Assessing Current Gaps in Transportation Emissions and Modeling their Effects on Air Quality

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Recent Studies Suggest Overestimate in U.S. NO_x Emissions

- **DISCOVER-AQ (2011):** Mobile source NO_x high by **51-70%** in the National Emissions Inventory (NEI) 2011 (Anderson et al., *Atmos. Env. 2014*)
- **UBWOS (2012-13):** Oil & gas NO_x in the Uintah Basin, UT high by factor of **~4x** in the NEI (Ahmadov et al., *Atmos. Chem. Phys. 2015*)
- **SEAC^{4}RS (2013):** Industrial and mobile source NO_x high in the NEI, **30-60%** reductions needed (Travis et al., *Atmos. Chem. Phys. 2016*)

Mobile Sources

Industry

Oil & Gas Development

Research Objectives

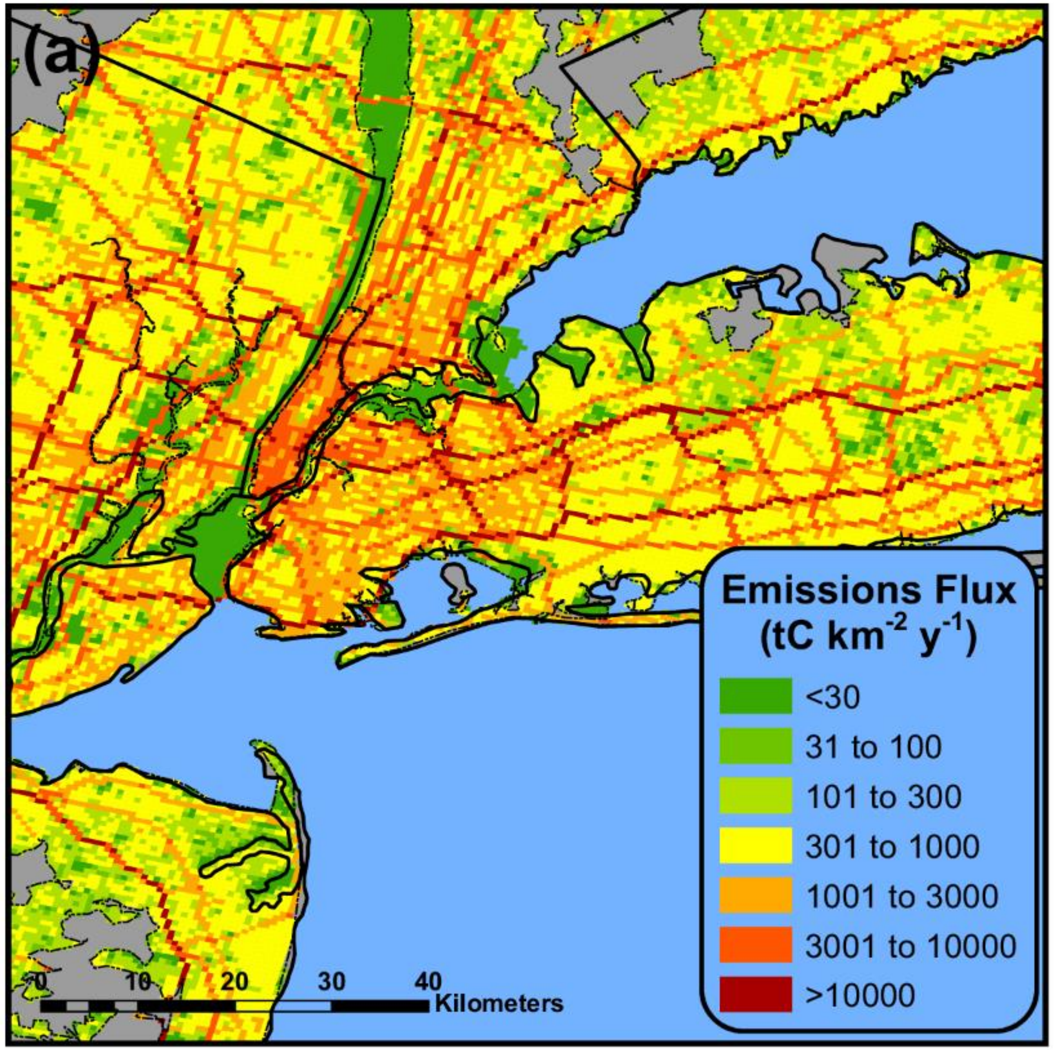
(1) **Evaluate transportation NO_x emissions**
- Construct fuel-based inventory and compare with EPA MOVES model

(2) **Test sensitivity of ground-level O_3 to transportation NO_x in AQ model**

(3) **Assess importance of transportation as source of urban VOCs**

Fuel-Based Inventory of Vehicle Emissions (FIVE)

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



State-level taxable gasoline and diesel fuel sales reports

- Public and annual

Map on-road CO_2 emissions

- Using traffic count data
- Basis for scaling co-emitted combustion byproducts

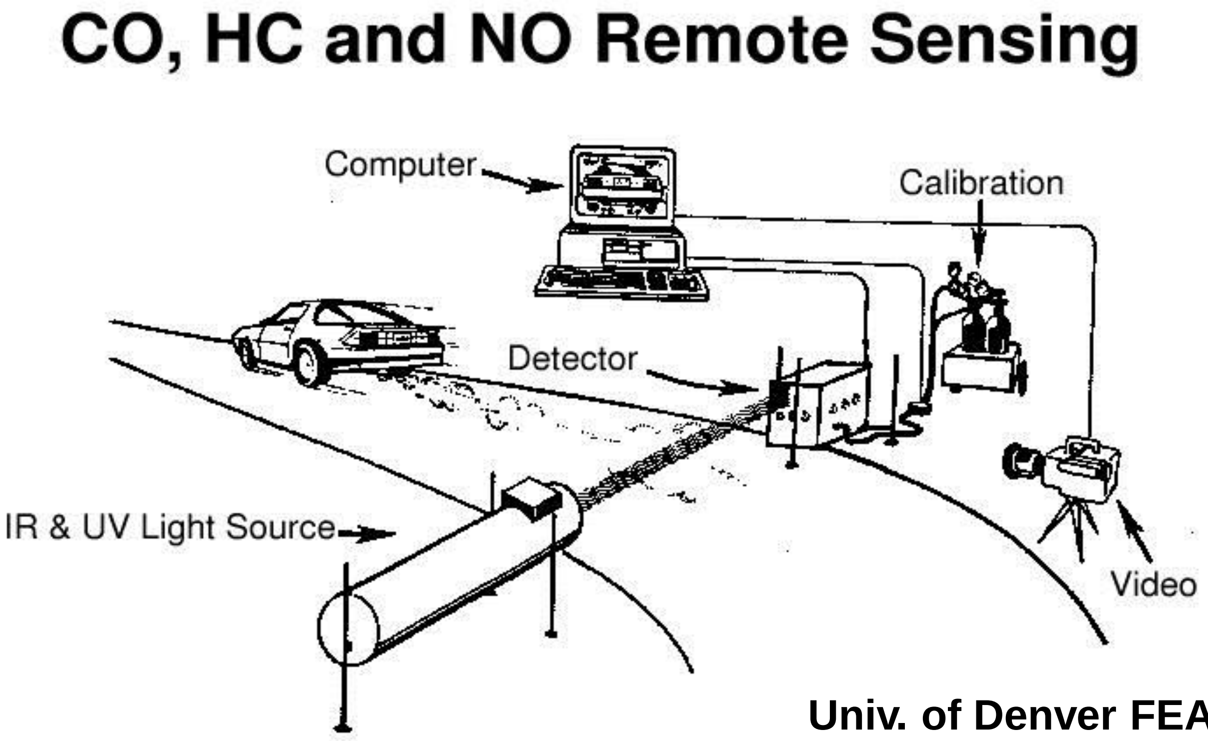
McDonald et al. (*J. Geophys. Res.* 2014)

Use of Roadway Studies for Emission Factors

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

Roadside monitoring data

- Measures in-use vehicles
- Captures high-emitters
- Regulatory models typically rely on chassis dynamometer tests



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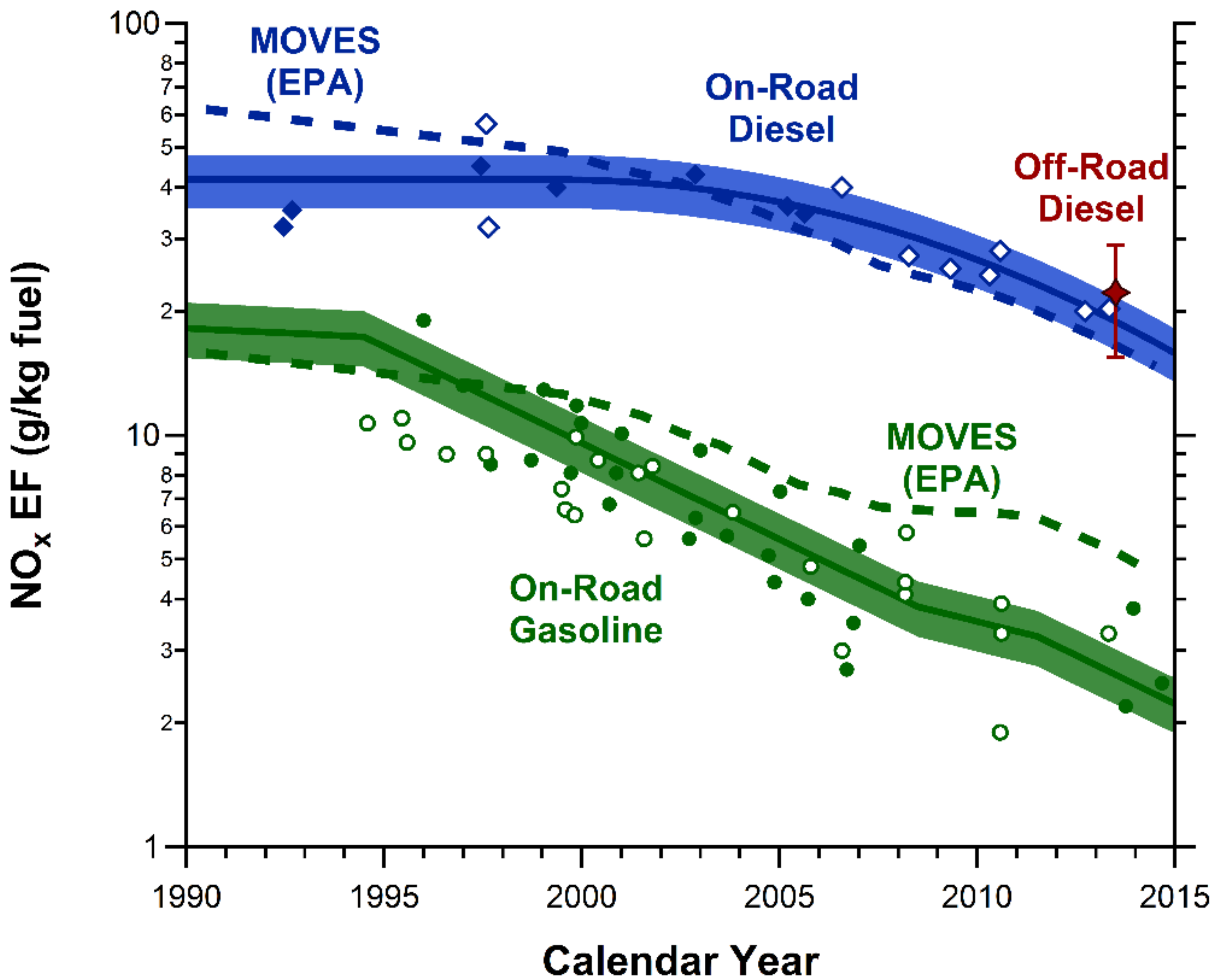
Long-Term Trends in On-Road NO_x Emission Factors

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

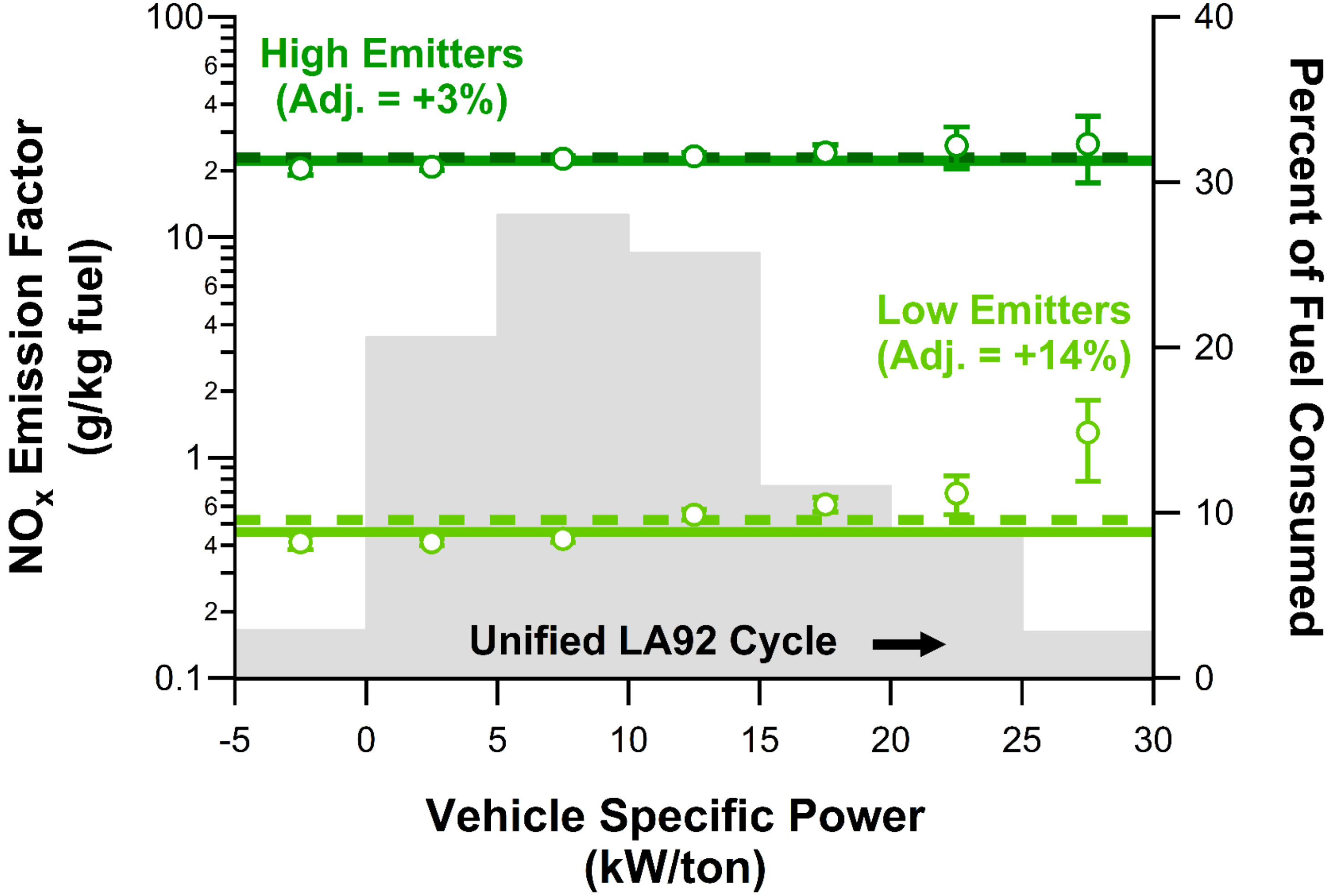


Diesel EF within ~20%

Gasoline EF high by factor of ~2

(MOVES EF are default values)

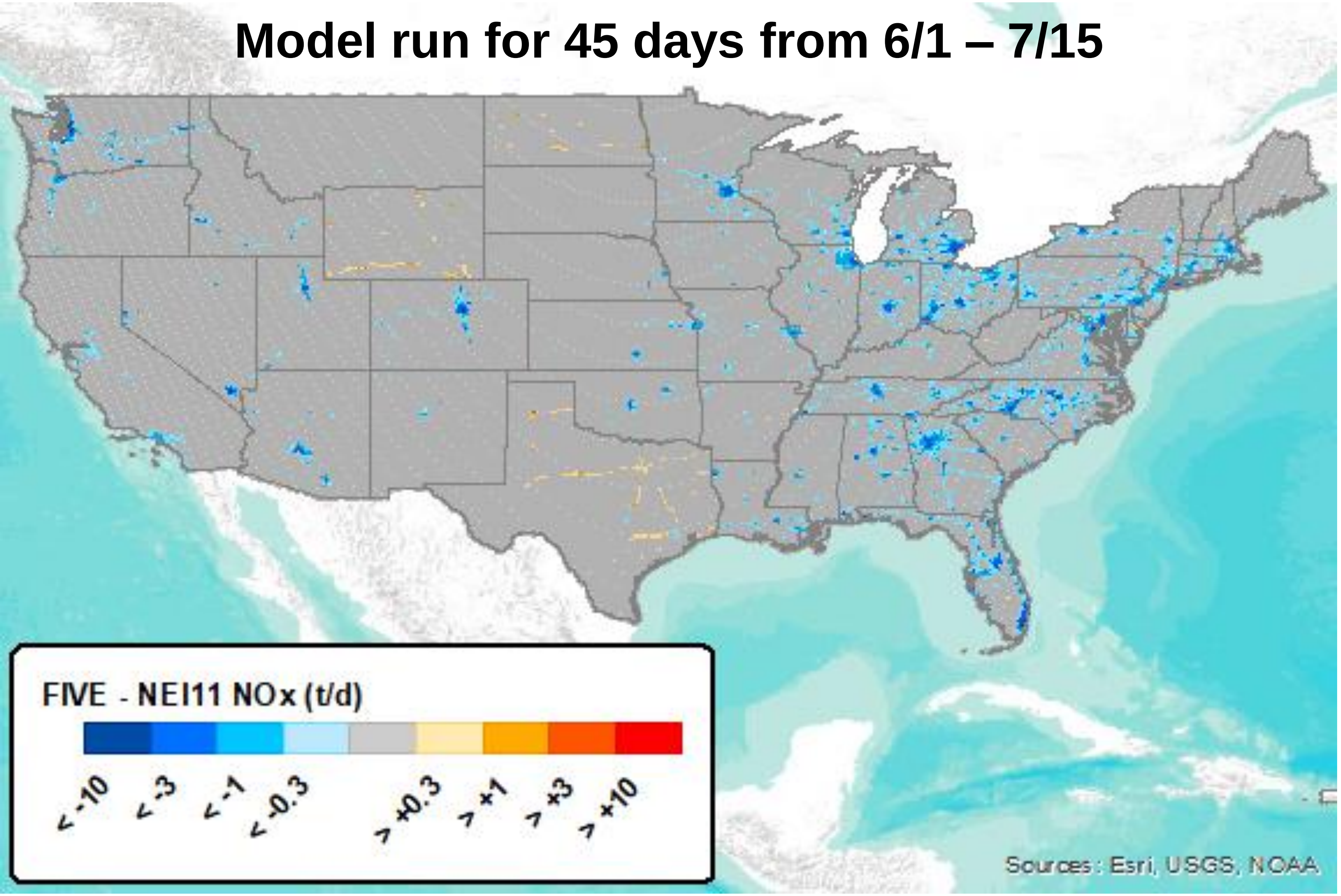
Drive Cycle Effects on On-Road NO_x Emission Factors



~10% of vehicle fleet accounts for ~85% of tailpipe emissions

Fuel-based emission factors less sensitive to effects of drive cycle

Atmospheric Modeling During Southeast Nexus (SENEX) Study in 2013



WRF-Chem Model v3.7

- 12 km x 12 km
- 61 vertical layers
- ECMWF-Era-Interim
- RACM Chemistry
- Static Chemical B.C.

Emission Cases:

(i) High NO_x, Low BVOC
(ii) High NO_x, High BVOC
(iii) Low NO_x, Low BVOC
(iv) Low NO_x, High BVOC

Δ = -15% +2x

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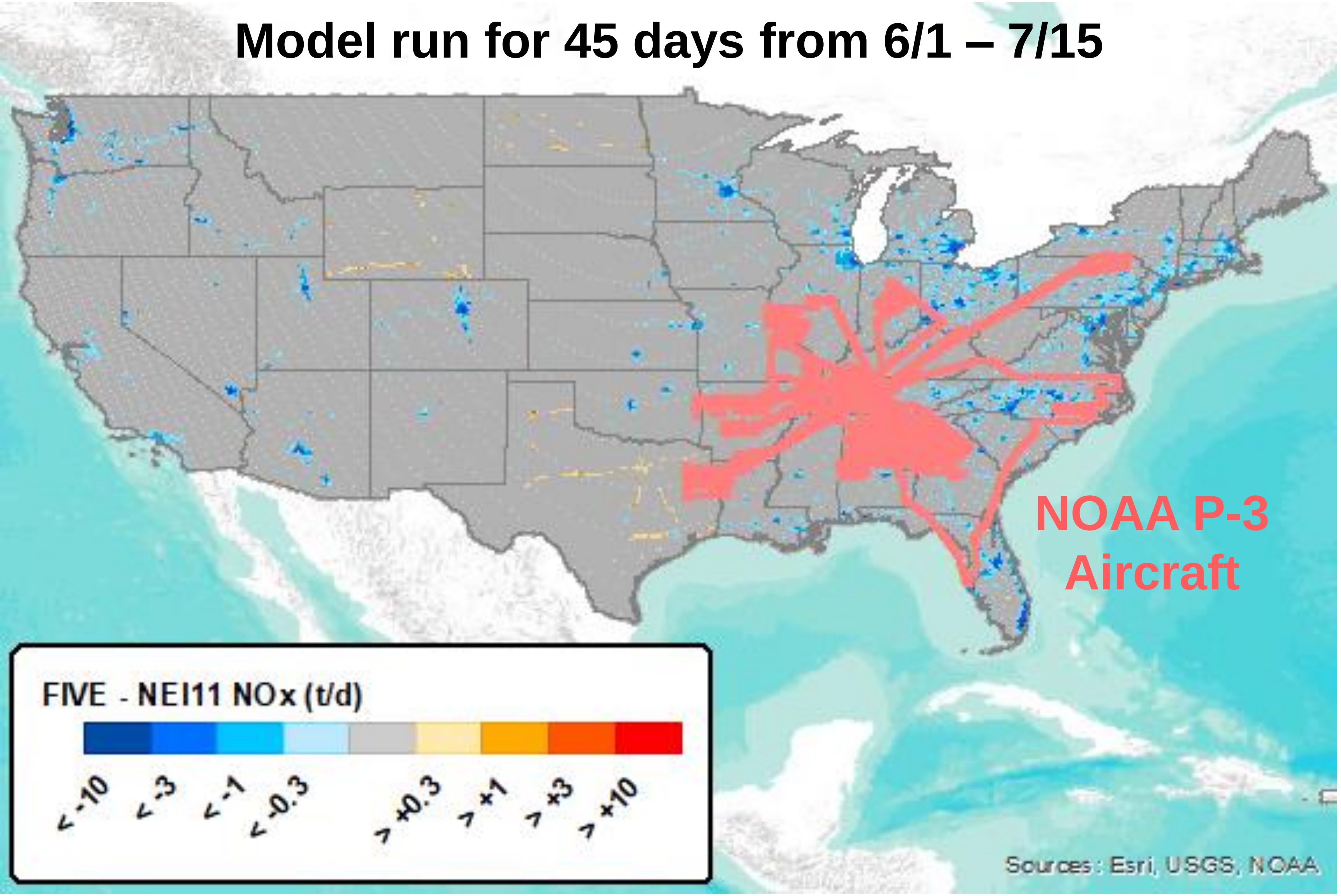

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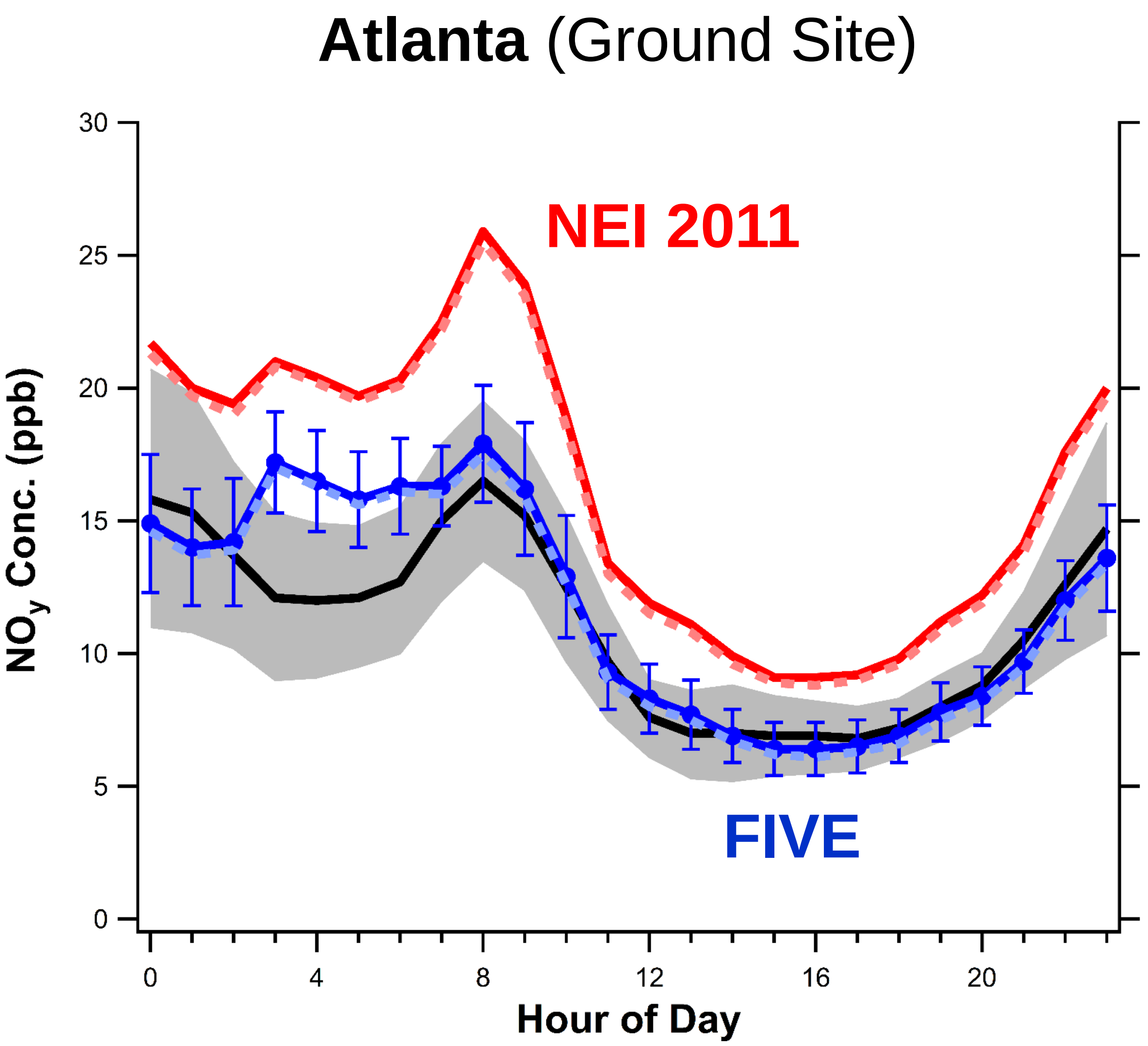
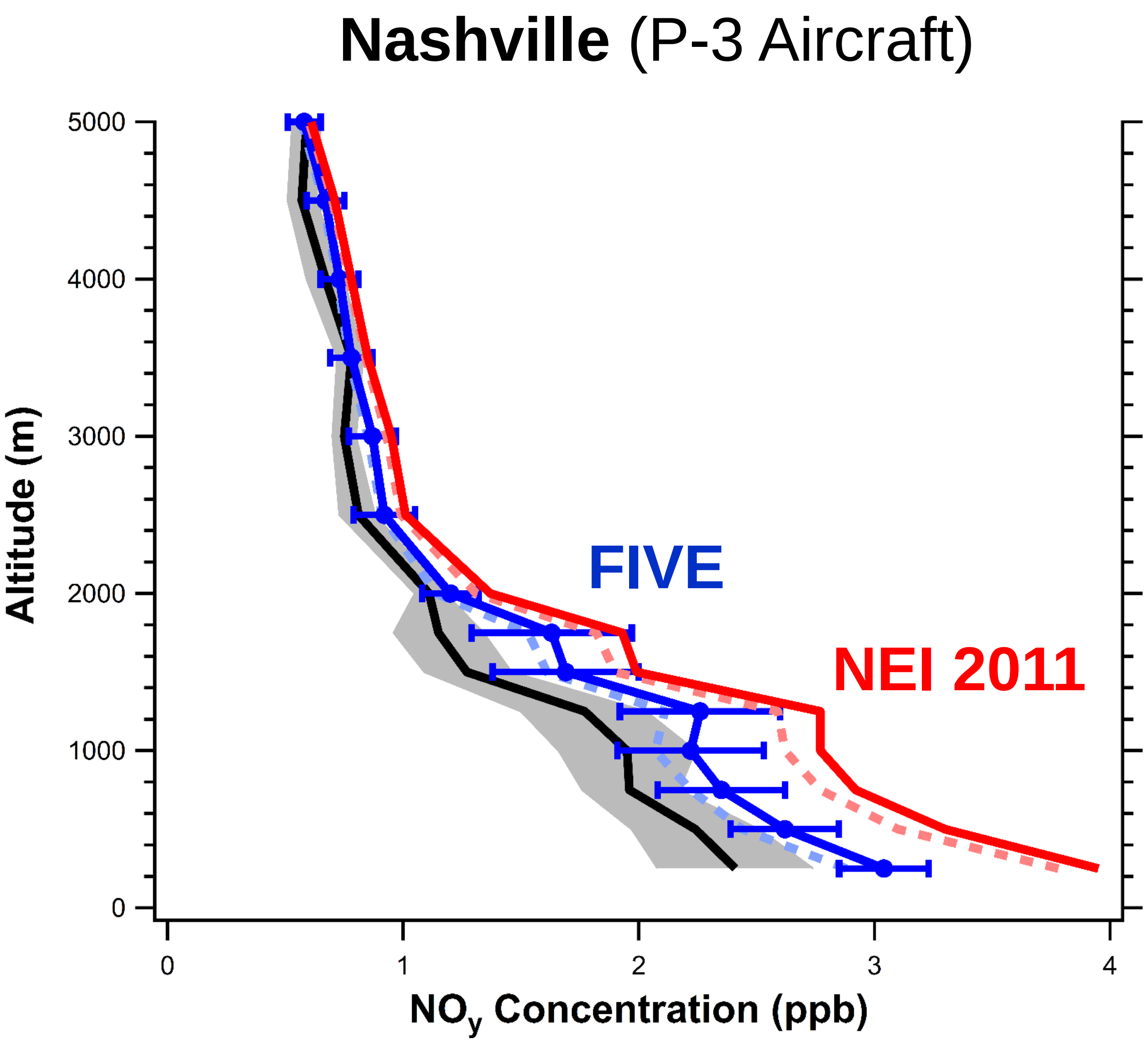
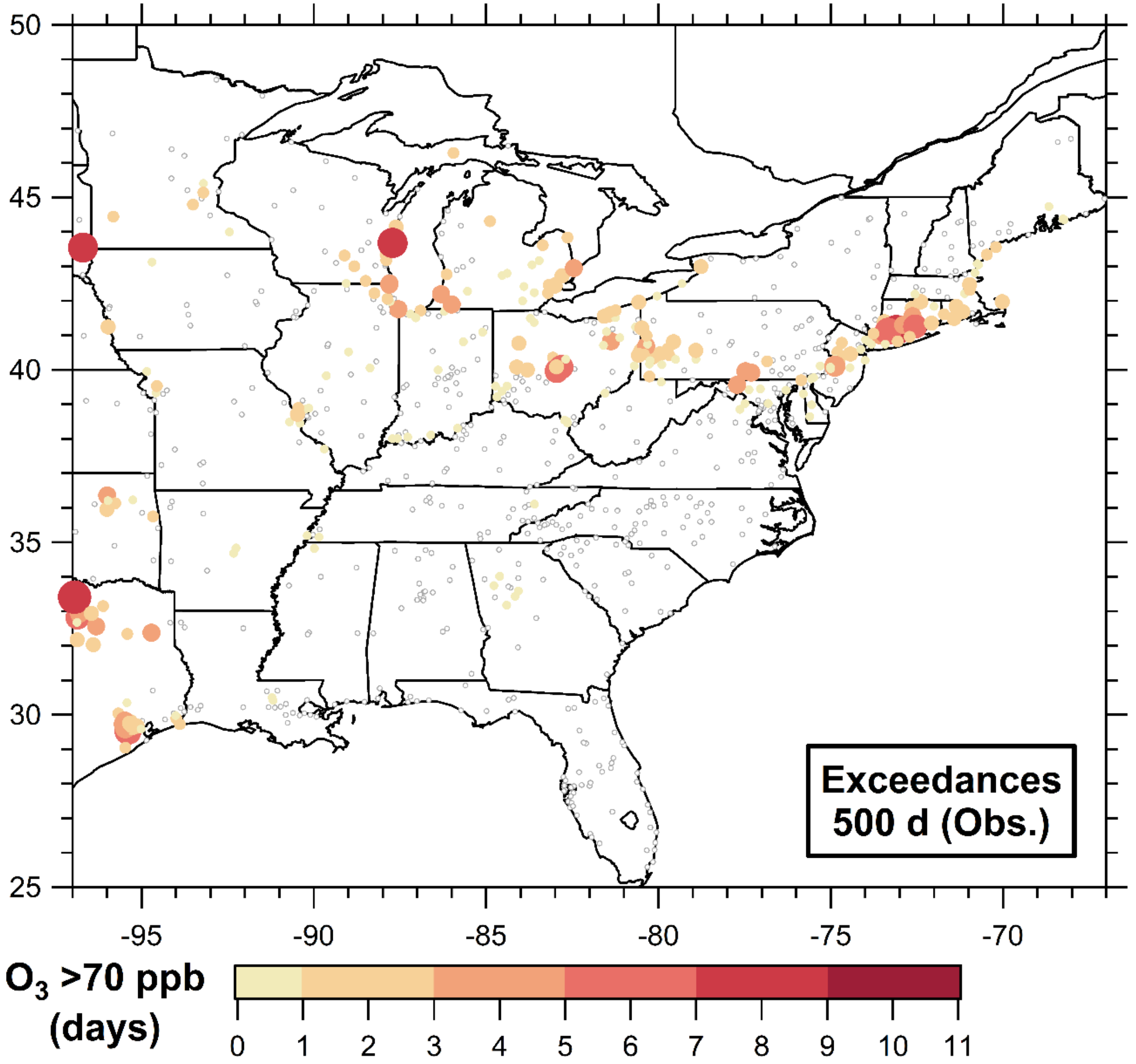
Model Evaluation of NO_x Emissions in Urban Plumes



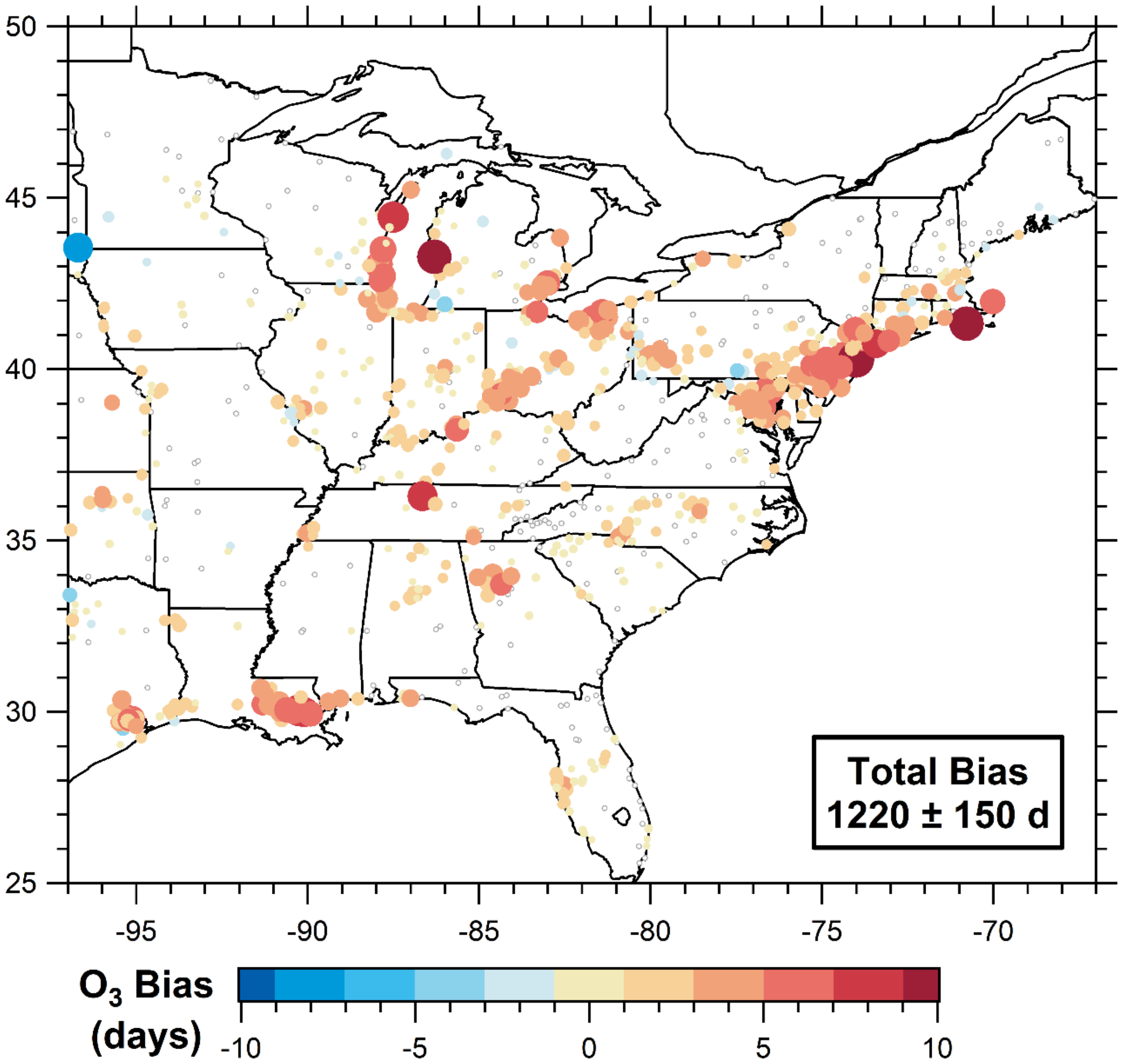


Strong agreement between fuel-based inventory and observations

Ozone Exceedance Days Sensitive to Mobile Source NO_x Emissions



Observations (~45 d in summer 2013)



Model Bias (NEI 2011)

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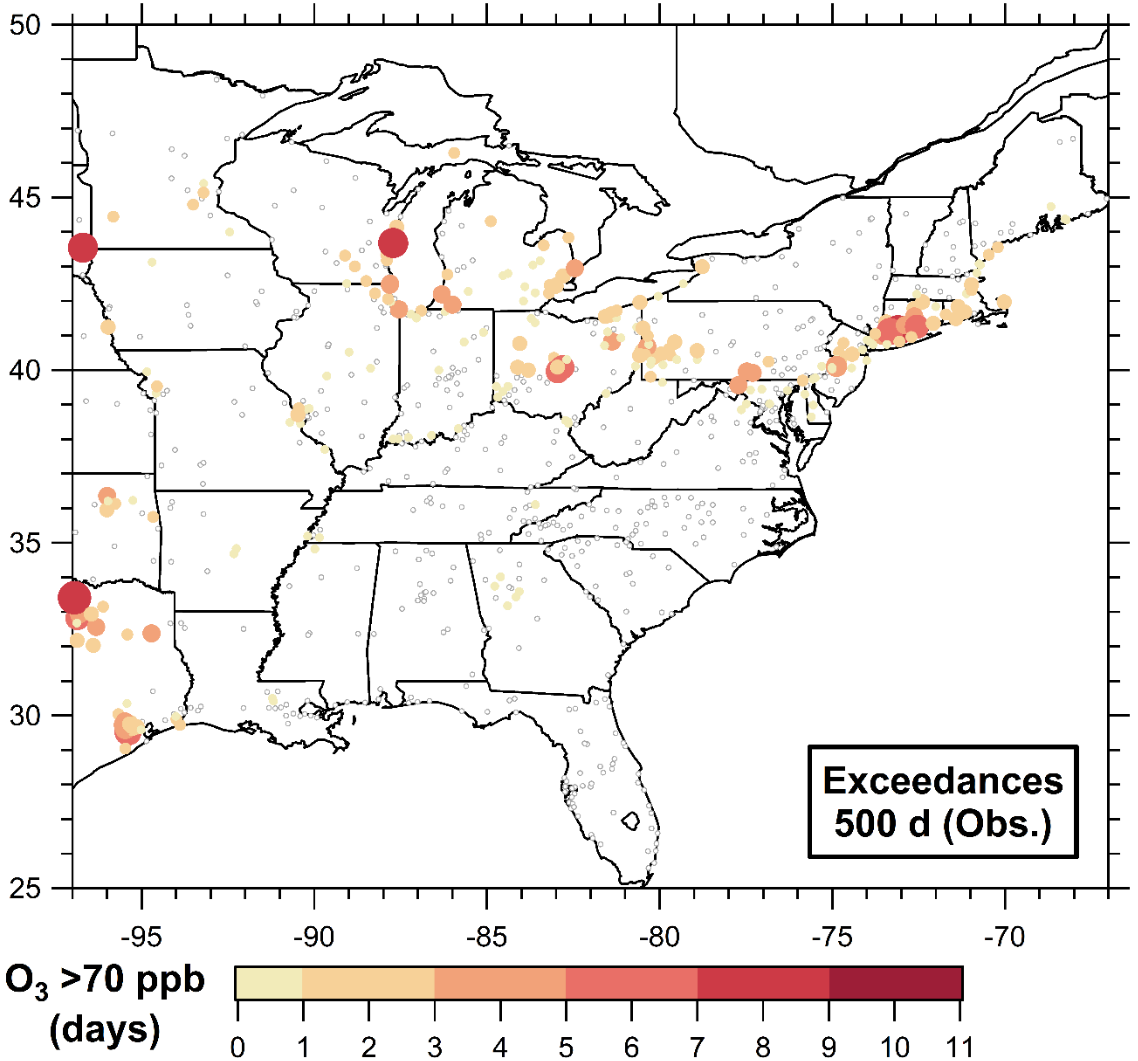

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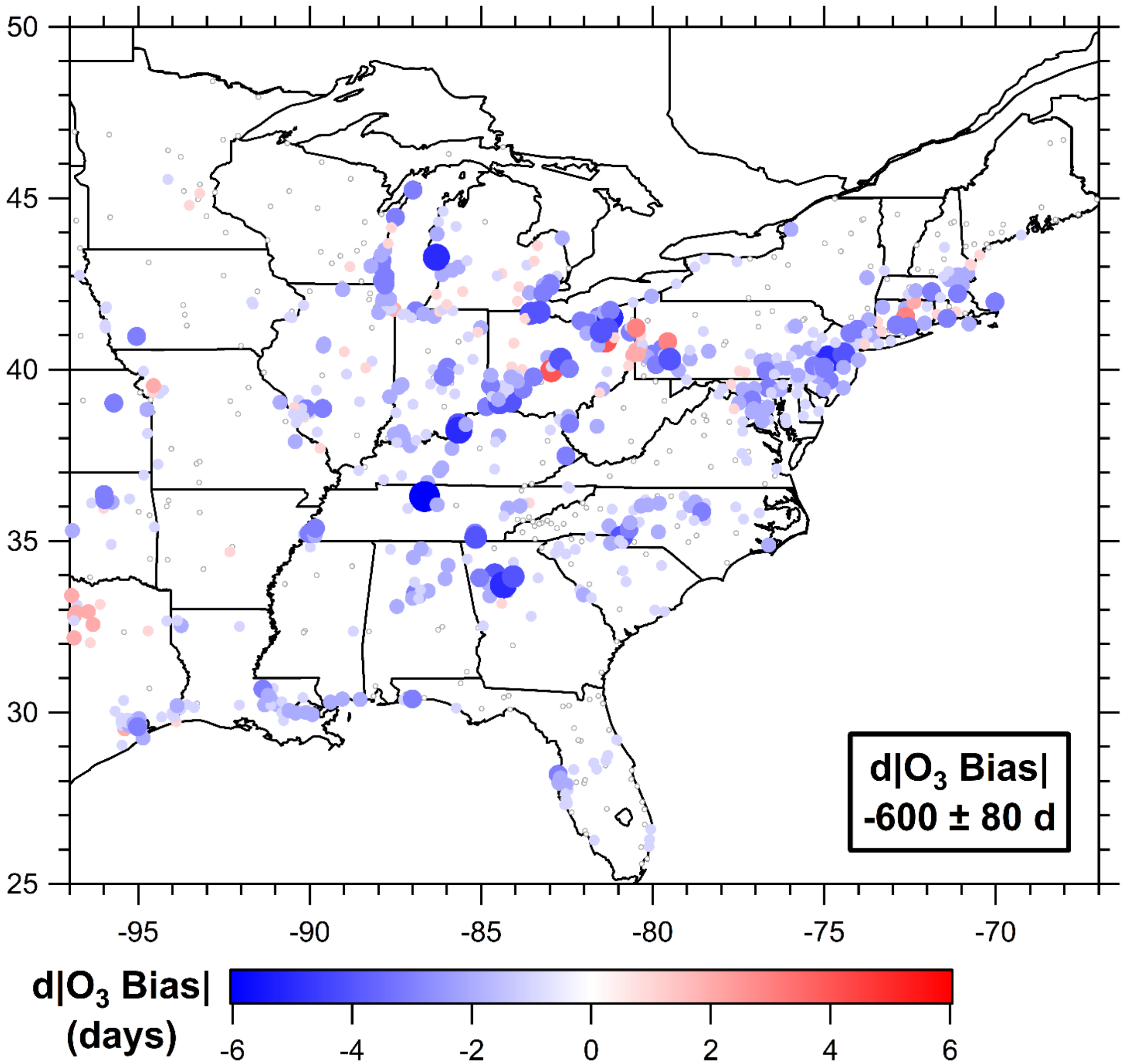


← FIVE is better **FIVE is worse→**

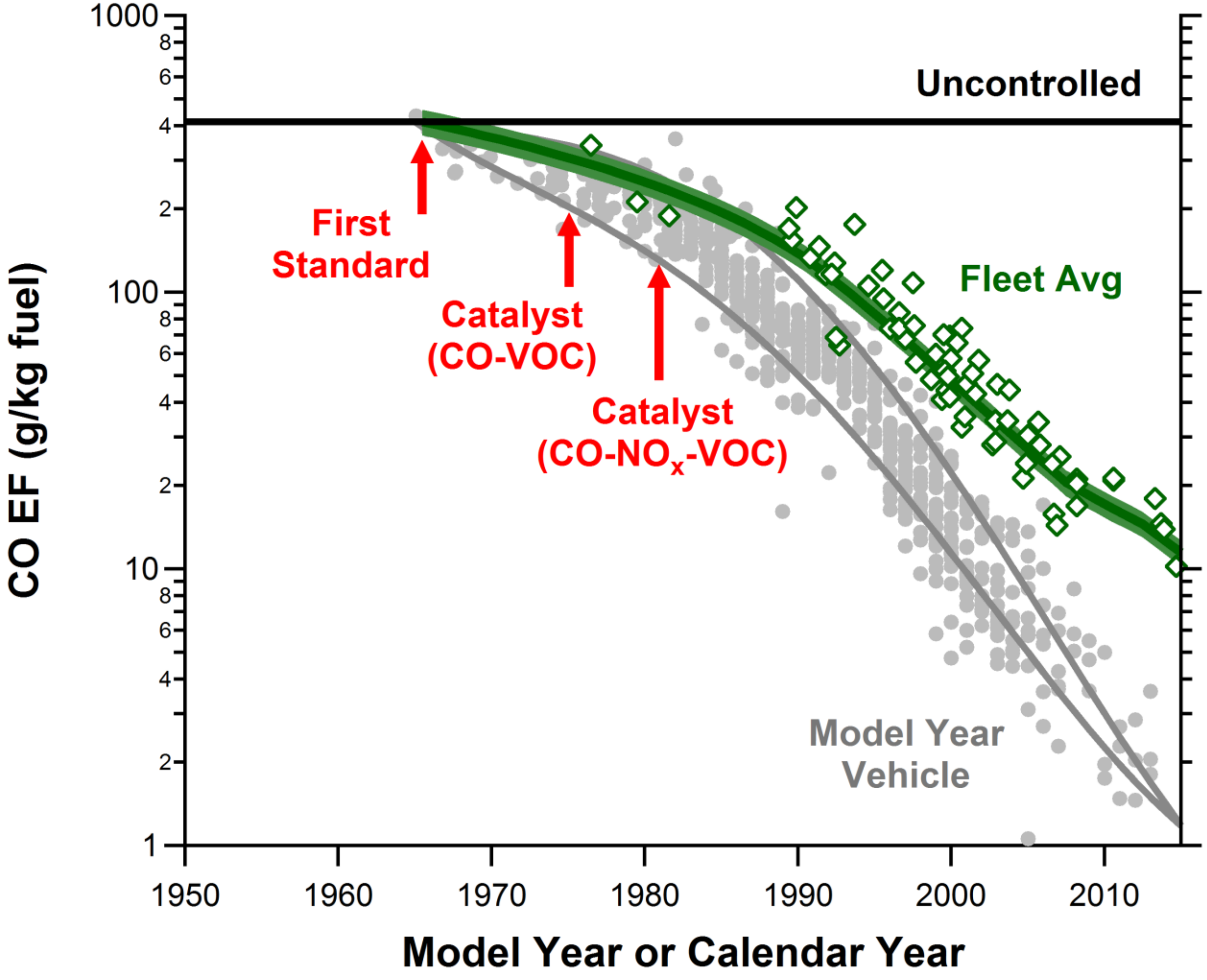
Sensitivity of Model to NO_x and Biogenic VOC Emissions

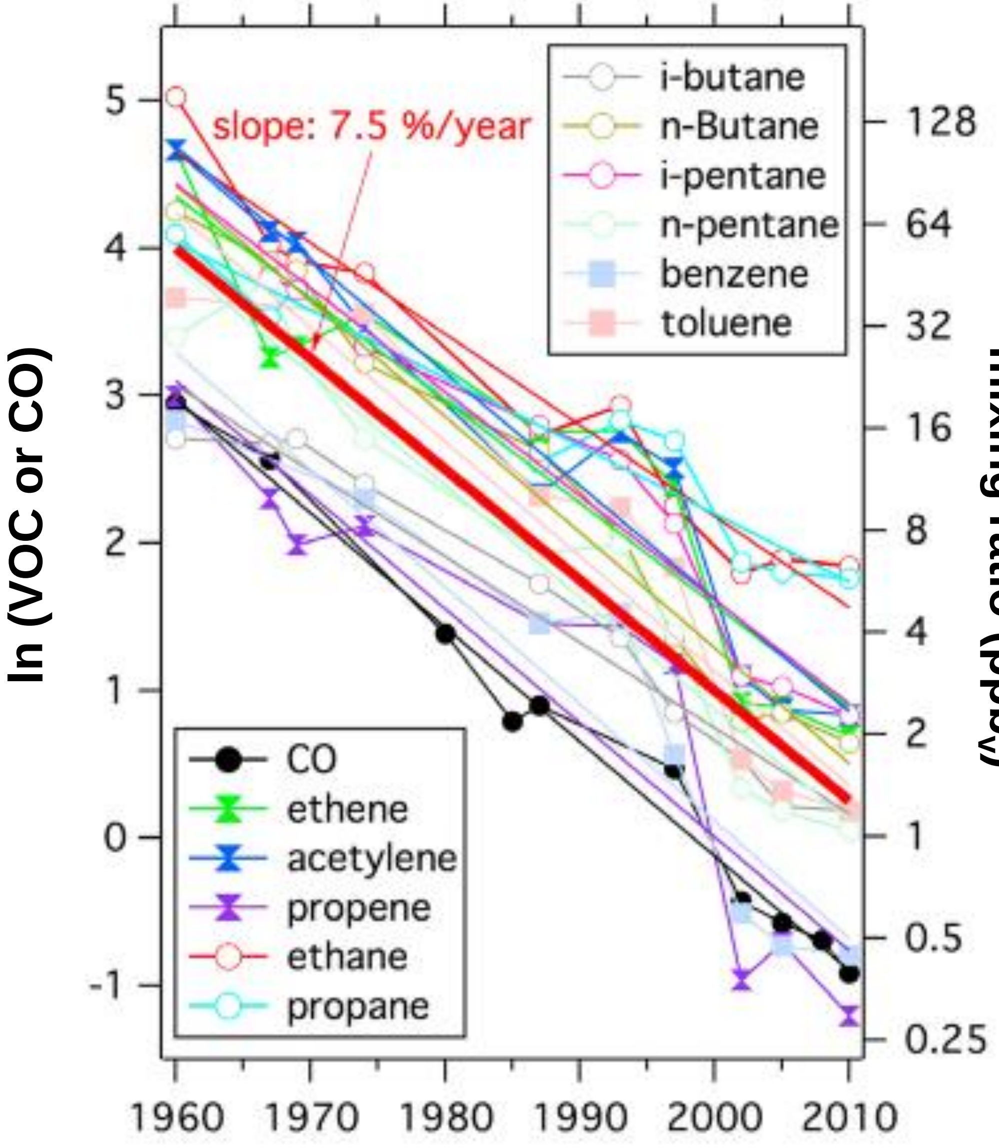
$\Delta(O_3$ days) >70 ppb during SENEX study period

Model Sensitivity	Eastern U.S.	Northeast U.S.
-15% Anthro. NO_x	-830 ± 110 d	-95 ± 17 d
+2x Biogenic VOC	+180 ± 110 d	+66 ± 17 d

In northeast U.S., model O_3 responds to small reductions in NO_x, but also influenced by VOCs

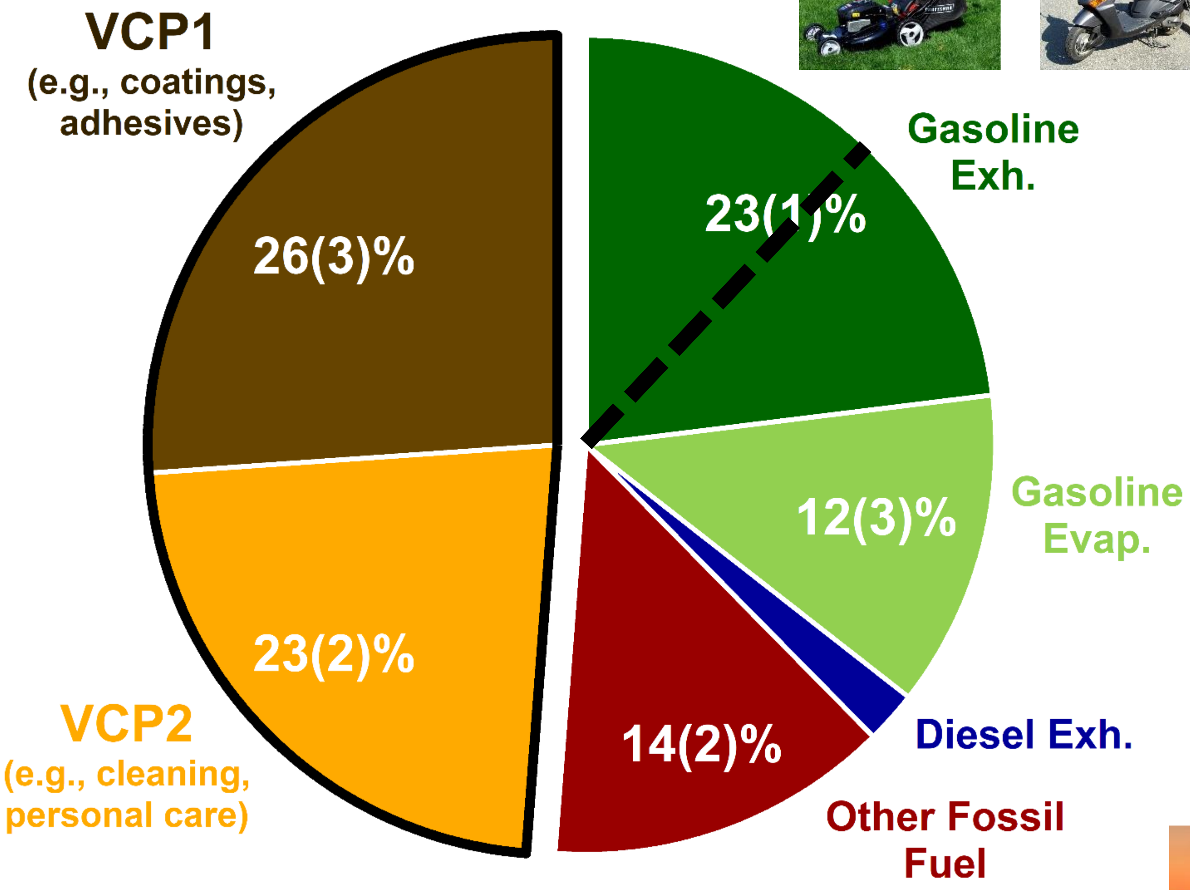
Large Reductions in Tailpipe CO and VOC Emissions





Warneke et al. *J. Geophys. Res.* 2012

Distribution of Anthropogenic VOC Emissions in Los Angeles (2010)



VOC Emissions = 820 ± 200 t/d

Urban VOC emissions shifting away from energy- to non-energy related sources

Summary

Passenger vehicle NO_x emissions overestimated (by ~2x)

- Ground-level O_3 sensitive to mobile source NO_x emissions
- Can be constrained with roadway studies

Rapid decreases in transportation VOC emissions

- Growing influence of non-energy related emission sources

Environ. Sci. Technol. **1986**, *20*, 790–796

Non-Methane Organic Composition in the Lincoln Tunnel

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(Carslaw et al., *Atmos. Env.* 2013)