Linking NO_2, HCHO, and surface ozone: Insights from analysis and modeling of LISTOS data (June-August 2018)

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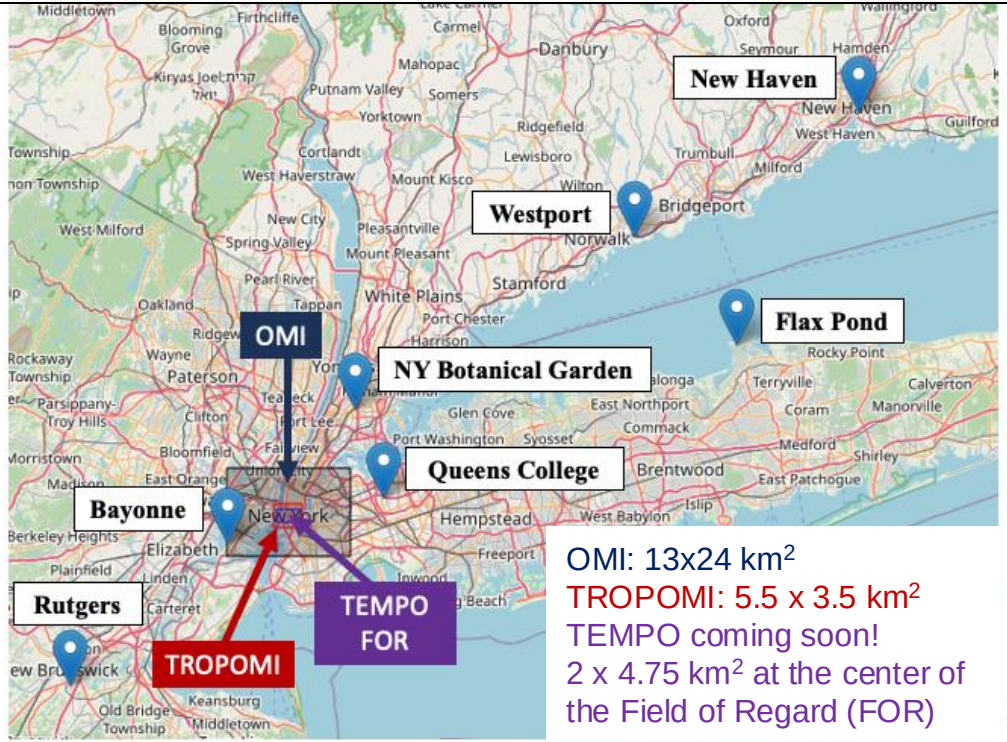
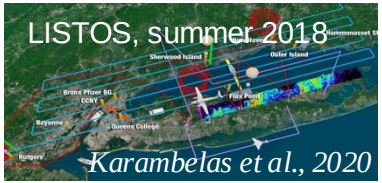


OMI: 13x24 km^2
TROPOMI: 5.5 x 3.5 km^2
TEMPO coming soon!
2 x 4.75 km^2 at the center of the Field of Regard (FOR)

How does ozone-forming chemistry vary along urban-to-rural gradients?
with time-of-day?



We are grateful to many collaborators!

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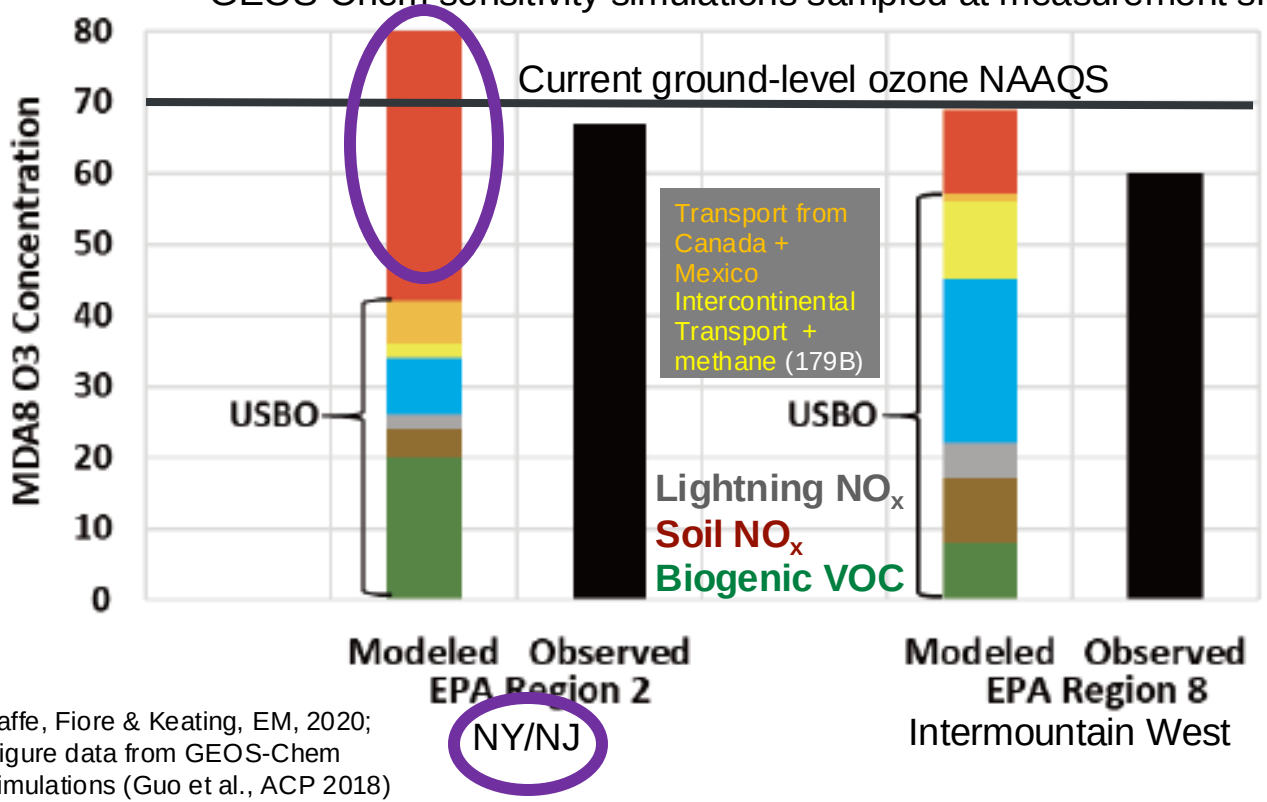
HAQAST Meeting
Salt Lake City, UT
October 20, 2023

Air quality management requires source apportionment, especially on exceedance days most relevant to NAAQS attainment

2004-2012 June-July-August MDA8 ozone averaged on days with 10 highest observations;
GEOS-Chem sensitivity simulations sampled at measurement sites



Jaffe, Fiore & Keating, EM, 2020;
Figure data from GEOS-Chem simulations (Guo et al., ACP 2018)

Total (measured) ozone

U.S. anthropogenic emissions

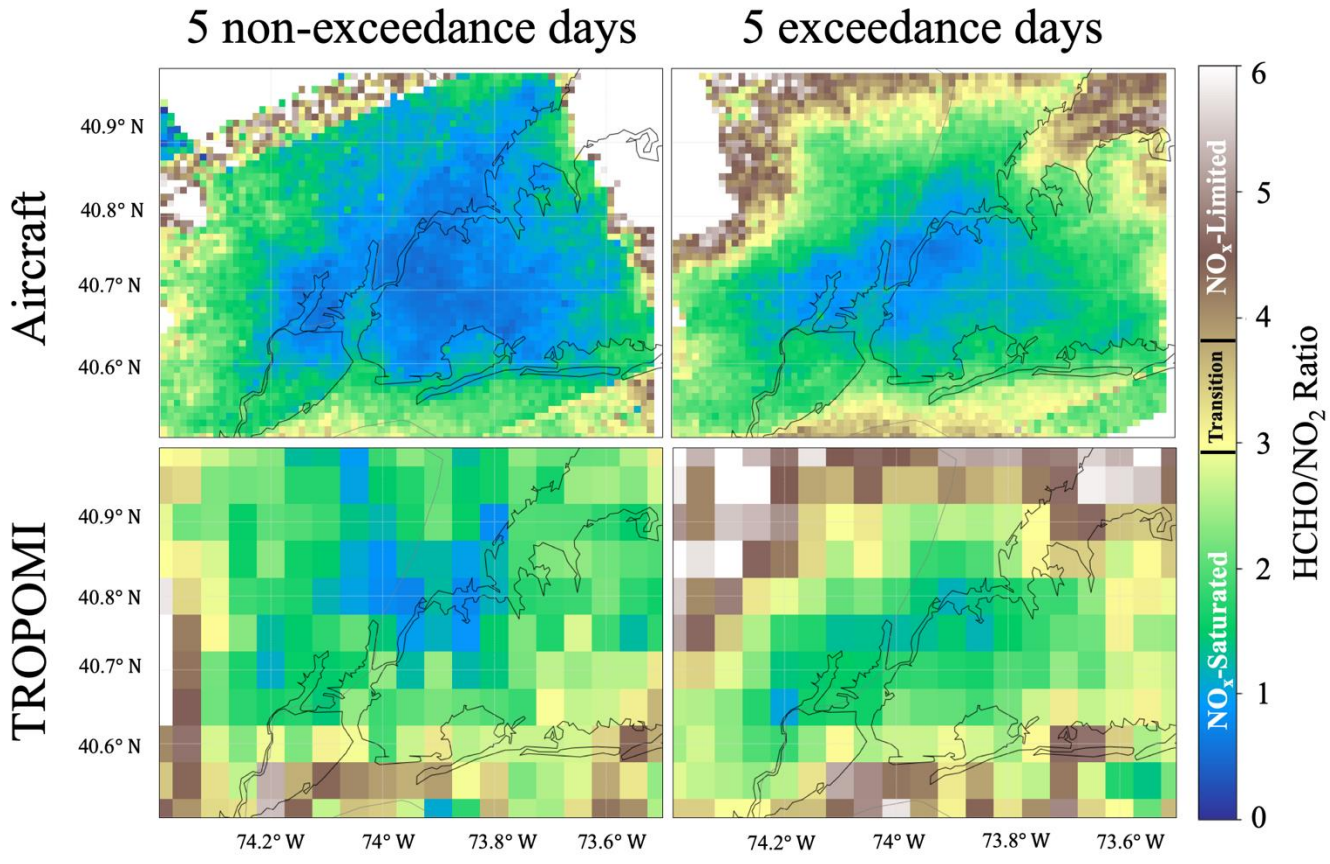
(110 State Implementation Plans
110(a)(2)(d) Interstate Transport
182(h) Rural Transport Areas)

Other USBO includes Stratospheric + Wildfires

(319 Exceptional Events)

What are we learning from on-the-ground measurements & models that can inform the use of satellite (TEMPO) data?

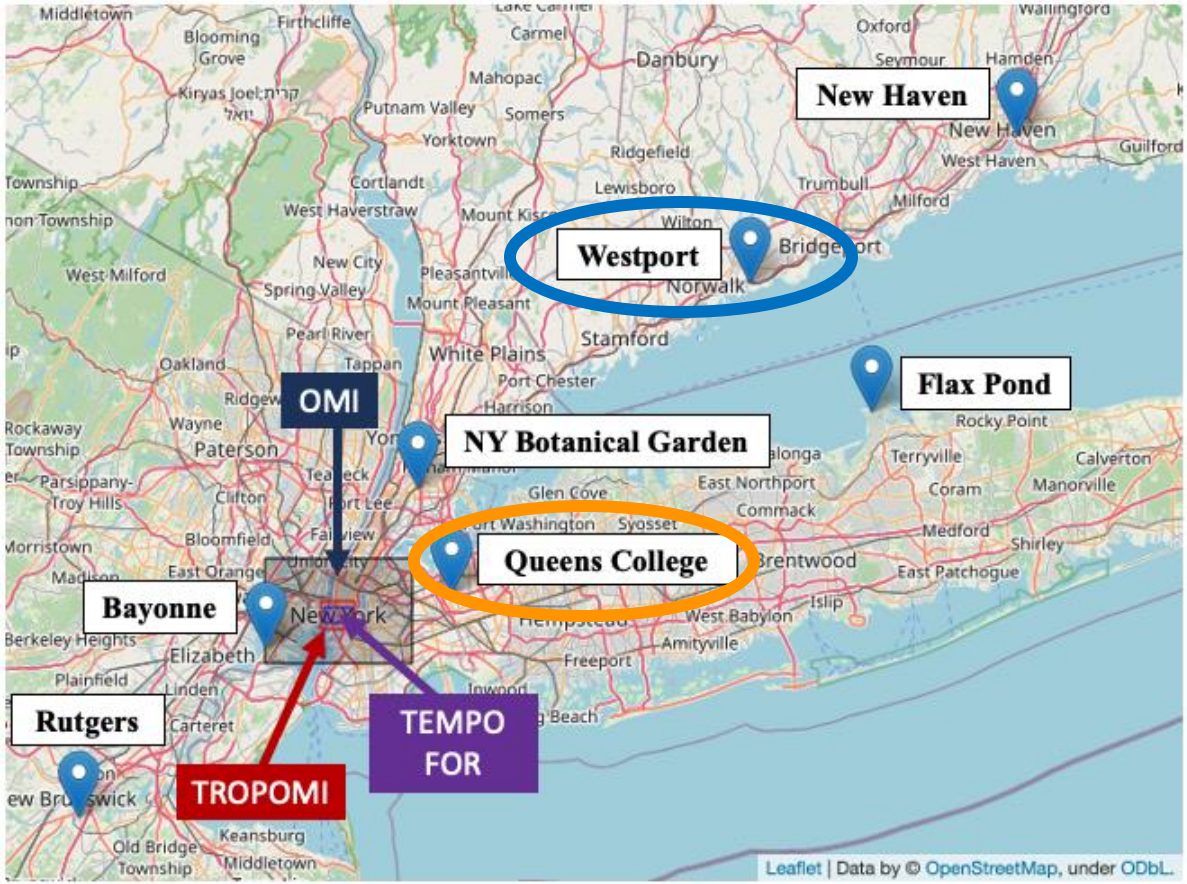
Over NYC area, airborne and satellite data imply local ozone photochemistry is more sensitive to controlling NO_x emissions on highest-ozone days



- Both NO_2 and HCHO increase but changes in HCHO dominate the overall ratio change.
- On polluted days, urban centers remain NO_x-saturated but broader region shifts towards transitional or NO_x-sensitive
- TROPOMI suggests higher sensitivity to NO_x than the airborne sensors

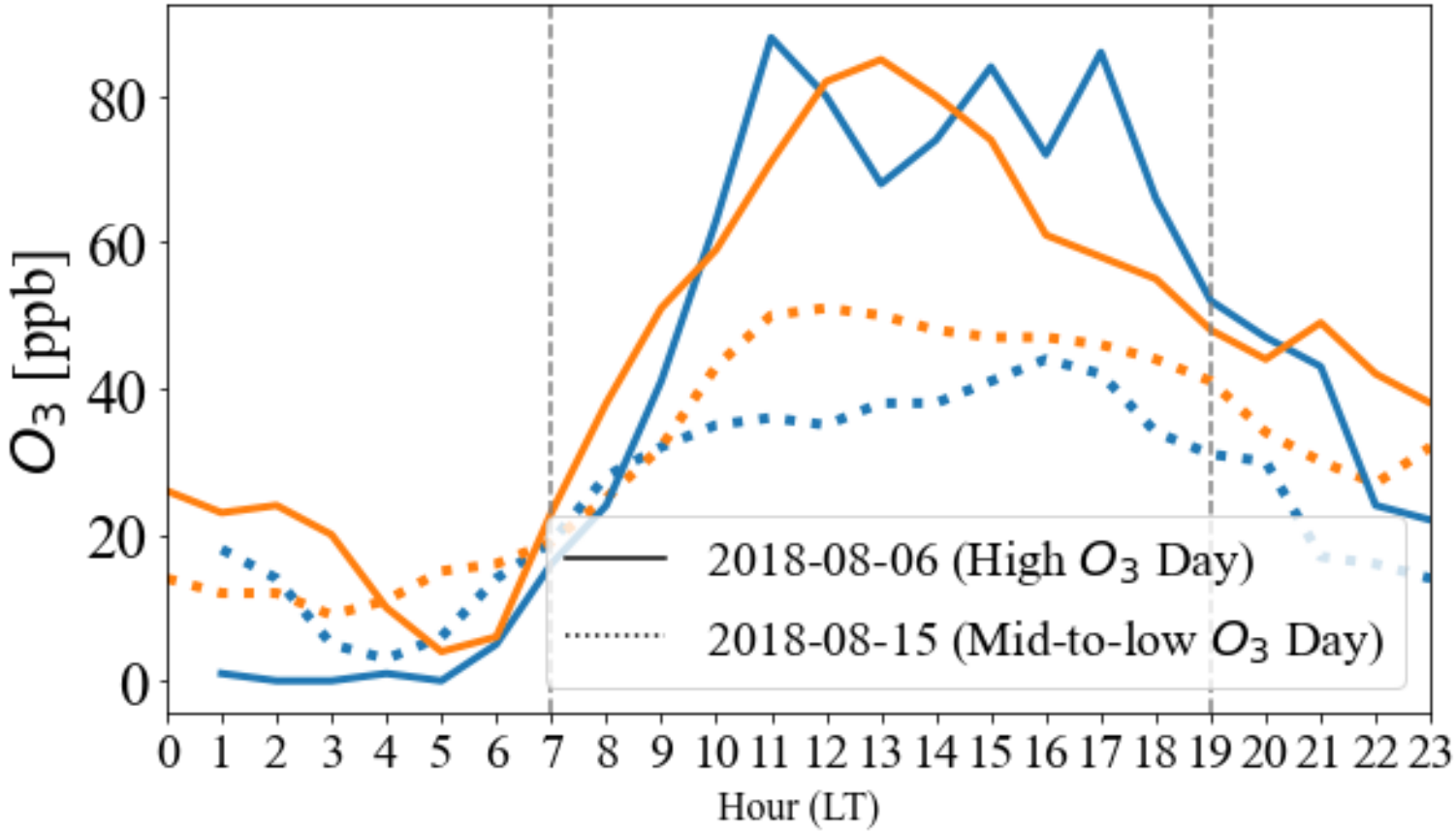
Tao et al., ES&T, 2022

How does local ozone production change on high-vs-lower ozone days? (urban core versus downwind site)

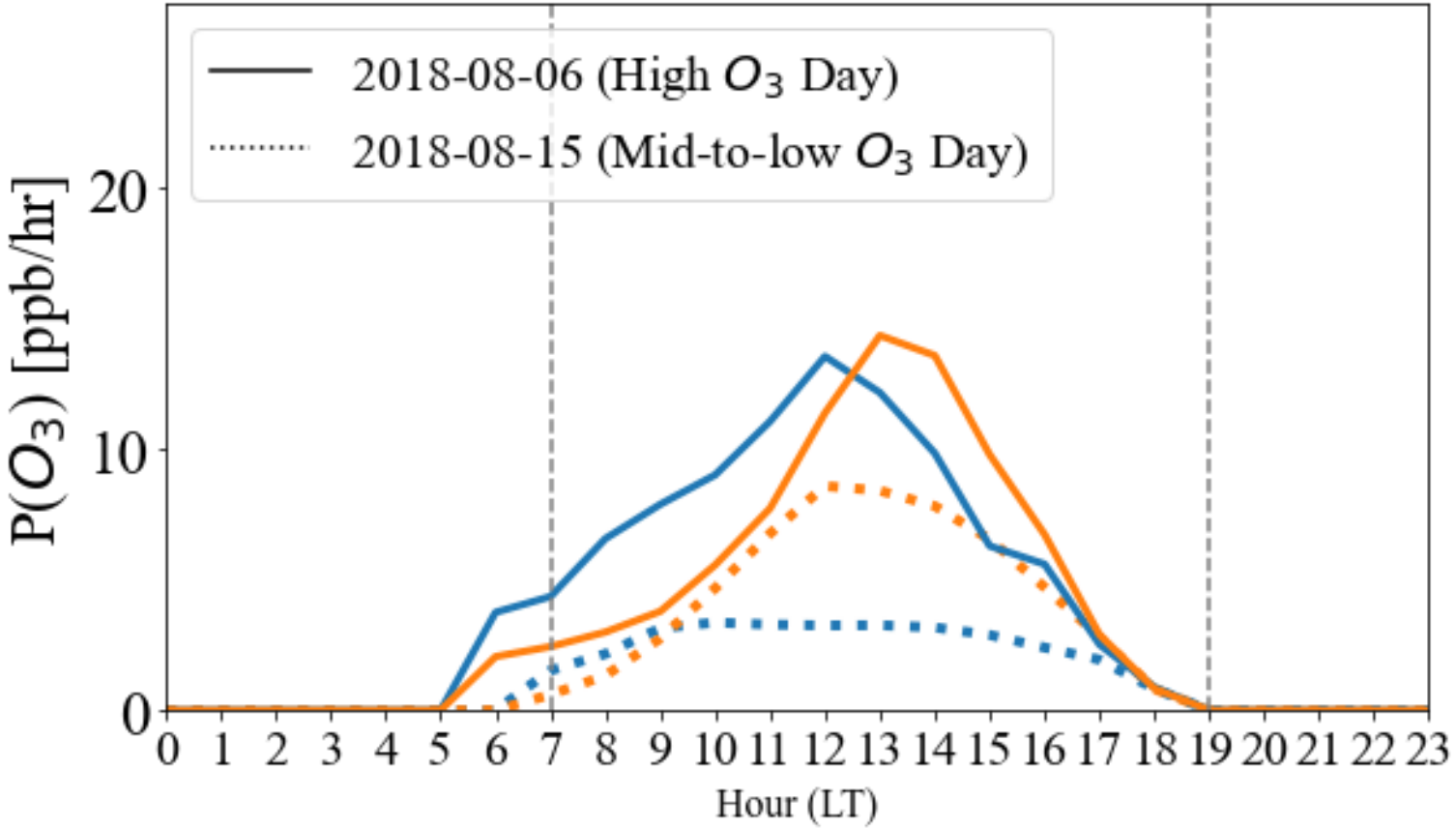


Calculate ozone production at each site using F0AM box model (*Wolfe et al., ACP, 2016*) constrained by observed concentrations of precursor gases or modeled by WRF-CMAQ (1.33 km x 1.33 km; c/o A. Karambelas, NESCAUM) where observations are lacking.

Observed ozone at Queens College, NY and Westport, CT



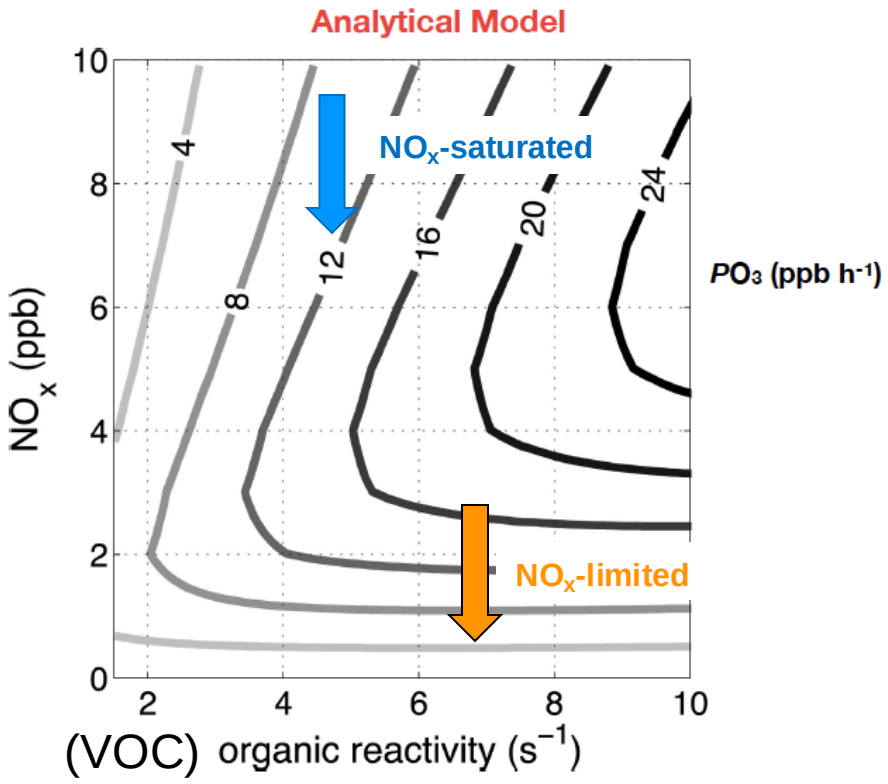
Local ozone production calculated with F0AM box model at both Queens College, NY and Westport, CT increases on higher ozone day



Ozone chemistry depends non-linearly on its precursor gases

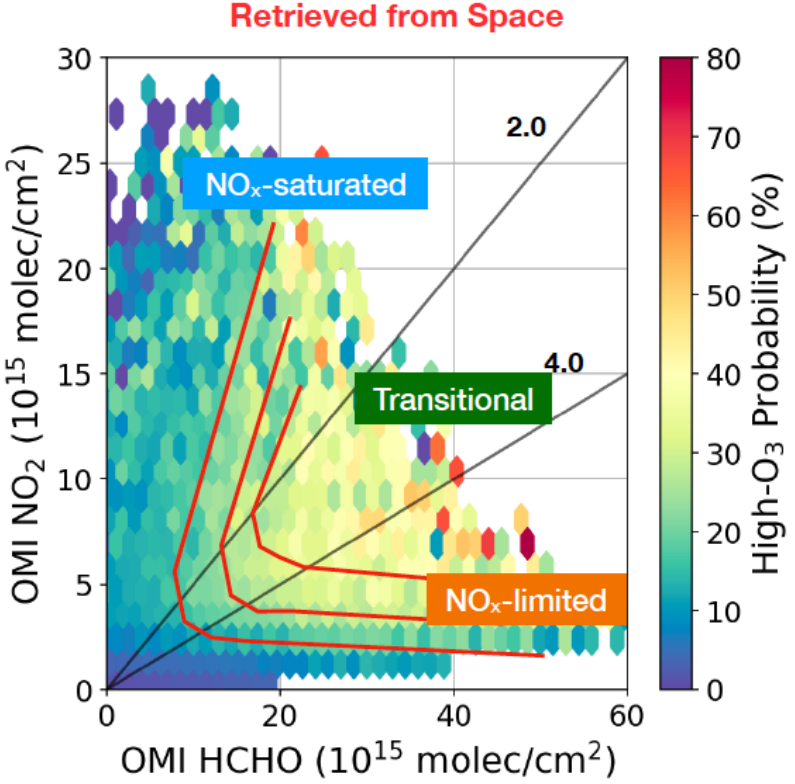
Space-based ozone isopleths?

from OMI NO_2 and HCHO gridded QA4ECV daily products & ground-based O_3 EPA AQS network excluding rural sites



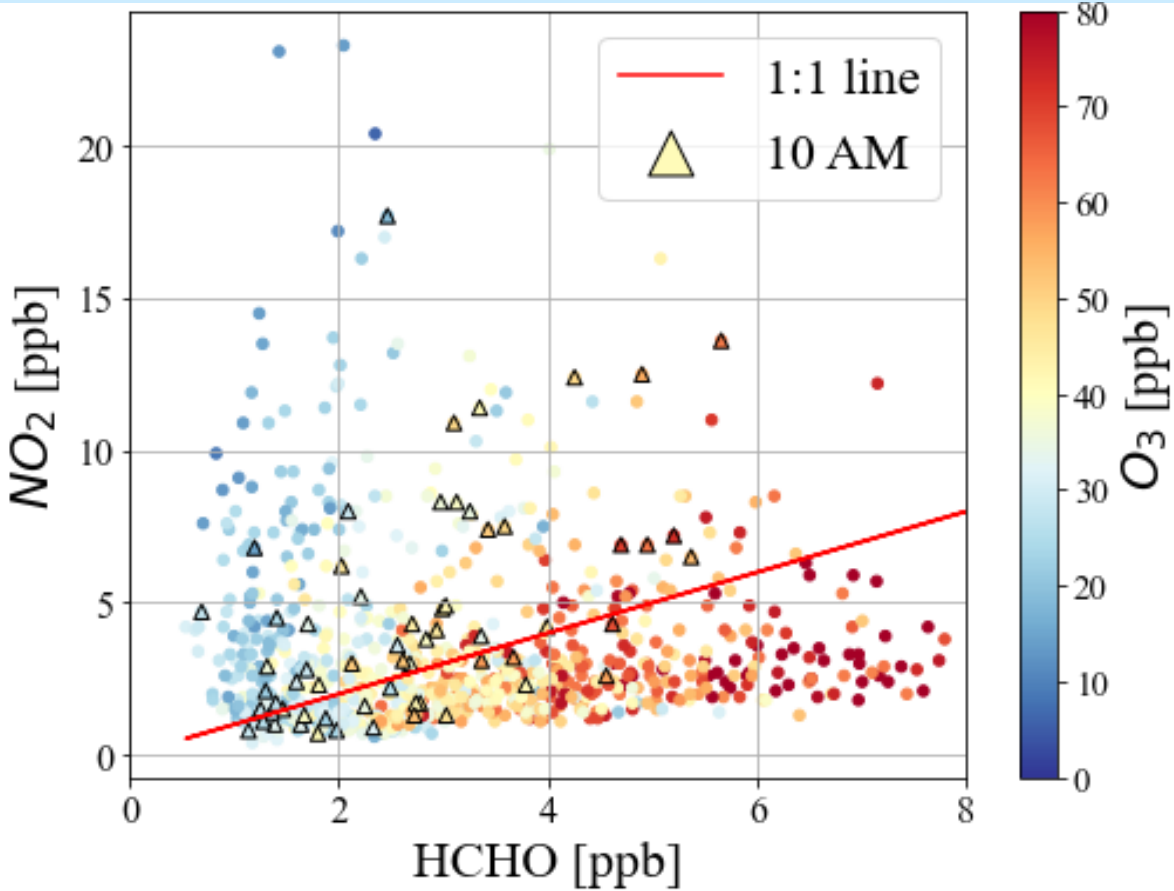
c/o X.Jin

Pusede et al., 2015



Jin et al., ES&T, 2020

Shifts in ozone chemical regimes apparent from in situ measurements at Westport, CT (hourly daytime 7am-7pm, June-Aug 2018)

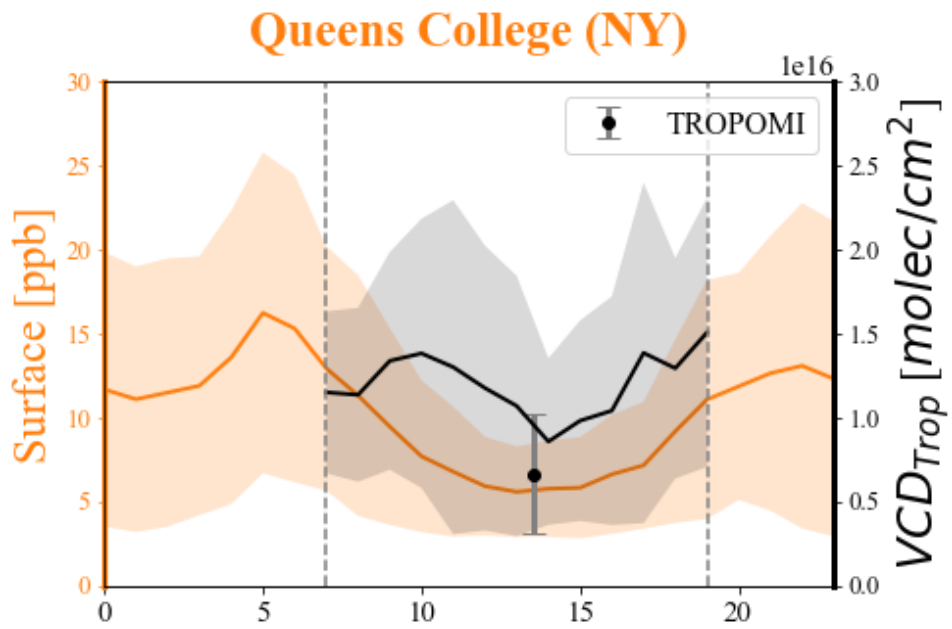


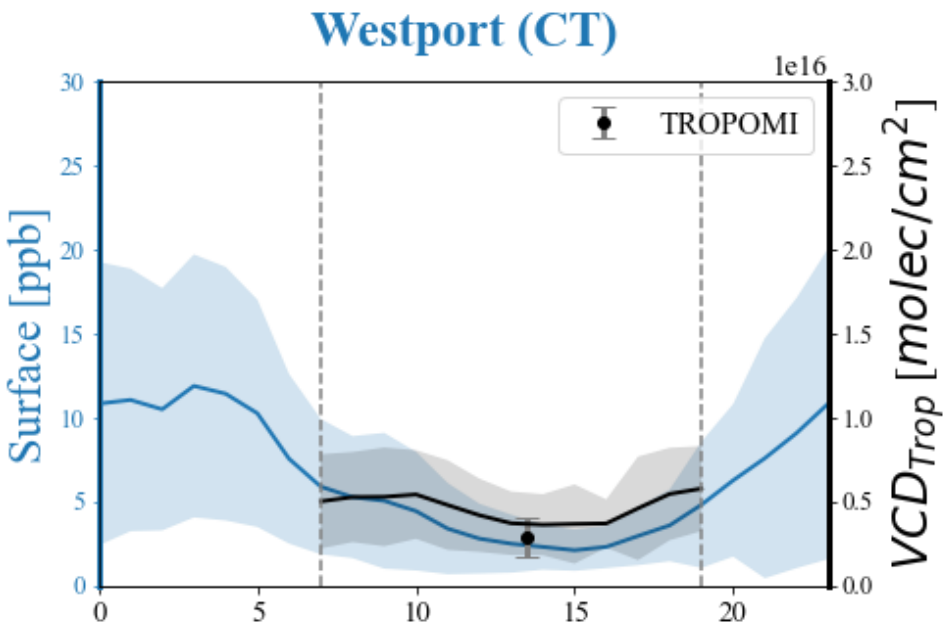
How does the timing of peak column of NO_2 concentrations relate to those at the surface?

M. Tao

Intra-day NO_2 variations differ between surface and tropospheric column; relevant to interpreting satellite products

June-Aug 2018 mean: **Column (Pandora, TROPOMI VCD_{Trop})** versus **Surface**





→ delay in morning peak in column relative to surface, missed by 1:30 overpass

→ *Geddes et al., JGR, 2021* note challenge of sea breeze for models (and retrievals)

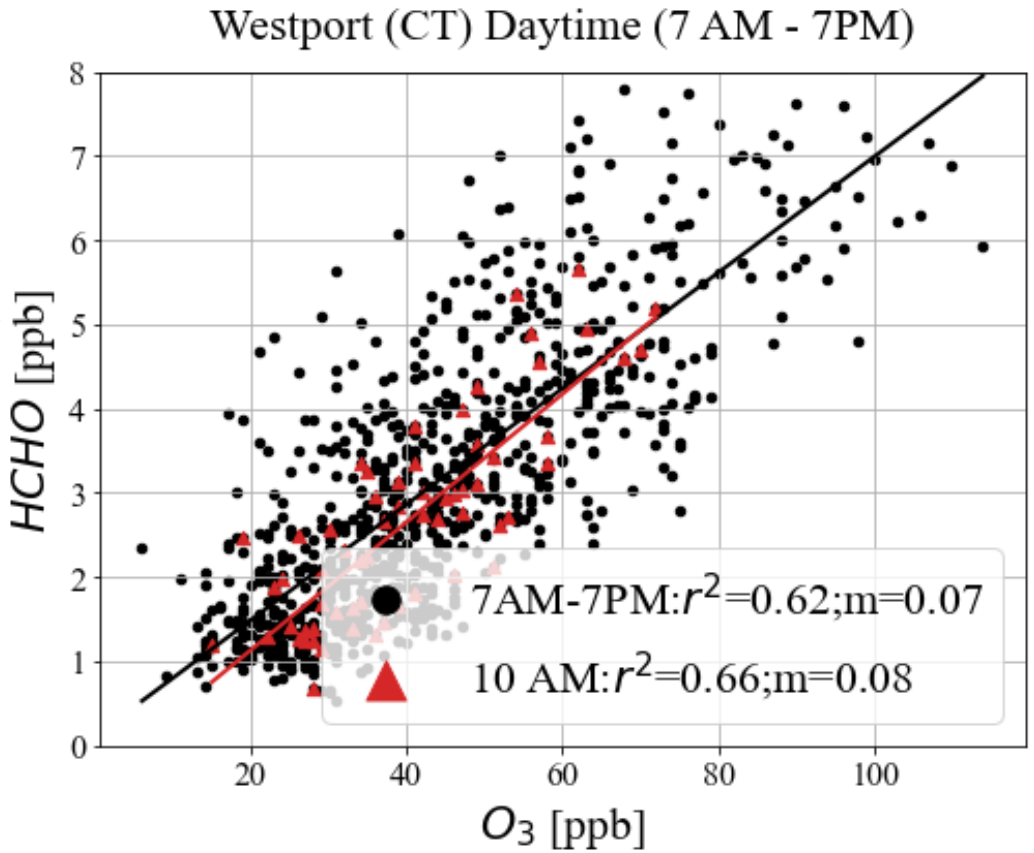
Collaborators: A. Karambelas & P. Miller (NESCAUM); L. Valin & J. Szykman (EPA); L. Judd (NASA GSFC)

M. Tao

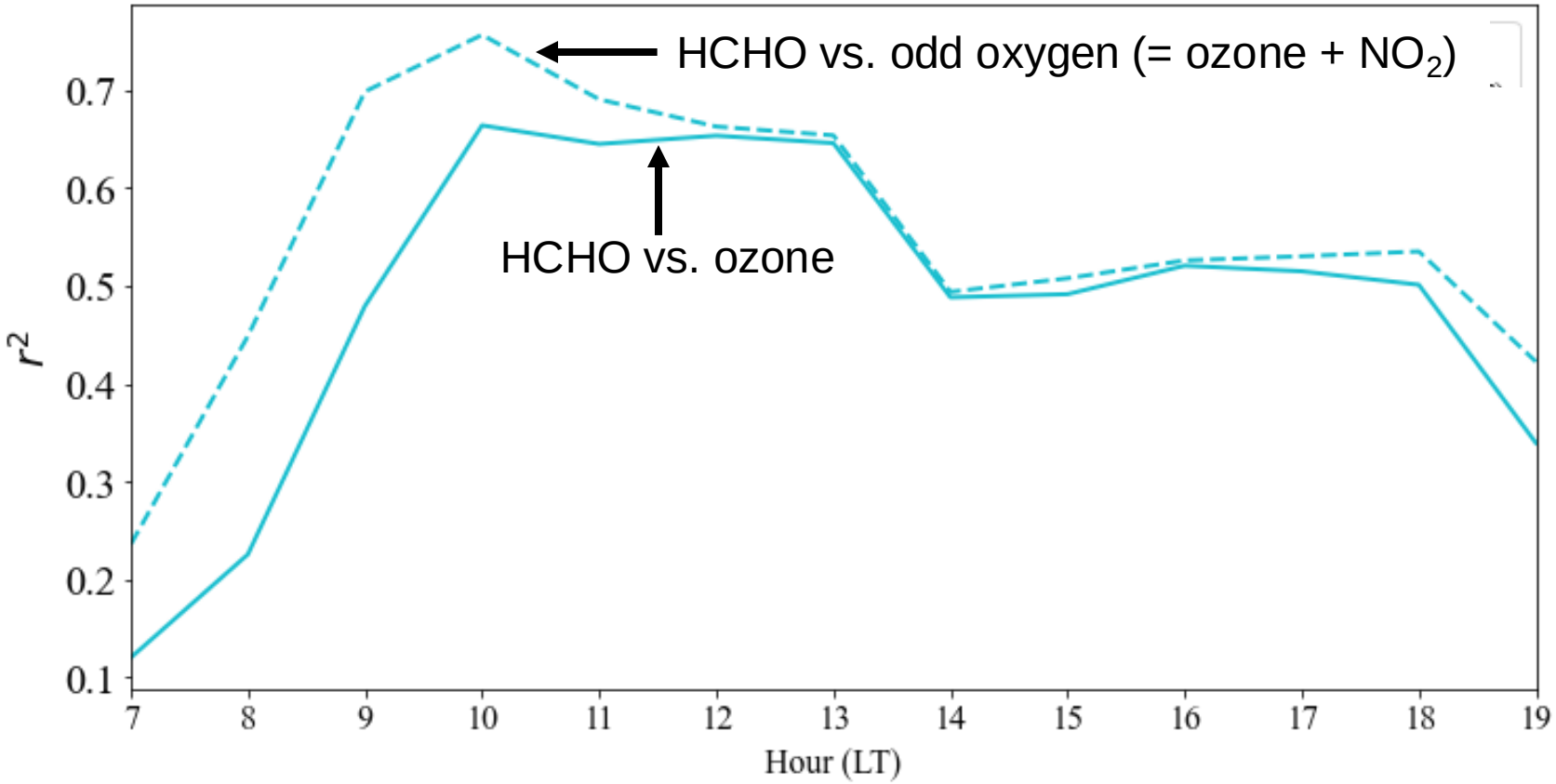
Day-to-day variations in formaldehyde correlate strongly with surface ozone

Schroeder et al., JGR 2016 and *Travis et al., JGR, 2022* *previously showed that column HCHO tracks ground-level ozone (and related oxidants)*

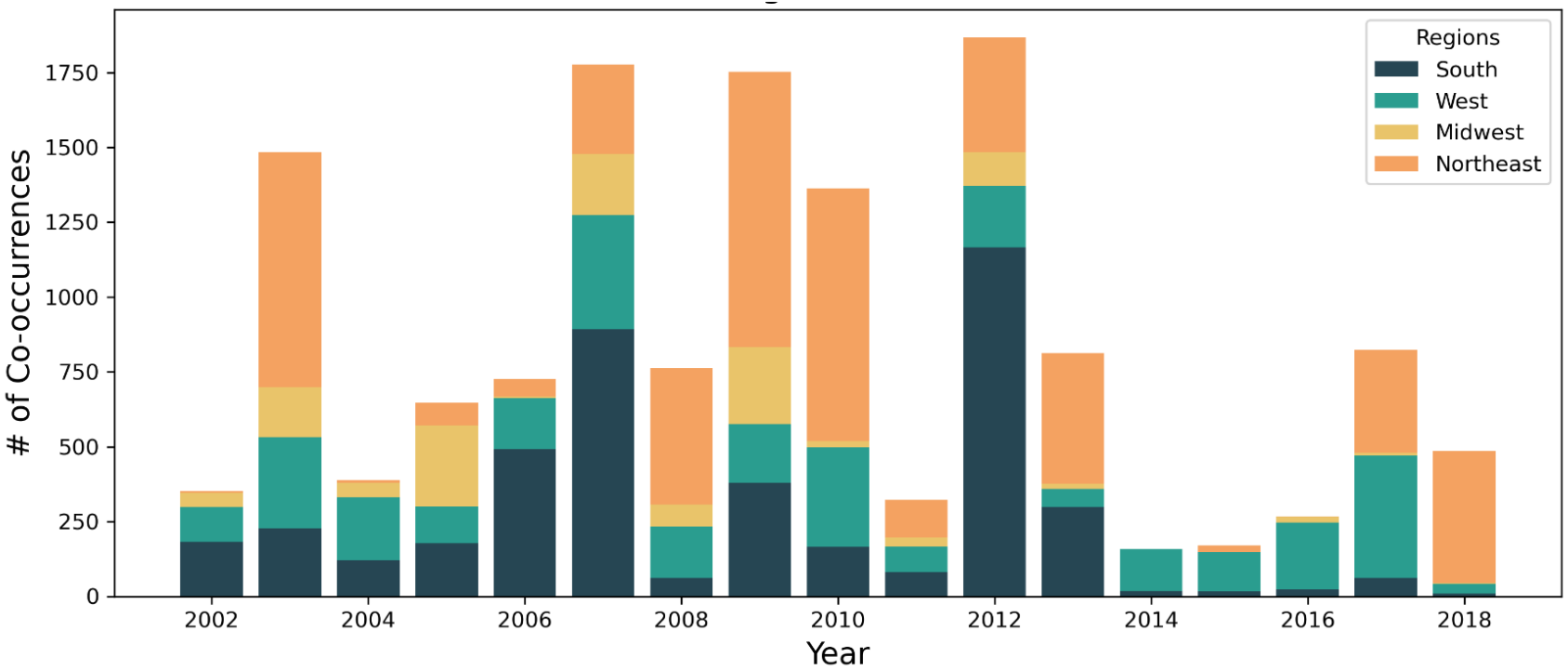
How does the formaldehyde-ozone correlation vary with time of day?



The formaldehyde-ozone (and ozone + NO_2) correlation varies with time of day; strongest in the morning



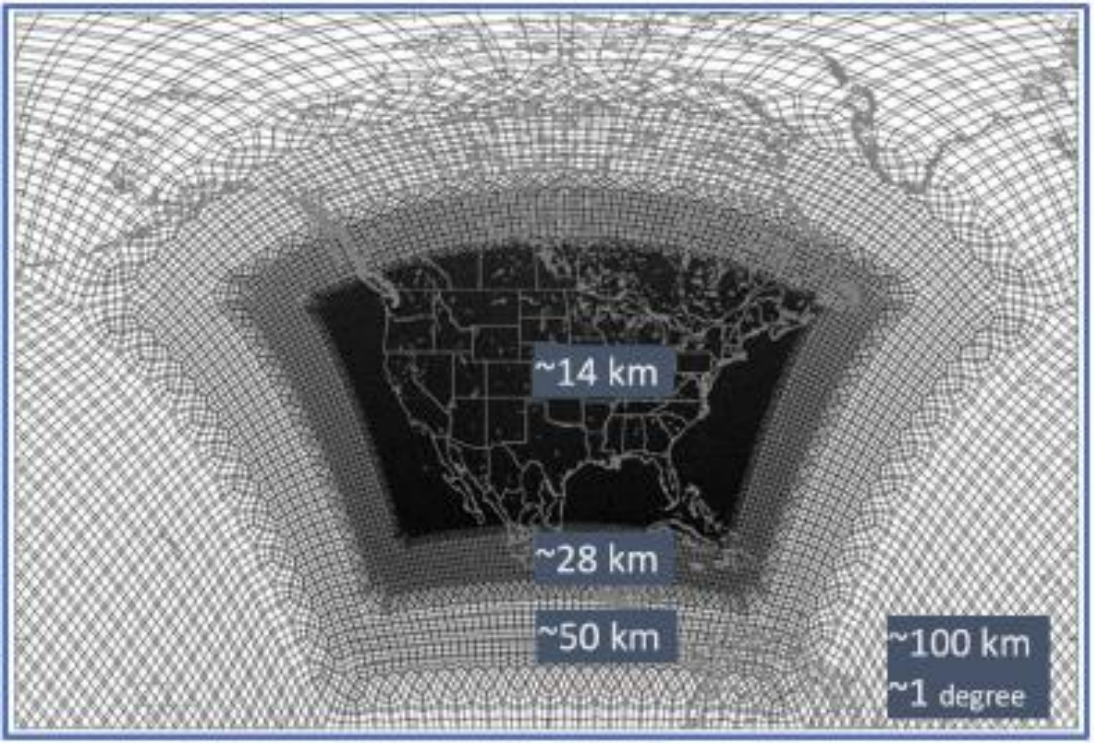
Connecting air pollution & heat extremes: How often are high ozone, fine particles, and heat events co-occurring over U.S. regions each summer?



Amy Shi
MIT
undergrad

Implications for human health?
Will climate change alter these events?

Using a 3D model to better connect the view from space to the ground & consider local versus background influences on ozone, HCHO, and NO_2 across the U.S.A.



Multi-Scale Infrastructure for Chemistry and Aerosols (**MUSICA**)
a global chemistry-transport model with regional refinement

Pfister et al., BAMS, 2020
Schwantes et al., JAMES, 2022
Tang et al., JGR, 2022

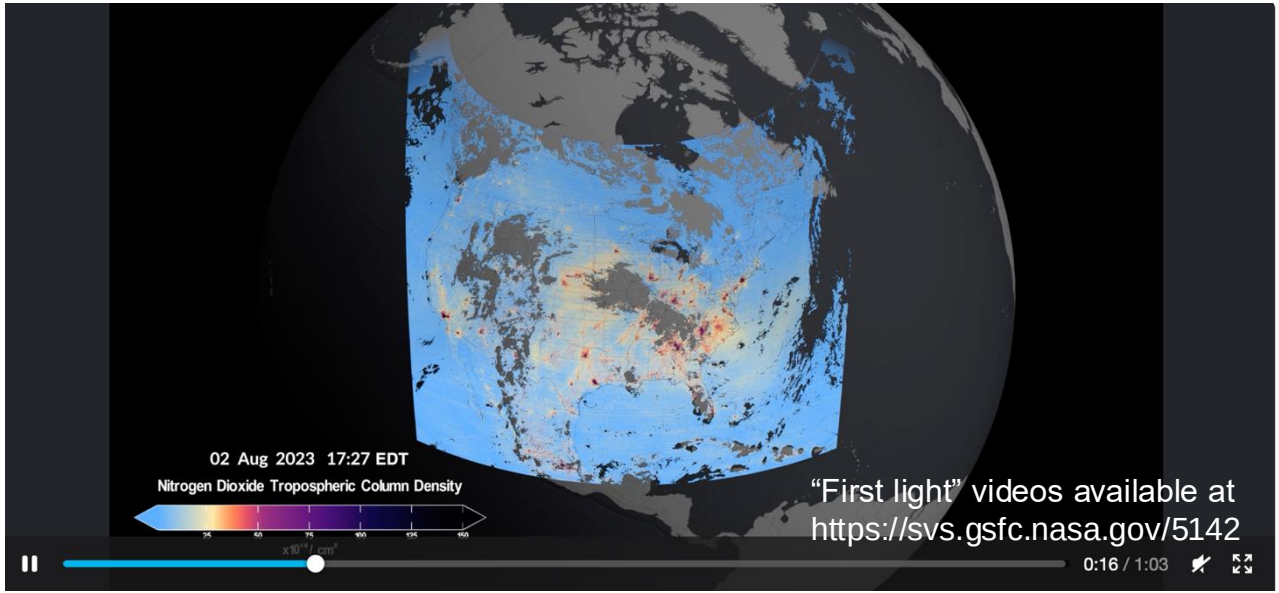
MUSICAv0 (June-Aug 2018)
-- standard configuration
-- now with hourly NEI 2017 emissions

M. Tao, L. Emmons, G. Pfister, D. Jo

NCAR
NATIONAL CENTER FOR ATMOSPHERIC RESEARCH

Analysis to support air quality and health TEMPO applications for surface ozone

A NASA HAQAST3 Y3 Tiger Team (July 2023-December 2024)



This summer we conducted listening sessions with LADCO; MDE; CT DEEP; NYS DEC; GA EPD; Tracking California; Public Health Institute; US EPA; Union of Concerned Scientists; HEI; Urban Institute

HAQAST PIs/Co-Is: Arlene Fiore (MIT and LDEO/Columbia) Daniel Goldberg (GW), Tracey Holloway (U WI Madison), Jen Kaiser (Georgia Tech), Jingqiu Mao (U AK Fairbanks), Talat Odman (Georgia Tech), Randall Martin (WUSTL), Ted Russell (Georgia Tech), Daniel Tong (GMU), Chris Uejio (FSU), Jun Wang (U Iowa), Amber Soja (NASA LaRC); Emily Gargulinski (NIA) **& many other collaborators**

Common themes emerging from listening sessions: Five topical foci

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- Exposure burdens (aggregate, multi-stressor)
  - smoke/ozone; pollution/heat; EJ; time-of-day variations
- Fire smoke and ozone exceedances
  - prescribed burns; non-fire sources; spring events; attribution
- Understanding and communicating uncertainties
  - ozone profile; validation; column-vs-surface; data fusion
- Emission inventories
  - trends; location; sectoral (traffic, ports; ag; soil; intermodal)
- Ozone-forming chemistry
  - evaluation: field campaigns, Pandoras, lidars; attribution

Next TEMPO-ozone TT Call: Monday November 13th at noon Eastern
-- Open meetings: Please join us for any of our upcoming calls --

Common themes emerging from listening sessions: Three types of deliverables

- "Plain-language" tip sheets
  - strengths/limitations; pitfalls to avoid; best practices; communicate uncertainties (margin of error, associated with spatial resolution, time of day, combined with other datasets)
- "Use-case" documents
  - technical guidance with real-world examples, e.g. how to: compare Pandoras and TROPOMI, TEMPO; download TEMPO data; plot a map
- "Usable" datasets
  - in preferred formats, standardized, policy-relevant (census tract, zip code), different temporal/spatial averages, with uncertainty; pre-made scripts

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