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Real - World Vehicle Emissions Measurements

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Real-World Vehicle Emissions Measurements

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- Colorado Office of Energy Conservation
- Coordinating Research Council
- California Air Resources Board
- Envirotest Systems Corp. (commercial partner)
- Numerous foundations, city, state, federal agencies, international groups, many students and other professional co-workers.

Our Data, Reports and Publication Repository

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Fuel Efficiency Automobile Test

In 1987, with a grant from the Colorado Office of Energy Conservation, the first successful remote sensor used to test light-duty vehicle emissions was developed at the University of Denver and named **FEAT (Fuel Efficiency Automobile Test)**.

Research concept was to measure the tailpipe emissions of in-use vehicles and find the highest carbon monoxide emitting vehicles and repair them to improve their fuel efficiency.

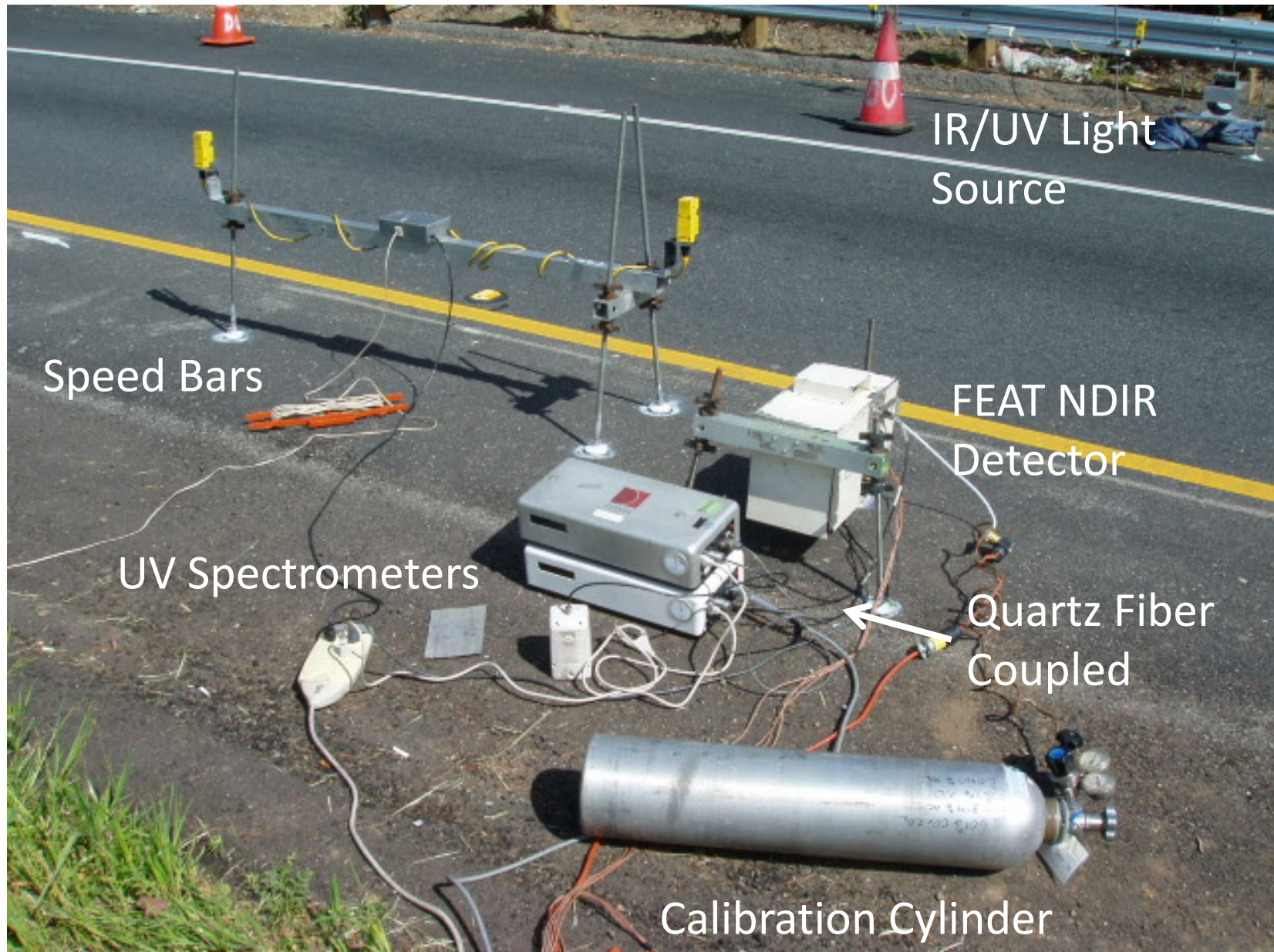
More than 50 peer reviewed journal articles and an additional 100+ reports

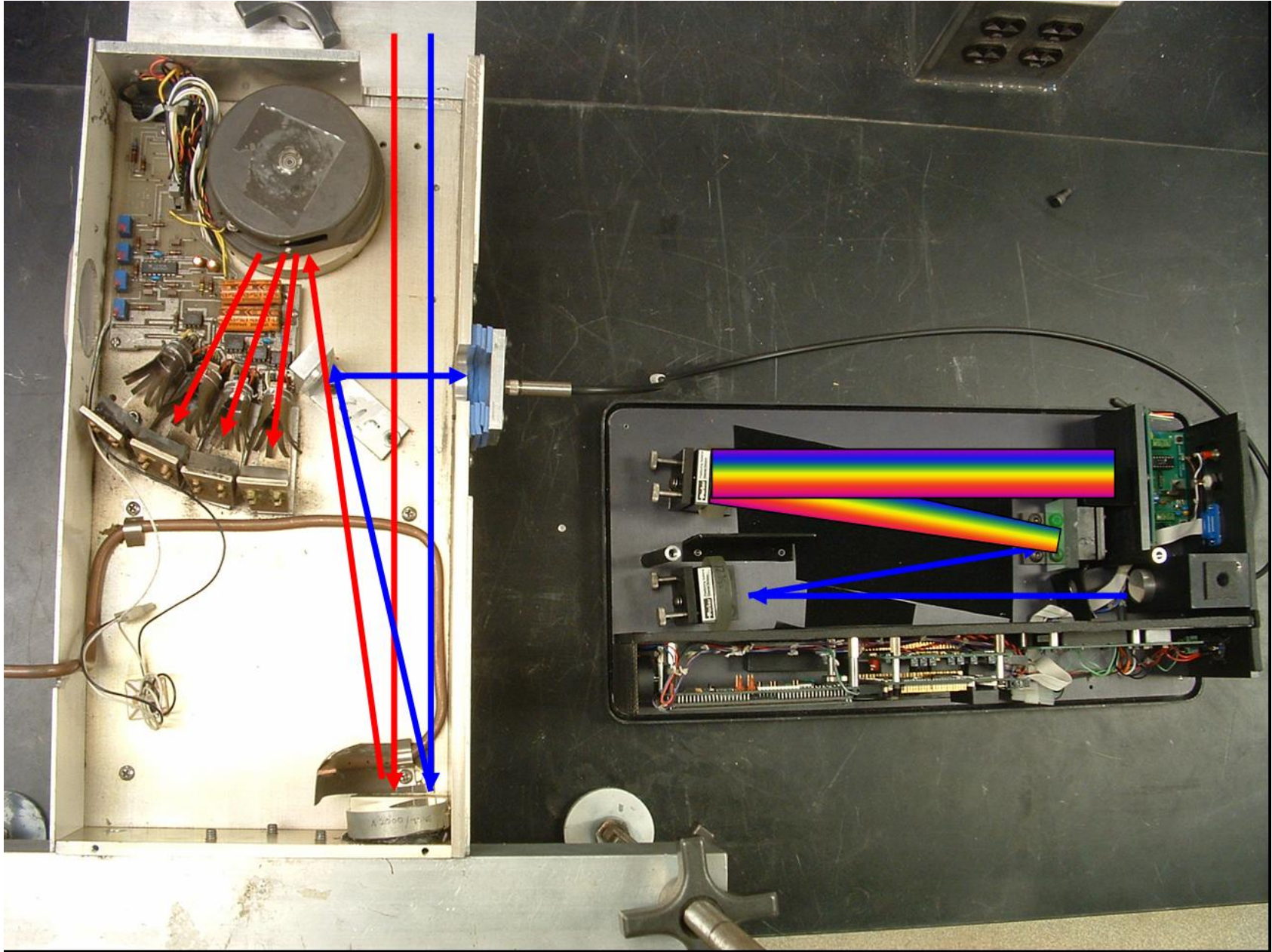
Current FEAT Remote Sensor

- Measures absorptions using:
 - Infrared (non-dispersive)
 - CO @ 2170 cm^{-1} / CO₂ @ 2330 cm^{-1}
 - HC @ 2940 cm^{-1} / Reference 2560 cm^{-1}
 - Ultraviolet (dispersive)
 - NO @ 226nm, SO₂ @ 215nm and NH₃ @ 205nm
 - NO₂ @ 430 nm
- FEAT compares the pollutant ratios (CO/CO₂, HC/CO₂, NO/CO₂ etc.) in the vehicle exhaust to the pollutant ratios in a certified gas cylinder.

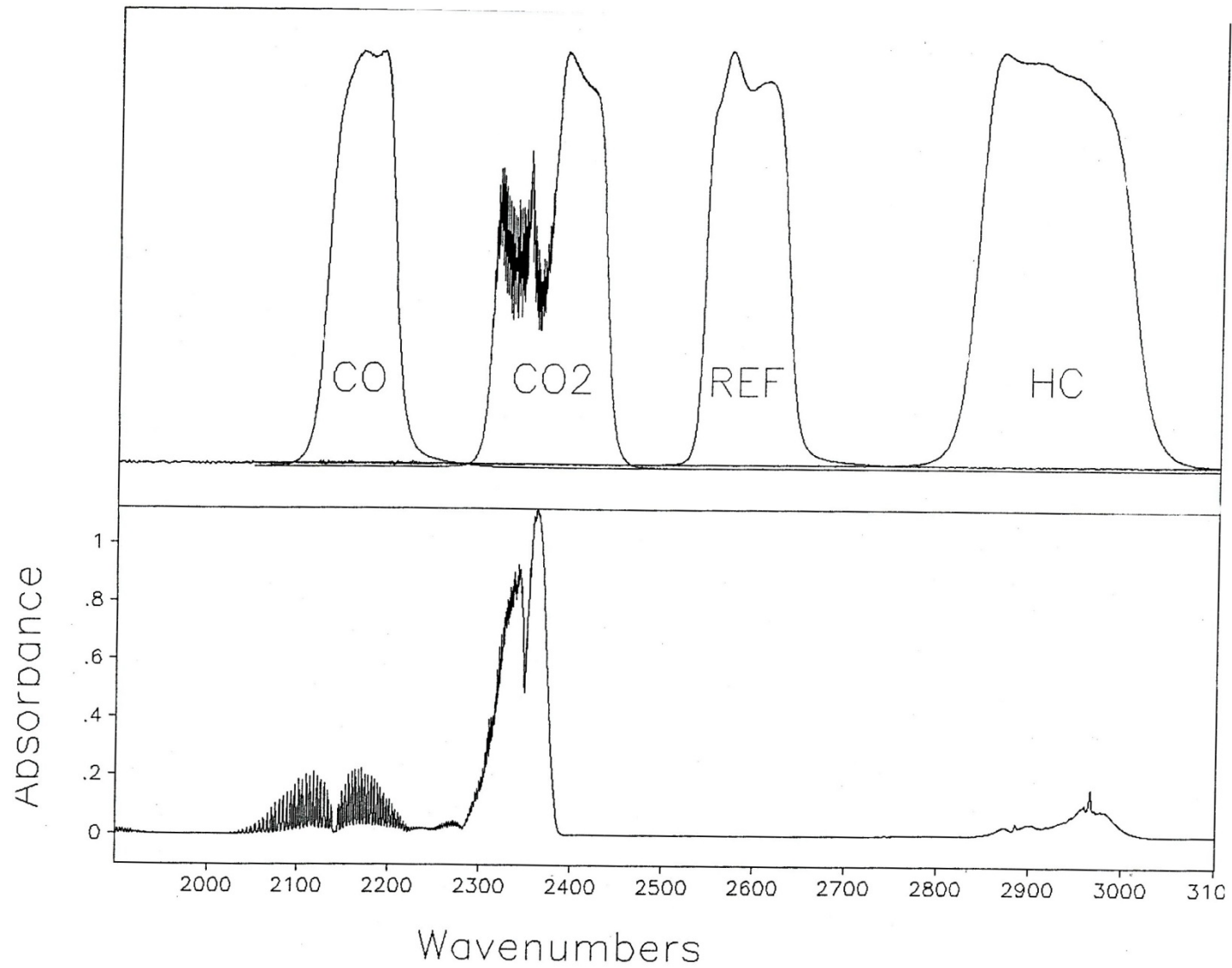


Roadside Instrument Setup

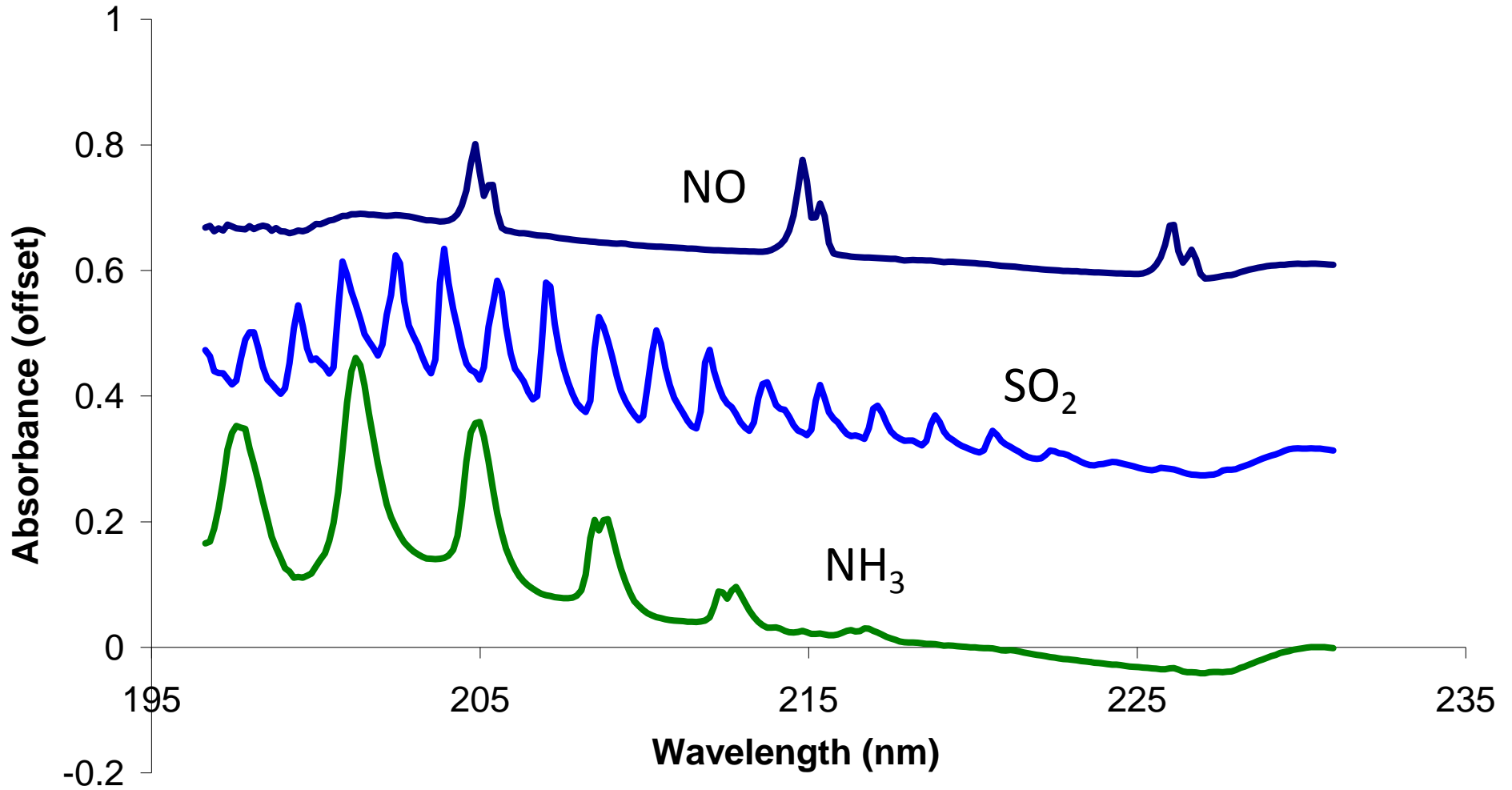




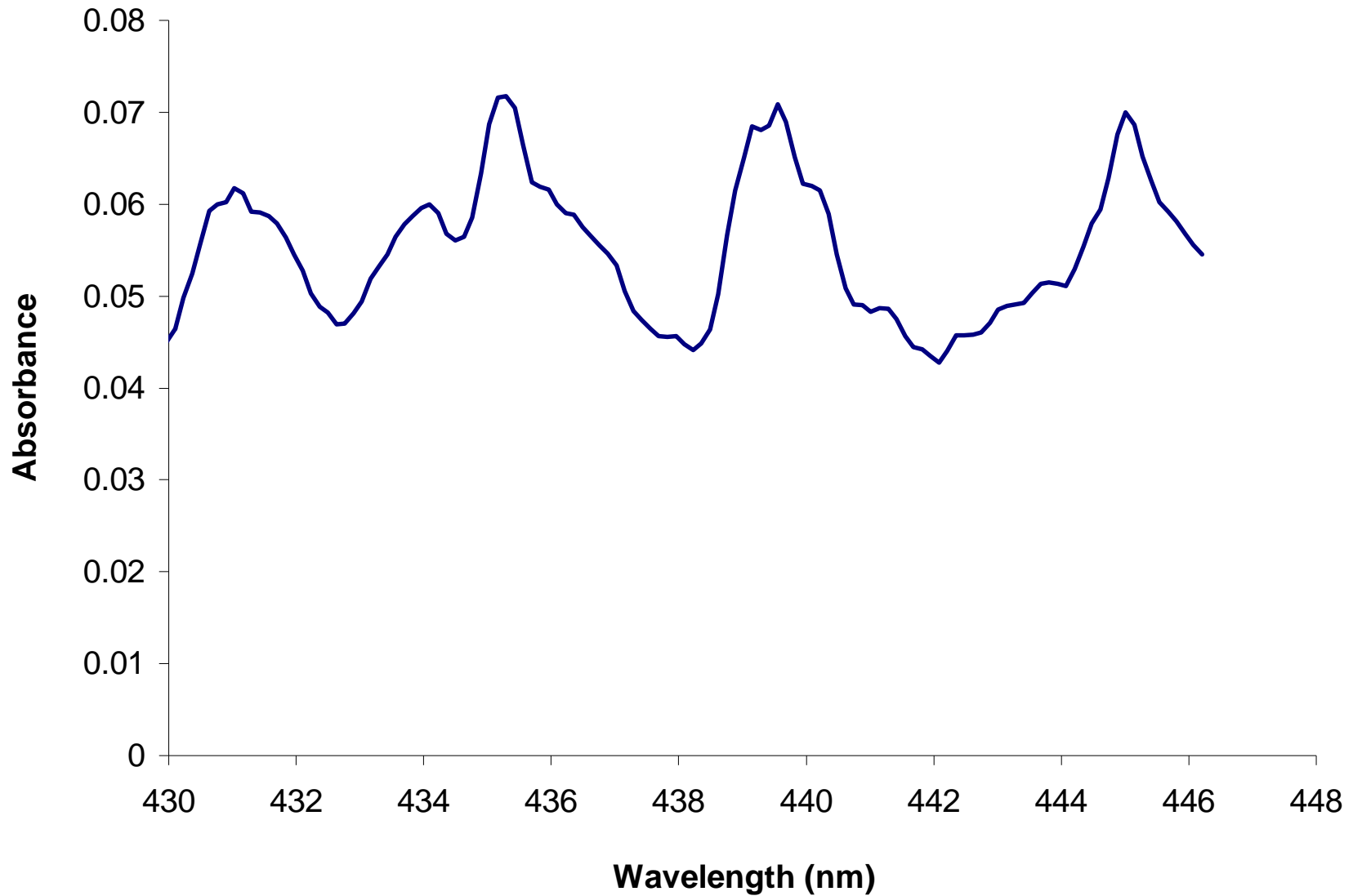
IR Non Dispersive



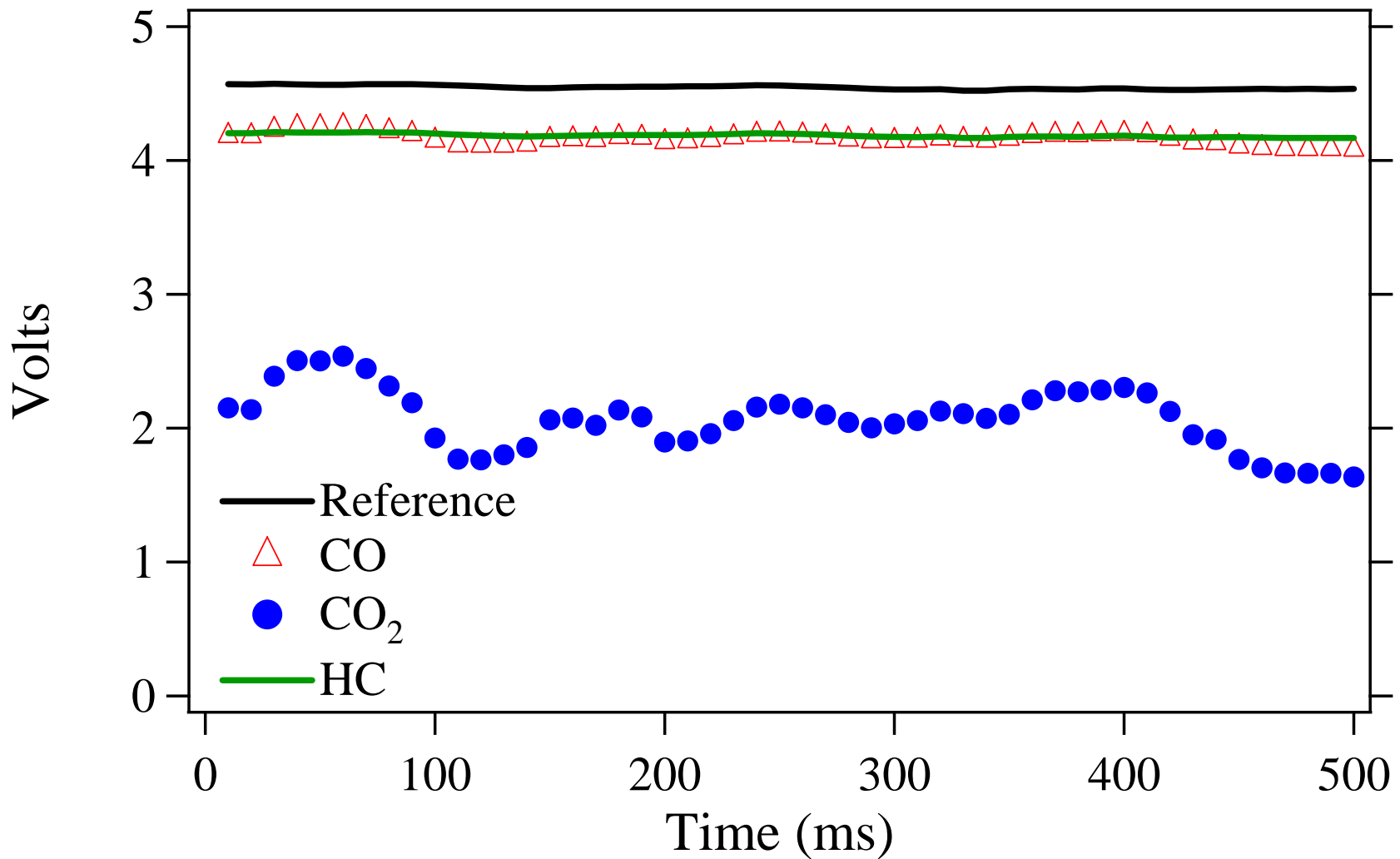
NO, SO₂ and NH₃ Spectrum from FEAT Spectrometer



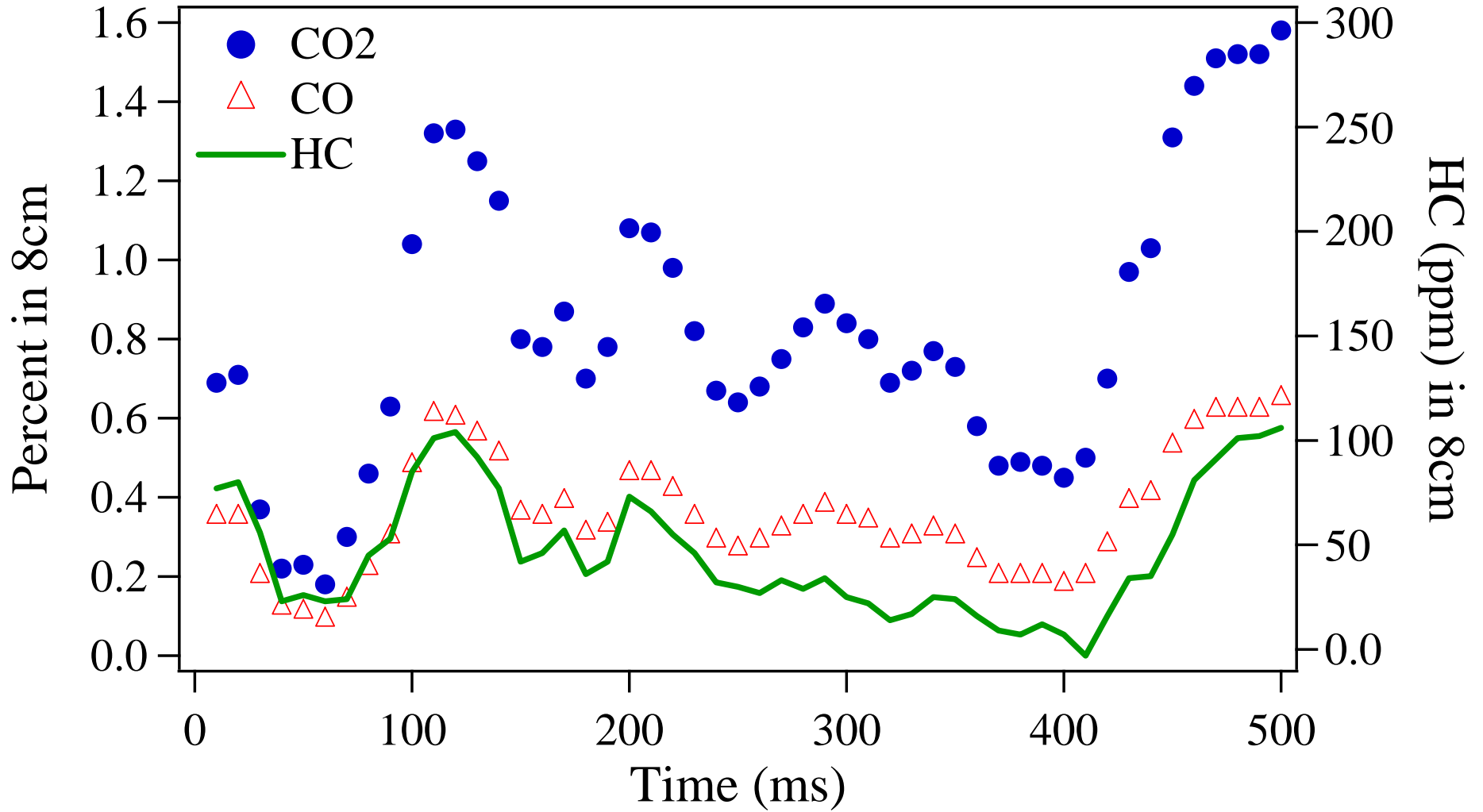
NO₂ Spectrum from FEAT Spectrometer



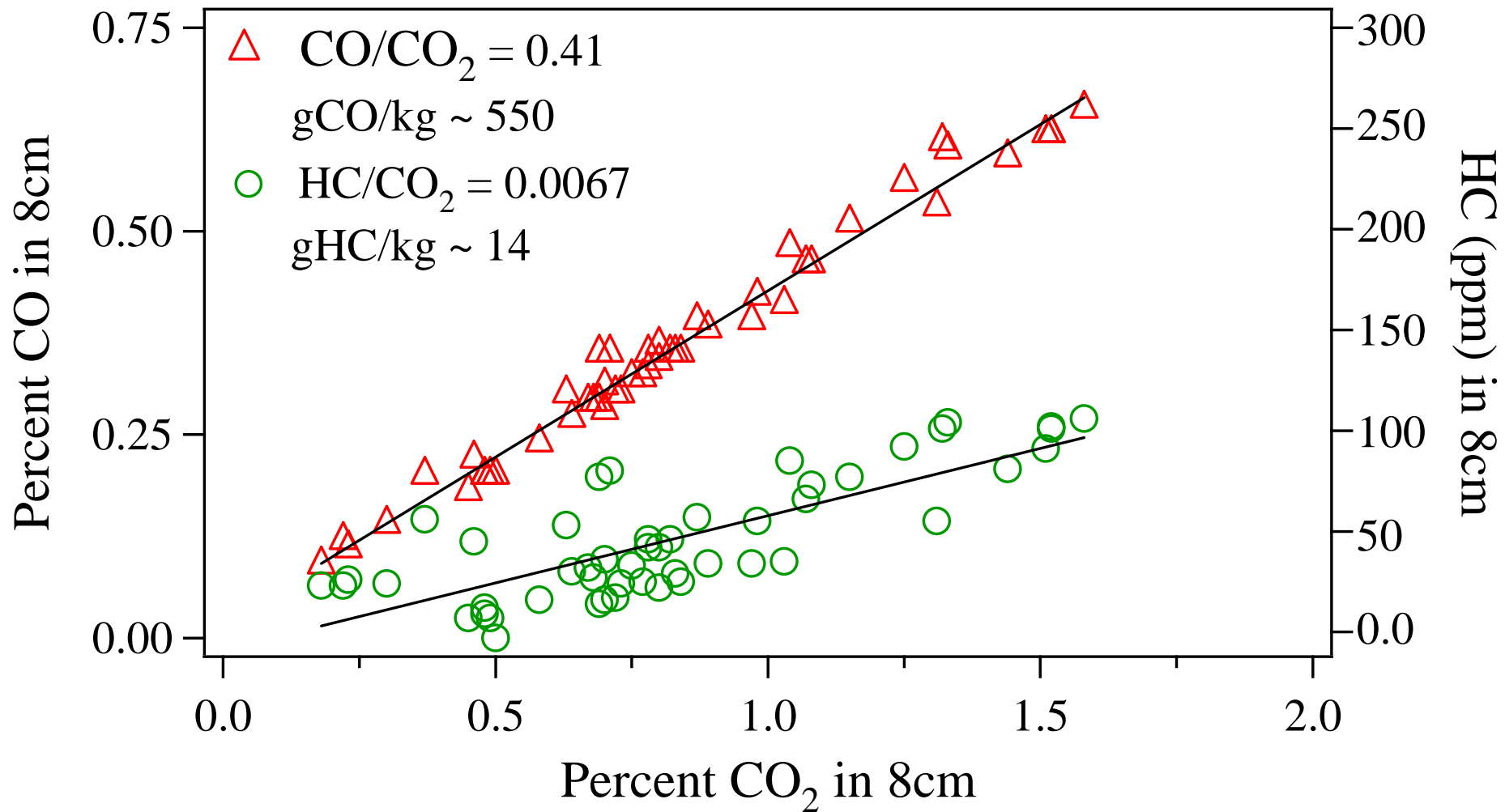
IR Plume Signal vs. Time



Pollutant Readings vs Time



Pollutant Ratio Plots







Lion's Gate Bridge, Vancouver BC

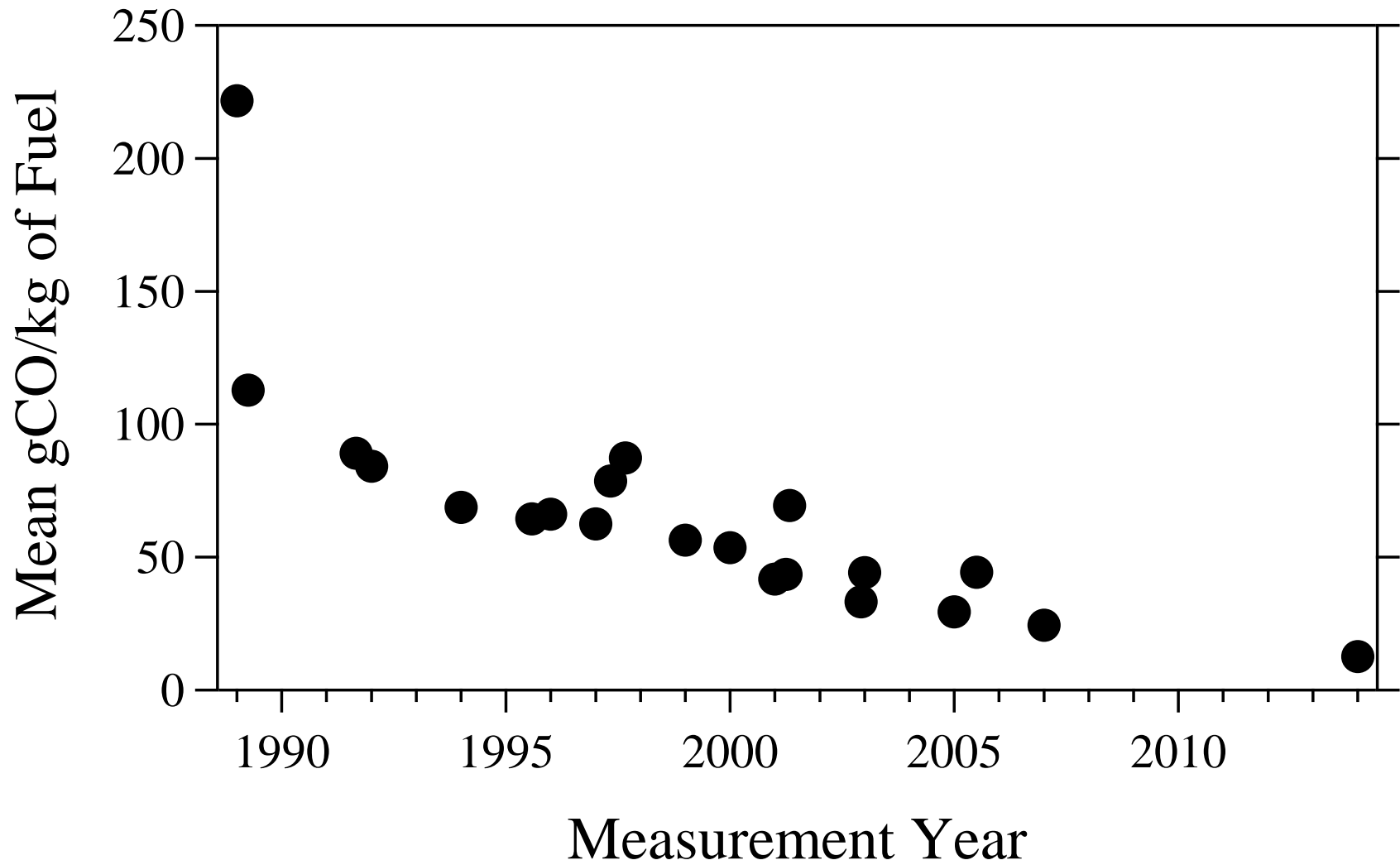


FEAT Record

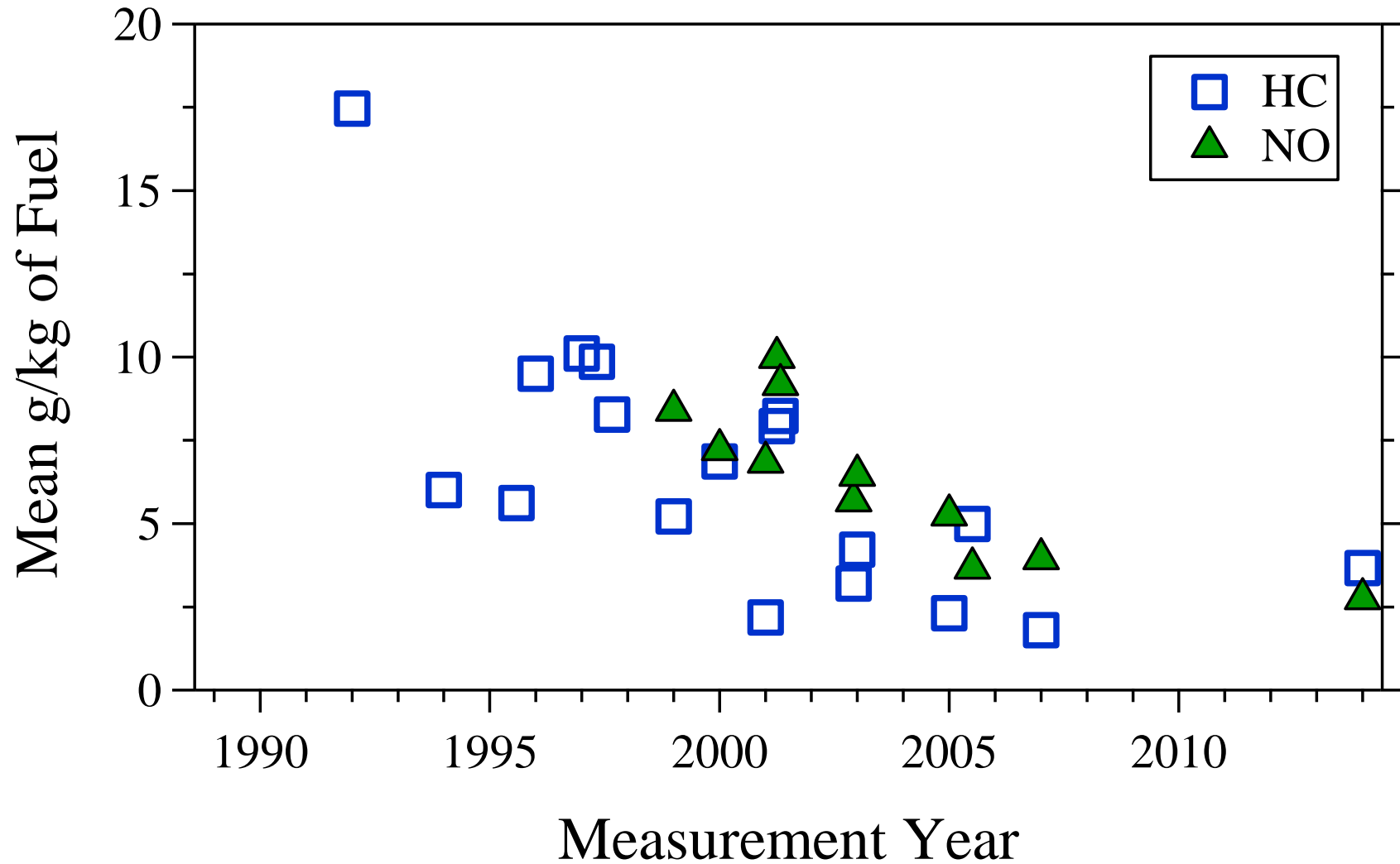
- More than 1.6 million light-duty car and truck measurements collected from more than 30 locations in the US and 21 countries worldwide.
- More than 27,000 Heavy-duty truck measurements.
- Snowmobile and Snow-Coach measurements in Yellowstone National Park
- Locomotive measurements in NE and WA
- Commercial Aircraft at Heathrow Airport
- Ocean going vessels in Vancouver BC
- Small water craft at a lock in Seattle

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Colorado On-Road Mean CO Emission Trends

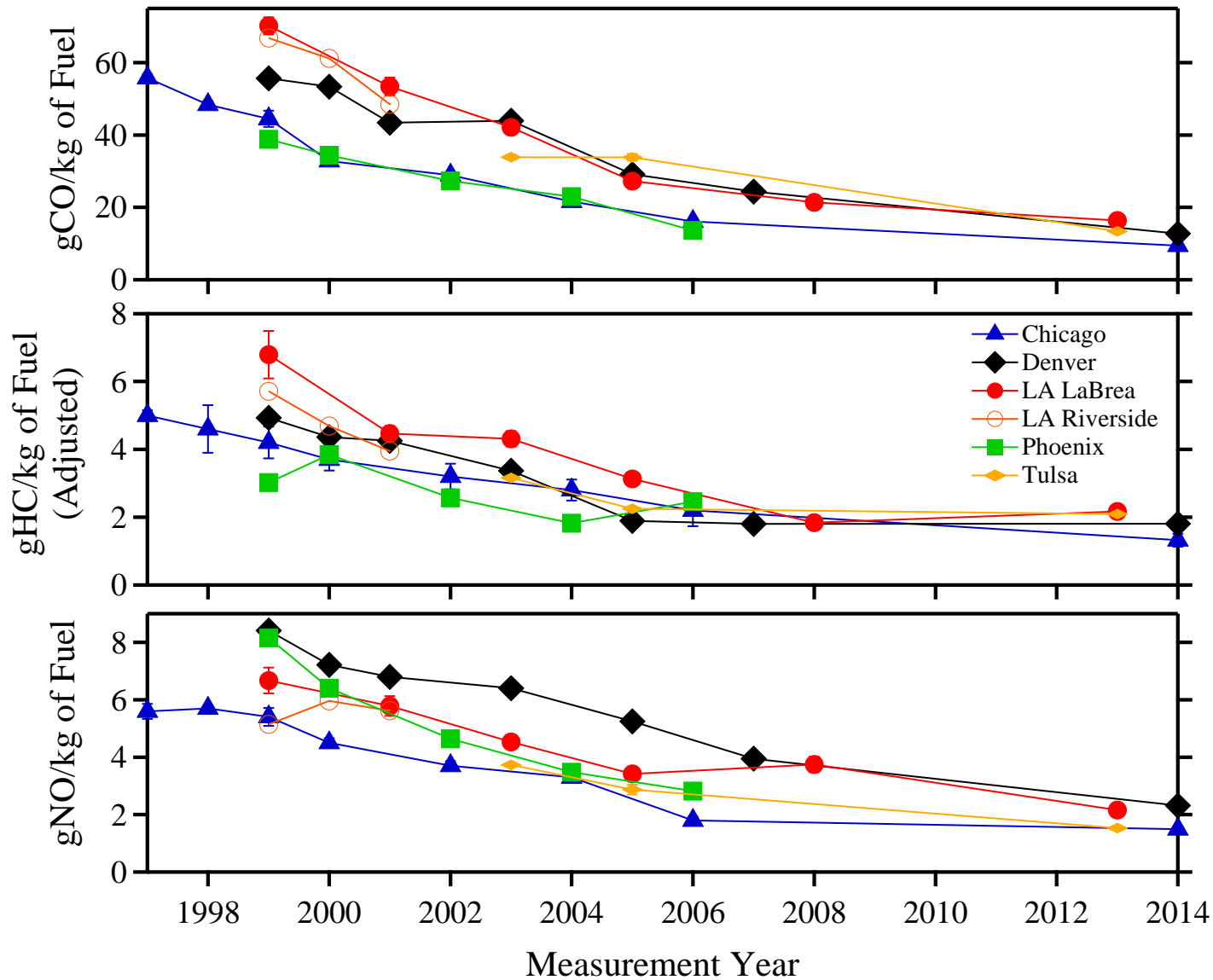


Colorado On-Road Mean HC and NO Emission Trends

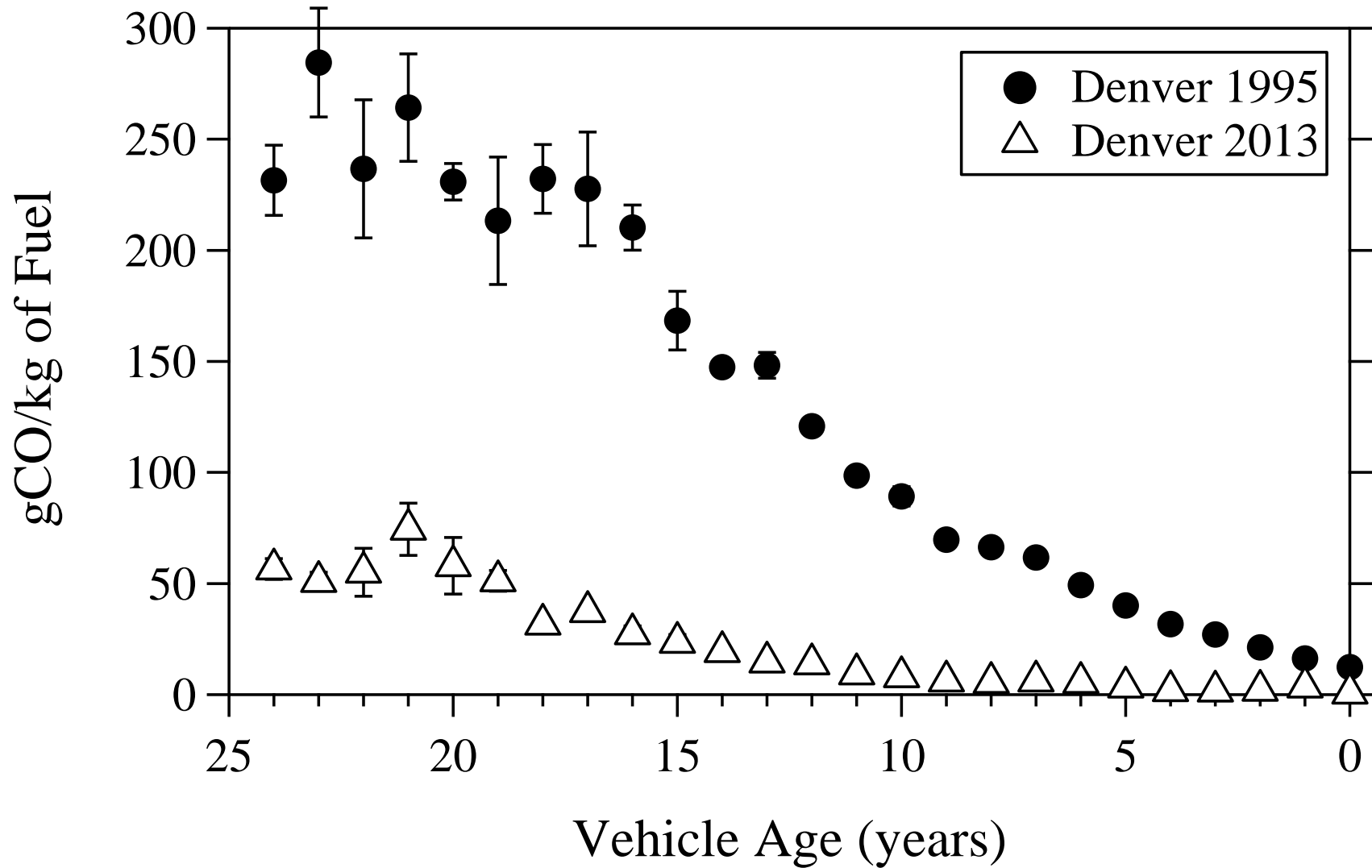


Colorado is not Unique!

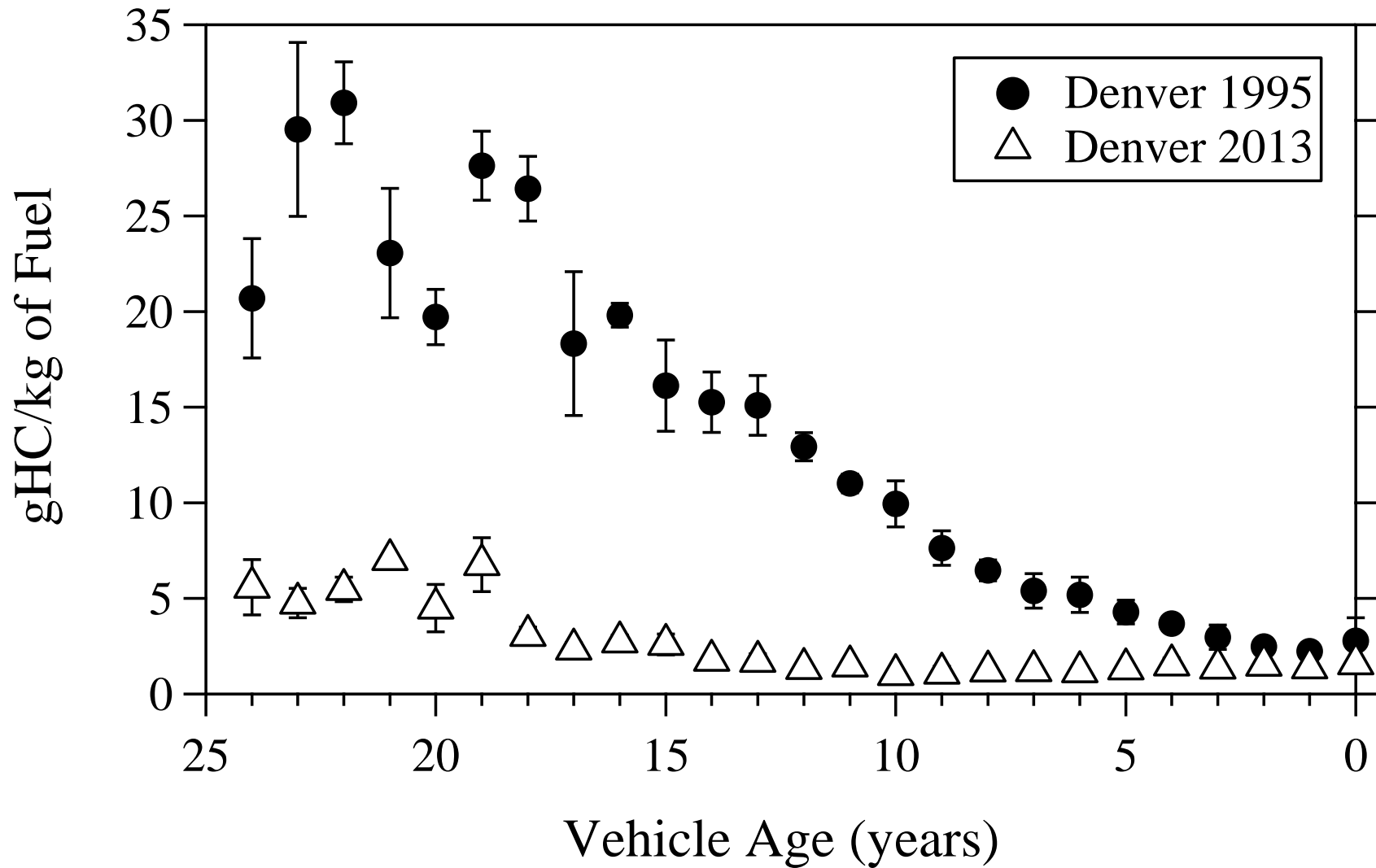
Emissions are decreasing Everywhere



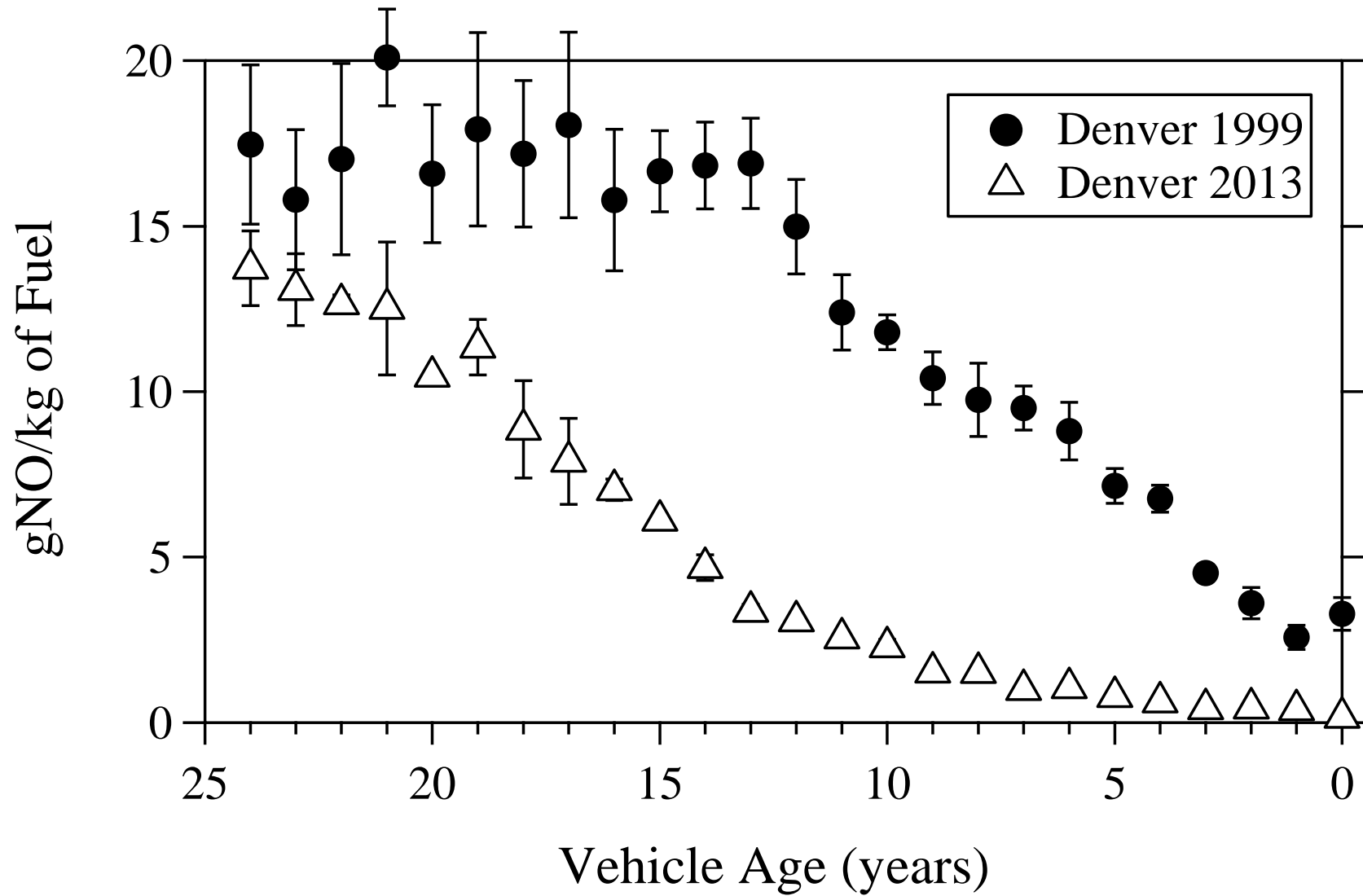
Denver CO Emissions Comparison by Vehicle Age



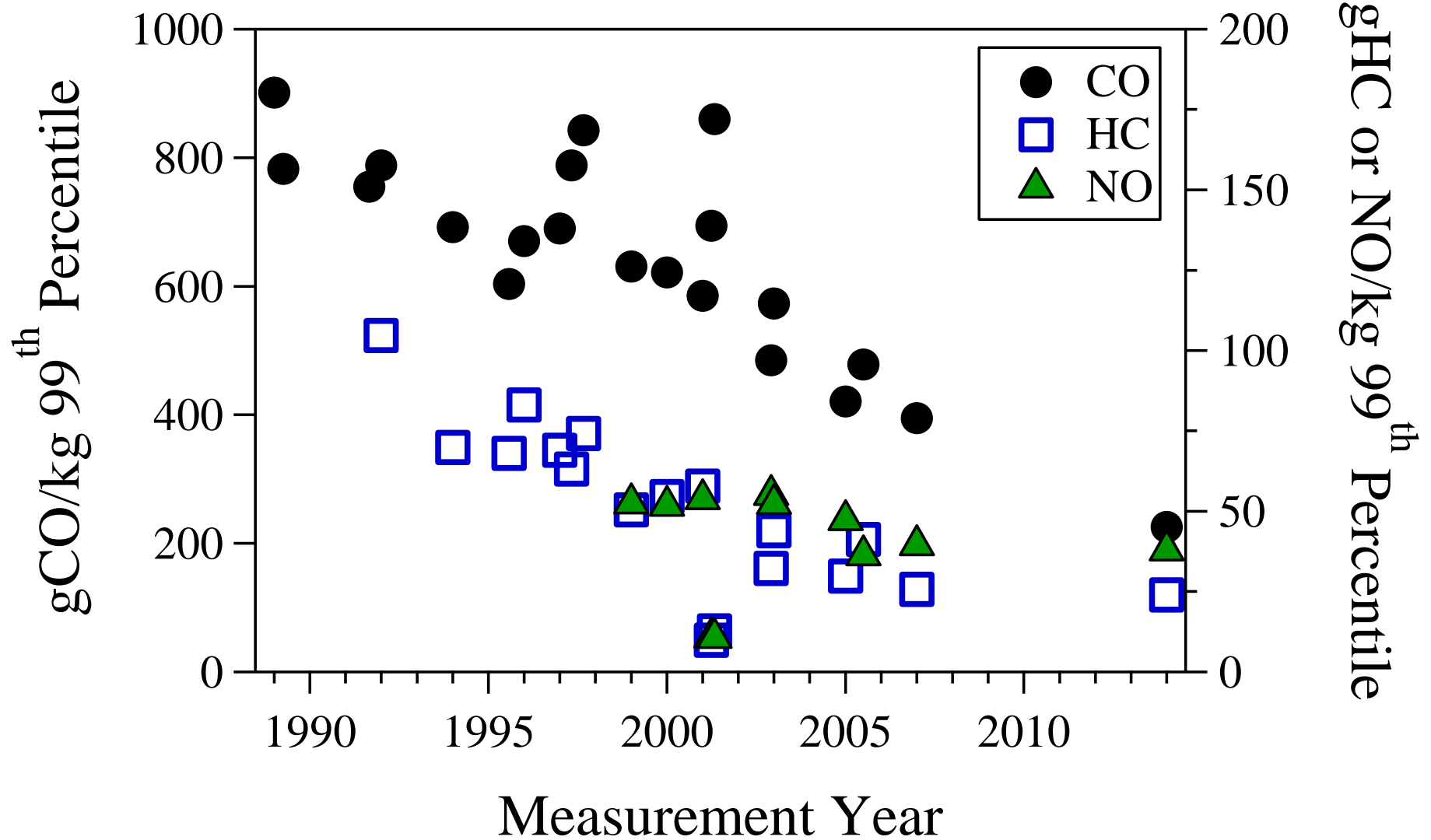
Denver HC Emissions Comparison by Vehicle Age



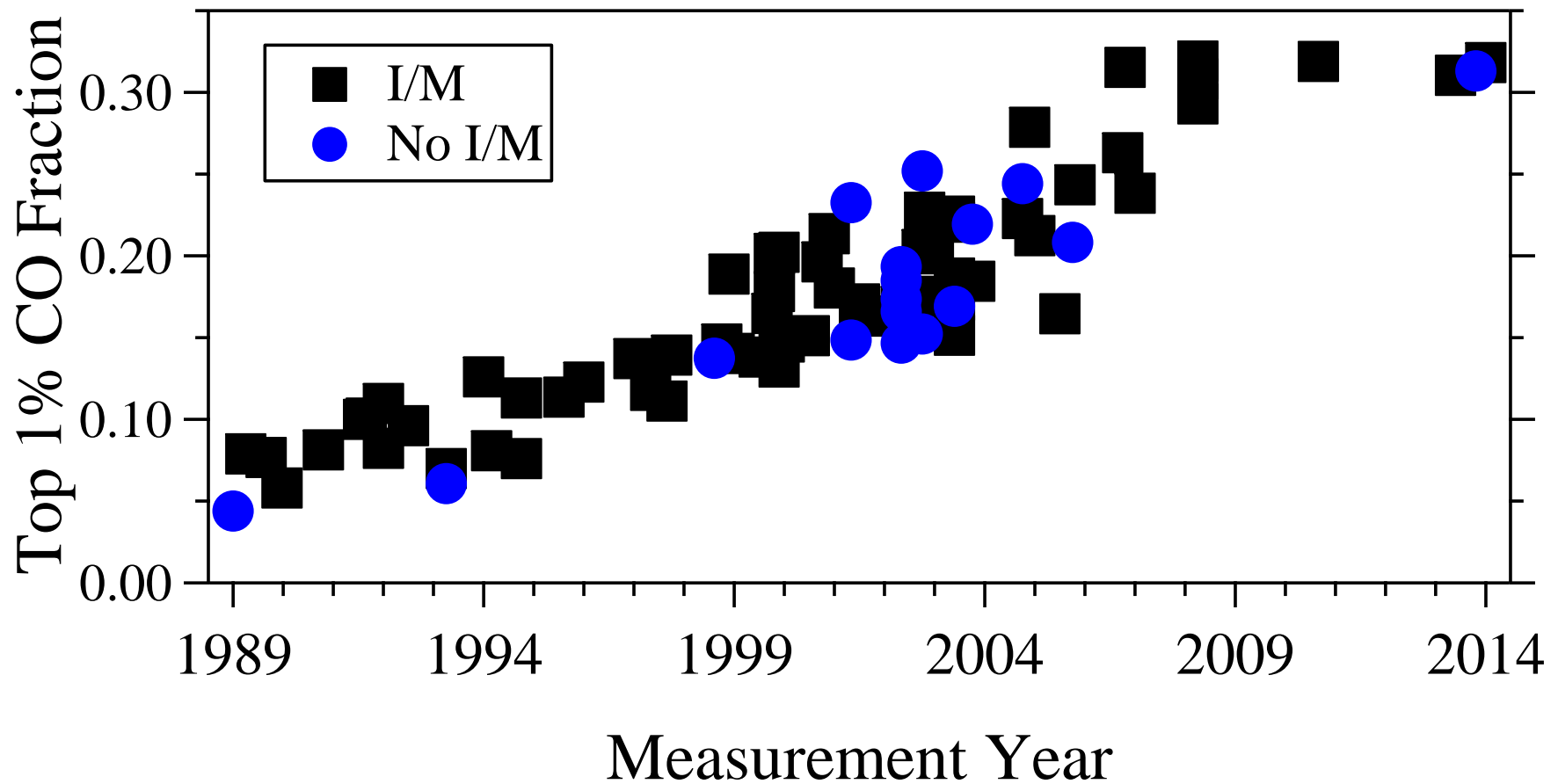
Denver NO Emissions Comparison by Vehicle Age



Colorado 99th Percentile Trends



The Tail Wags the Dog



Who are the 99th Percentile?



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Volkswagen is just the latest automaker to try to trick a system that aims to reduce pollution but provides lucrative incentives to cheat

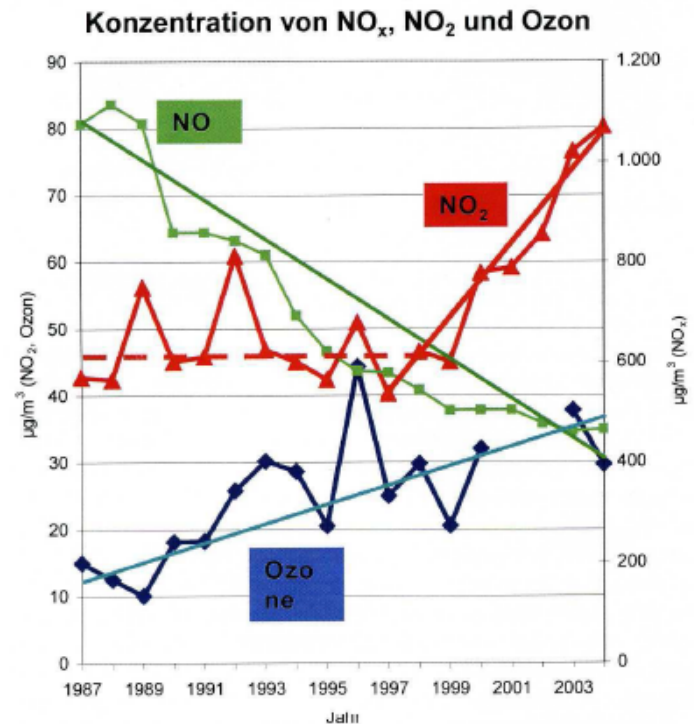
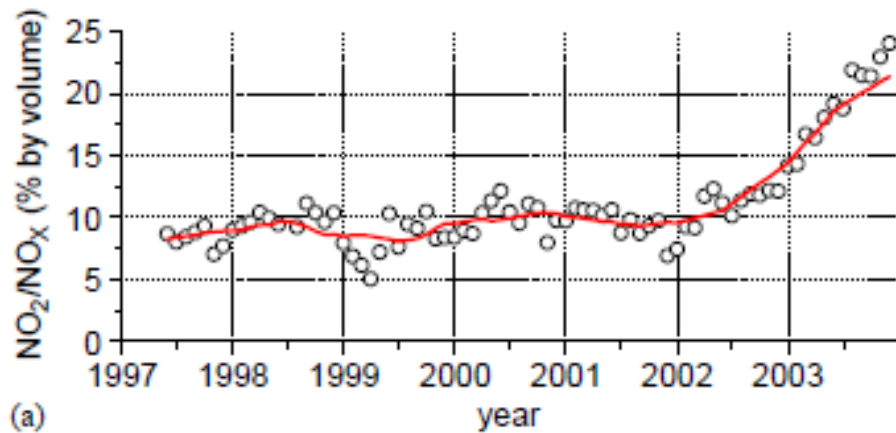
Los Angeles Times
MUNDAY OCT. 5, 2015
How important are those emissions tests that VW cheated on?
VOLKSWAGEN'S "DEFEAT DEVICE"

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BUSINESS
Colorado pollution data helped expose VW emissions cheat
VW diesel sedan emissions were way above diesel light trucks and comparable gasoline engines, Colorado records proved.
By Aldo Svaldi
The Denver Post
POSTED: 10/02/2015 12:01:00 AM MDT | UPDATED: 3 DAYS AGO
ADD A COMMENT
RapidScreen vans monitoring tailpipe emissions as cars zoom onto metro Denver highways proved key witnesses to the manipulation of emissions control software on Volkswagen diesel sedans.
"They had emissions many times higher than the other passenger vehicles," said Peter McClintock,

Brief Research History of Vehicle NO_x Emissions in Europe and the US

Germany 2007

London 2005

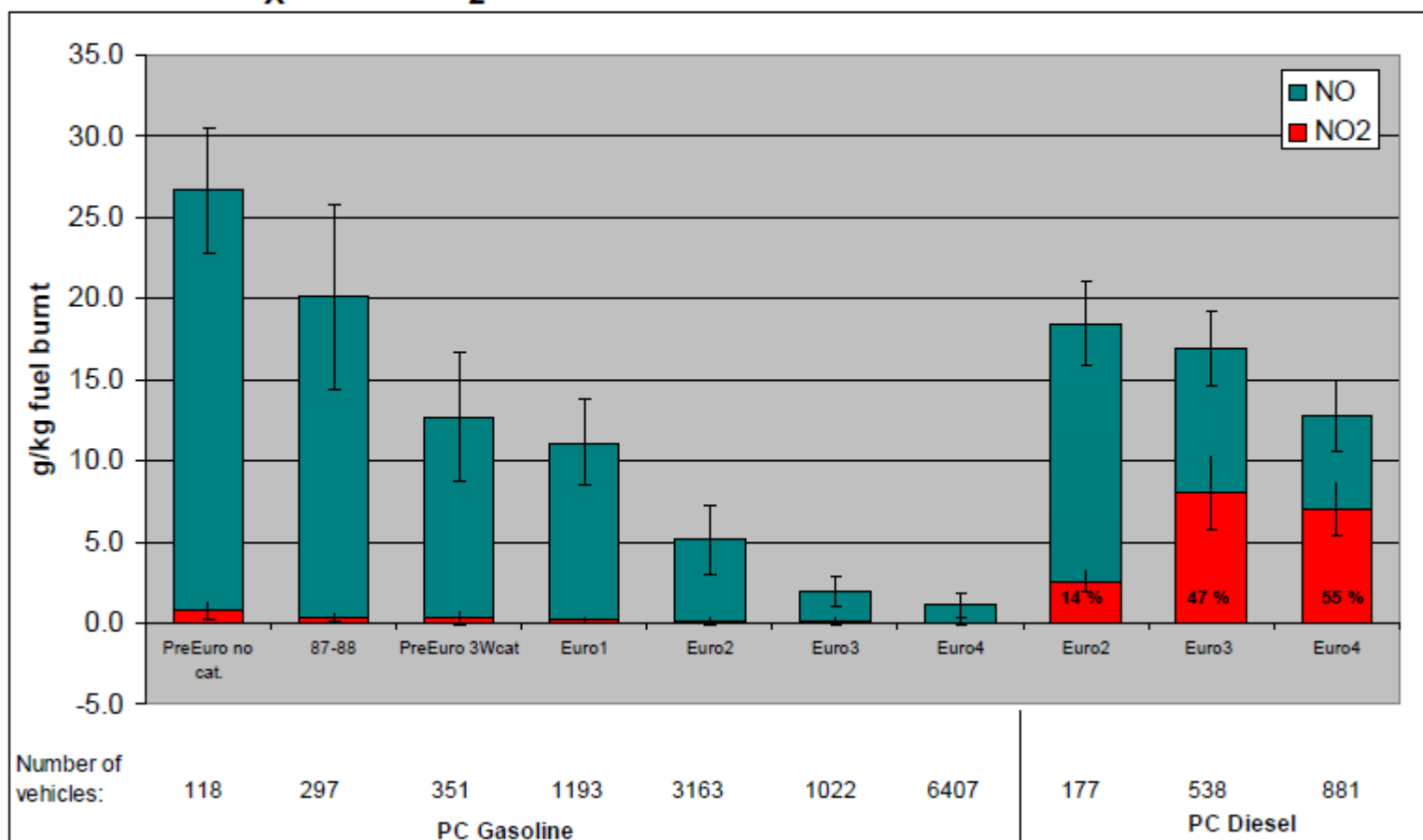


David C. Carslaw, Evidence of an increasing NO₂/NO_x emissions ratio from road traffic emissions. *Atmos. Environ.* **2005**, 39, 4793-4802.

Jacques Lemaire, How to select efficient diesel exhaust emissions control strategies for meeting air quality targets in 2010. *Österreichische Ingenieur-und Architekten-Zeitschrift* **2007**, 152, 1-12.

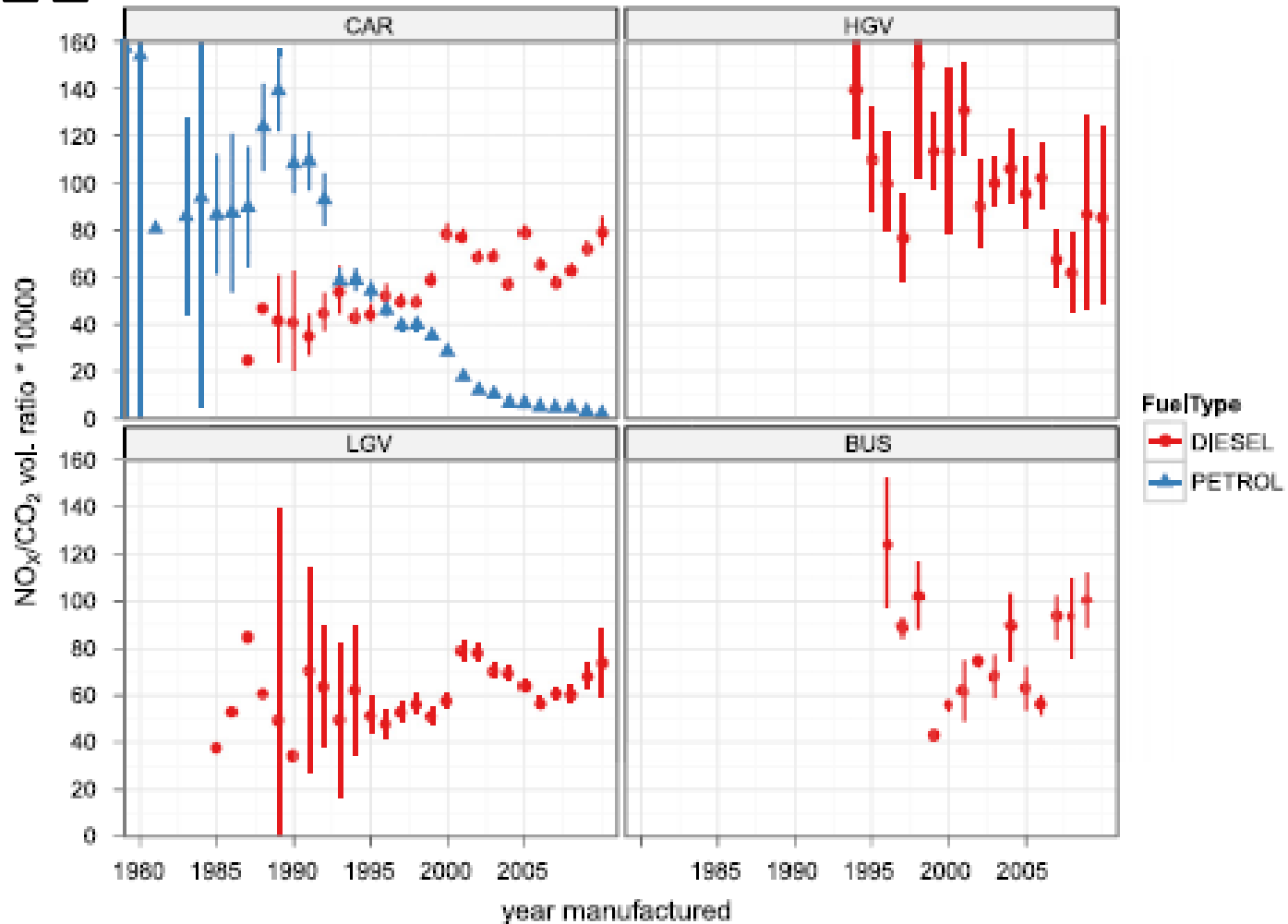
Sweden 2008

Gasoline and diesel passenger cars – NO_x and NO₂ emissions vs Euro class in 2007



Martin Jerksjö and Åke Sjödin, On-road Emission Performance of a European Vehicle Fleet Over the Period 1991 – 2007 as Measured by Remote Sensing, presented at the 18th CRC On-road Vehicle Emissions Workshop, San Diego, **2008**.

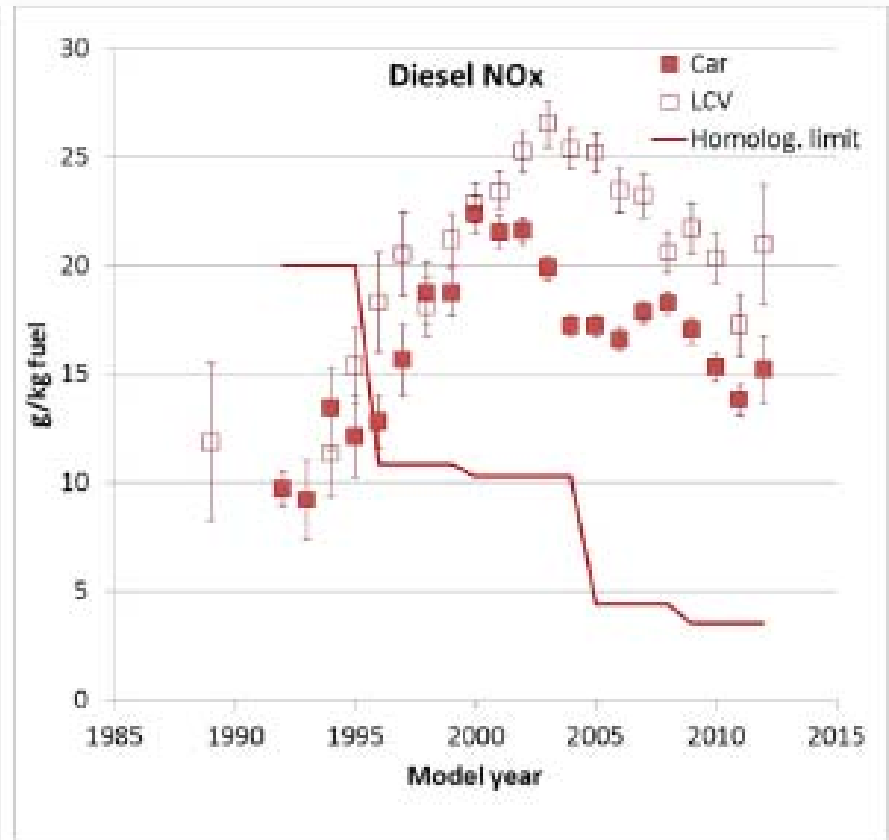
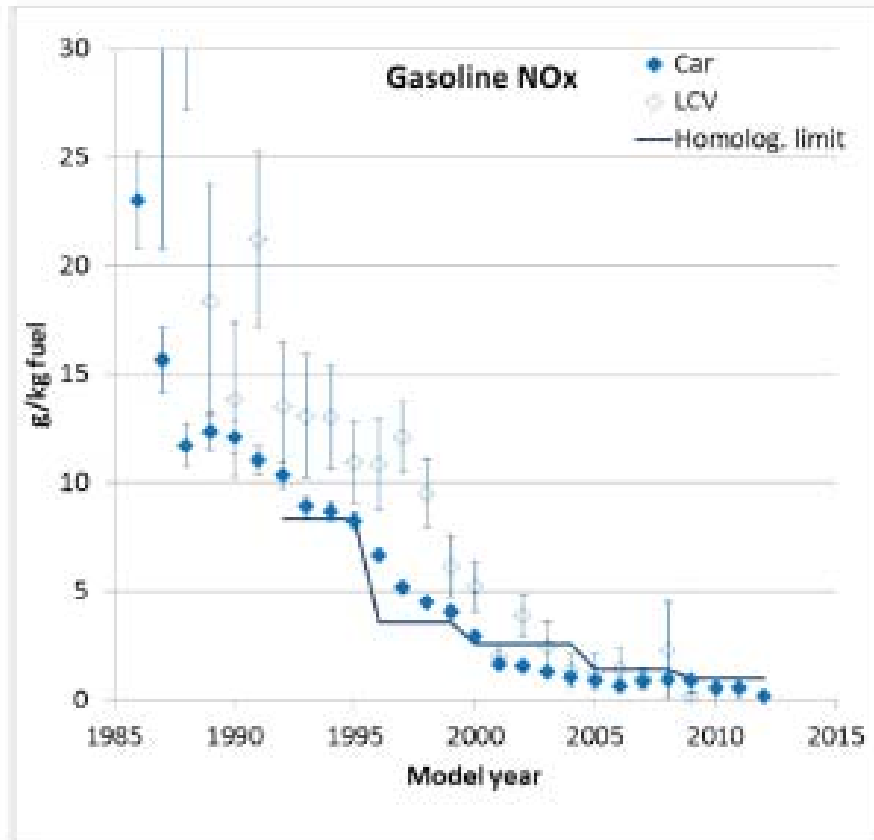
UK 2011



David Carslaw et al., Recent evidence concerning higher NO_x emissions from passenger cars and light duty vehicles. *Atmos. Environ.* **2011**, 45, 7053-7063.

Martin Williams and David Carslaw, New directions: Science and policy - Out of step on NO_x and NO₂? *Atmos. Environ.* **2011**, 45, (23), 3911-1912

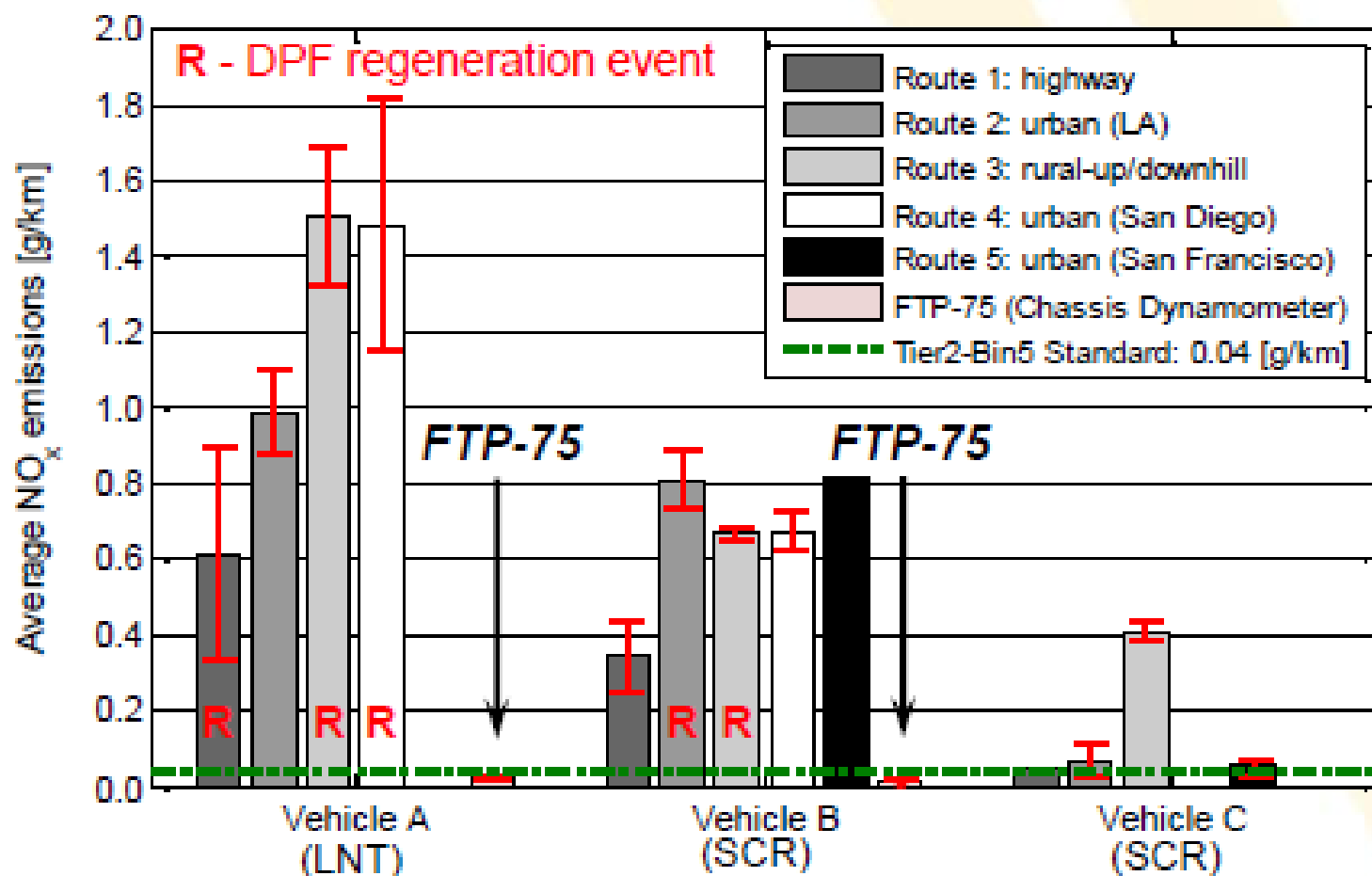
Zurich 2014



Yuche Chen and Jens Borken-Kleefeld, Real-driving emissions from cars and light commercial vehicles - Results from 13 years remote sensing at Zurich/CH.

Atmos. Environ. **2014**, 88, 157-164.

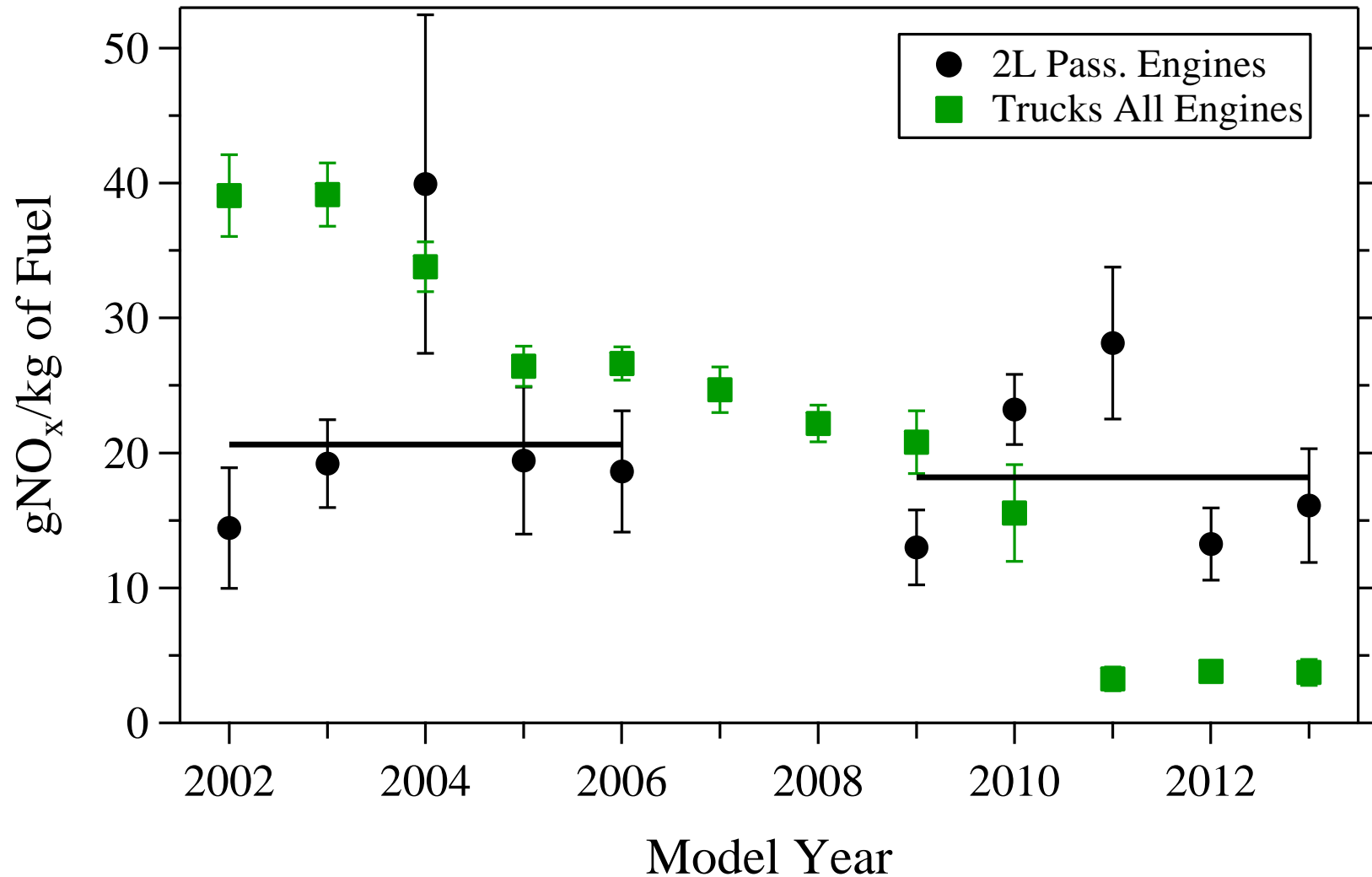
US 2014



Marc Besch et al., Off-Cycle Light-duty Diesel Vehicle Emissions Under Real-World Driving Conditions, presented at the 24th CRC On-road Vehicle Emissions Workshop, San Diego, 2014.

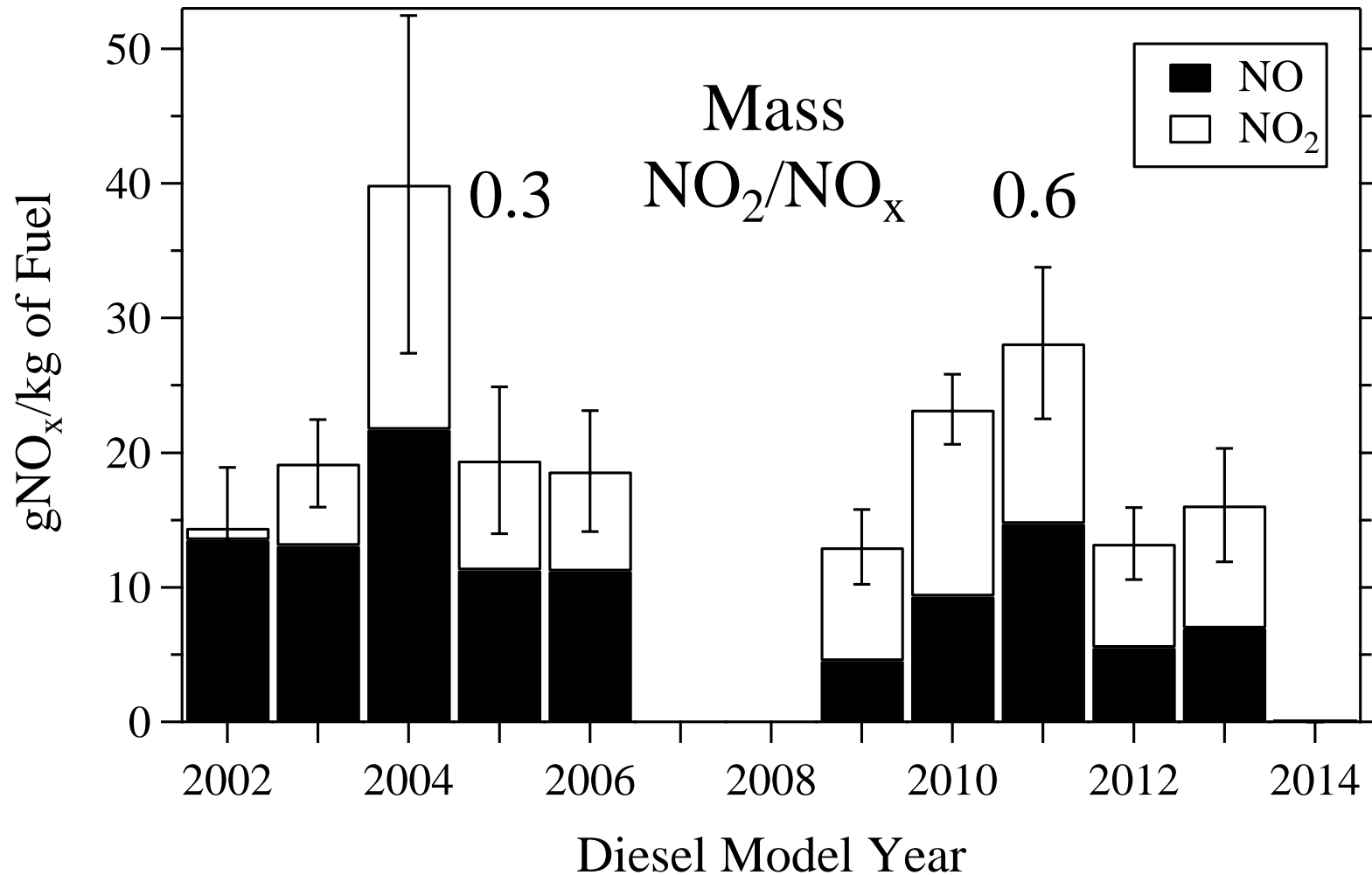
Certification Does not Always Work

2013 LD Diesel Data from Denver, LA and Tulsa



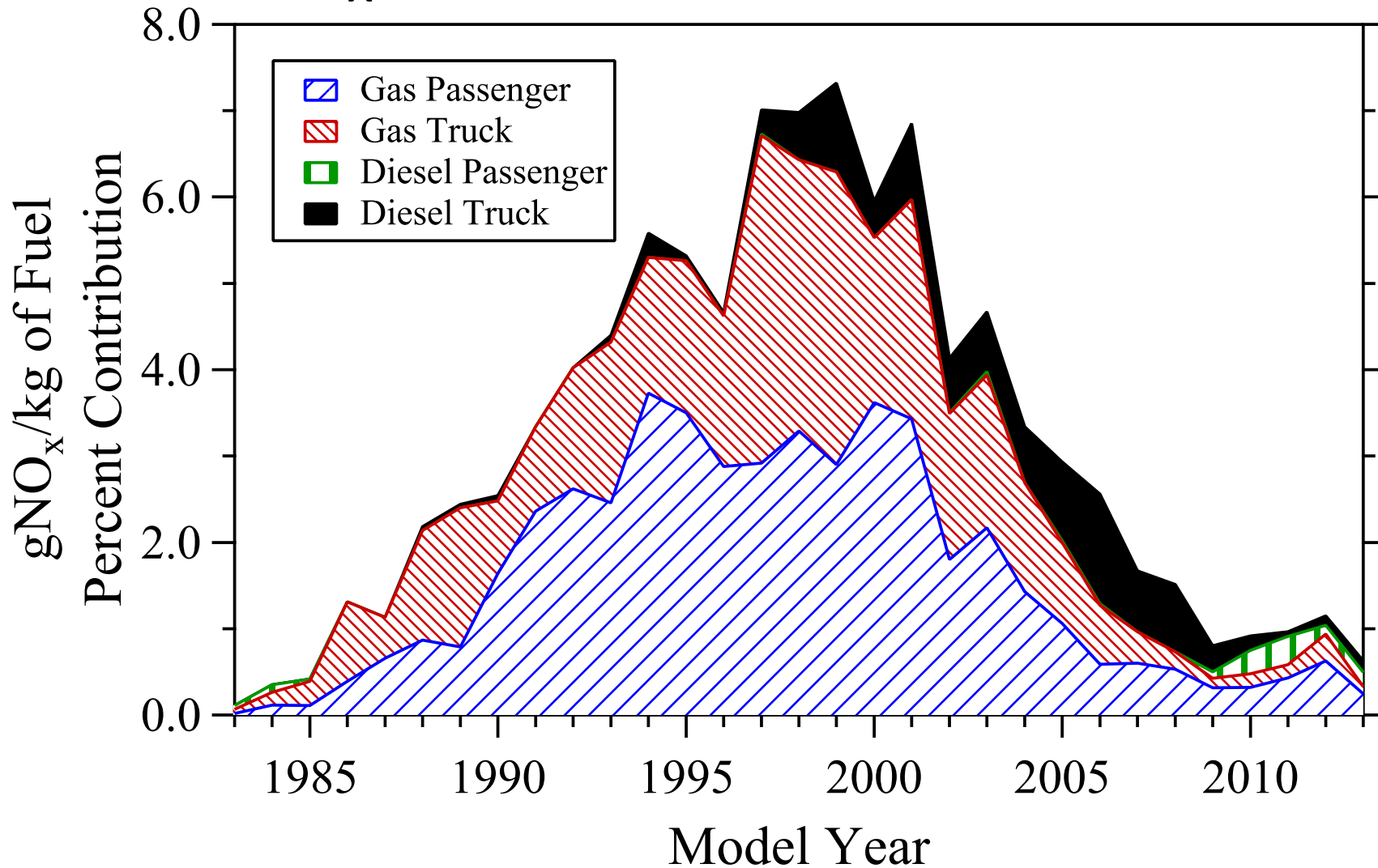
2013 LD 2 Liter Diesel NO₂/NO_x Ratios

Combined Data from Denver, LA and Tulsa

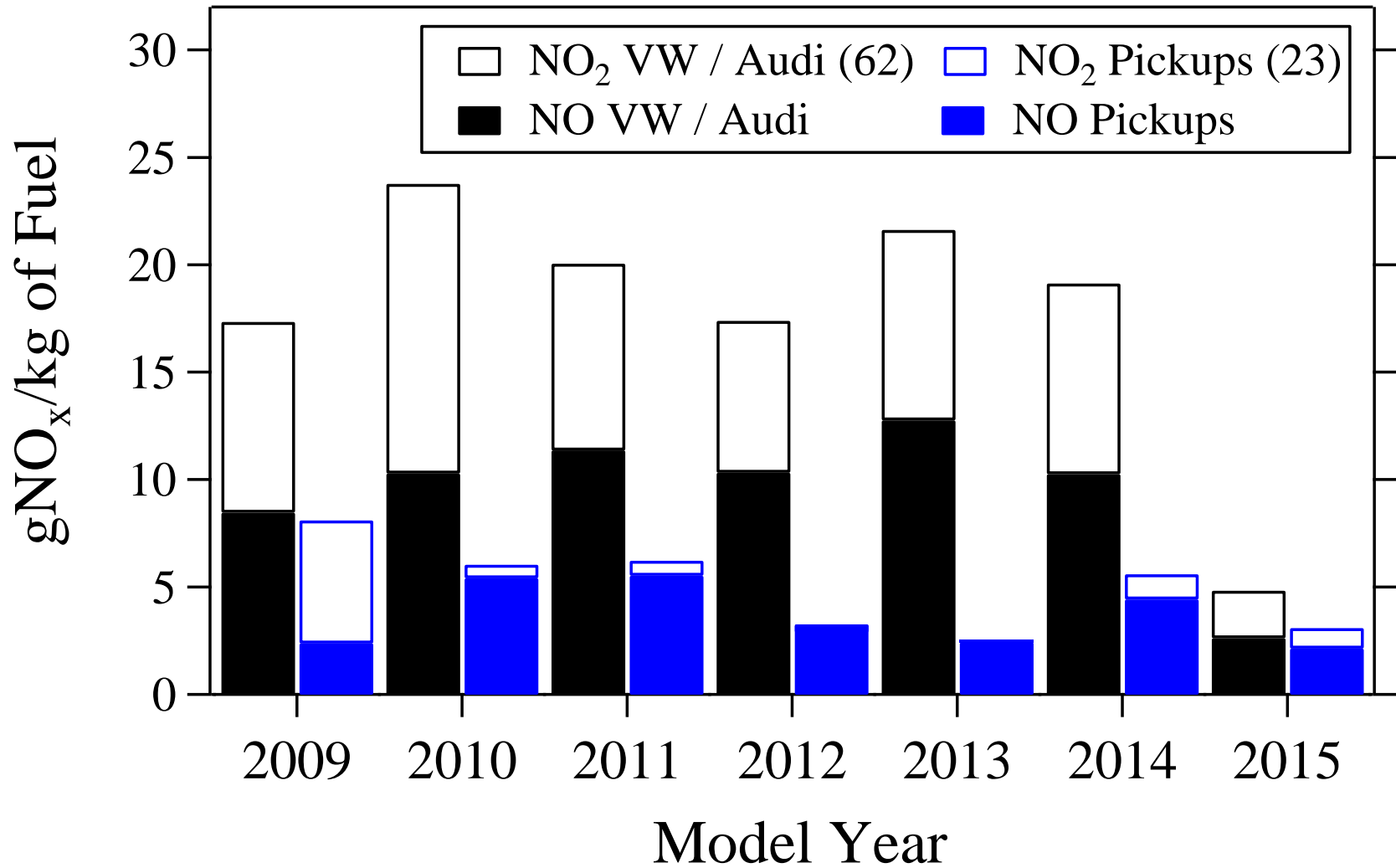


Bishop and Stedman, Reactive Nitrogen Species Emission Trends in Three Light-/Medium-Duty United States Fleets. *Environ. Sci. Technol.* **2015**, 49, 11234-11240.

2013 Los Angeles Light/Medium –duty NO_x Emissions Contributions



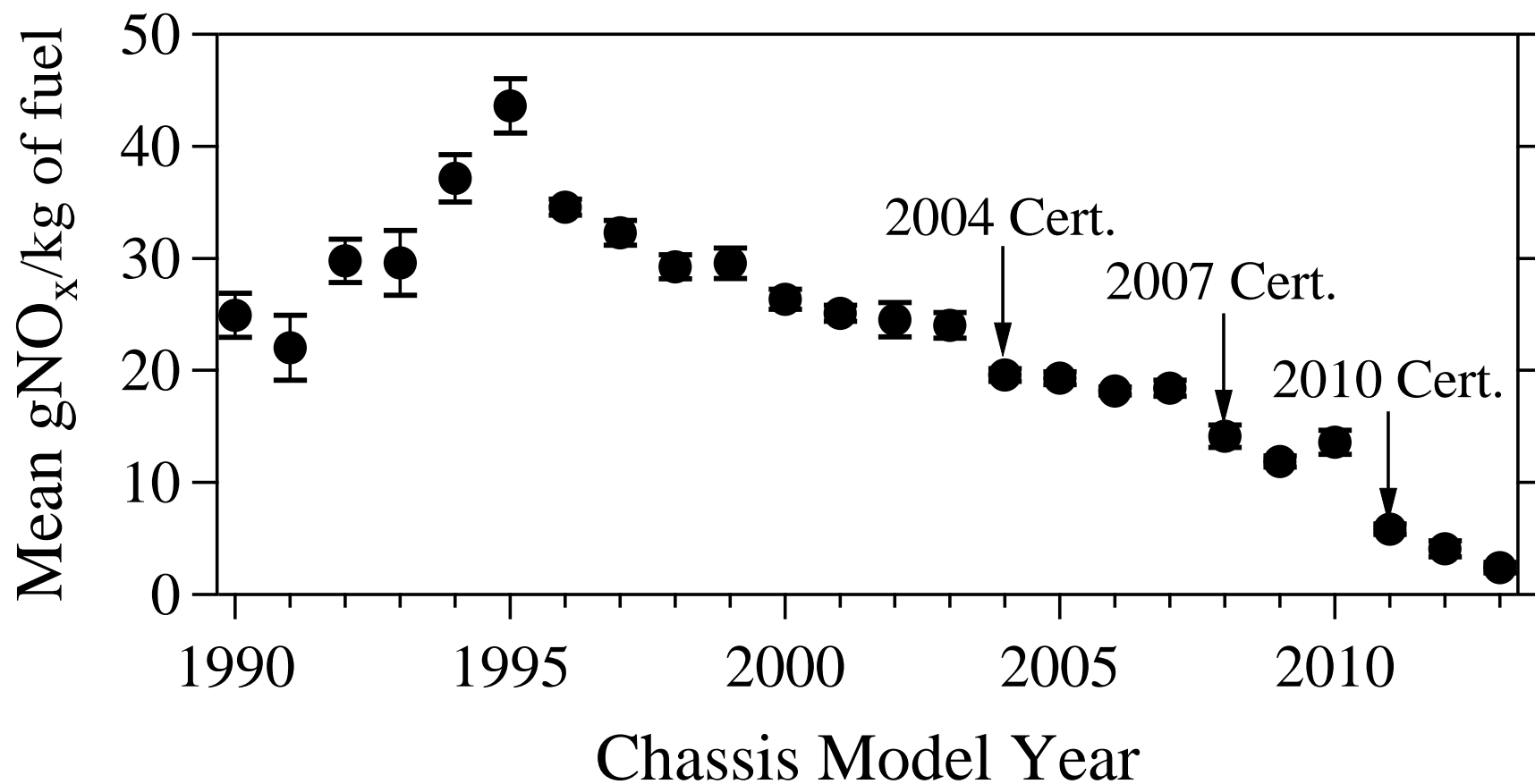
2015 West Los Angeles Diesels





Artist: Barnbrook *“Now that we’ve been caught we are trying to make you think that we care about the environment. But we are not the only ones.”*

2012 Heavy-duty NO_x Emissions Peralta Weigh Station California



Bishop et al., Heavy-Duty Truck Emissions in the South Coast Air Basin of California.
Environ. Sci. Technol. **2013**, 47, (16), 9523-9529

On-road Heavy-duty Measurement System



Bishop et al., On-road Heavy-duty Vehicle Emissions Monitoring System. *Environ. Sci. Technol.* **2015**, 49, (3), 1639-1645.

Summary

- ❖ We've made lots and lots of vehicle emission measurements with FEAT!
- ❖ The "Great News" is that the US transportation fleet continues to have lower and lower emissions.
- ❖ The not so great news is that because of the skewed nature of emissions distribution a minority of vehicles (broken ones) holds the fleet back from realizing even lower emission levels.
- ❖ Since broken vehicles dominate emission distributions special emission certifications and so-called "clean fuels" are generally irrelevant.
- ❖ Government regulations don't always turn out as planned.

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