Long-Term Trends in Mobile Source Emissions and Urban Air Quality

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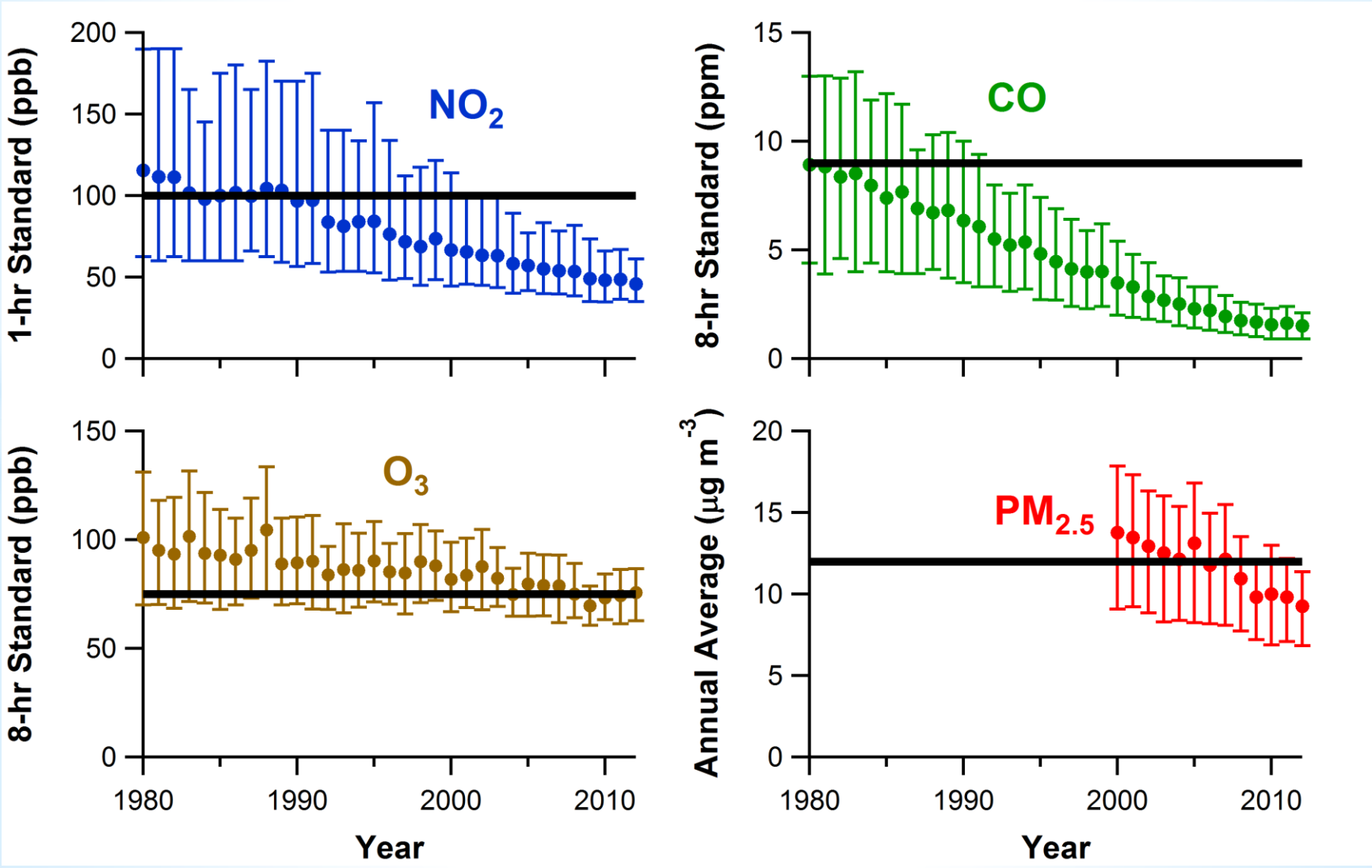
April 16, 2015

Significant Improvement in U.S. Air Quality

Mean, 10th, and 90th percentiles shown across all EPA routine monitoring locations



Source: EPA 2011, "Our Nation's Air – Status and Trends"

Research Objectives

(1) Assess long-term trends in mobile source emissions

- Focus on BC, CO, and NO_x

(2) Map motor vehicle emissions spatially and temporally

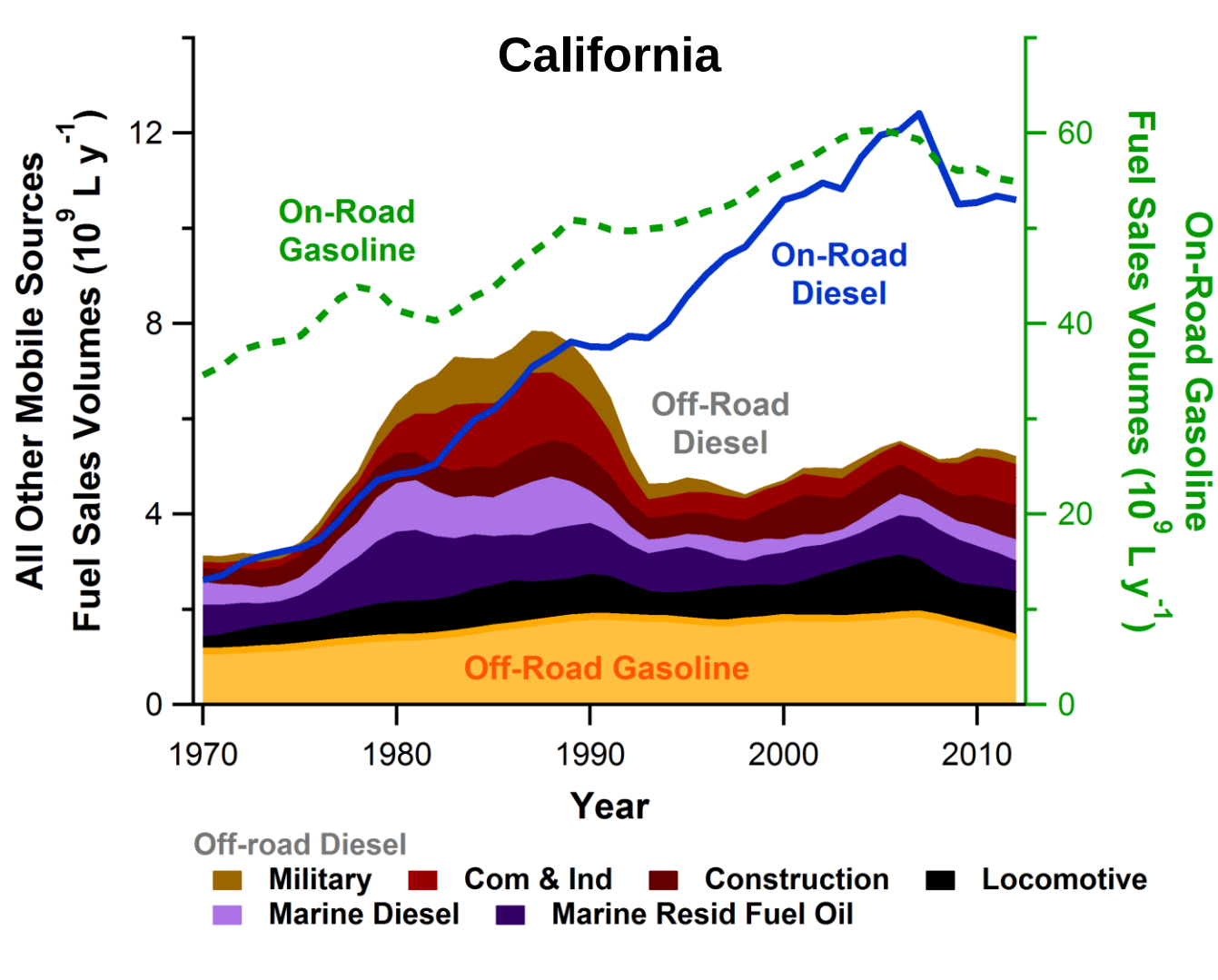
- Demonstrate a fuel-based approach to mapping emissions
- Account for differences between heavy-duty trucks (diesel) and passenger vehicles (gasoline)

(3) Urban air quality modeling

- Reconcile fuel-based mobile source emission inventory with observations

Fuel-Based Approach to Estimating Emissions

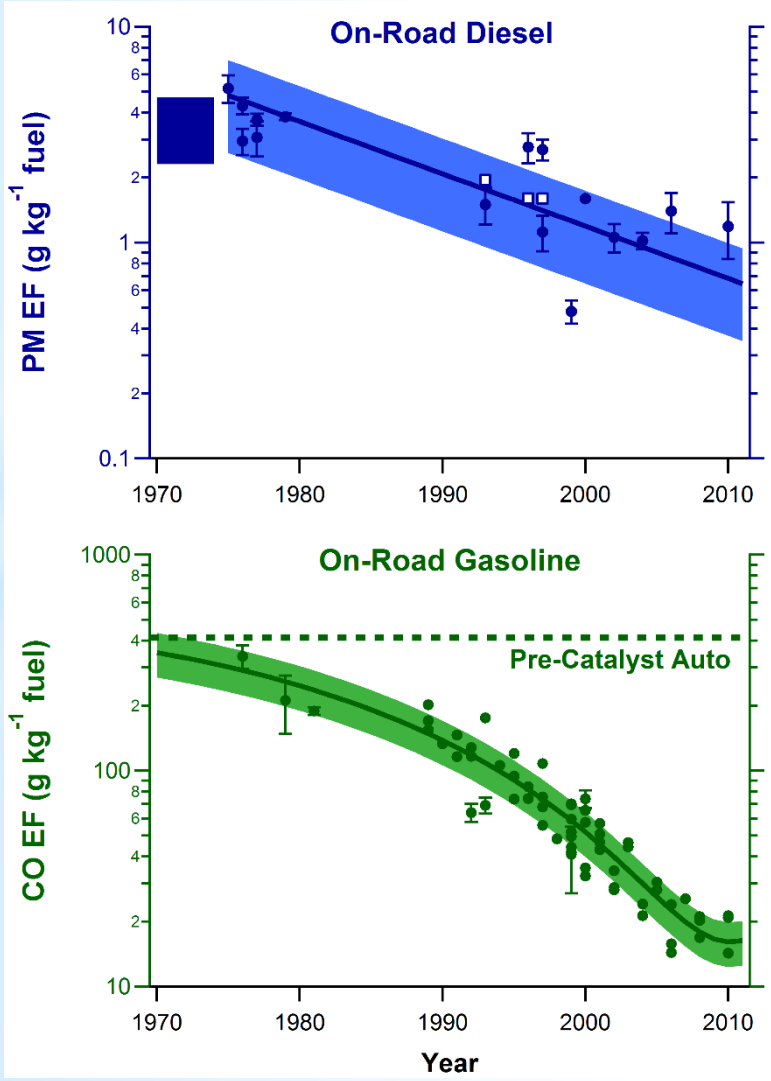
Emissions = Activity (kg fuel) x Emission Factor (g/kg fuel)



McDonald et al. (*ES&T* 2015)

On-Road Emission Factors from Roadway Studies

Emissions = Activity (kg fuel) x Emission Factor (g/kg fuel)



- **Emission factors obtained from roadway studies**
  - IR remote sensing
  - Tunnel studies
- **Other pollutants analyzed**
  - NO_x, VOCs, BC, POA

McDonald et al. (*ES&T* 2015)

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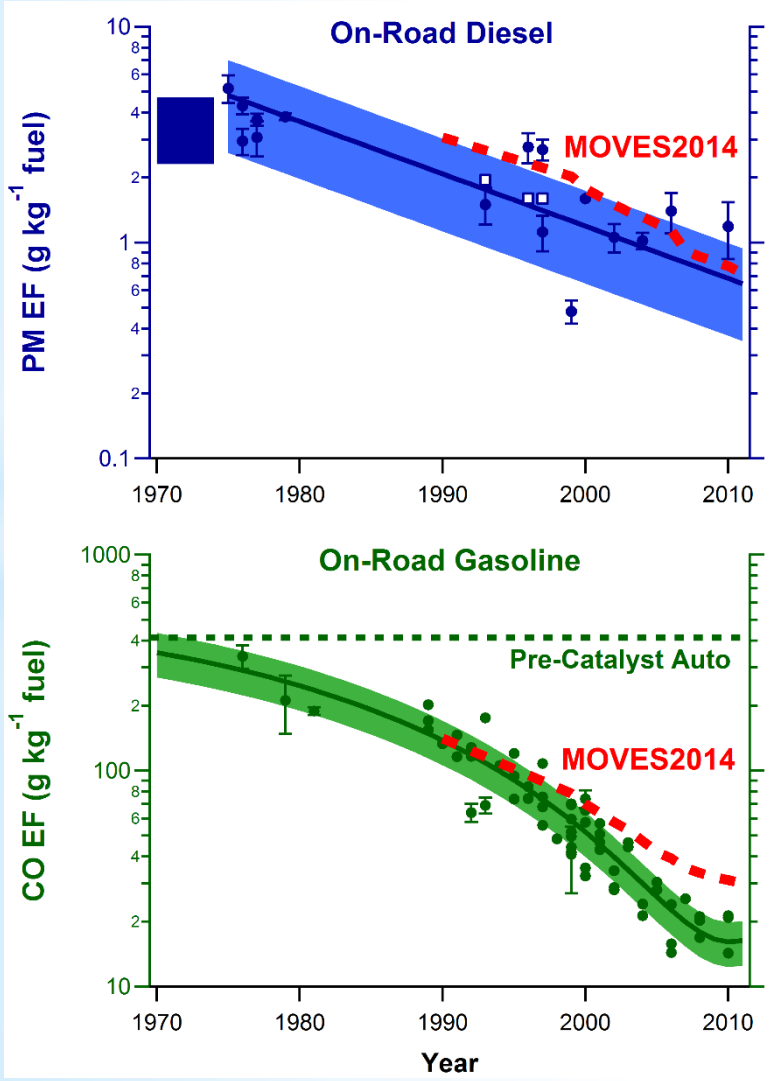

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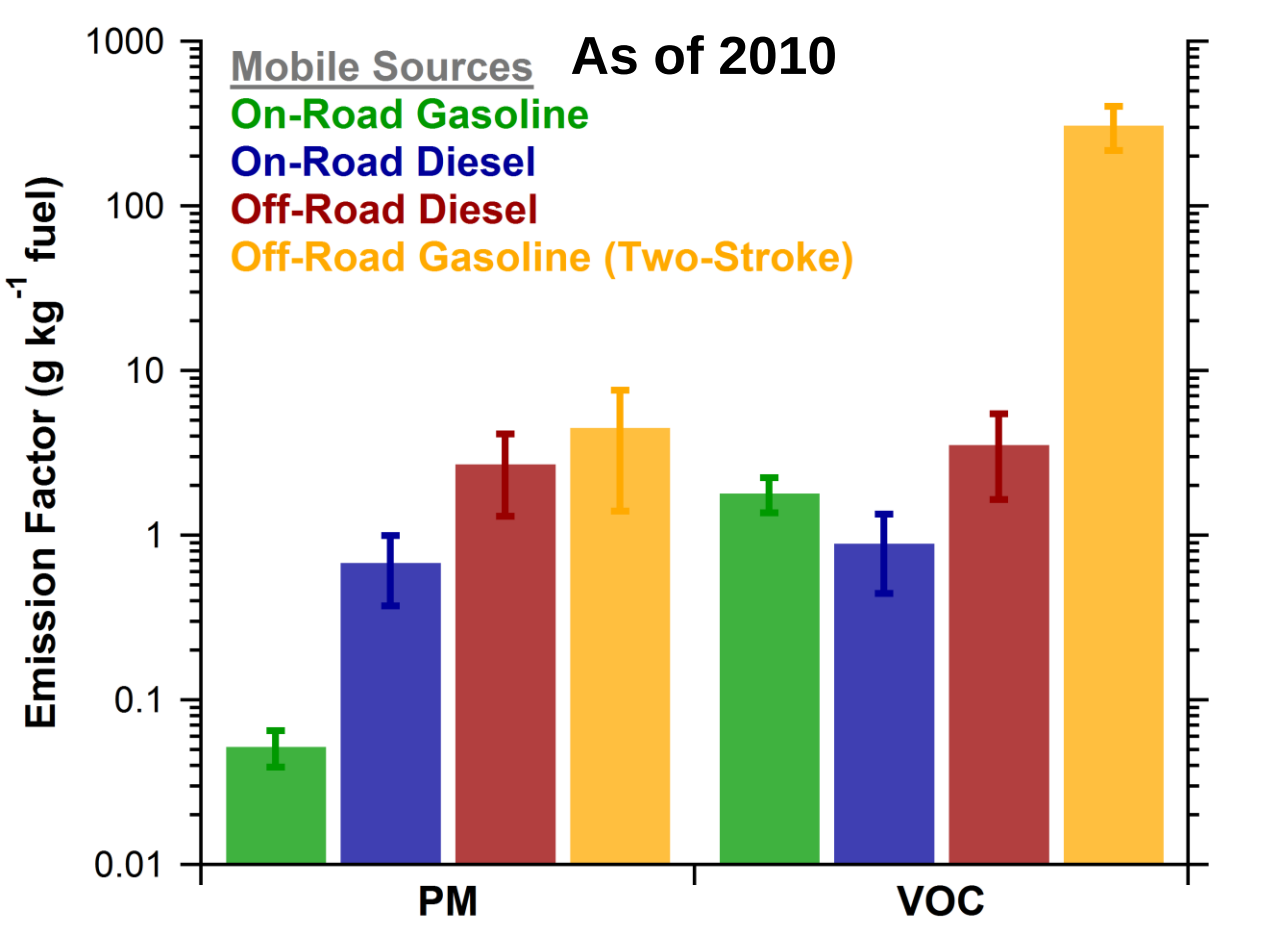
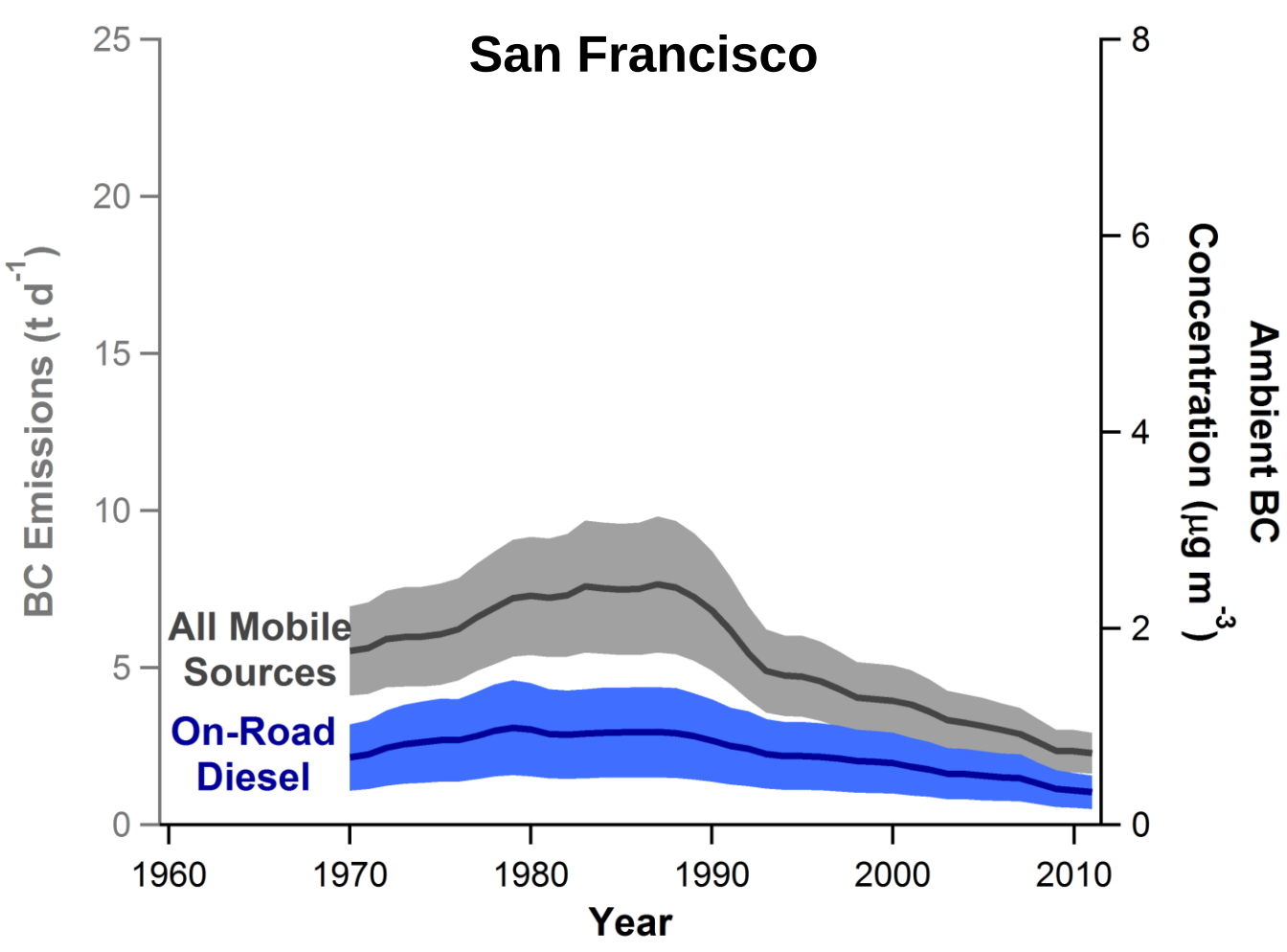
Large Off-Road Emission Factors (in g kg^{-1} fuel)



PM and VOC emission factors for off-road engines are now larger than for on-road engines.

Emission factors from McDonald et al. (*ES&T* 2015)

Overall Decrease in BC Emissions



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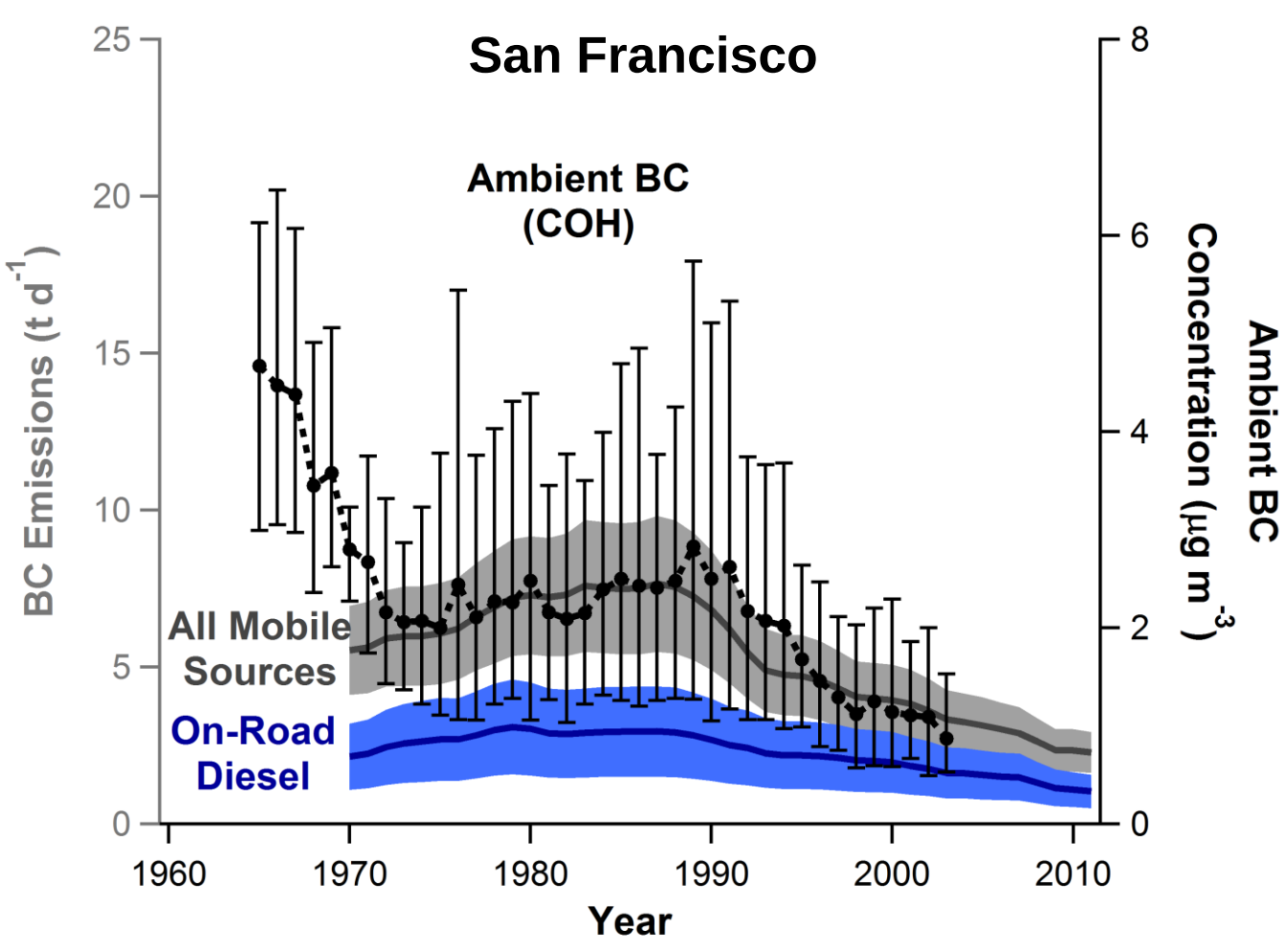
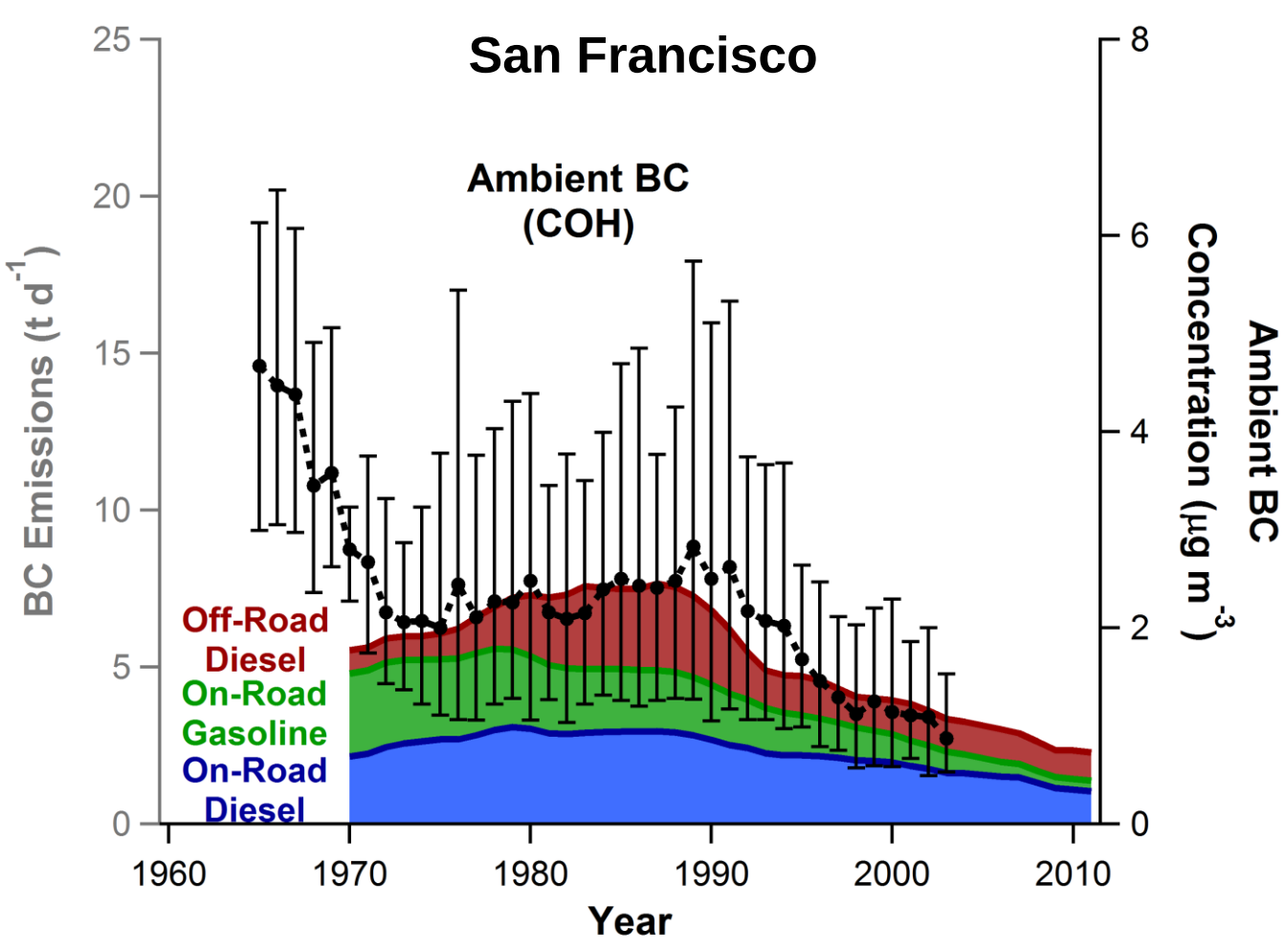
Similarity in Ambient BC and Emission Trends



Since 1970, mobile source emissions have dominated ambient BC in the SF Bay Area.

McDonald et al. (*ES&T* 2015)

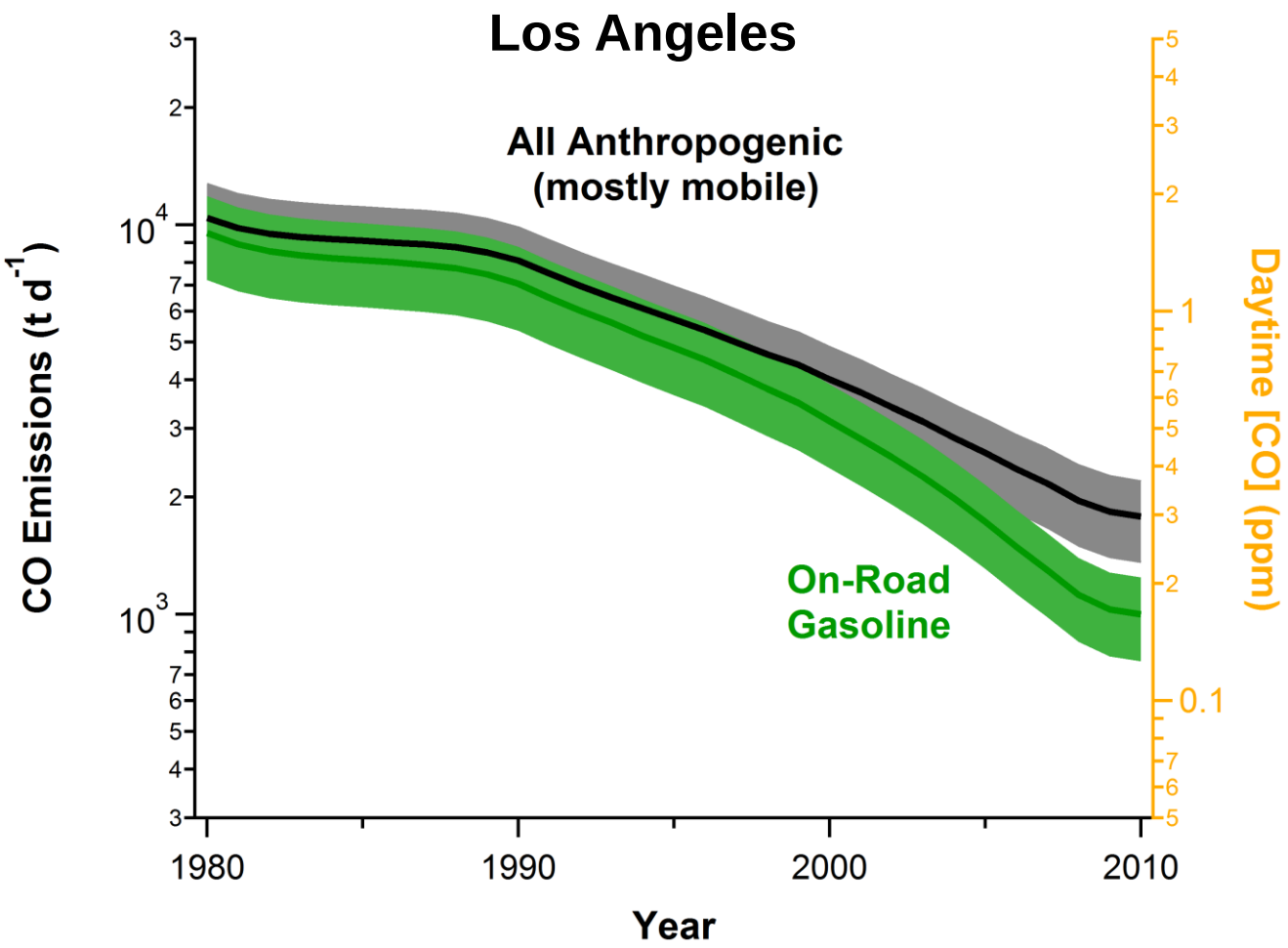
BC Emissions by Mobile Source Category



Diesel trucks are an important source of BC, but not the only mobile source contributor.

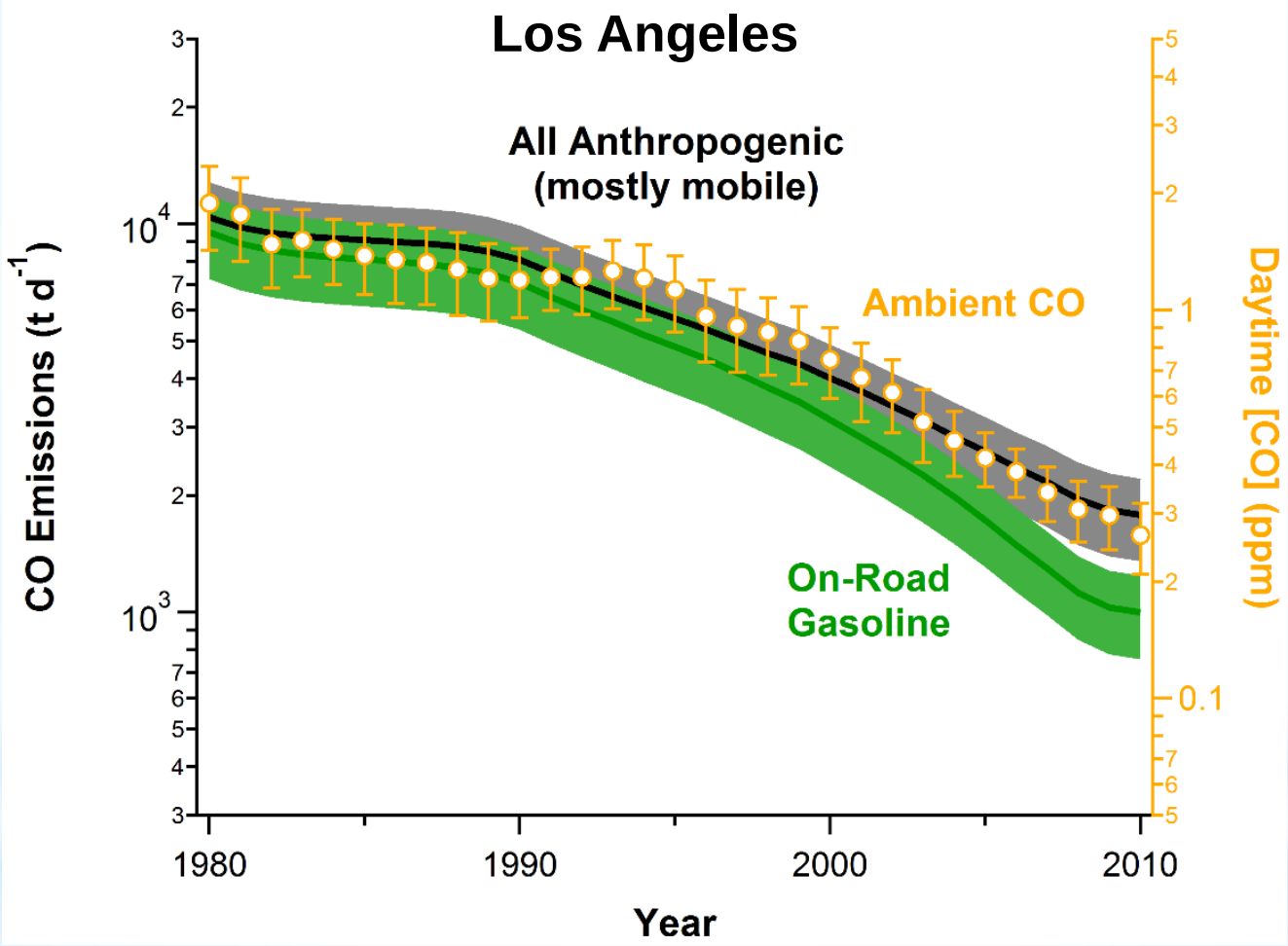
McDonald et al. (*ES&T* 2015)

Large Decrease in CO Emissions



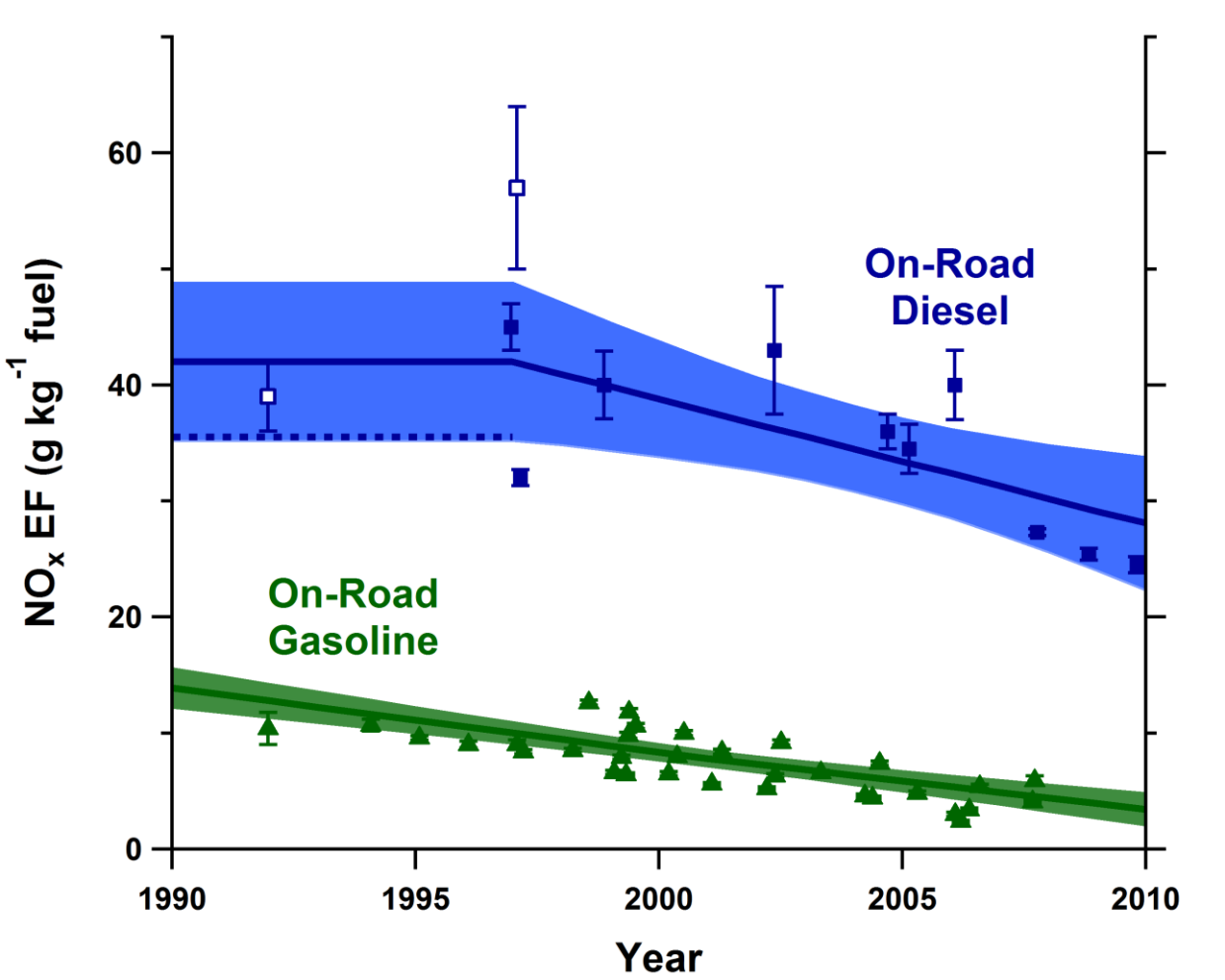
Increasing importance of off-road gasoline engines accounts for slower decrease in total anthropogenic emissions.

Similar Trends in Ambient CO



CO emissions dominated by mobile sources in LA.

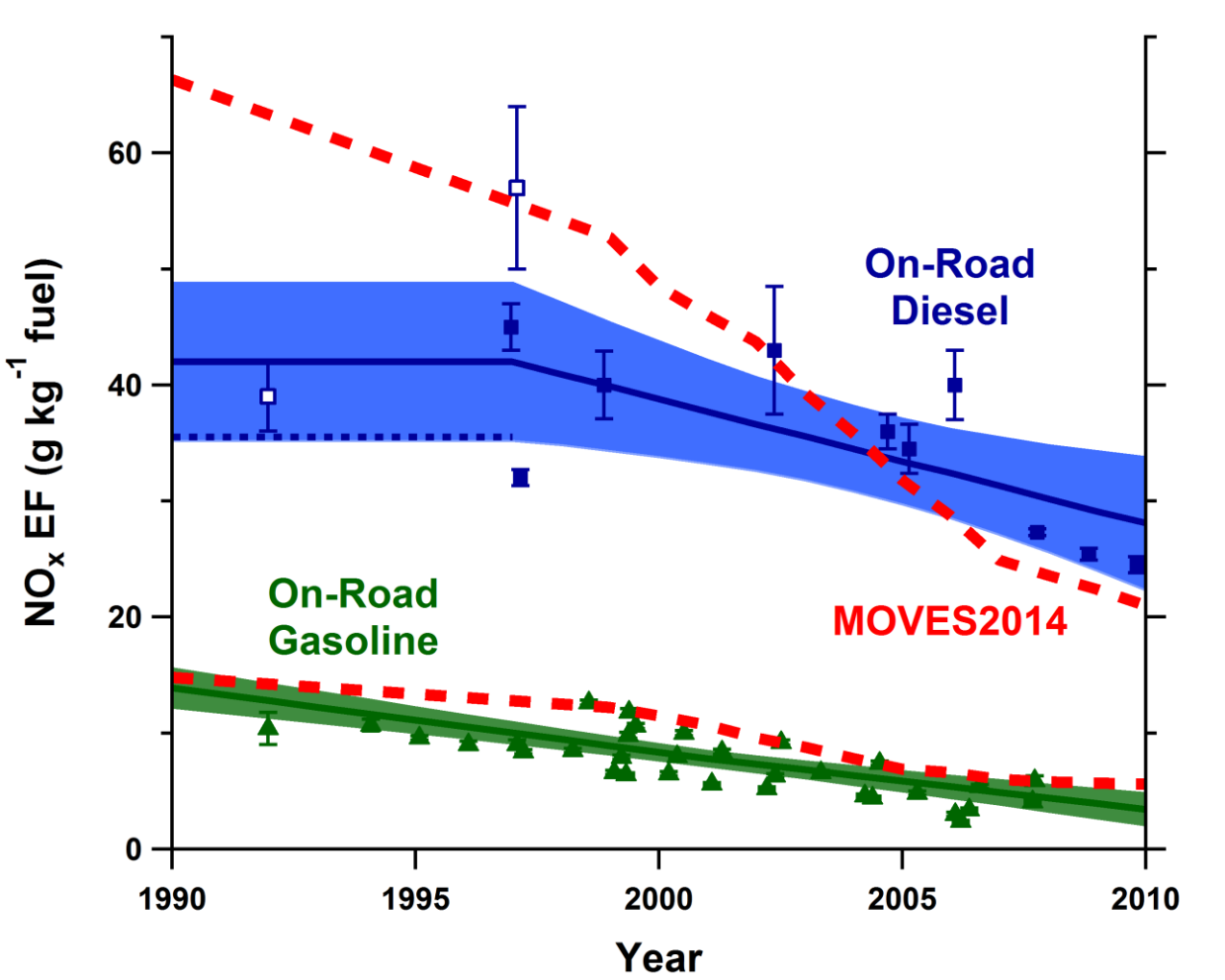
Trends in Running Exhaust NO_x Emission Factors



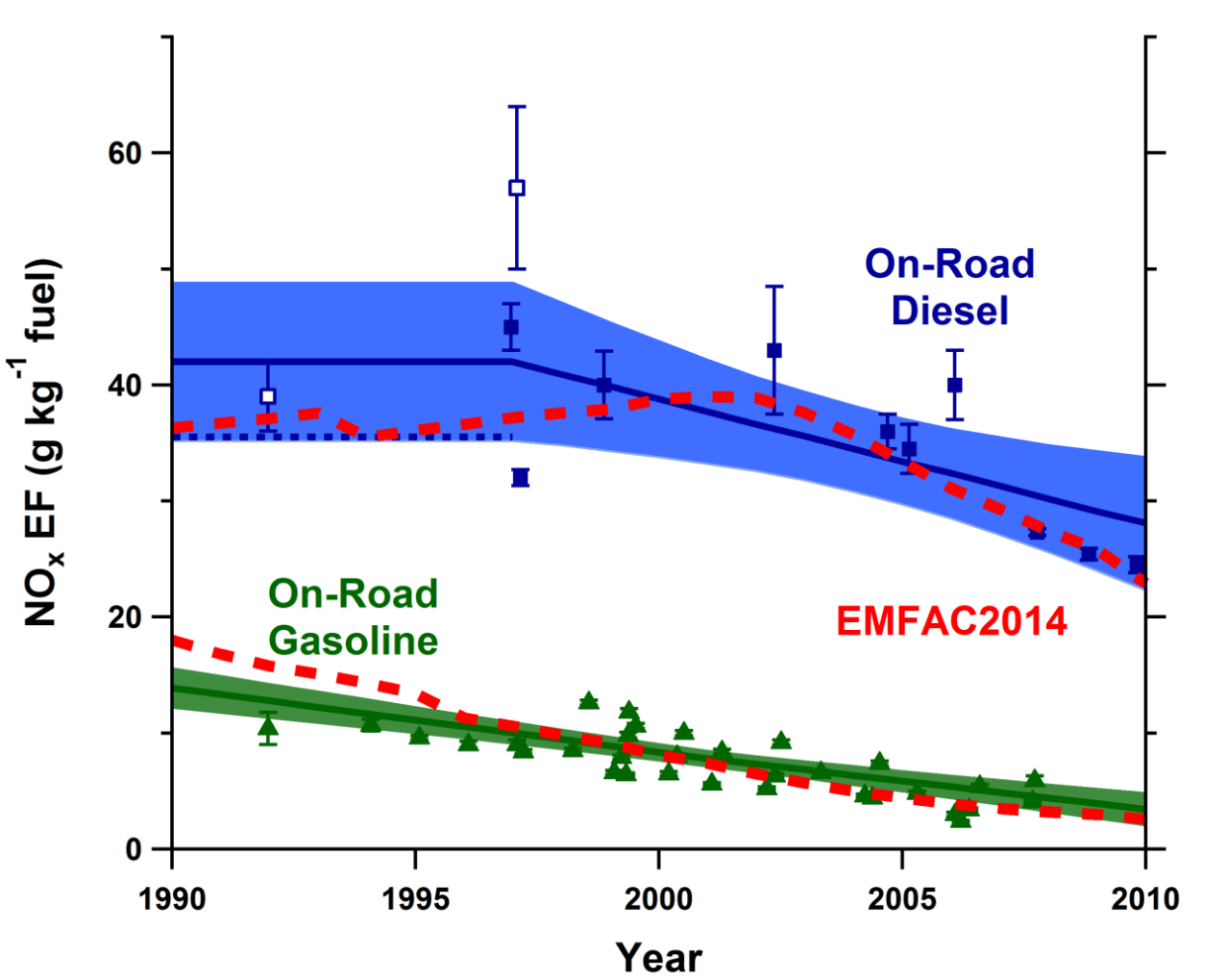
Slower decrease in diesel NO_x emission factors.

McDonald et al. (*JGR* 2012)

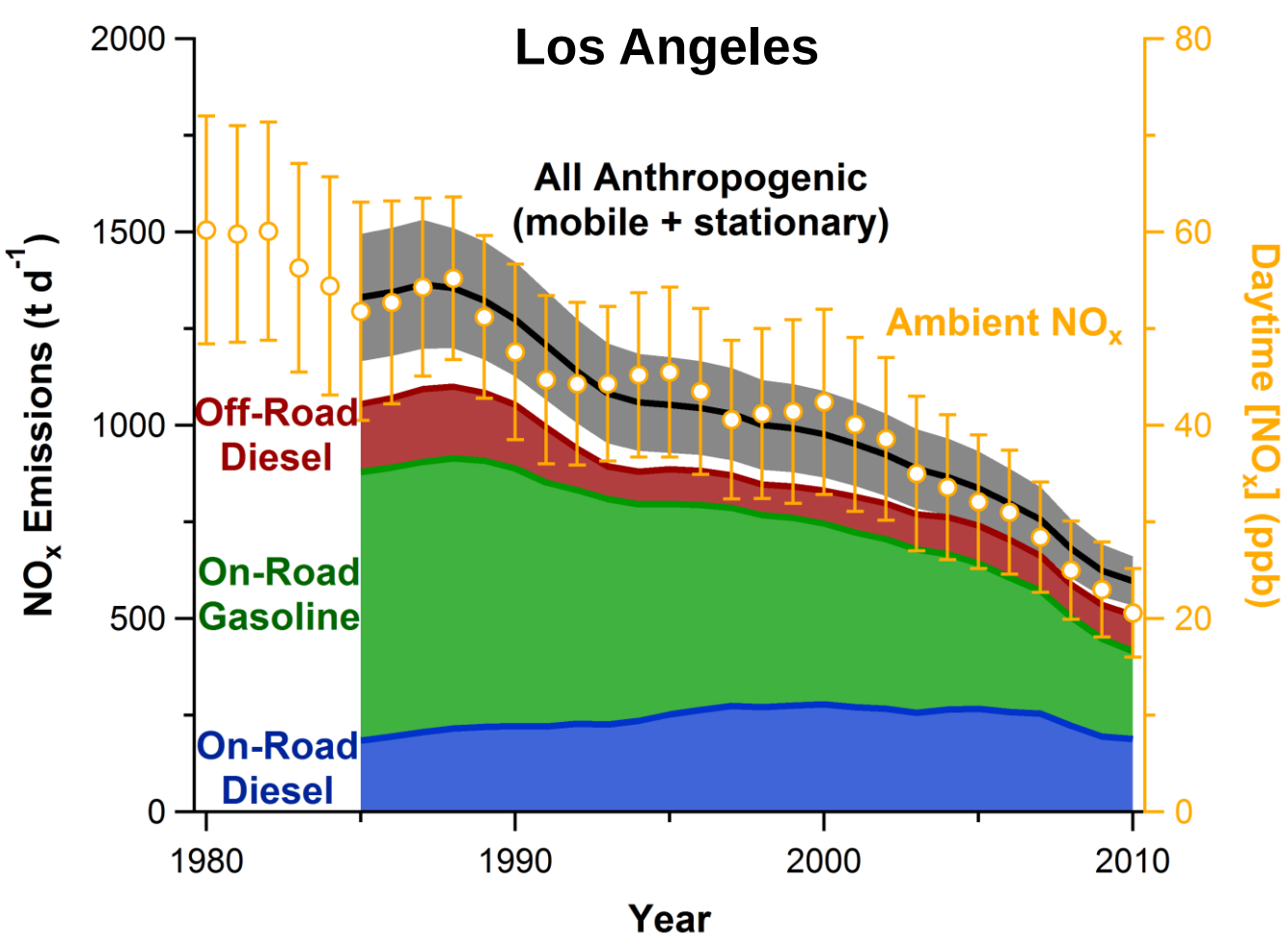
Comparison with MOVES (EPA)



Comparison with EMFAC (ARB)



Trends in NO_x Emissions with Ambient Trends

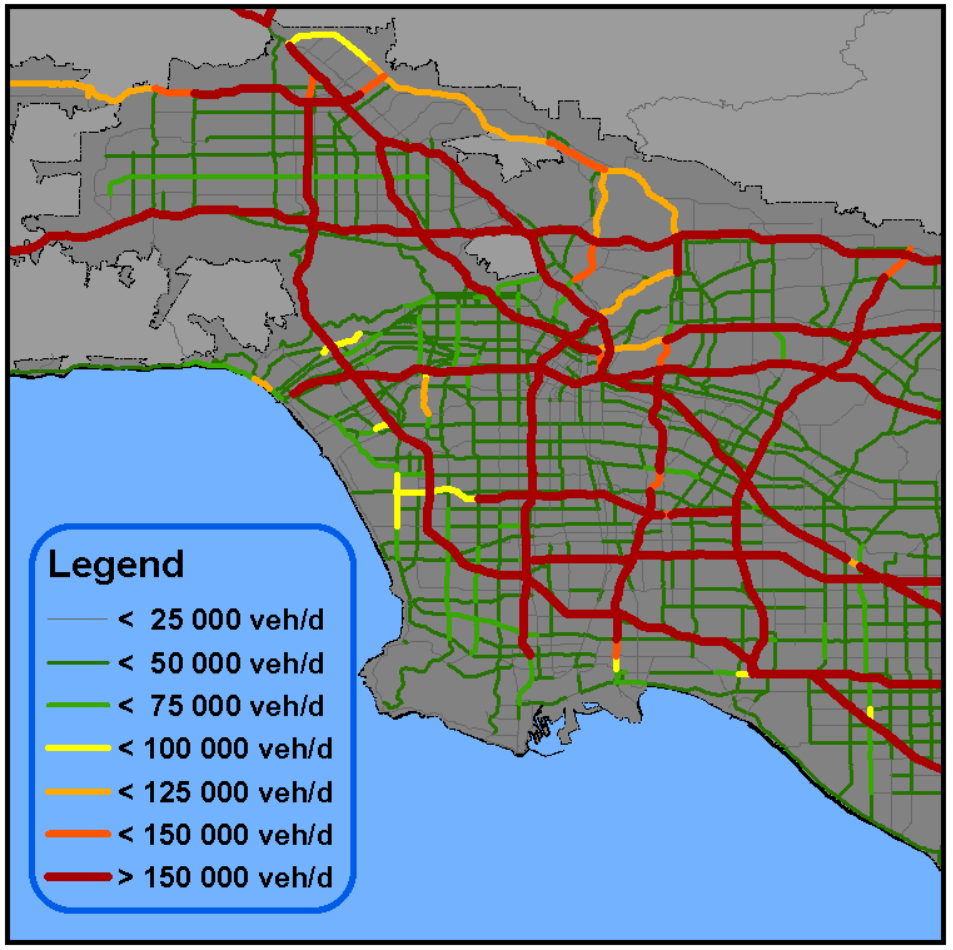


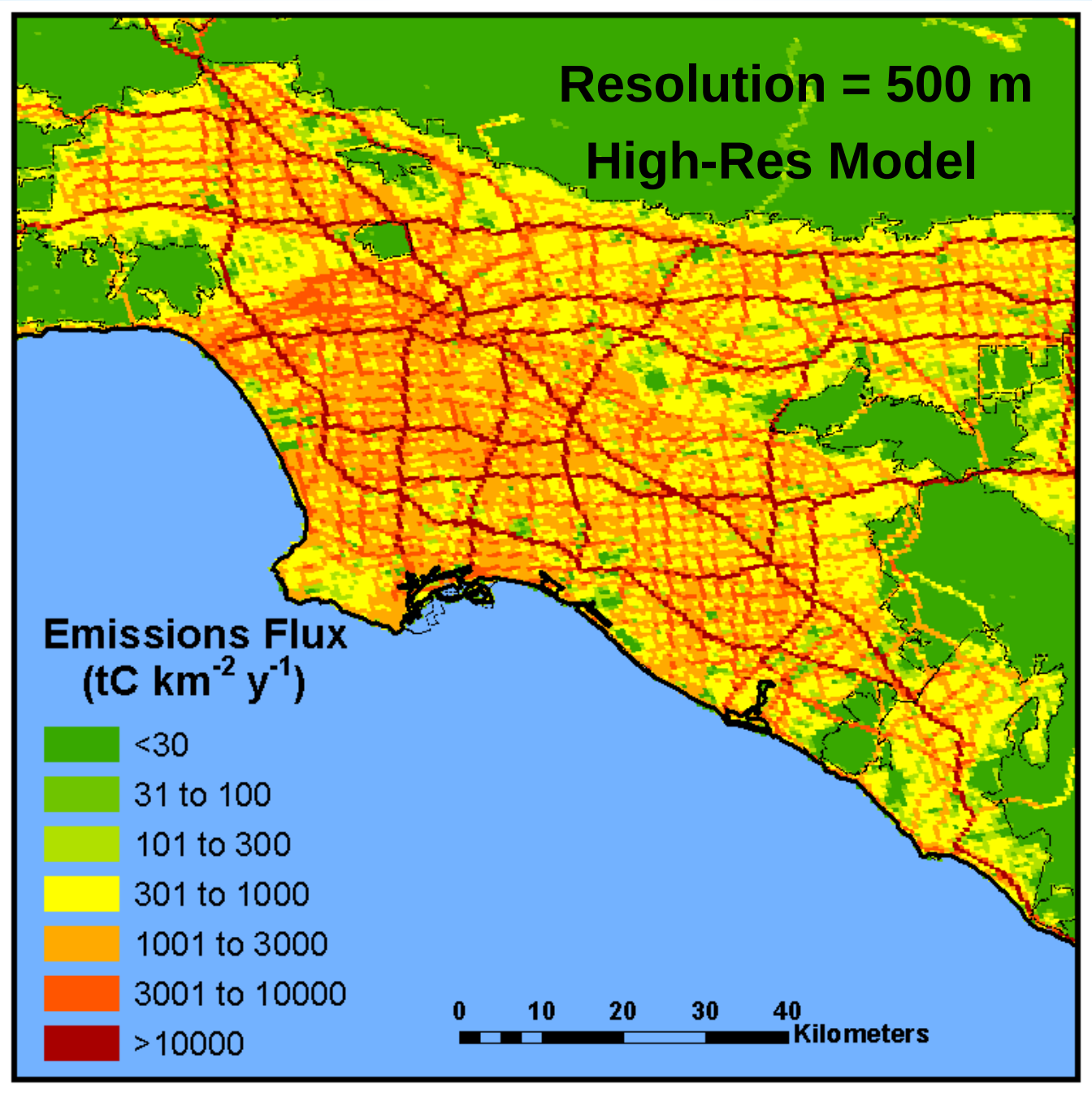
NO_x emissions dominated by mobile sources in LA.

Adapted from McDonald et al. (*JGR* 2012)

Fuel-Based Inventory of Vehicle Emissions

- **Taxable gasoline and diesel fuel sales by state**
- **Census traffic count data**
  - Explicitly resolves ~70% of national passenger and ~80% of truck traffic
- **Road density**
  - Surrogate for remaining ~30% of passenger and ~20% of truck traffic





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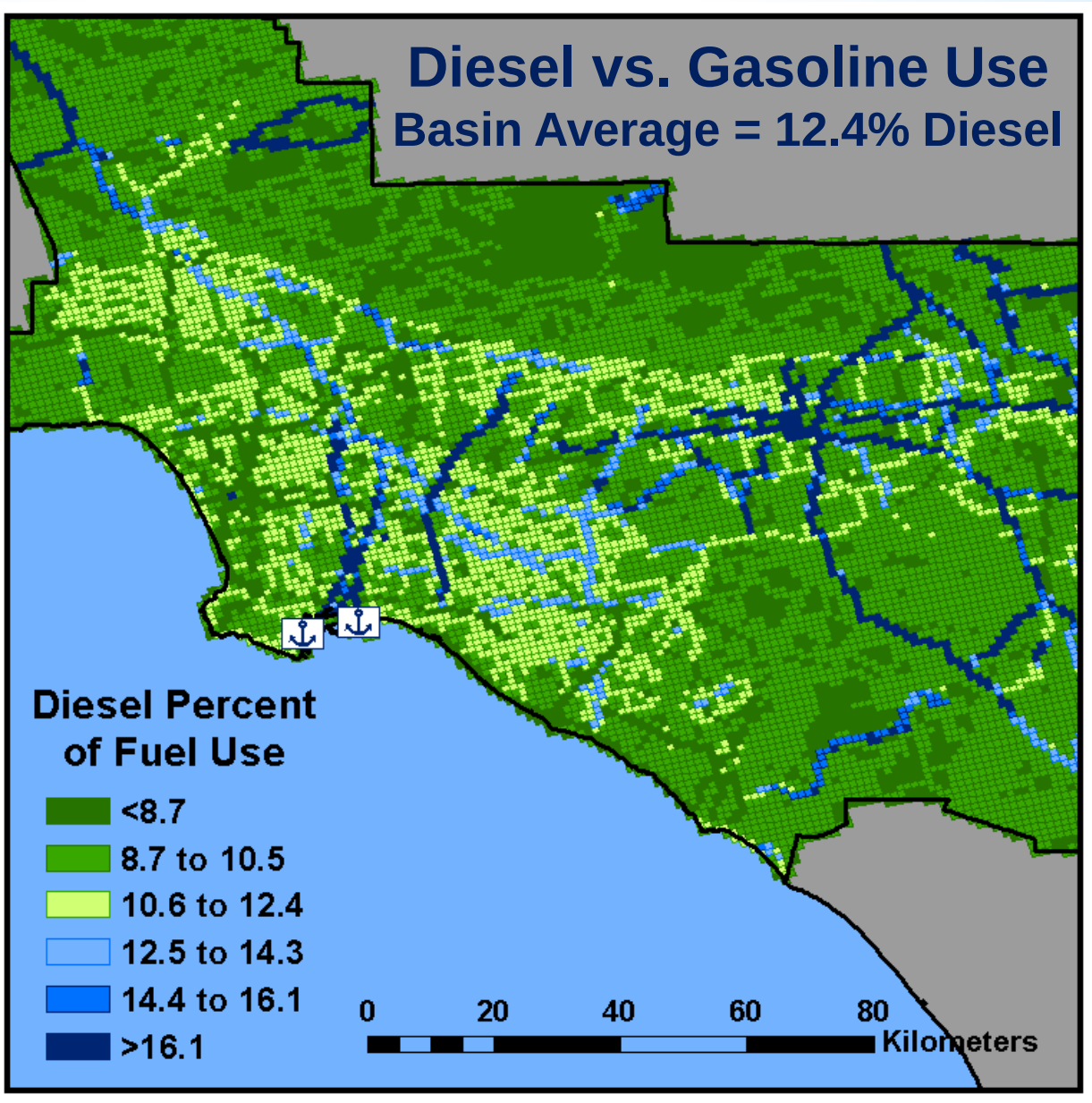


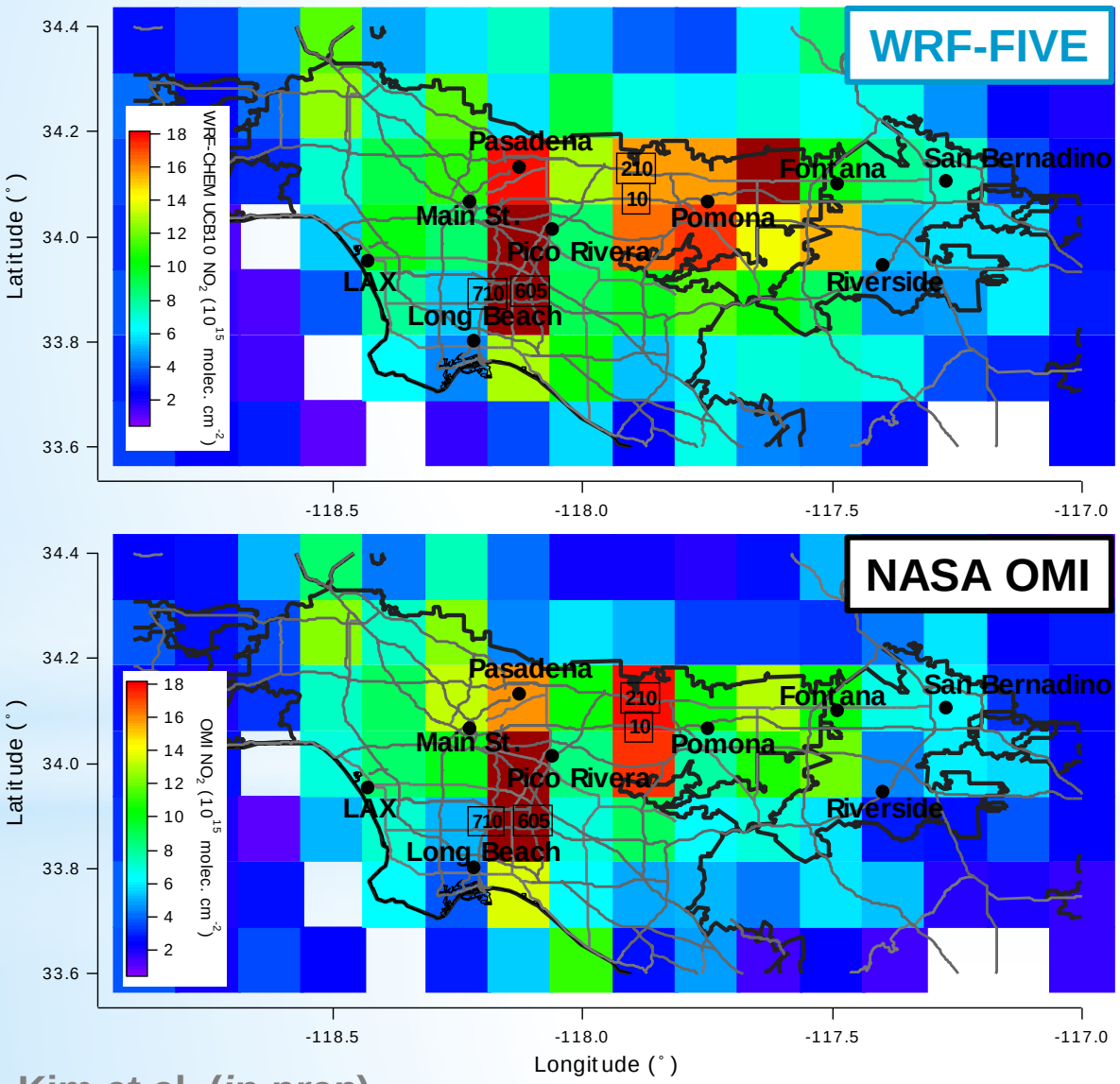
More Gasoline

More Diesel

Heavy-duty trucks and passenger vehicles exhibit different spatial patterns of activity.

Air Quality Modeling of NO_2 (CalNex 2010)

May to July 2010, Local Time 13:30



WRF-Chem simulation of fuel-based inventory

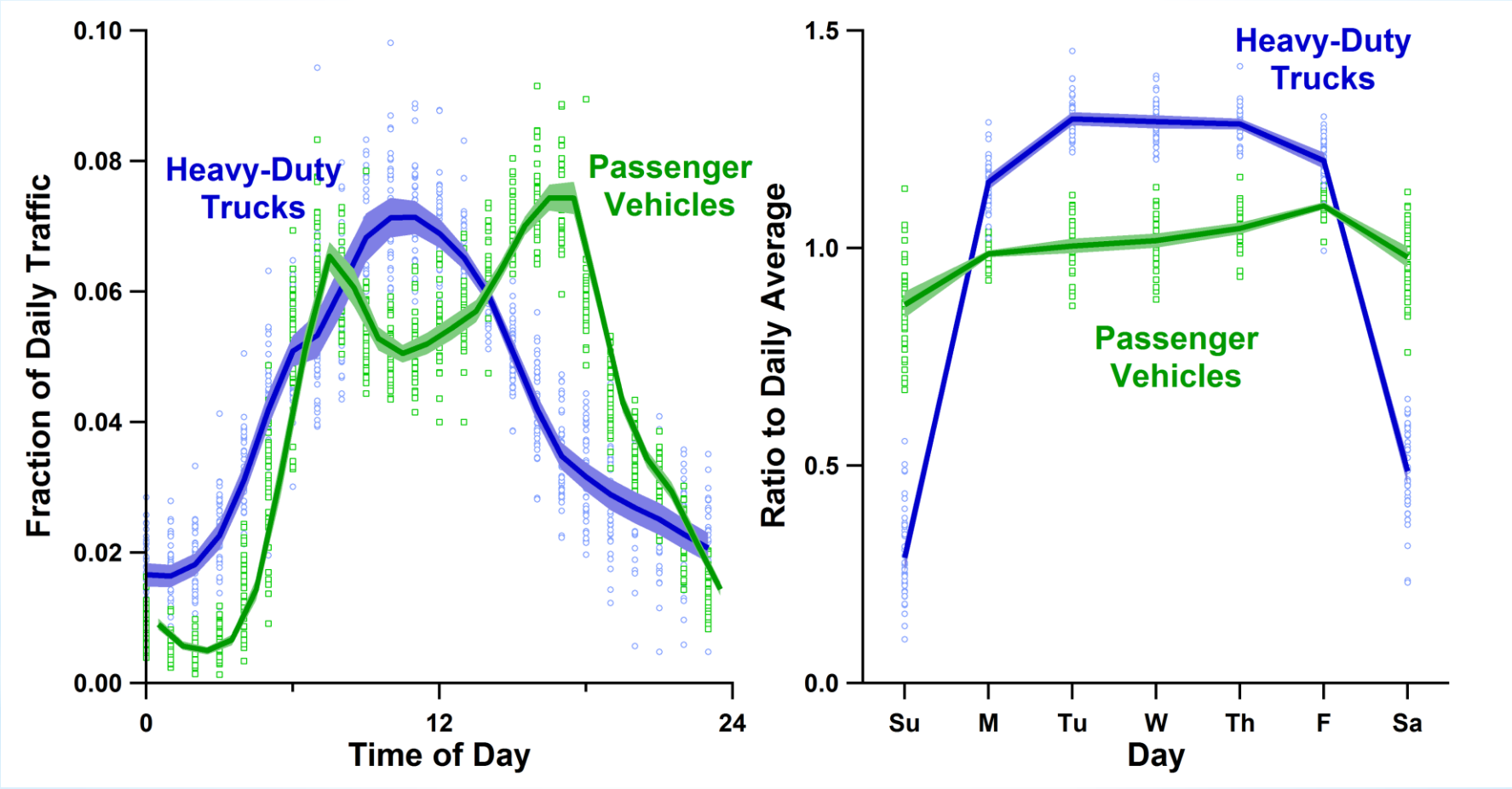
Satellite retrieval of NO_2 columns

Similarity in spatial pattern of NO_2.

Kim et al. (*in prep*)

Temporal Patterns of Vehicle Activity (Urban)

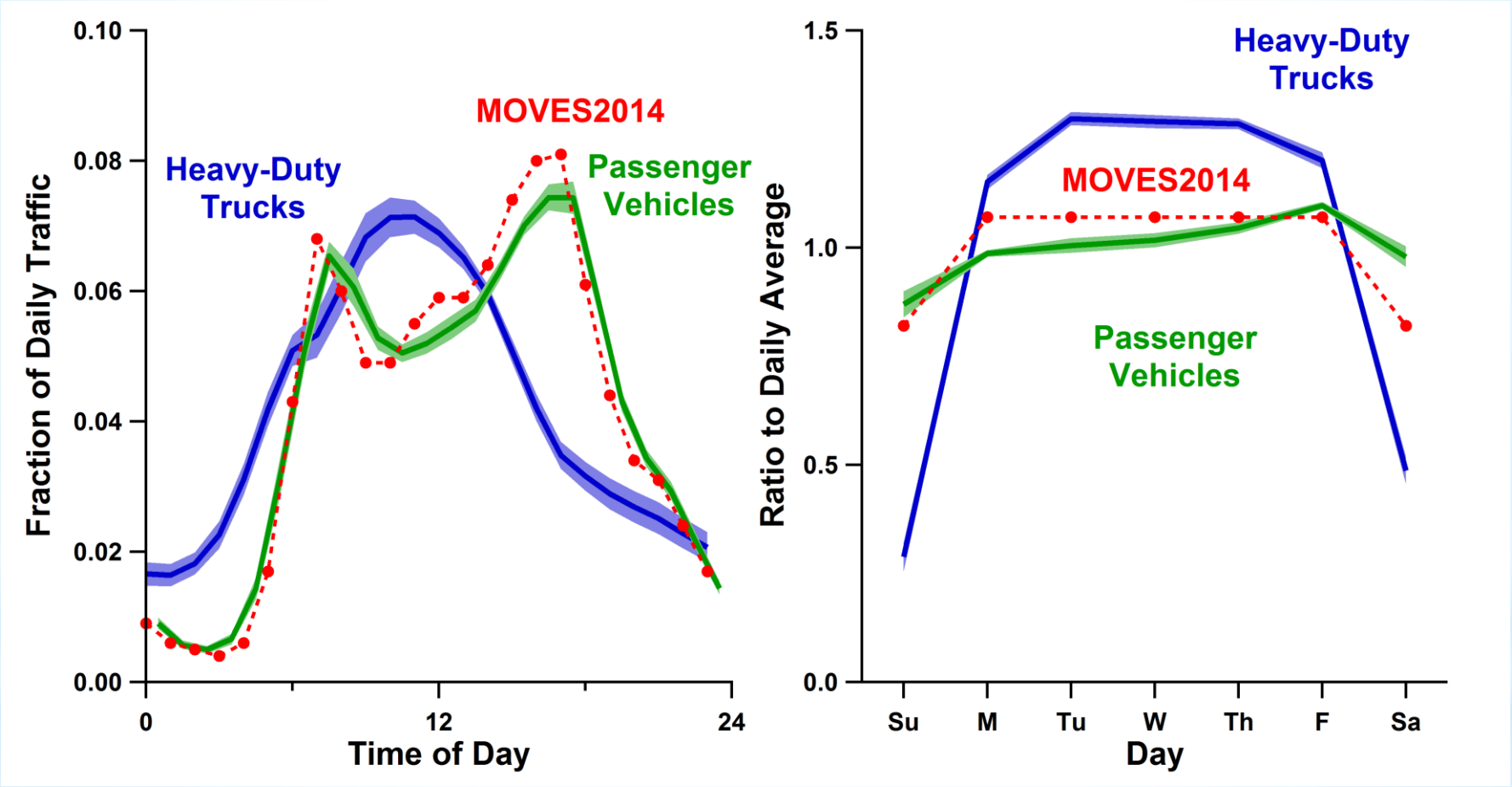
Derived from ~70 weigh-in-motion stations across CA



Heavy-duty trucks and passenger vehicles exhibit different diurnal and day-of-week patterns.

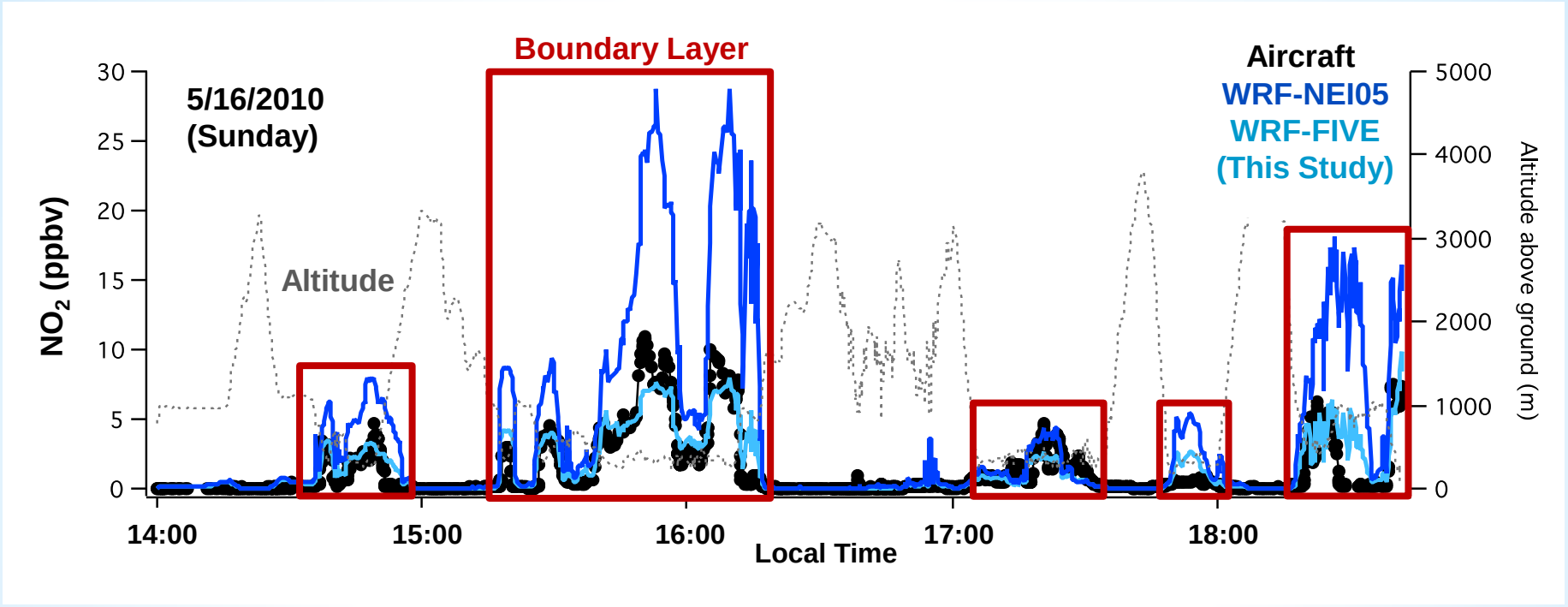
McDonald et al. (*JGR* 2014)

Temporal Patterns of Vehicle Activity (Urban)



Defaults in MOVES treat light- and heavy-duty vehicles the same.

McDonald et al. (*JGR* 2014)



Good temporal agreement between fuel-based inventory and aircraft data.

Kim et al. (*in prep*)

Summary

➢ Long-term trends of mobile source emissions

- Similarity in emissions and ambient trends suggests dominance of mobile sources for BC, NO_x, and CO in urban regions
- Growing importance of off-road engines to urban air pollution

➢ High-resolution mapping of on-road emissions

- Merged fuel sales, traffic count, and weigh-in-motion data to map motor vehicle emissions spatially and temporally
- Light- and heavy-duty vehicles have different activity patterns

➢ Air quality modeling of fuel-based inventory

- Fuel-based inventory (input to WRF-Chem) reconciled with spatial and temporal patterns of NO_2 during CalNex 2010