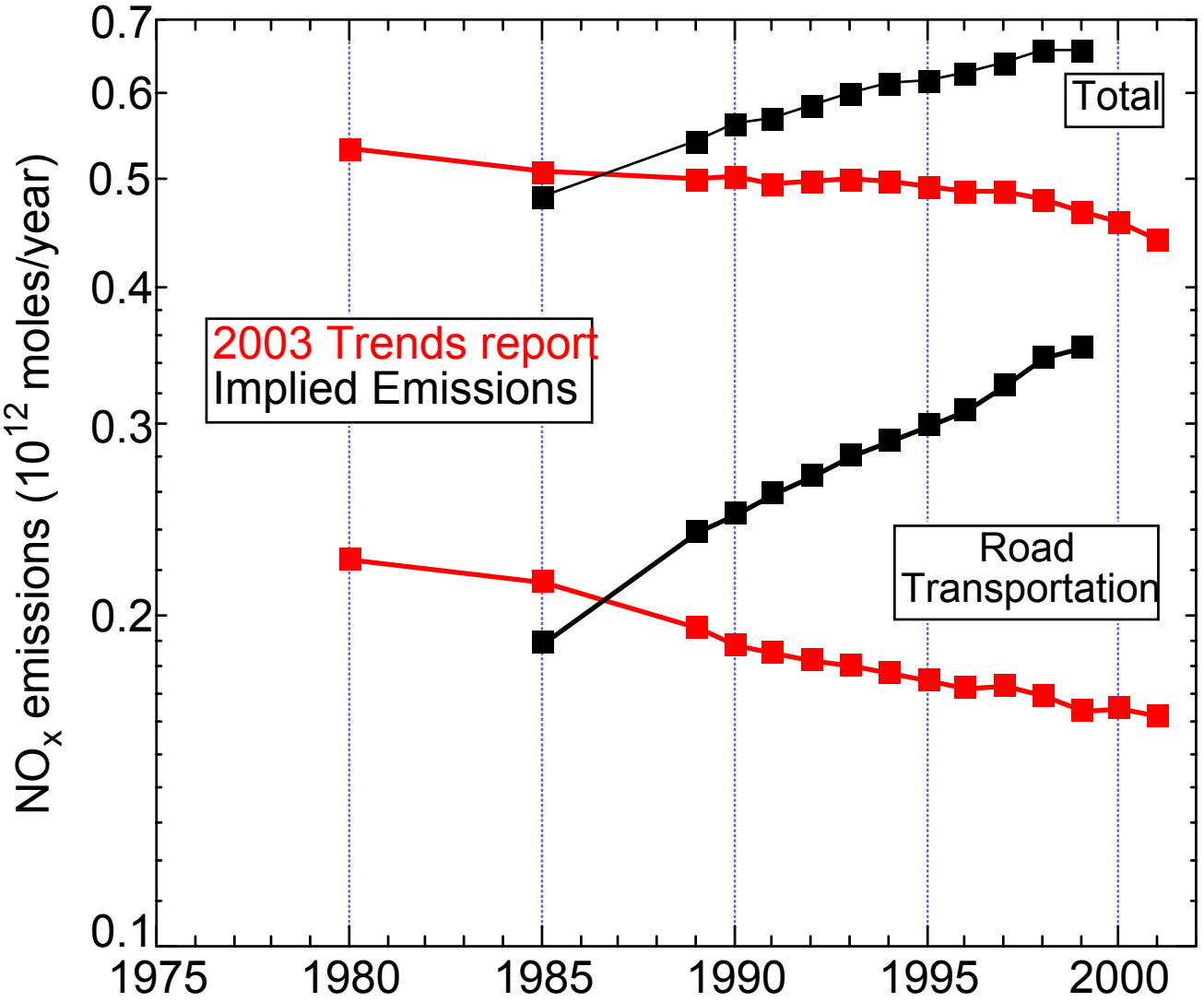


National NO_x Emissions Inventory Implications

If CO road emissions from Trends Report 2003 are correct,

And if Nashville-LA CO to NO_x ratio does equal national road emission ratio, Then

2003 Trends Report underestimates total and road transport NO_x emissions. The road emissions are then increasing at ≈ 4%/yr ???



Conclusions

EPA Mobile Source emissions estimates are inaccurate:

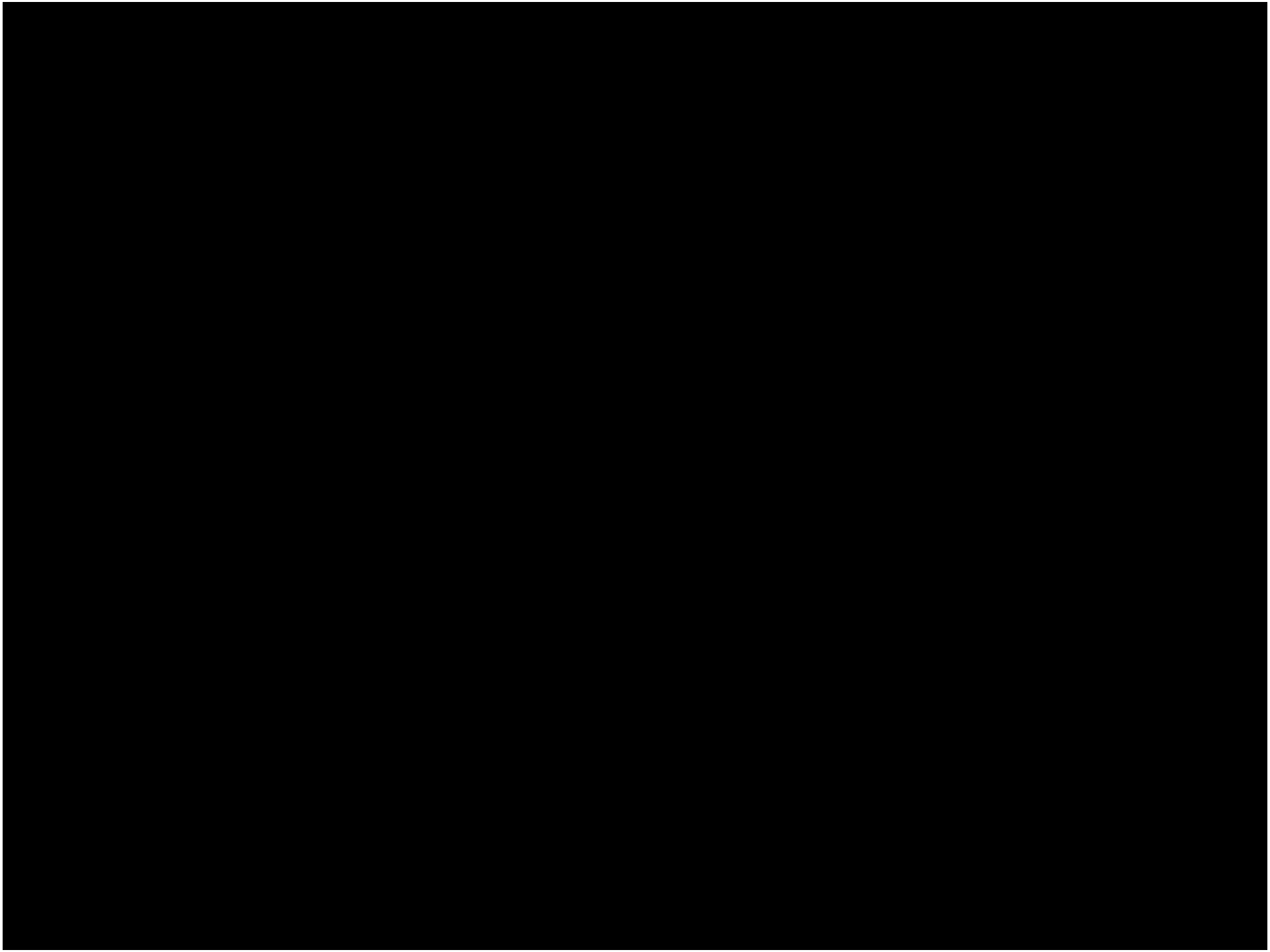
- For CO they vary widely, and are not converging.
- 2003 Trends Report has reasonable CO time trend, but CO to NO_x ratio is too high by factor of ≈ 2.
- Likely that NO_x emissions are underestimated, and are increasing, not decreasing.

Recommendations

- Challenge inventories with ambient measurements.

(Appropriate sites, measurement techniques, data analysis.)

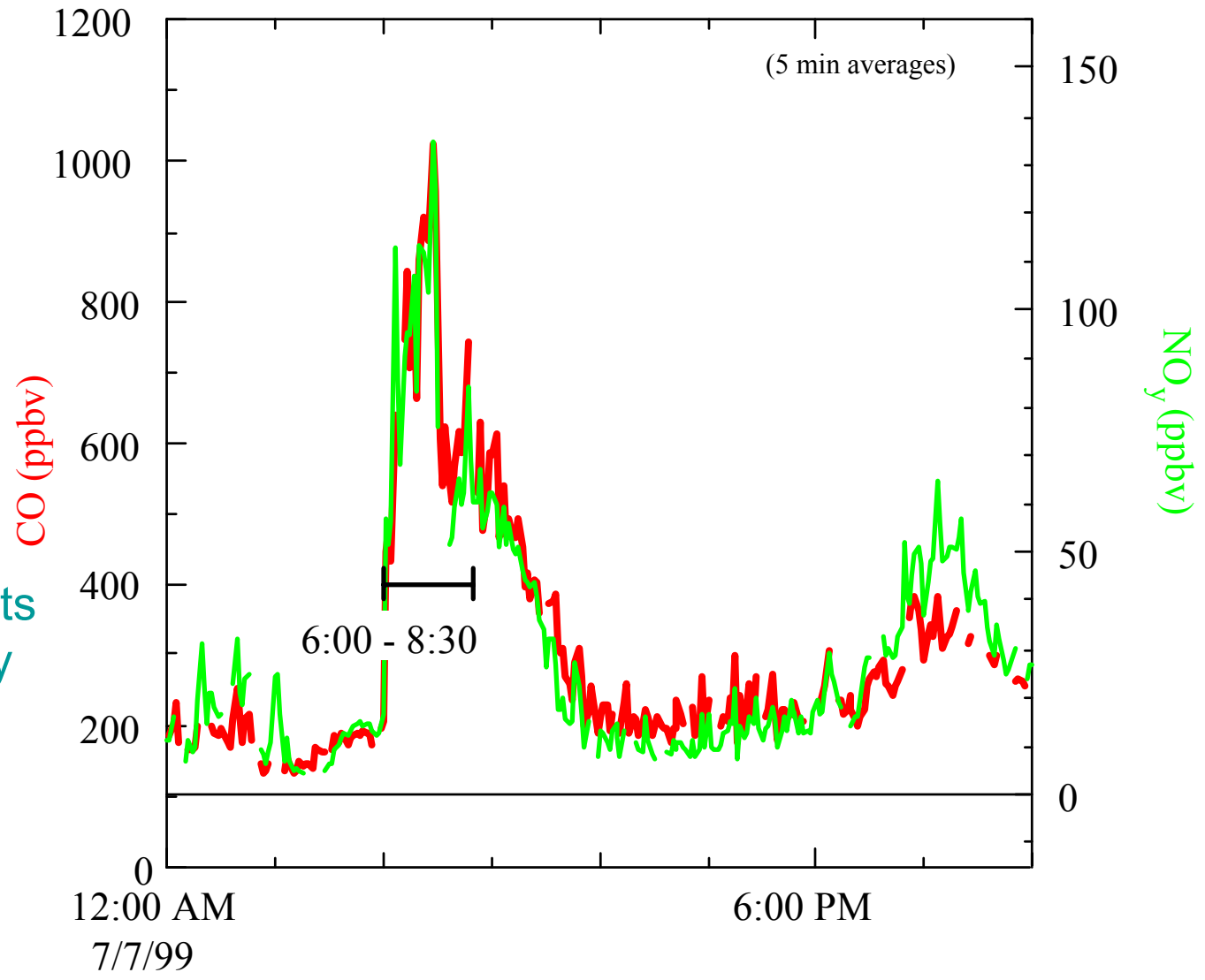
- Interaction and feedback between inventory and measurement folks.



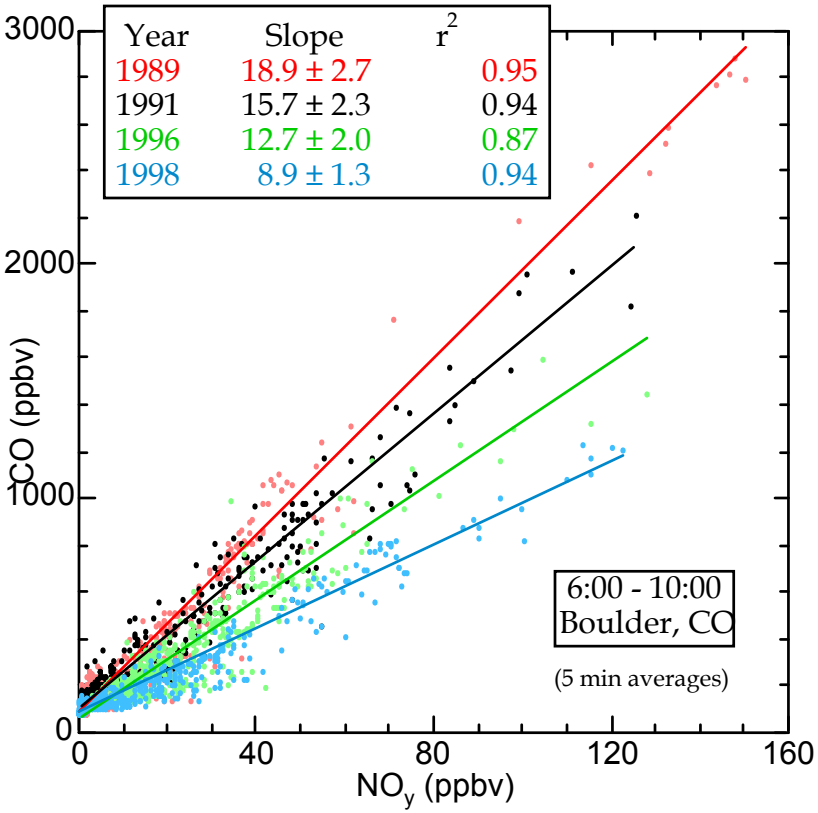
CO to NOx Ratio in Urban Vehicle Exhaust

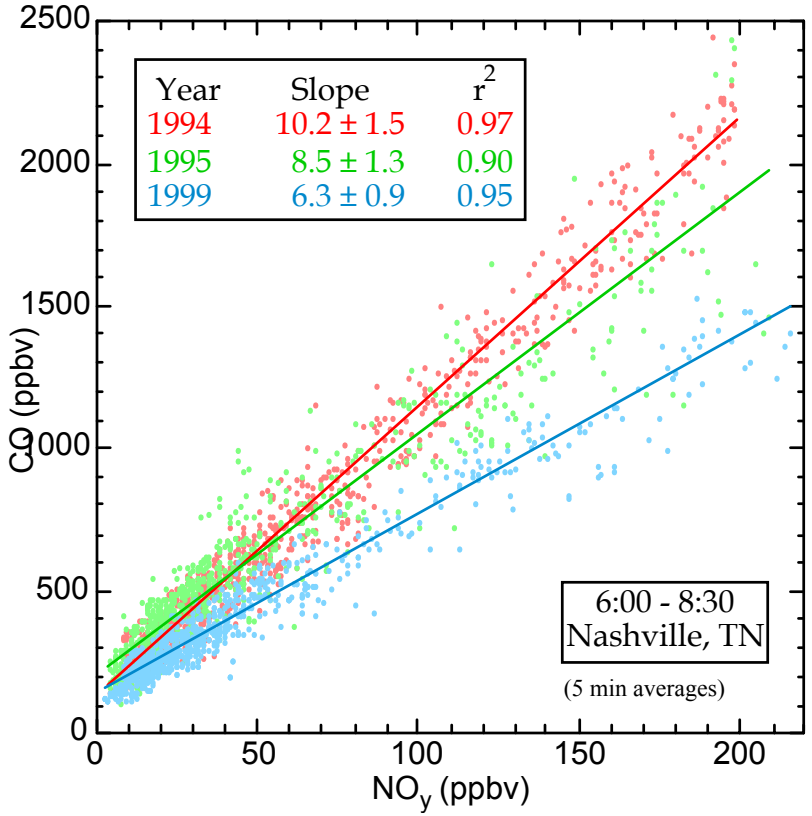
Ambient CO and NOy correlate well during morning rush hour.

Ambient measurements characterize CO/NOy emission ratio in vehicle exhaust.



CO to NO_x automotive exhaust emission ratios

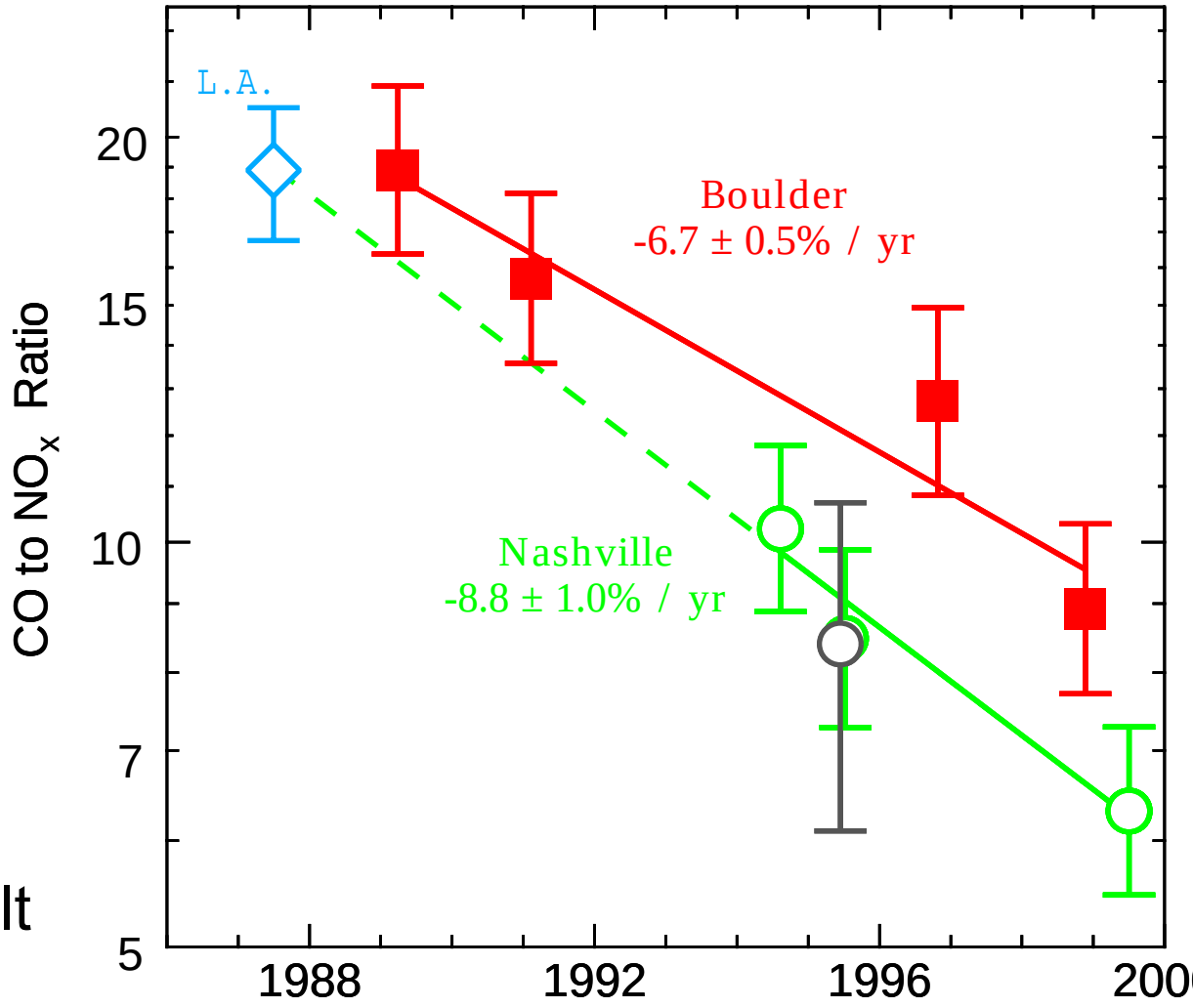




- Ratio of CO to NO_x in vehicle exhaust has decreased dramatically at these two sites from 1989 to 1999.

Comparison of Ambient Ratio Determinations

- Decrease in ratio is a factor of 2.5 to 3.1 in the 12 years.
- Our ratio agrees with independent determination
- Summer Nashville extrapolates to SCAQS study result

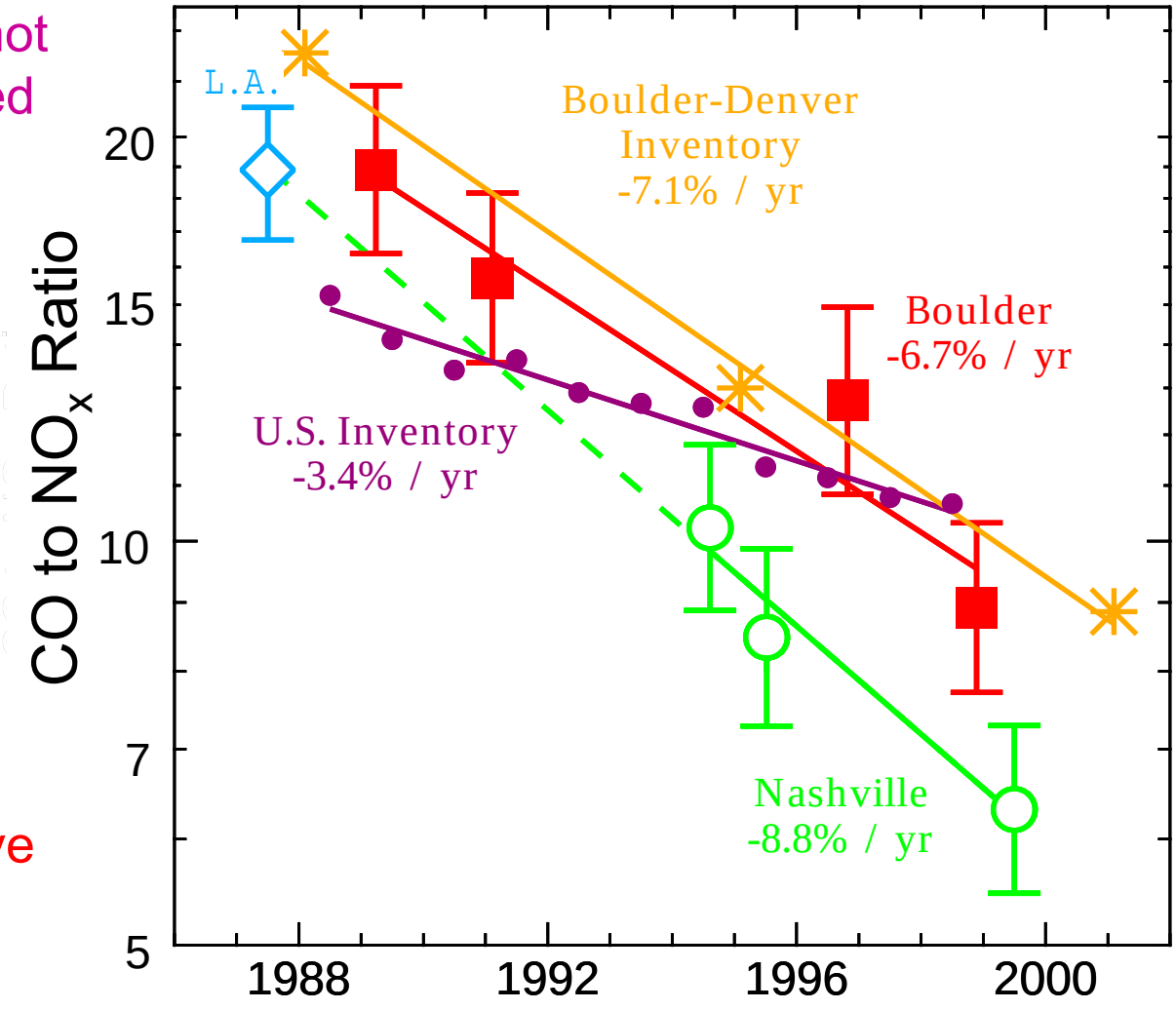


Harley et al., J. Geophys. Res., 106, 3559-3567 (2001)

Harley et al., Environ. Sci. Tech., 31, 2829-2839 (1997)

Comparison to Emission Inventories

- National inventory does not accurately reflect observed decrease.
- Colorado inventory does reflect Boulder decrease.
- VOC emissions parallel CO emissions.
- The character of urban photochemistry must have changed as well.



(National Air Pollutant Emission Trends, 2000)

(Colorado Department of Public Health and Environment)

Nashville and Boulder are representative