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United States Light and Heavy -Duty Fuel Specific On -Road NO and NO x Emission Factor Trends and Their Importance in Inventory Calculations

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Acknowledgments

Coordinating Research Council
E-23 & E-106

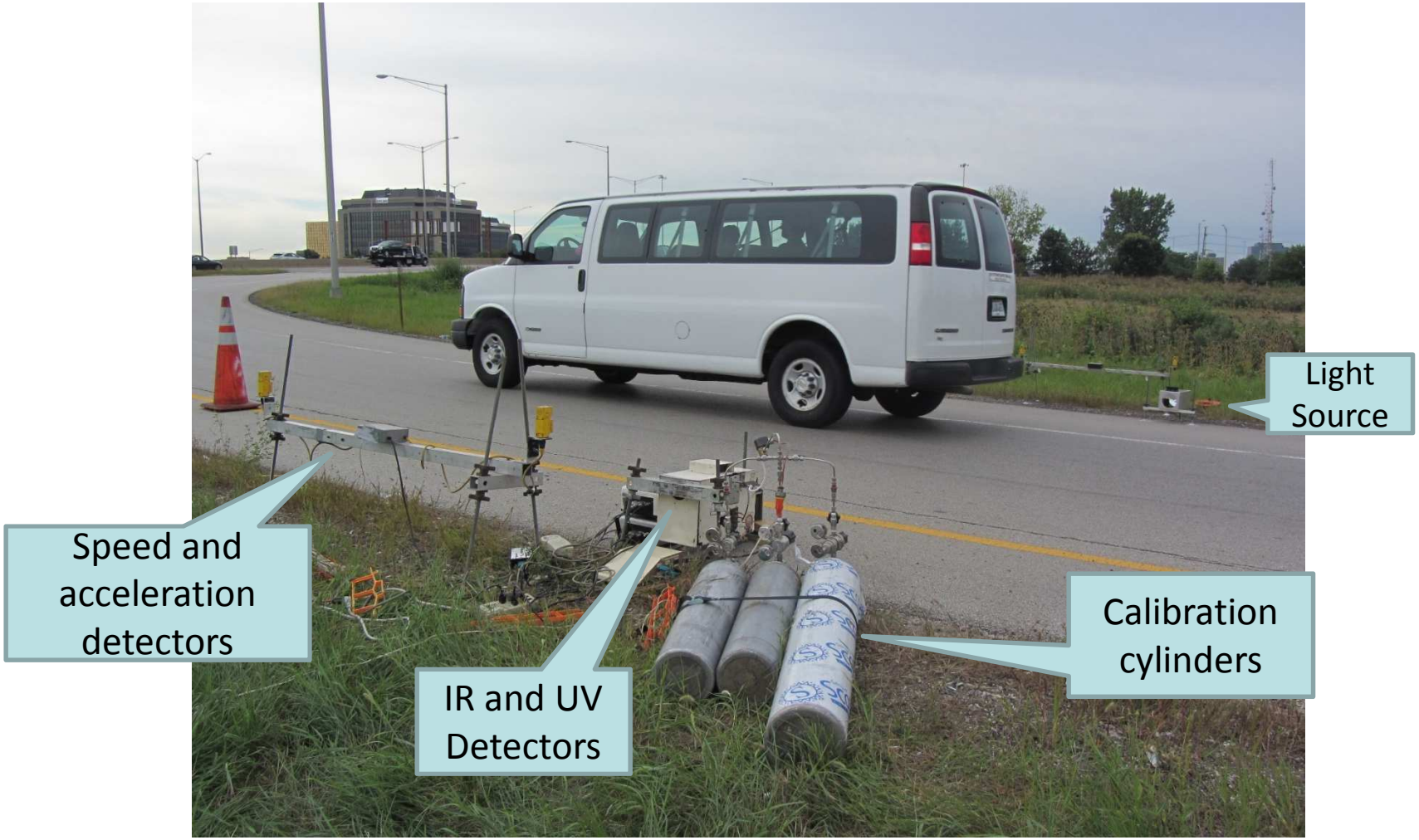
California Air Resources Board

Opus Inspections

University of Denver

The Late Dr. Donald H. Stedman

Fuel Efficiency Automobile Test (FEAT)



Bishop and Stedman, Measuring the emissions of passing cars. Acc. Chem. Res. 1996, 29, 489-495.

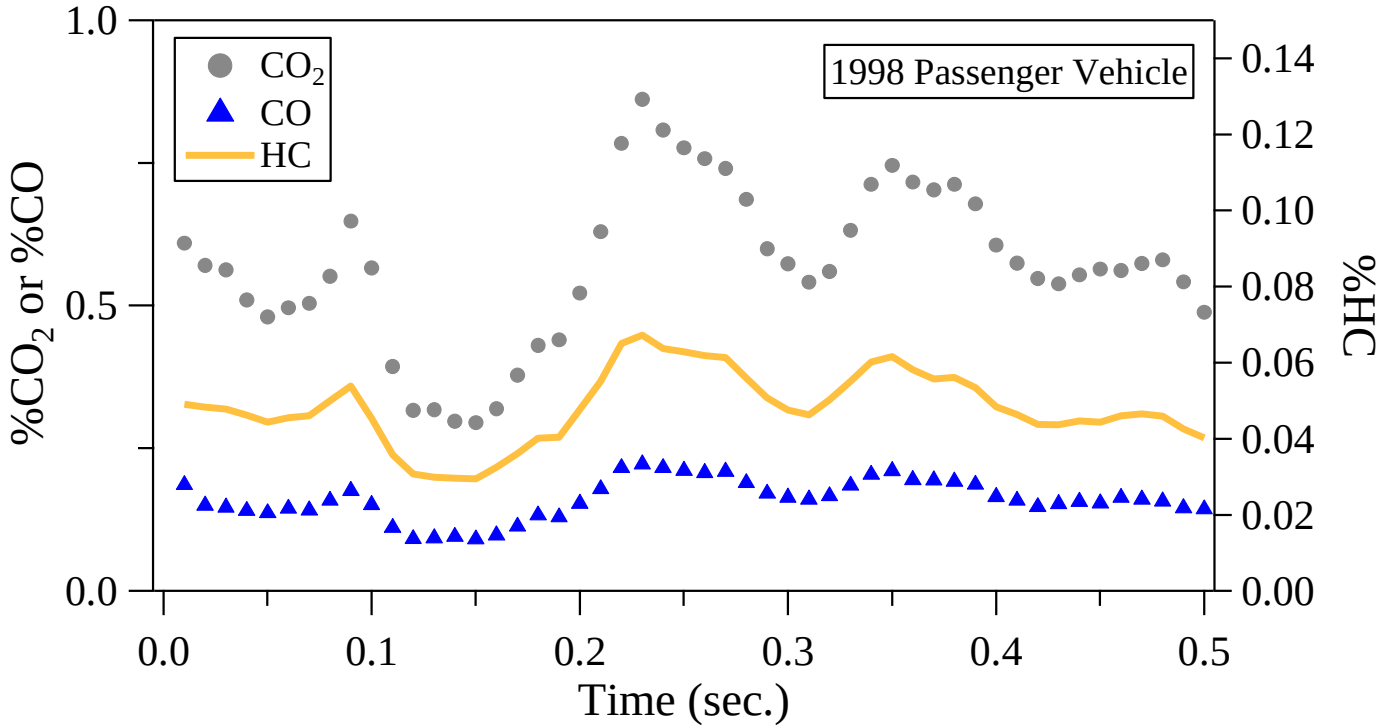
FEAT Measuring Heavy-Duty Vehicles

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

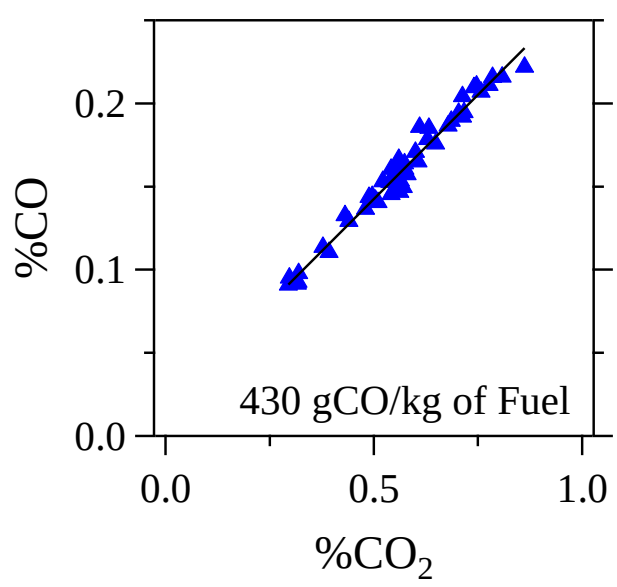
On-Road Heavy-Duty Vehicle Emissions Monitoring System (OHMS)

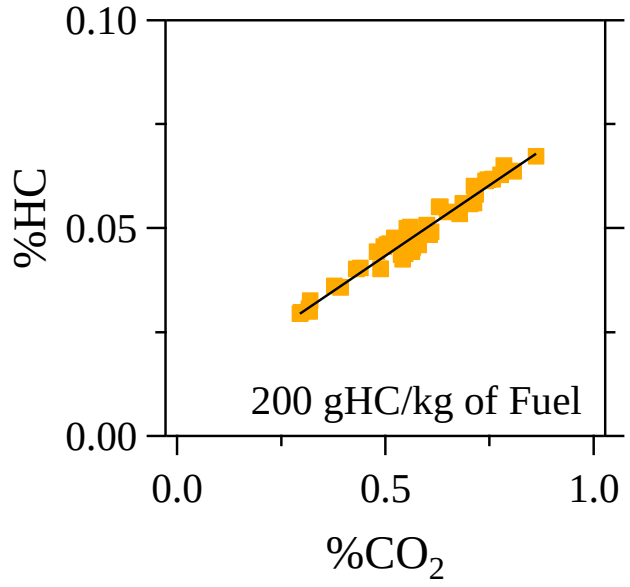
Haugen and Bishop. Repeat fuel specific emission measurements on two California heavy-duty truck fleets. *Environ. Sci. Technol.* **2017,** 51, (7), 4100-4107.

How We Measure Fuel Specific Tailpipe Emissions



0.5 Second of exhaust behind vehicle





Ratio graphs

Measurement Species and Techniques

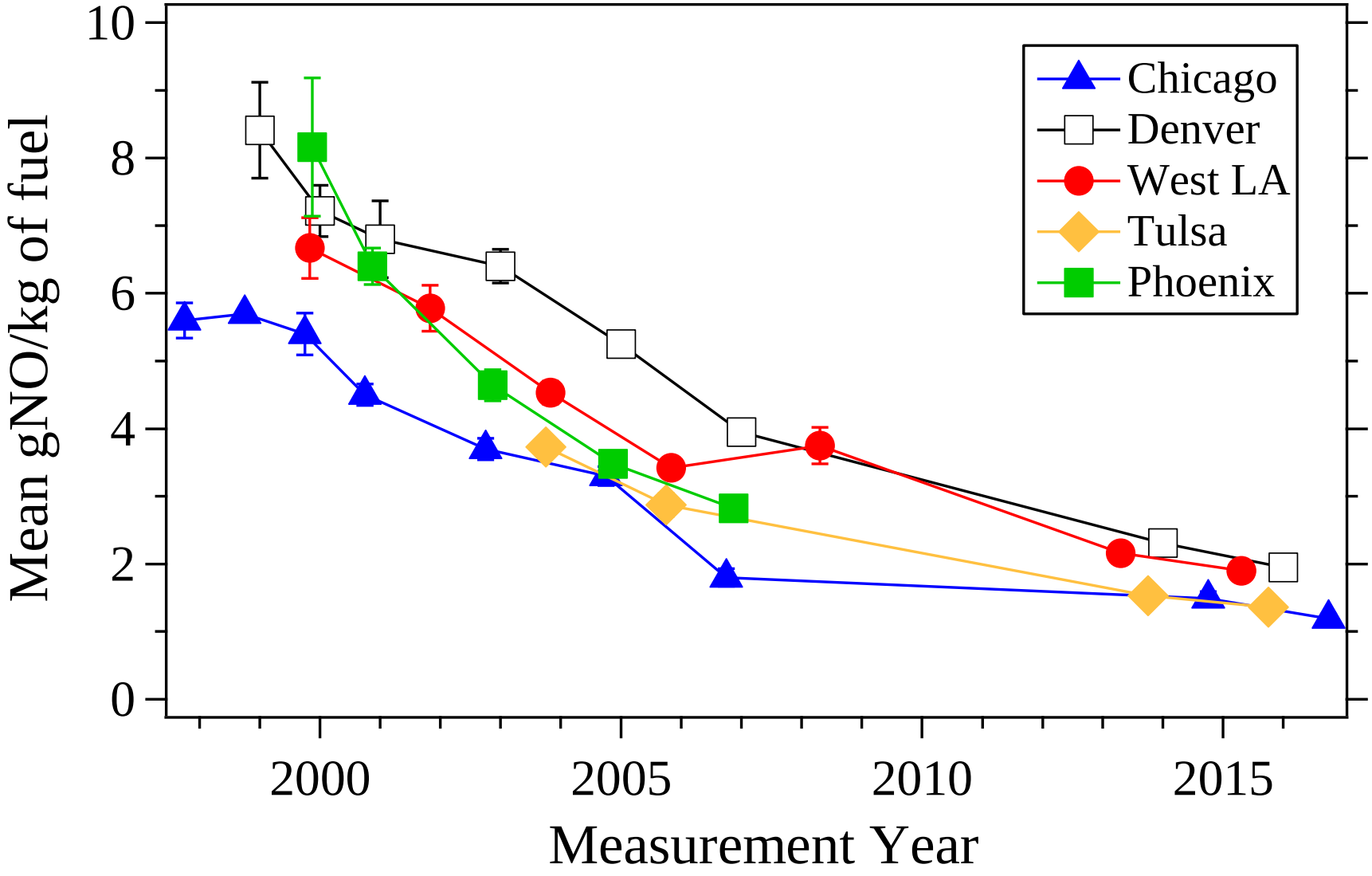
FEAT	OHMS
Single Measurement St. dev.	
NDIR – CO_2	NDIR – CO_2 / CO
CO ± 4 g/kg	FID – HC
HC ± 4 g/kg	Chemi – NO / NO_x
%Opacity ± 0.8%	Electrical Low Pressure
UV – NO ± 0.4 g/kg	Impactor – Total PM / PN
NO_2 ± 0.3 g/kg	Photoacoustic – Total BC
NH_3 ± 0.02 g/kg	
Speed and Acceleration	Speed and Acceleration
License Plate Photo	License Plate Photo

History of U.S. Light-duty NO Measurements (NO_2 since 2008)

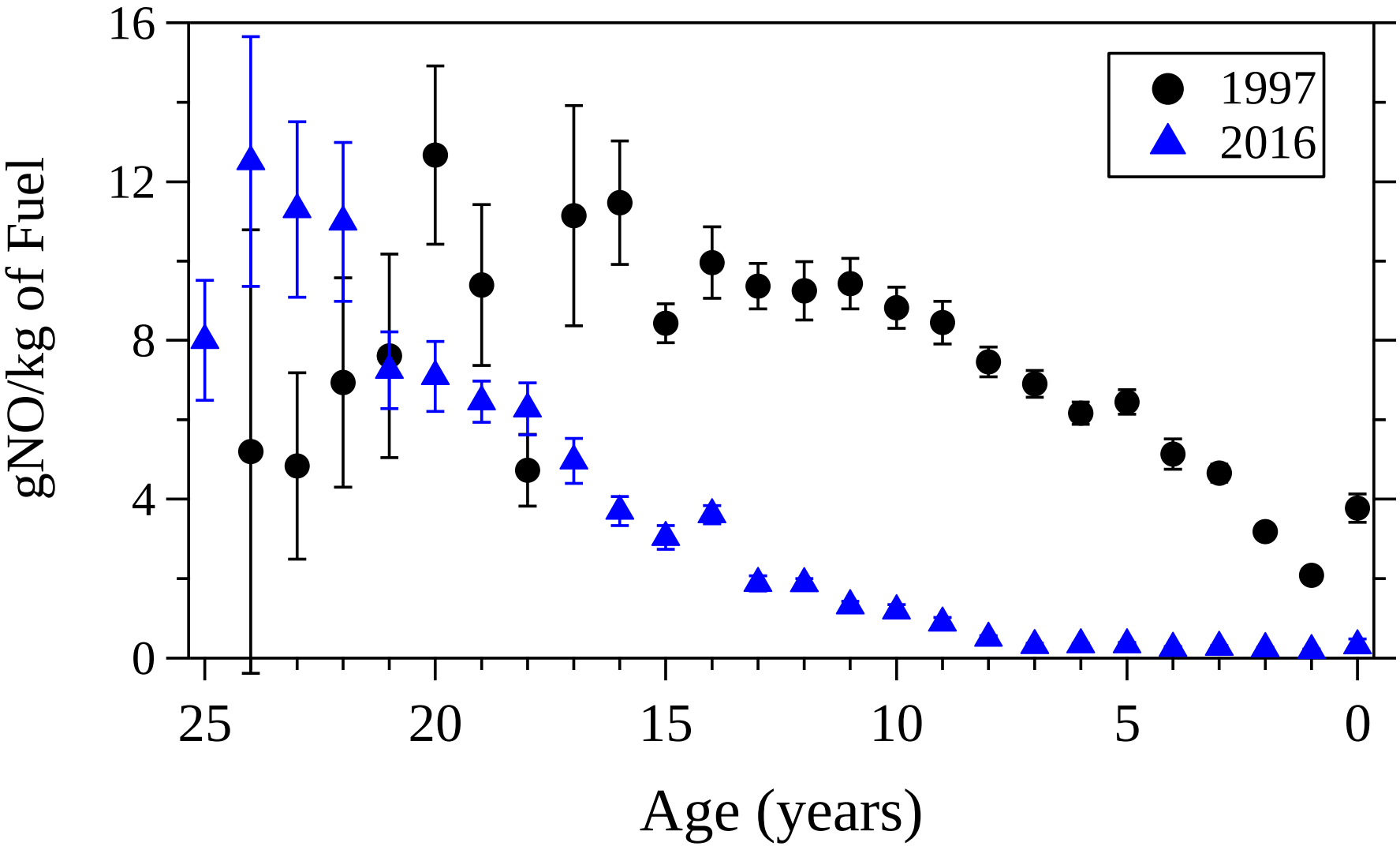
- Chicago, IL – 1997 - 2000, 2002, 2004, 2006, 2014, 2016
- Dallas, TX – 2002, 2003
- Denver, CO – 1999 - 2002 (2), 2003, 2005 (2), 2007, 2013, 2015
- Fresno, CA – 2008
- Grand Junction / Glenwood Springs, CO – 2001
- Omaha, NE – 2002, 2004
- Phoenix, AZ – 1998 - 2000, 2002, 2004, 2006
- Riverside, CA – 1999 - 2001
- Sacramento, CA – 1999
- San Jose, CA – 1999, 2008
- Tulsa, OK – 2003, 2005, 2013, 2015
- W. Los Angeles, CA – 1999, 2001, 2003, 2005, 2008, 2013, 2015
- Los Angeles 710, CA – 1999
- Van Nuys, CA – 2010

51 Campaigns, 1,039,000+ Emission Measurements,
Data and Publications are Available at www.feat.biochem.du.edu.

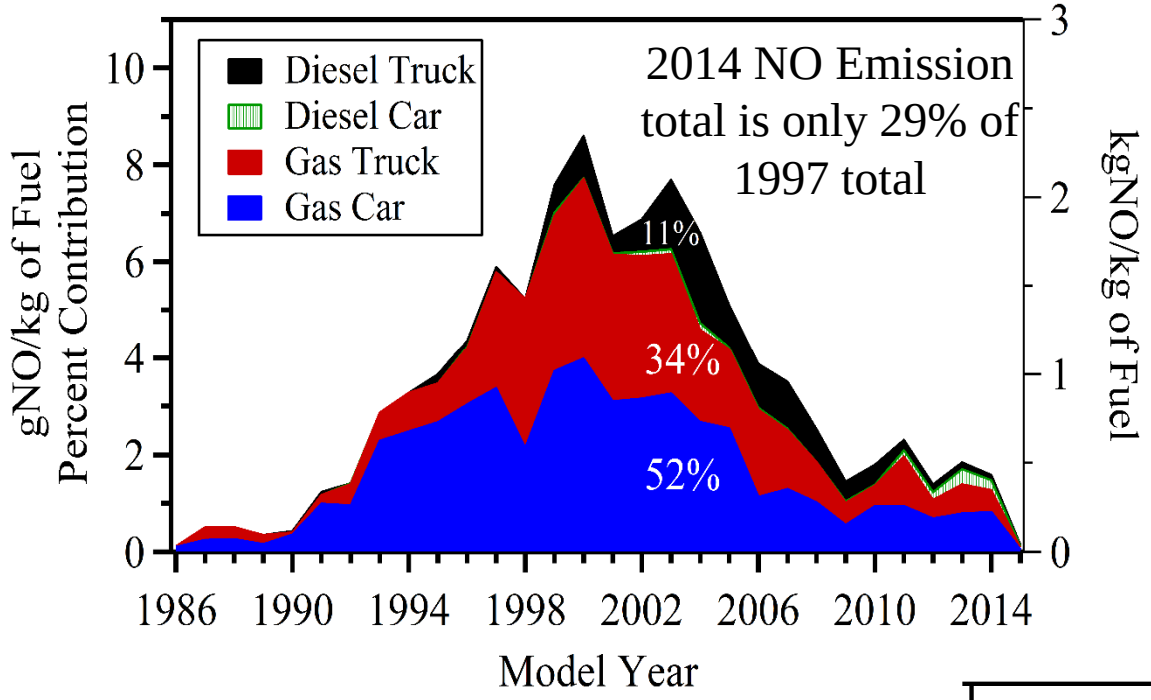
Historical U.S. Light-duty NO Emission Trends

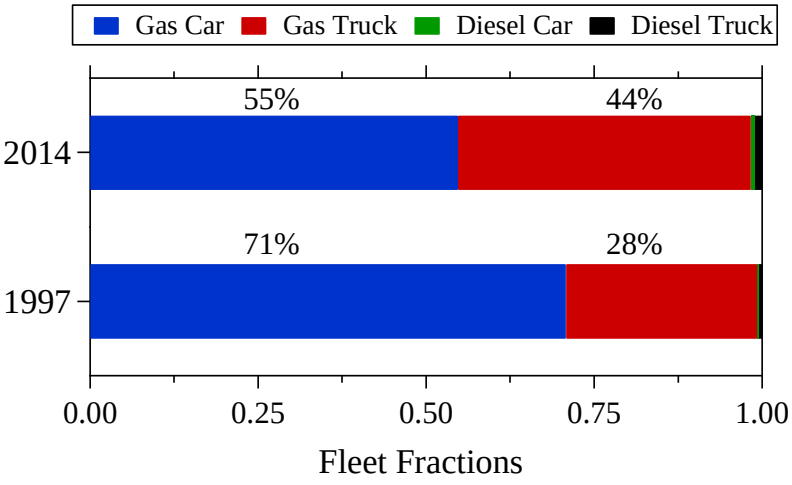


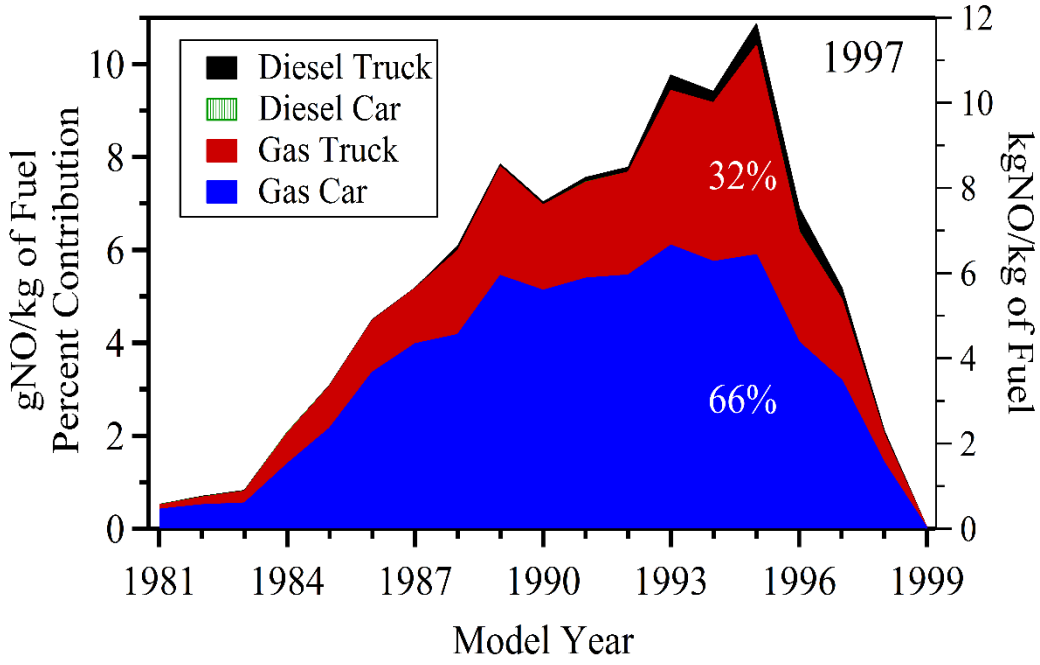
Chicago NO Emissions Comparison



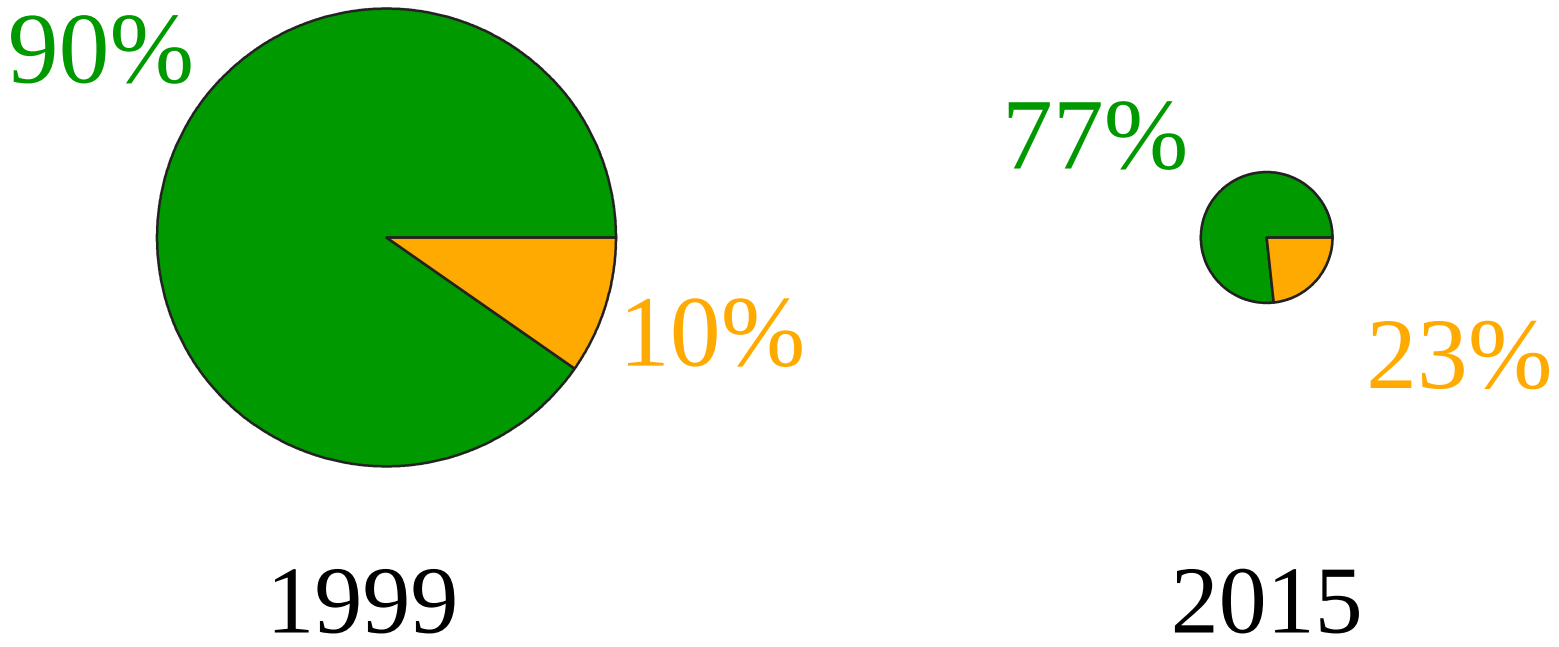
Light/Medium Duty NO Emissions Contribution Changes for the Chicago Fleet



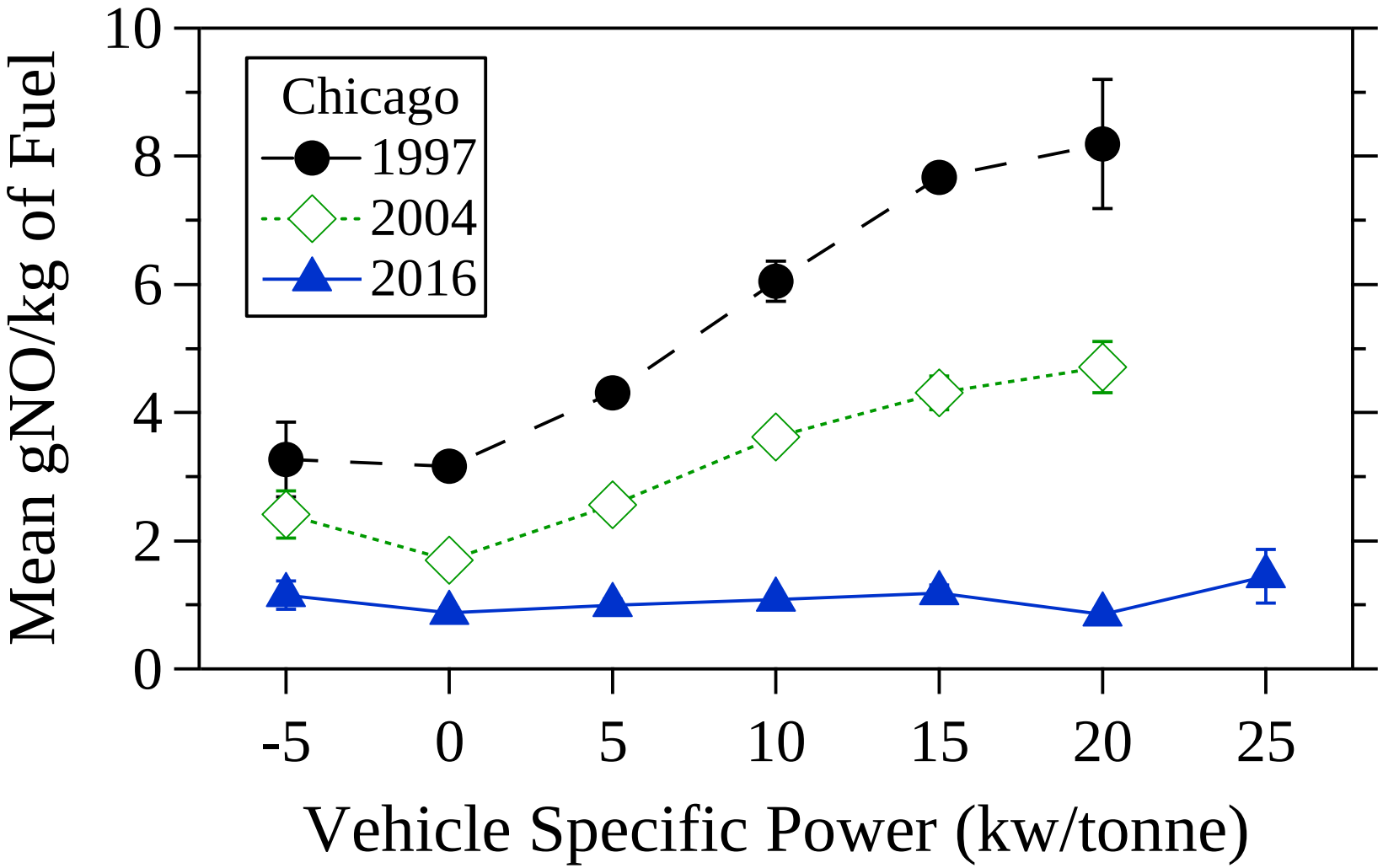




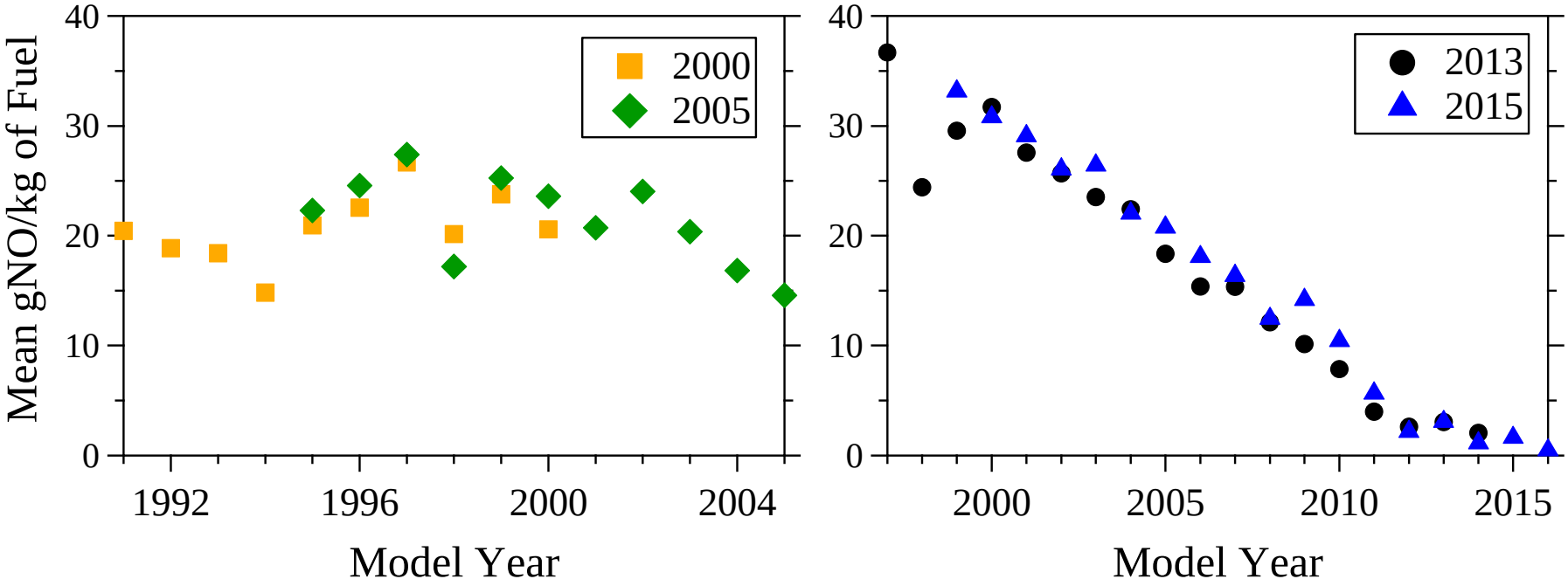
West Los Angeles Percentage of NO Contributed by the 99th Percentile



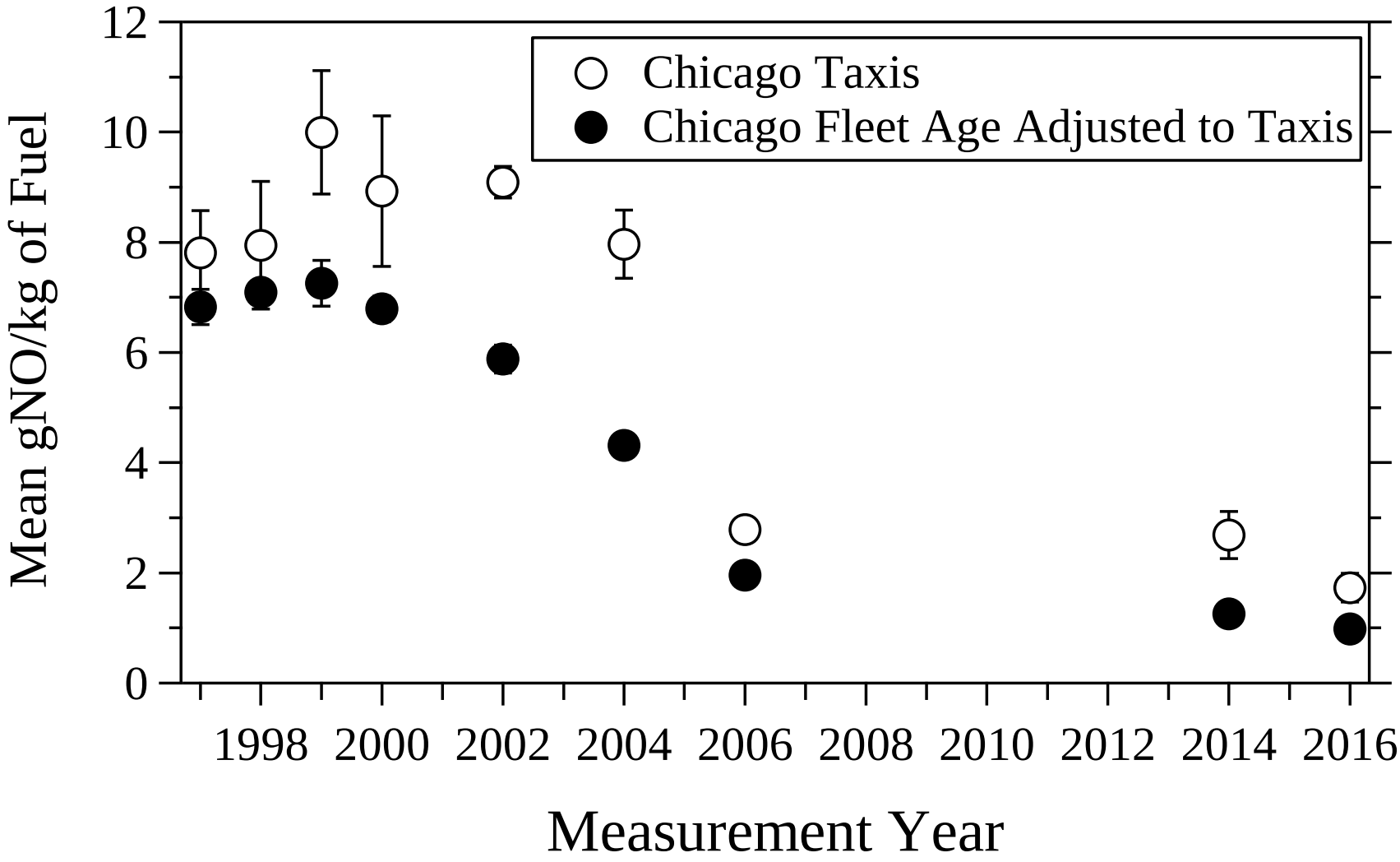
Elimination of Driving Mode Effect For Fuel Specific Emissions



Denver Fuel Specific NO Emission Trends for Light-Duty Diesel Powered Vehicles



High Mileage Vehicle Emissions
Not All Vehicles are Equal



History of U.S. Heavy-duty NO and NO_x Measurements

FEAT

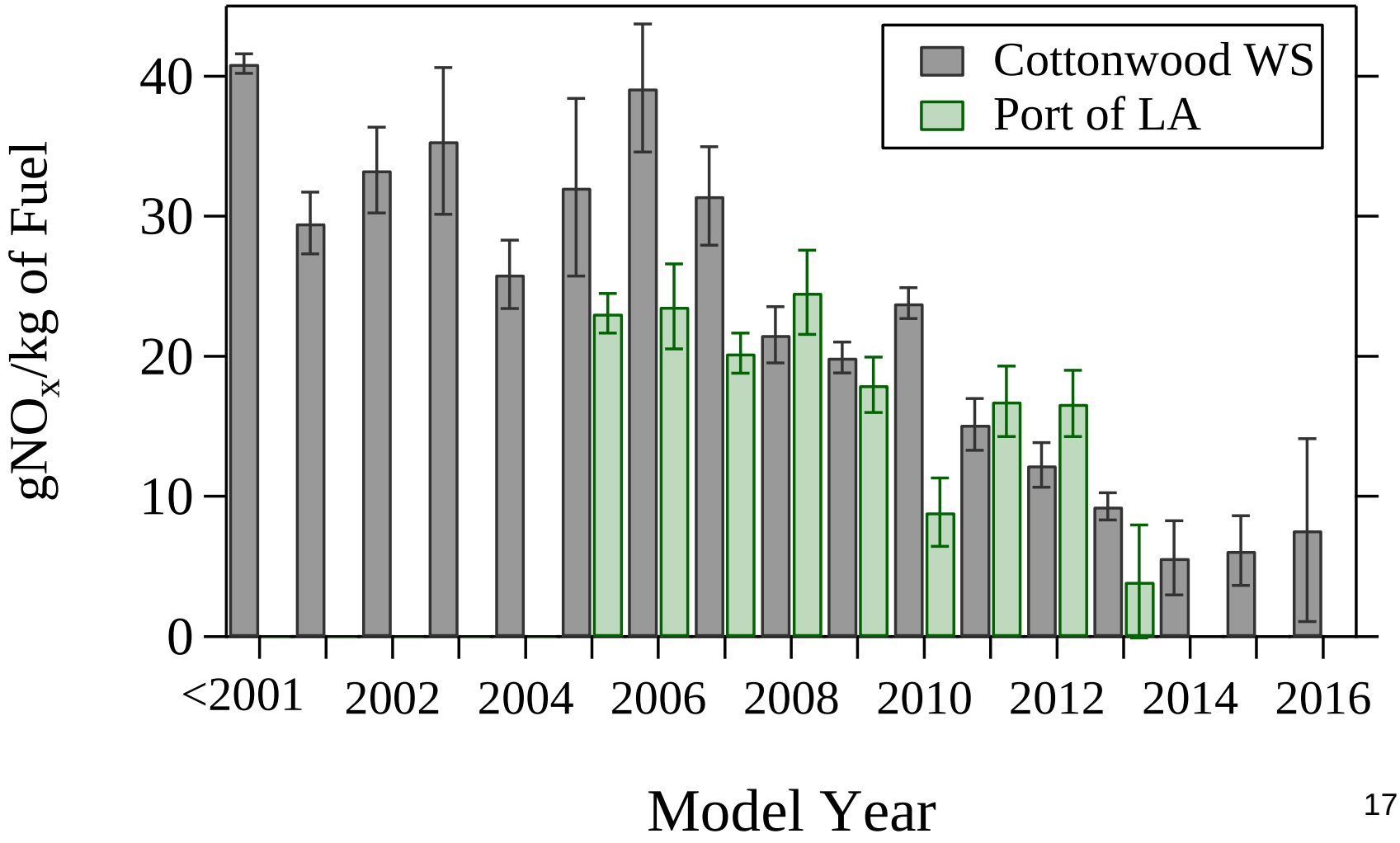
- Anaheim, CA – 1997, 2008 - 2010, 2012, (2017)*
- Dumont, CO – 1999, 2005
- Golden, CO – 1999, 2005
- Port of Los Angeles, CA – 2008 - 2010, 2012
- Port of Houston, TX – 2009
- San Marcos, TX – 1998

OHMS

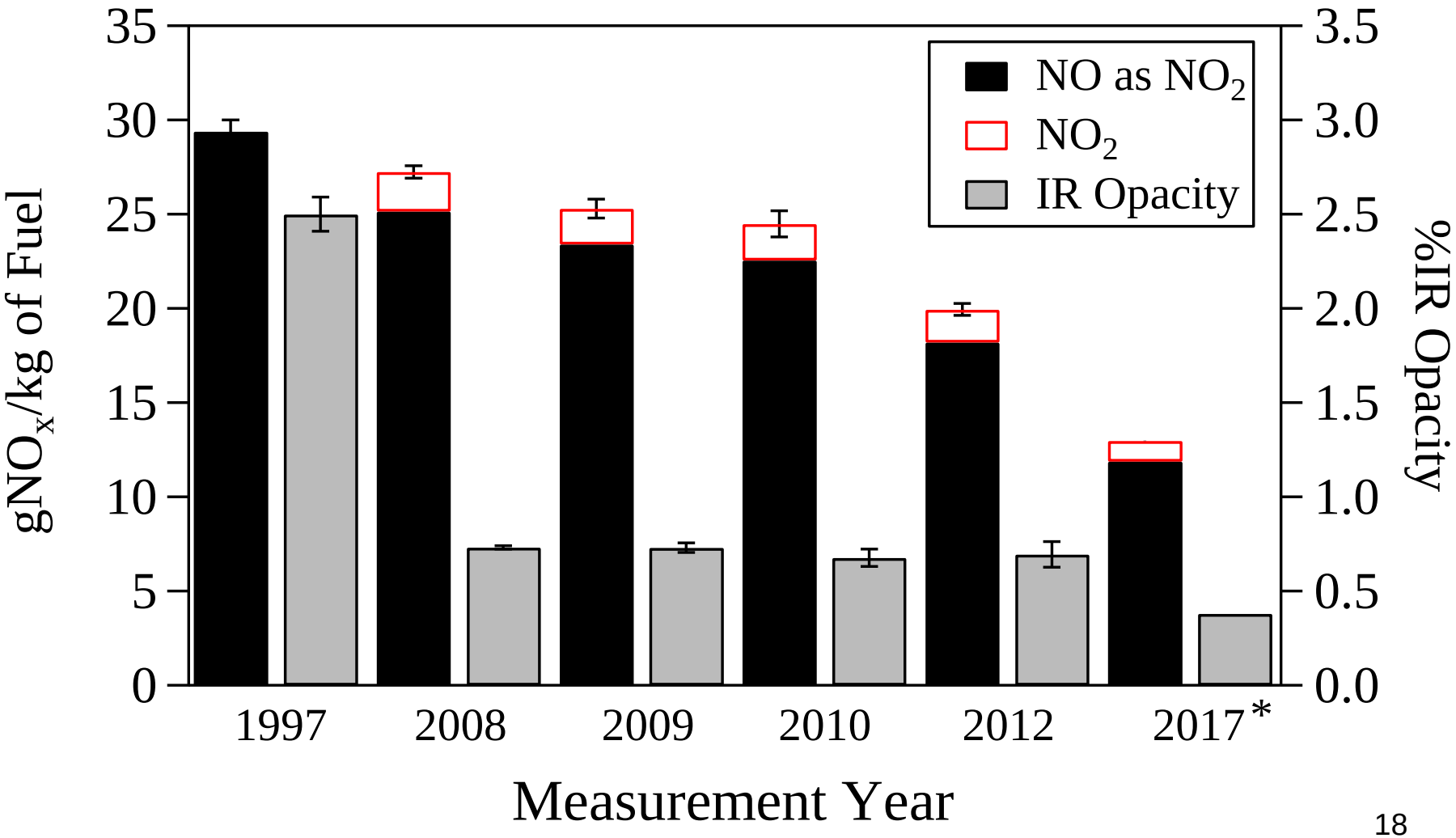
- Port of Los Angeles, CA – 2013, 2015, (2017)*
- Cottonwood, CA – 2013, 2015, (2017)*

22 Campaigns, 32,000+ Emission Measurements,
Data and Publications are Available at www.feat.biochem.du.edu.
*Measurements collected, data not final

2015 Heavy-duty Diesel Truck NO_x Emissions by Model Year



Historical HD Diesel Truck NO_x Emissions, Peralta WS CA



Conclusions

- Light-duty gasoline and diesel fleet NO_x emission reductions were late to the party but are now rapidly declining!
- Fuel specific LD truck and diesel emissions contributions are increasing, LD driving mode is no longer a factor and all vehicles do not contribute proportionally to the total.
- NO distributions are more skewed today.
- Heavy-duty NO_x emissions are also declining but operating mode/catalyst temperatures can have a significant influence on levels.