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

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Significant Improvement in U.S. Air Quality

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

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)
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- Emission factors obtained from roadway studies
  - IR remote sensing
  - Tunnel studies

- Other pollutants analyzed
  - NO$_x$, VOCs, BC, POA

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McDonald et al. (ES\&T 2015)
Large Off-Road Emission Factors (in g kg$^{-1}$ fuel)

As of 2010

Mobile Sources
- On-Road Gasoline
- On-Road Diesel
- Off-Road Diesel
- Off-Road Gasoline (Two-Stroke)

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

PM and VOC emission factors for off-road engines are now larger than for on-road engines.
Overall Decrease in BC Emissions

San Francisco

McDonald et al. (ES&T 2015)
Since 1970, mobile source emissions have dominated ambient BC in the SF Bay Area.

McDonald et al. (*ES&T* 2015)
Diesel trucks are an important source of BC, but not the only mobile source contributor.

McDonald et al. (ES&T 2015)
Increasing importance of off-road gasoline engines accounts for slower decrease in total anthropogenic emissions.
Similar Trends in Ambient CO

Los Angeles

All Anthropogenic (mostly mobile)

Ambient CO

On-Road Gasoline

CO emissions dominated by mobile sources in LA.
Trends in Running Exhaust NO\textsubscript{x} Emission Factors

Slower decrease in diesel NO\textsubscript{x} emission factors.

McDonald et al. (JGR 2012)
Comparison with MOVES (EPA)

![Graph showing NOx EF (g kg\(^{-1}\) fuel) over years for On-Road Diesel, On-Road Gasoline, and MOVES2014.]
Comparison with EMFAC (ARB)
Trends in NO$_x$ Emissions with Ambient Trends

Los Angeles

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
Resolution = 500 m
High-Res Model

Emissions Flux
(tC km^{-2} y^{-1})

- <30
- 31 to 100
- 101 to 300
- 301 to 1000
- 1001 to 3000
- 3001 to 10000
- >10000

McDonald et al. (JGR 2014)
Heavy-duty trucks and passenger vehicles exhibit different spatial patterns of activity.
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)
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.

CalNex 2010 Field Campaign in Los Angeles
NOAA WP-3D (May-June 2010)
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