Quantifying Urban Emissions Influencing Wintertime Ammonium Nitrate Formation

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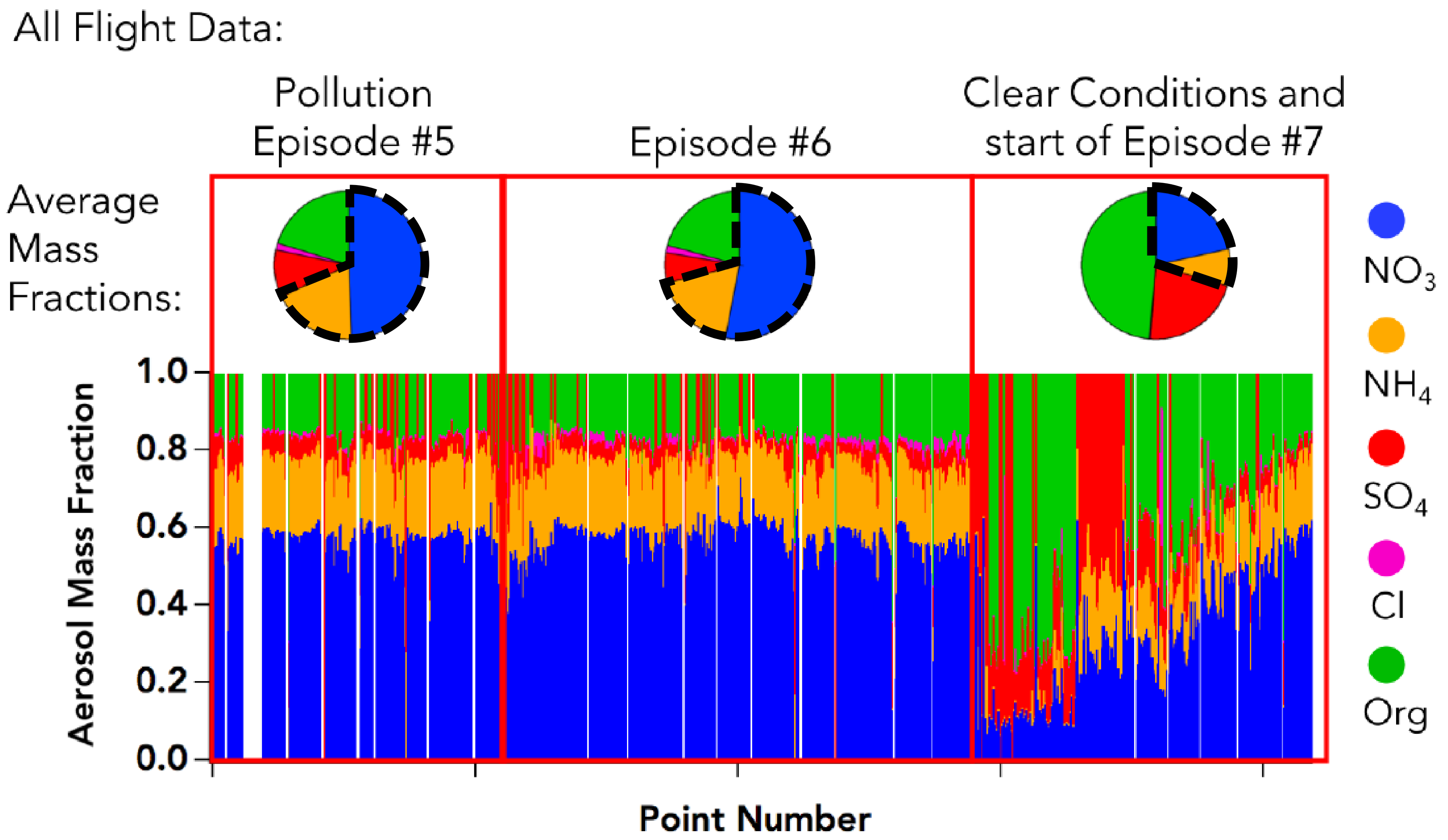
AQUARIUS Workshop (September 25, 2019)

During Cold Pool Episodes Ammonium Nitrate Dominates PM_1



Source: *2017 Utah Winter Fine Particulate Study – Final Report*

Overview

What gas-phase emission sources could contribute to ammonium nitrate formation?

(1) Potential gaps in mobile source NO_x emissions

- Lack of wintertime roadside emission factor studies
- Can satellite data help fill measurement gap?

(2) Emergence of volatile chemical products as sources of VOCs

Are mobile source NO_x emissions overestimated or not?

Summer *field campaigns suggested mobile source NO_x* ***overestimated***

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Measured and modeled CO and NO_y in DISCOVER-AQ: An evaluation of emissions and chemistry over the eastern US

Daniel C. Anderson [a,*], Christopher P. Loughner [b,c], Glenn Diskin [d], Andrew Weinheimer [e], Timothy P. Canty [a], Ross J. Salawitch [a,b], Helen M. Worden [e], Alan Fried [f], Tomas Mikoviny [g,1], Armin Wisthaler [h,1], Russell R. Dickerson [a]

Atmos. Chem. Phys., 16, 13561–13577, 2016
www.atmos-chem-phys.net/16/13561/2016/
doi:10.5194/acp-16-13561-2016

Atmospheric Chemistry and Physics
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EGU

Why do models overestimate surface ozone in the Southeast United States?

Katherine R. Travis[1], Daniel J. Jacob[1,2], Jenny A. Fisher[3,4], Patrick S. Kim[2], Eloise A. Marais[1], Lei Zhu[1], Karen Yu[1], Christopher C. Miller[1], Robert M. Yantosca[1], Melissa P. Sulprizio[1], Anne M. Thompson[5], Paul O. Wennberg[6,7], John D. Crounse[6], Jason M. St. Clair[6], Ronald C. Cohen[8], Joshua L. Laughner[8], Jack E. Dibb[9], Samuel R. Hall[10], Kirk Ullmann[10], Glenn M. Wolfe[11,12], Illana B. Pollack[13], Jeff Peischl[14,15], Jonathan A. Neuman[14,15], and Xianliang Zhou[16,17]

Environmental Science & Technology
Article
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Modeling Ozone in the Eastern U.S. using a Fuel-Based Mobile Source Emissions Inventory

Brian C. McDonald,[*,†,‡] Stuart A. McKeen,[†,‡] Yu Yan Cui,[†,‡,∇] Ravan Ahmadov,[†,§] Si-Wan Kim,[†,‡,○] Gregory J. Frost,[‡] Ilana B. Pollack,[†,‡,◆] Jeff Peischl,[†,‡] Thomas B. Ryerson,[‡] John S. Holloway,[†,‡] Martin Graus,[†,‡,¶] Carsten Warneke,[†,‡] Jessica B. Gilman,[‡] Joost A. de Gouw,[†,‡] Jennifer Kaiser,[∥,∞] Frank N. Keutsch,[∥,∞,⊗] Thomas F. Hanisco,[⊥] Glenn M. Wolfe,[⊥,#] and Michael Trainer[‡]

Winter *field campaigns suggested mobile source NO_x* ***not overestimated***

AGU100 ADVANCING EARTH AND SPACE SCIENCE
JGR
Journal of Geophysical Research: Atmospheres
RESEARCH ARTICLE
10.1029/2018JD029133
Special Section:
Winter INvestigation of Transport, Emissions and Reactivity (WINTER)

Nitrogen Oxides Emissions, Chemistry, Deposition, and Export Over the Northeast United States During the WINTER Aircraft Campaign

L. Jaeglé[1], V. Shah[1], J. A. Thornton[1], F. D. Lopez-Hilfiker[1,2], B. H. Lee[1], E. E. McDuffie[3,4,5], D. Fibiger[3,4], S. S. Brown[3,5], P. Veres[3], T. L. Sparks[6], C. J. Ebben[6], P. J. Wooldridge[6], H. S. Kenagy[6], R. C. Cohen[6], A. J. Weinheimer[7], T. L. Campos[7], D. D. Montzka[7], J. P. Digangi[8], G. M. Wolfe[9,10], T. Hanisco[9], J. C. Schroder[4,5], P. Campuzano-Jost[4,5], D. A. Day[4,5], J. L. Jimenez[4,5], A. P. Sullivan[11], H. Guo[12], and R. J. Weber[12]

Key Points:

- Existing anthropogenic NO_x inventory is consistent with aircraft

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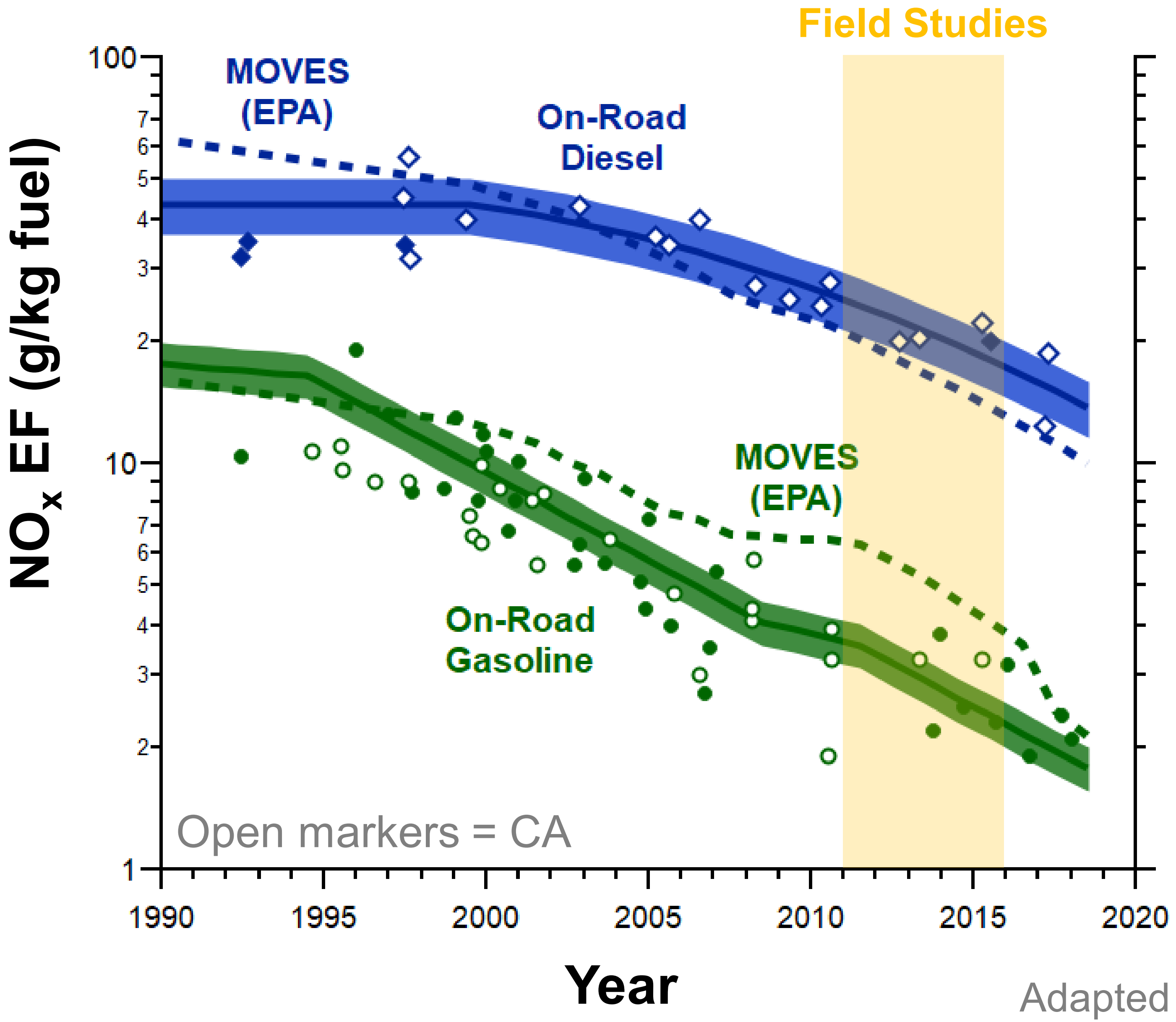
JGR
Journal of Geophysical Research: Atmospheres
RESEARCH ARTICLE
10.1029/2018JD028539
Special Section:
Winter INvestigation of Transport, Emissions and Reactivity (WINTER)

Top-Down Estimates of NO_x and CO Emissions From Washington, D.C.-Baltimore During the WINTER Campaign

O. E. Salmon[1], P. B. Shepson[1,2], X. Ren[3,4], H. He[4], D. L. Hall[4], R. R. Dickerson[4], B. H. Stirm[5], S. S. Brown[6,7], D. L. Fibiger[6,8,9], E. E. McDuffie[6,7,9], T. L. Campos[10], K. R. Gurney[11], and J. A. Thornton[12]

Debate over Summertime Mobile Source NO_x Emission Factors

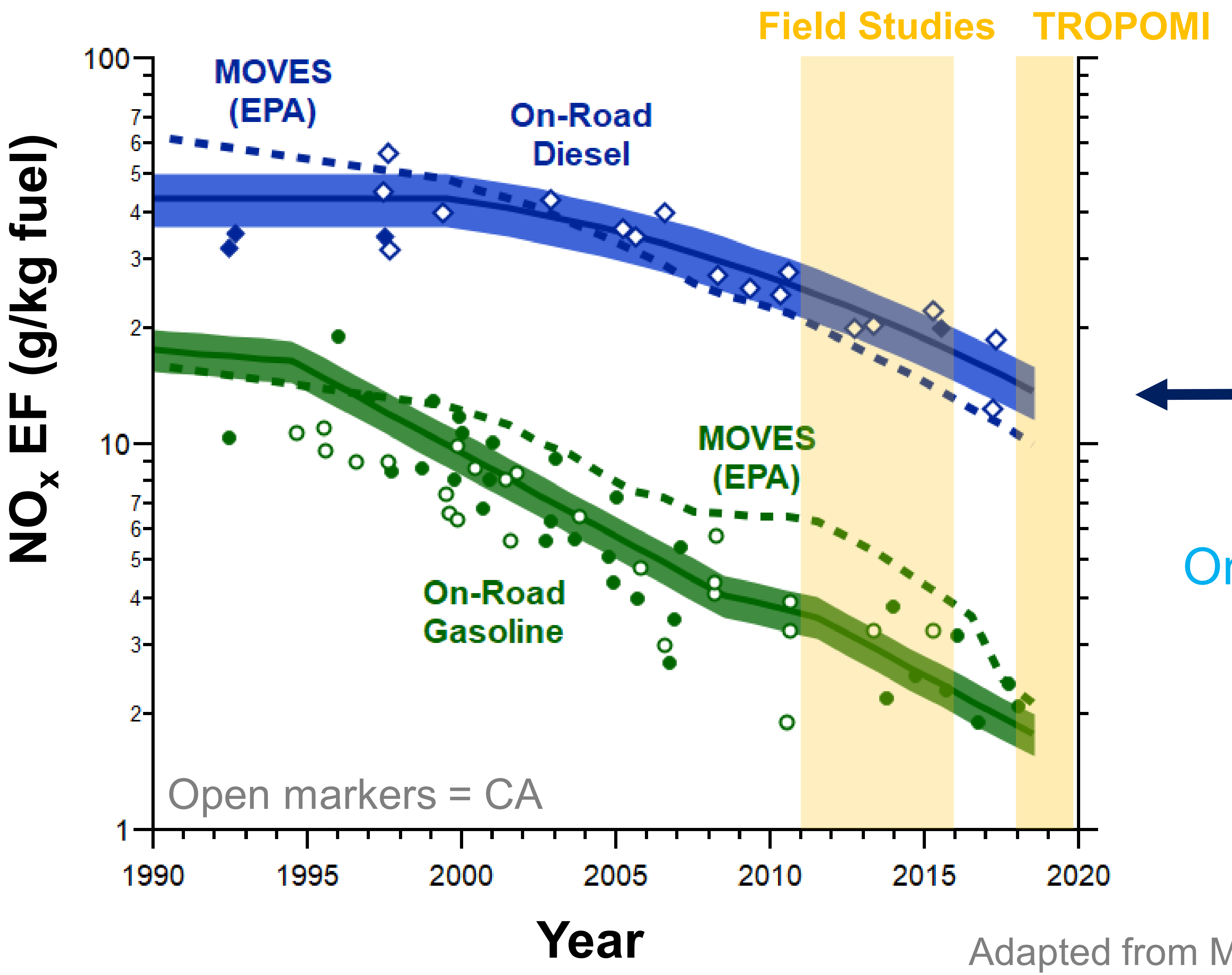


Diesel EF within **~30%**

Gasoline EF was **~2x** higher, now within **~20%**

Adapted from McDonald et al. *(Environ. Sci. Technol., 2018)*

Is there seasonal variability in mobile source NO_x EF?



Nearly all studies of heavy-duty NO_x in CA (i.e., mild winters)

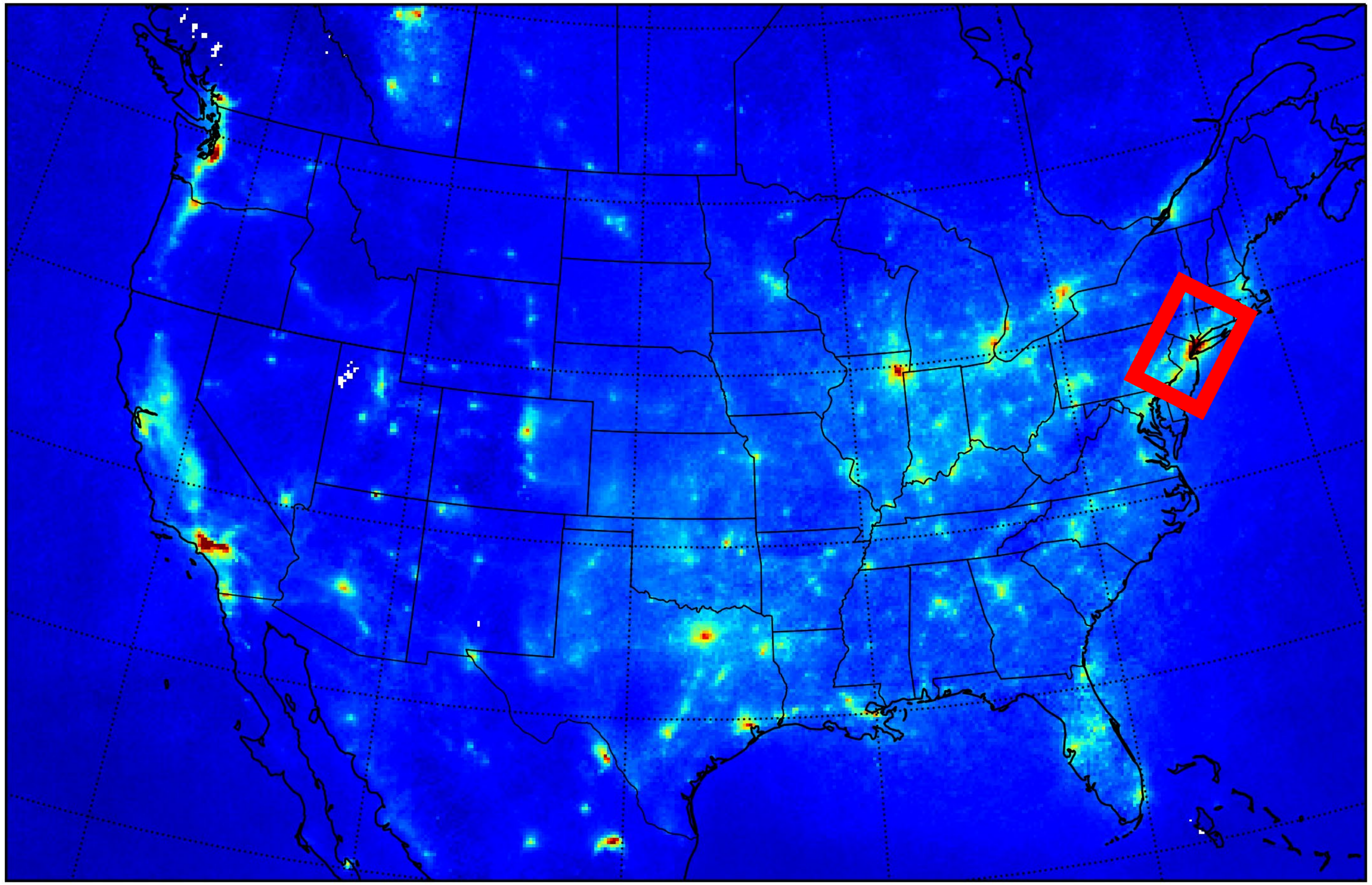
One recent winter and summer tunnel study in Baltimore (*HEI Report*, 2019)

Factor of **~2** difference

Adapted from McDonald et al. *(Environ. Sci. Technol., 2018)*

Utilizing Satellite Data to Evaluate NO_x Emission Inventories

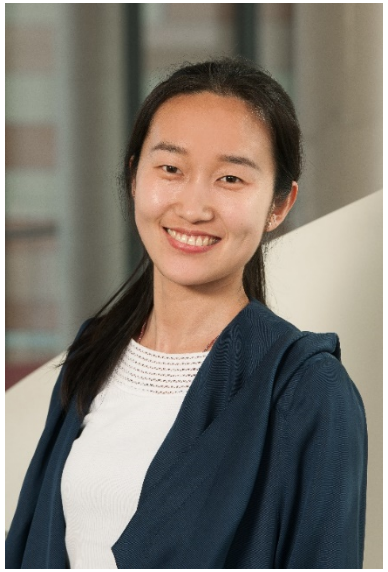
TROPOMI (12 km x 12 km) – July, 2018



0.0 0.2 0.4 0.6 0.8 1.0

Tropospheric NO_2
x 10^{16} molec. cm^{-2}

Measures **NO_2**, **HCHO**, **CO**, and **CH_4** at ~3 km x 7 km resolution (currently operational)

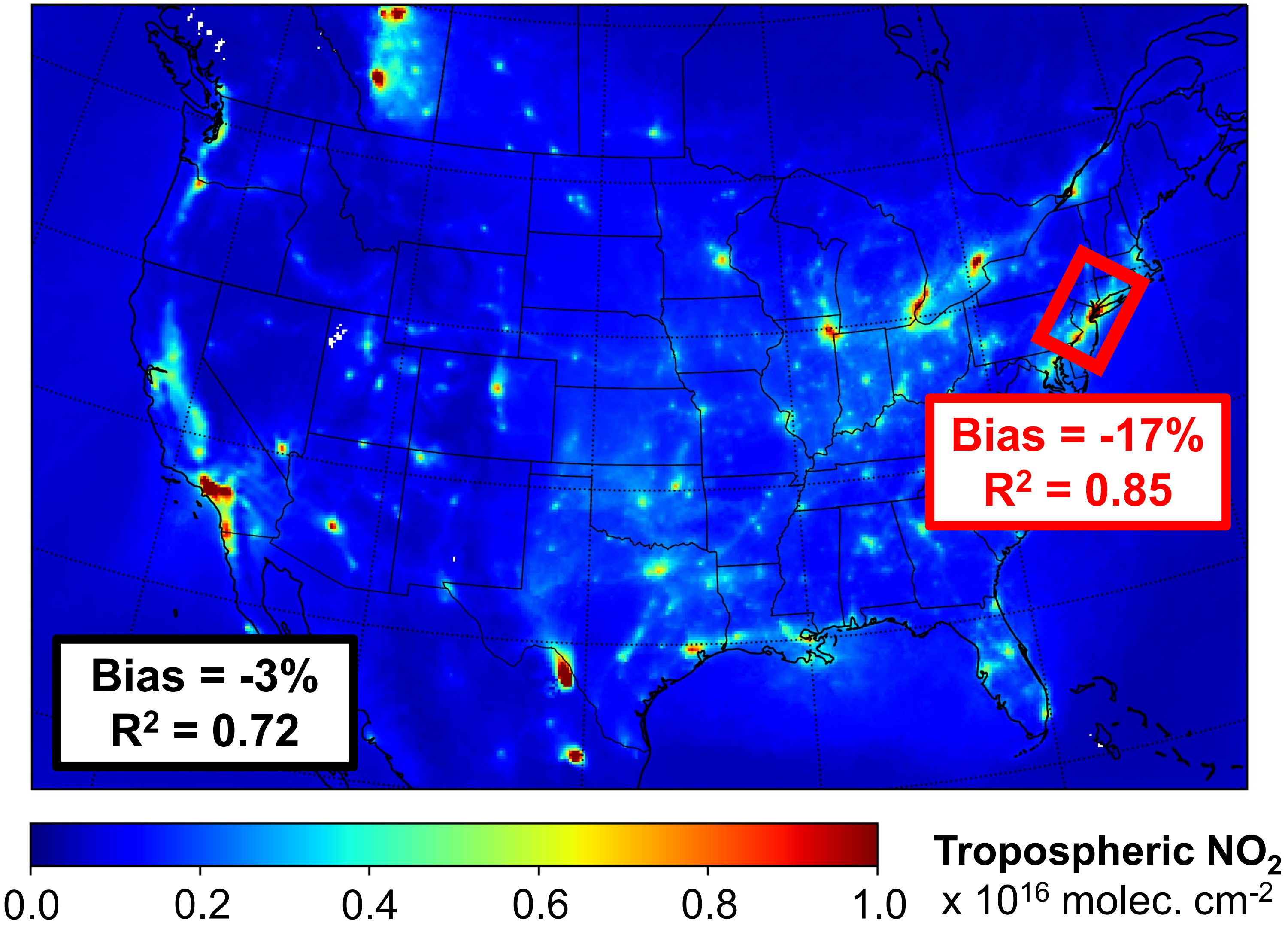


Meng Li (NOAA)

Recalculated AMF using model NO_2 profile (apples-to-apples)

Good Consistency between Model and TROPOMI NO_2

WRF-Chem (12 km x 12 km) – July, 2018

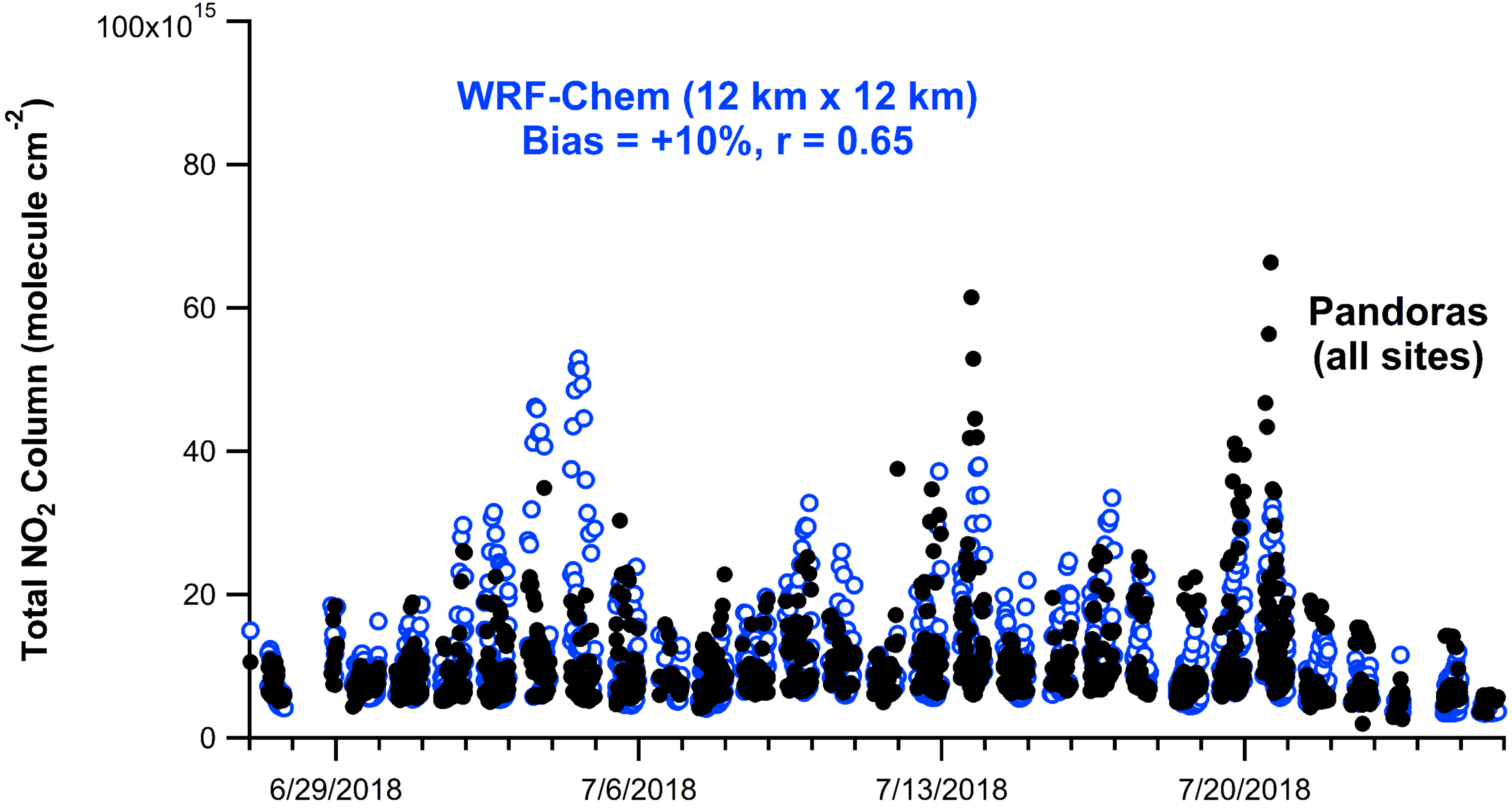


(1) Updated mobile sources with FIVE (McDonald et al., *Environ. Sci. Technol.*, 2018)

(2) Updated power plants with CEMS

(3) Updated other point + area sources to NEI14

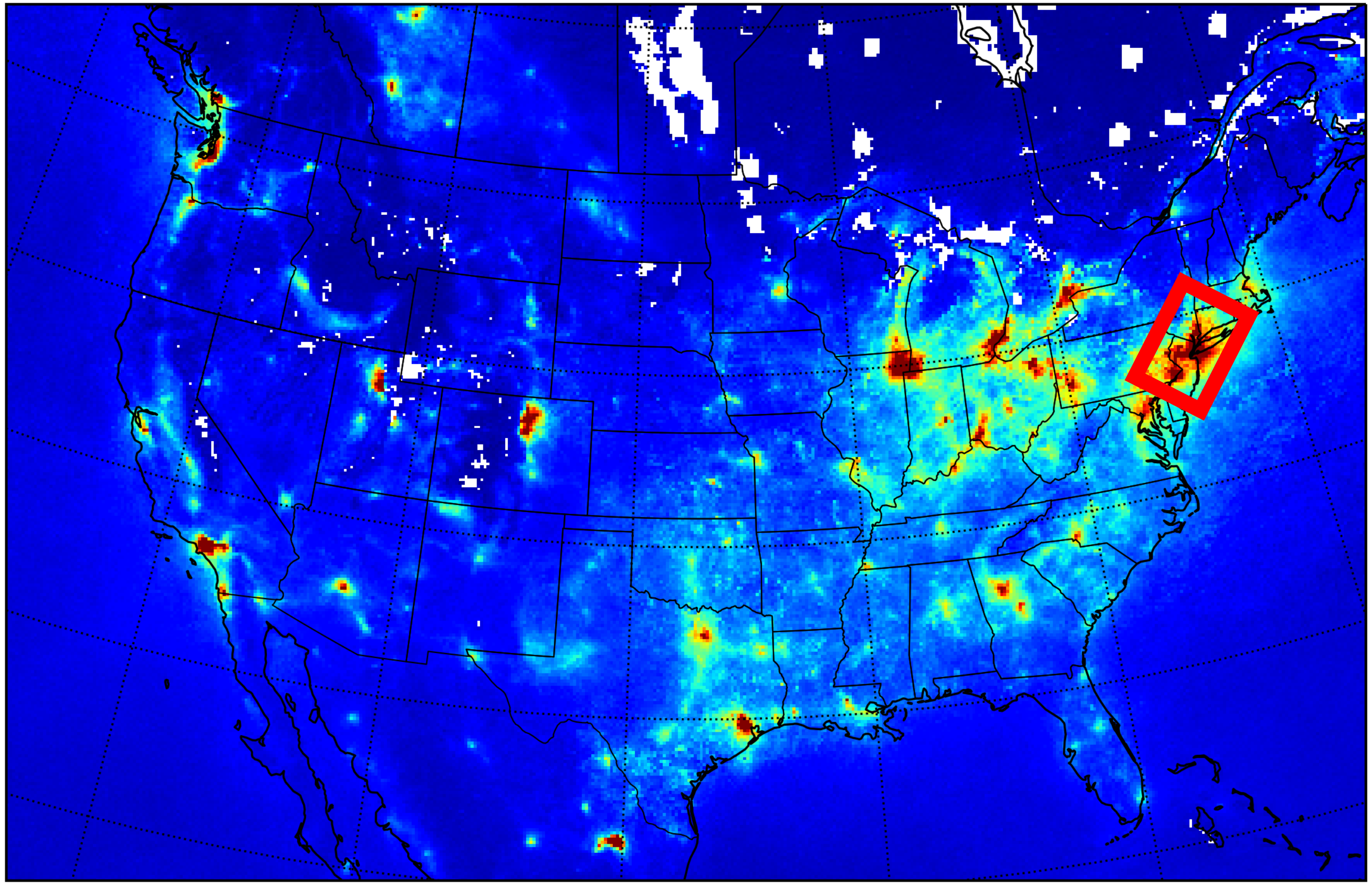
Ground-Based Truthing of Satellite Retrieval w/ Pandoras in NYC



Acknowledgments: Luke Valin and Jim Szykman (EPA), Bob Swap, Nader Abuhassan, Alexander Cede (NASA)

Preliminary Modeling of Wintertime NO_2 Columns

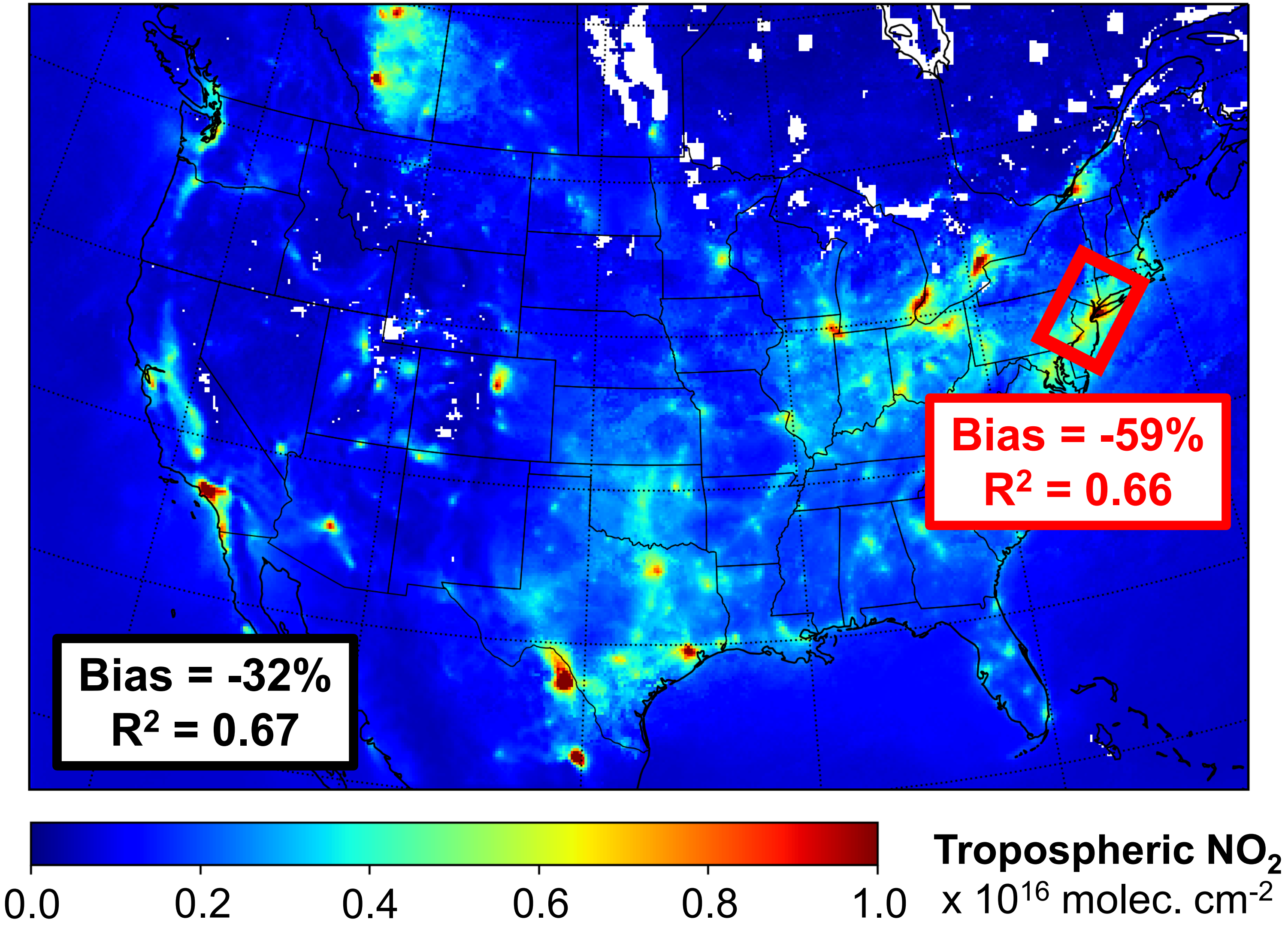
TROPOMI (12 km x 12 km) – March 2019



Hypothesis: If mobile source NO_x is underestimated in winter, then the model NO_2 will be biased low versus TROPOMI

Model Systematically Under-Predicts NO_2 Columns in Winter

WRF-Chem (12 km x 12 km) – March 2019



Can higher mobile source NO_x emissions in winter close gap?

~33% of US NO_x Emissions

Approaches to Measuring Heavy-Duty Diesel Truck Emissions

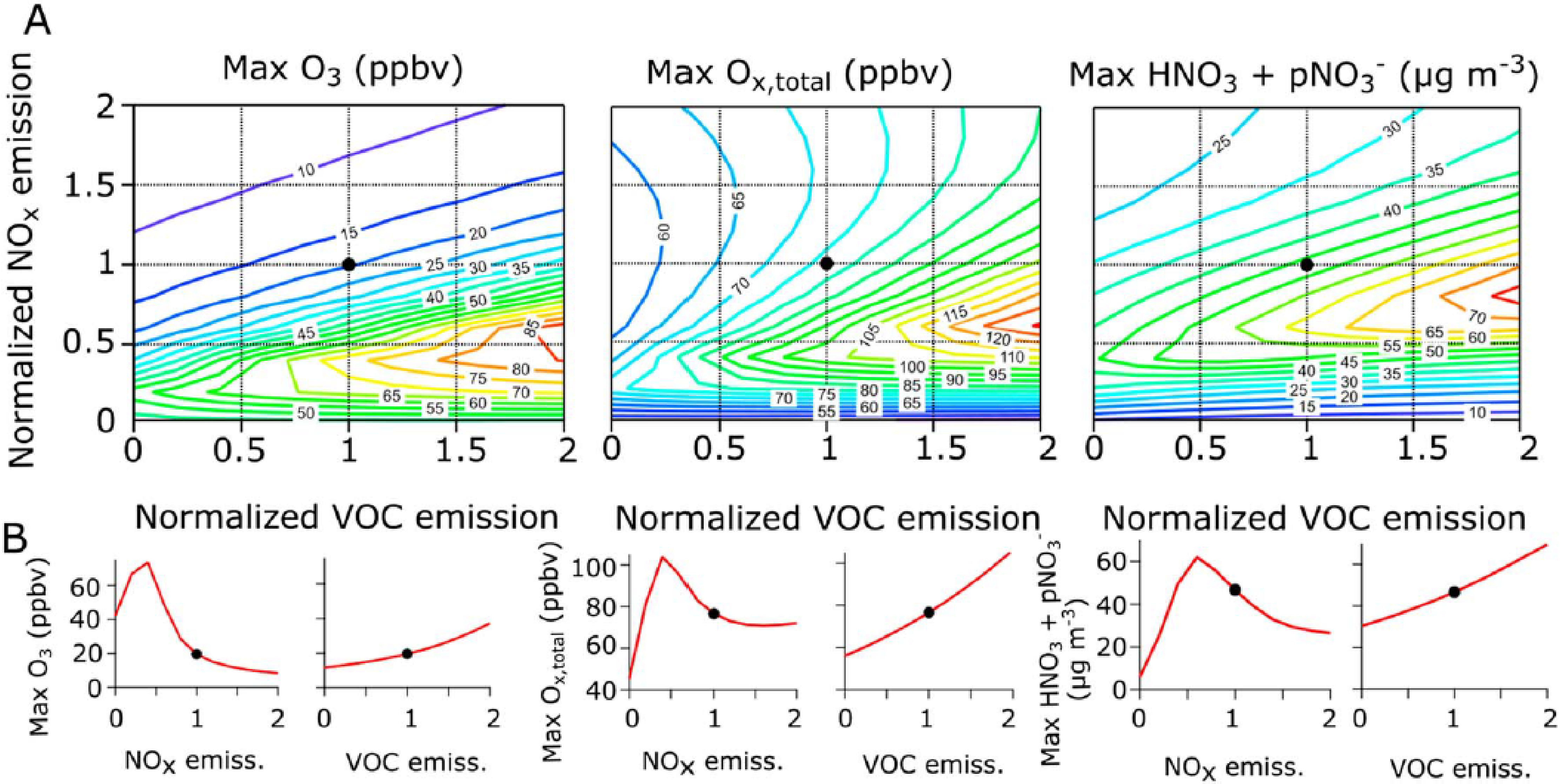
Mobile laboratory
(Dallmann et al.,
Environ. Sci. Technol. 2011)

Tunnel study
(Dallmann et al.,
Environ. Sci. Technol. 2012)

IR Remote Sensing
(Haugen and Bishop,
Environ. Sci. Technol. 2017)

Ideally measure **CO**, **CO_2**, **VOC**, **NO_x**, **NH_3**, **N_2O**, and **$PM_{2.5}$** (including speciation)

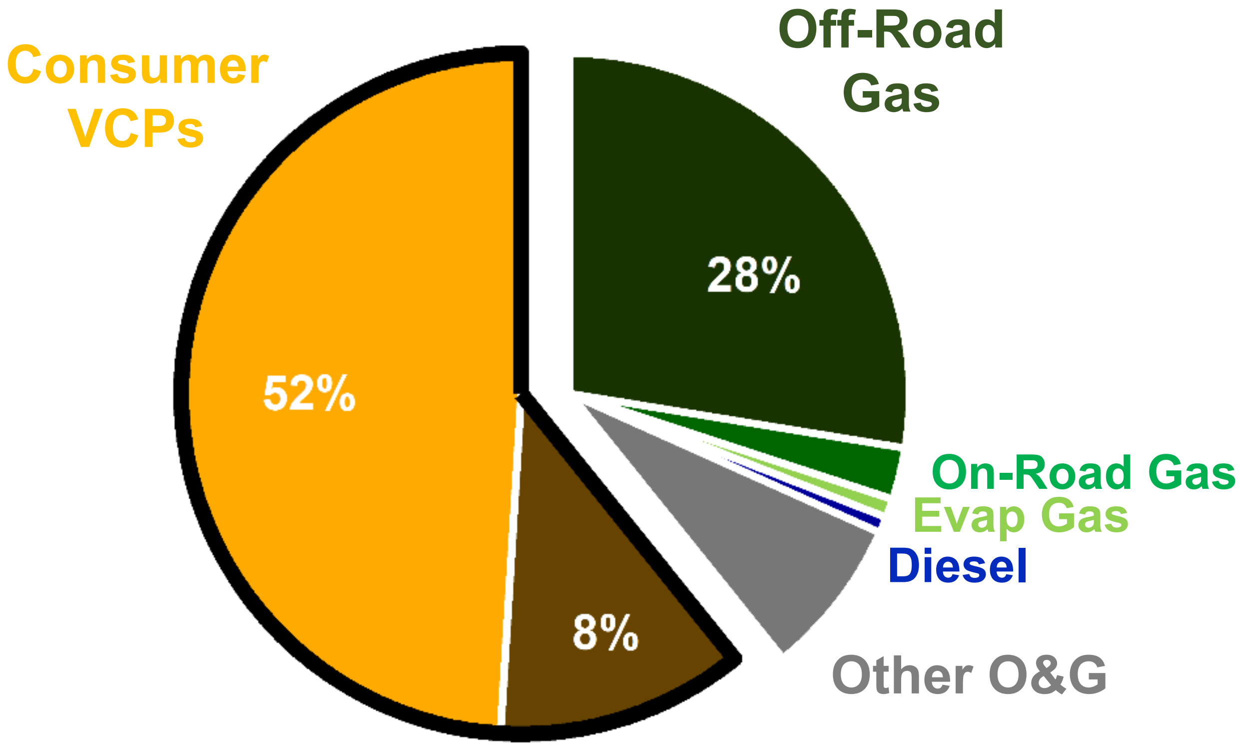
VOCs Can Also Influence Ammonium Nitrate Formation



Womack et al. *(Geophys. Res. Letters, 2019)*

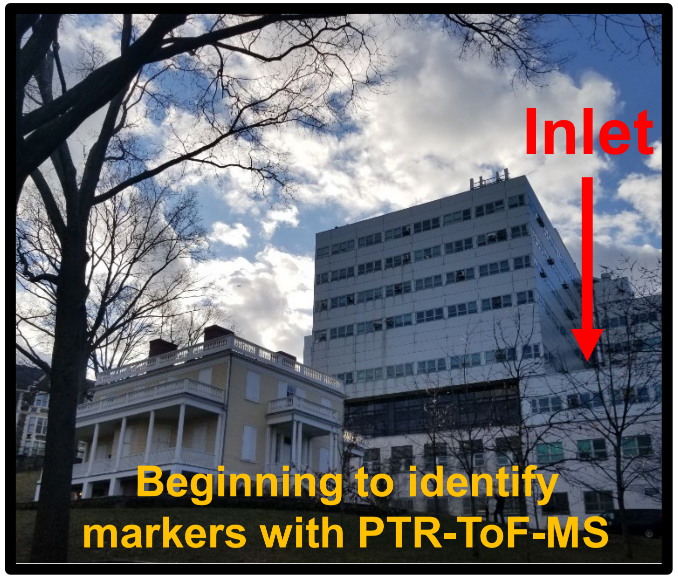
Source Apportionment of New York City VOCs (Winter 2018)

Manhattan (Winter 2018)



VOC Emissions = 46 ± 12 g/person/d

Coggon et al. (in preparation)



Matthew Coggon

Georgios Gkatzelis

Jessica Gilman

Suggestions for a Future Winter Field Campaign

(1) Satellites will measure during campaign (and beyond)

- Ground-based remote sensing measurements helpful for truthing
- Can help with constraining urban/regional emissions (e.g., NO_x)

(2) Roadside measurements could be helpful for estimating mobile source NO_x and other co-emitted species

- Potential for GHG co-related benefits

(3) Aircraft measurements of non-traditional urban VOC sources have been limited

- Helpful for evaluating emissions + chemistry of 3-D photochemical models