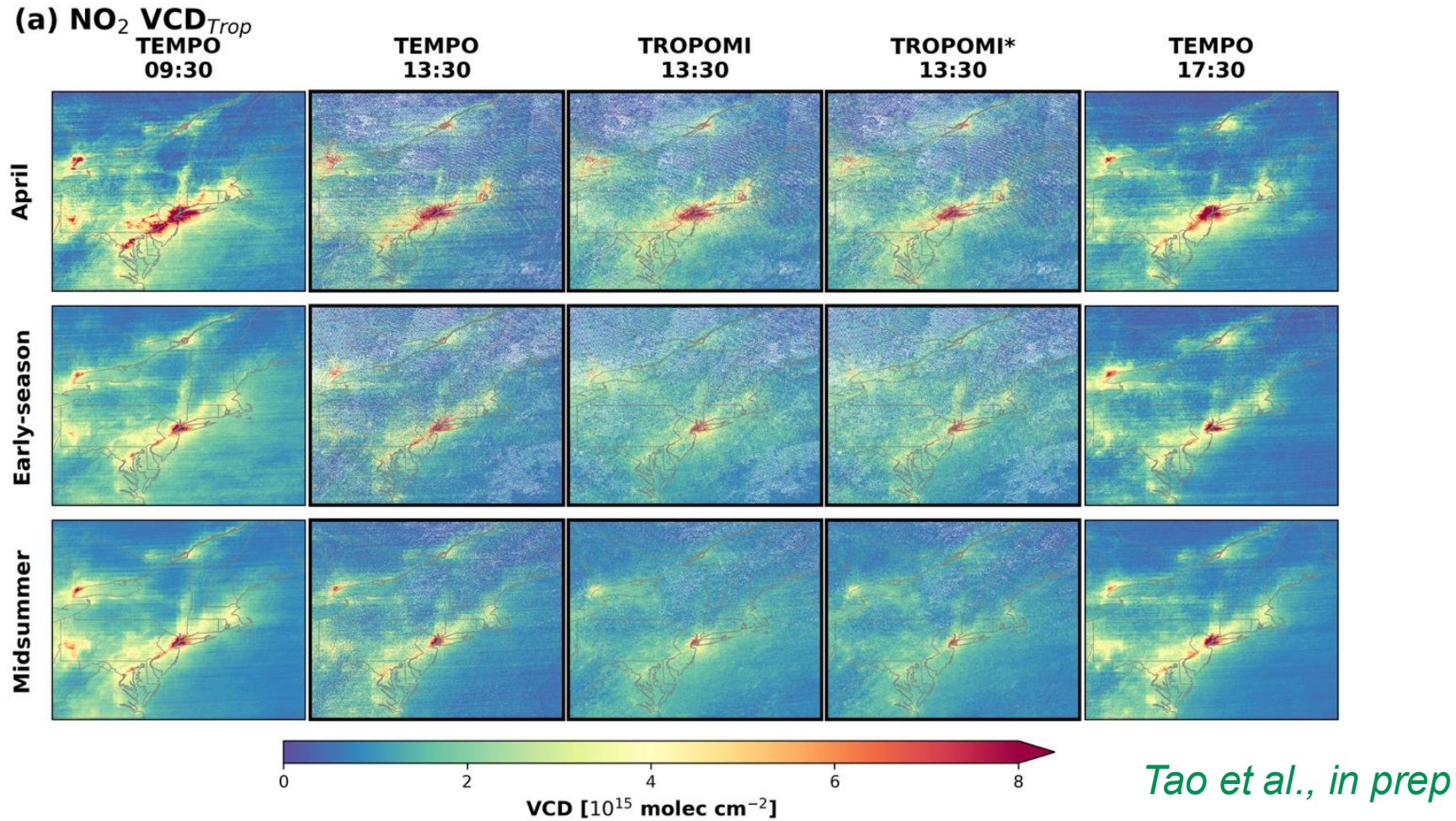


New space-based windows into ozone-forming chemistry



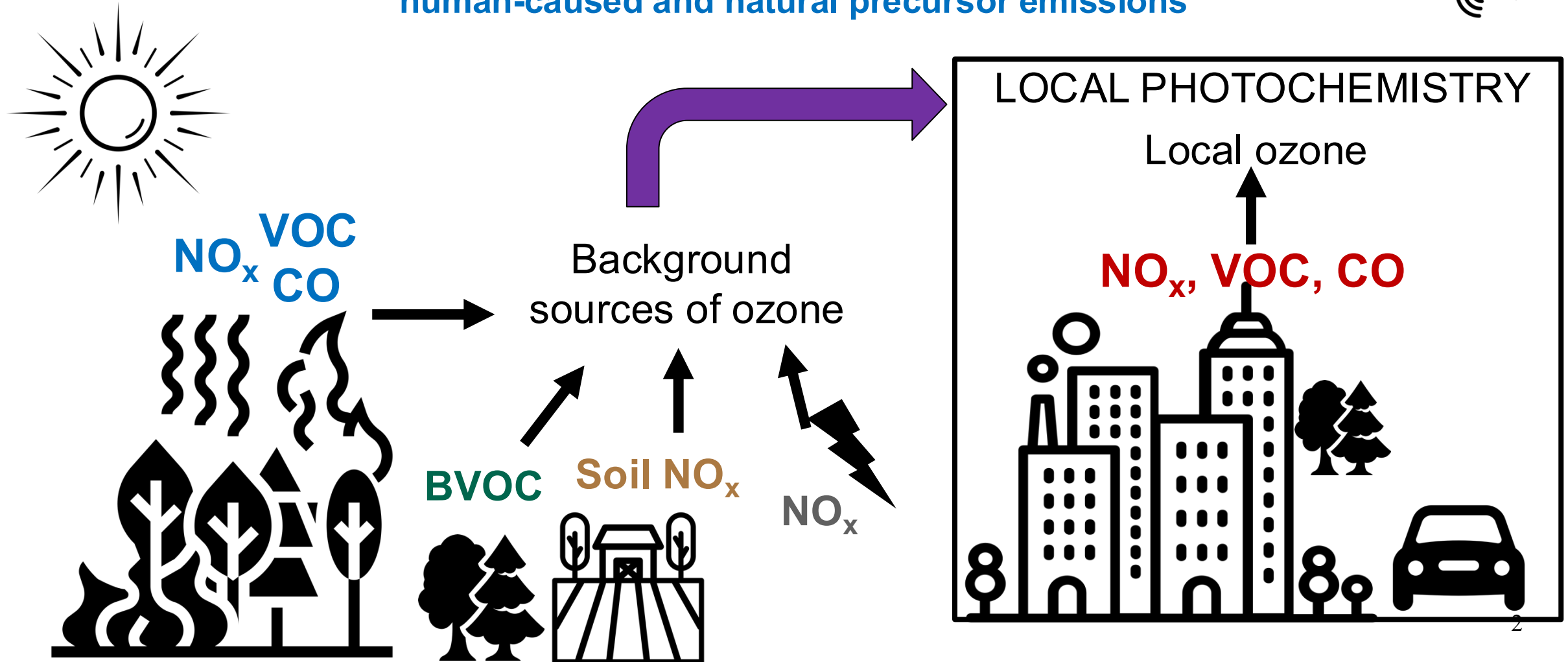
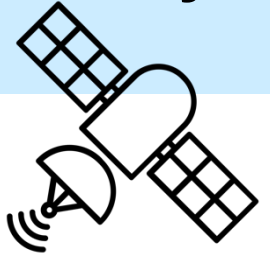
Arlene M. Fiore
amfiore @ mit.edu | teampacc.mit.edu



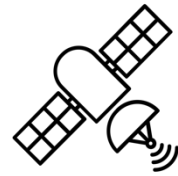
HAQAST Madison Meeting
University of Wisconsin – Madison
May 14, 2026

Ozone smog is not emitted directly but forms through atmospheric chemistry

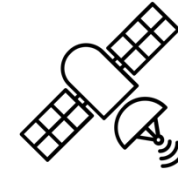
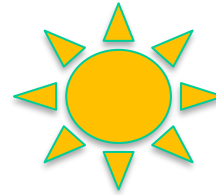
Measured ozone reflects an unknown combination of production from human-caused and natural precursor emissions



Satellites don't directly measure ground-level ozone



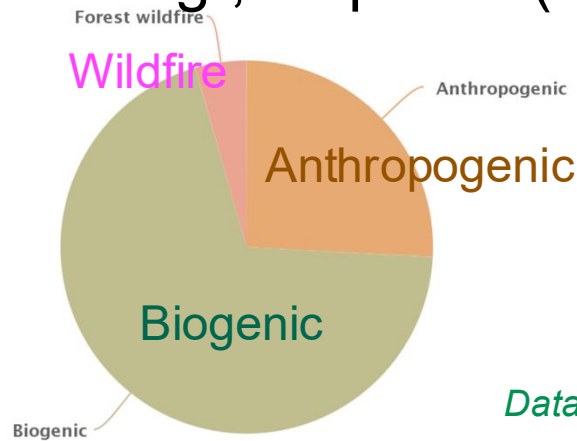
formaldehyde
HCHO



nitrogen dioxide
NO₂

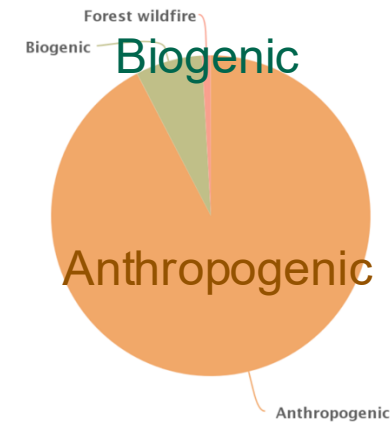
Volatile Organic Compounds (VOCs)

e.g., Isoprene (C₅H₈)



Nitrogen Oxides (NO_x)

= NO + NO₂

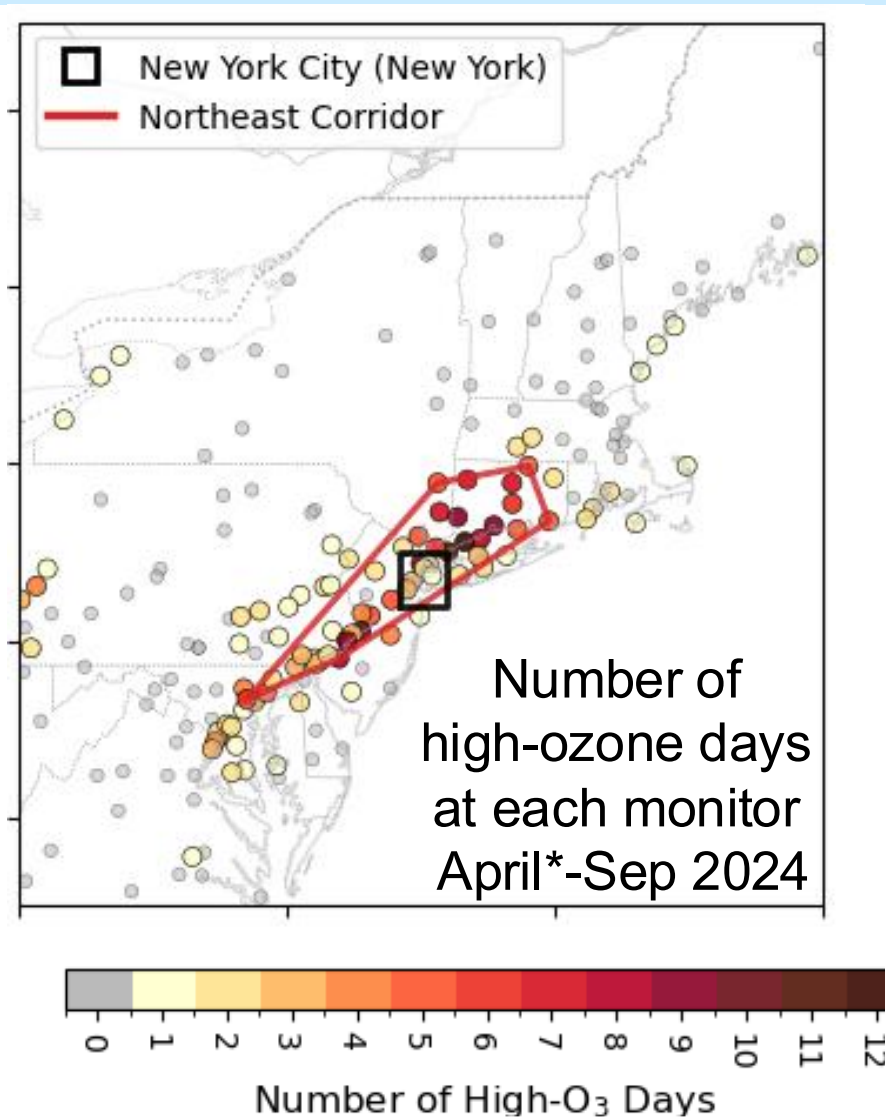


OZONE
(O₃)

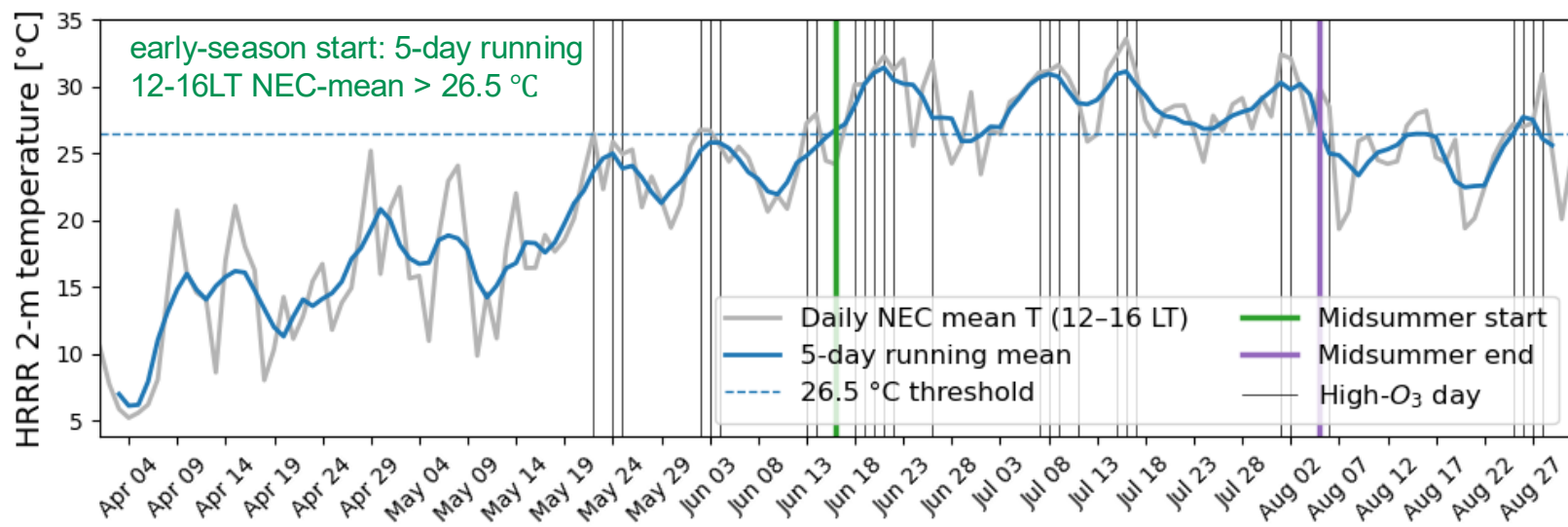
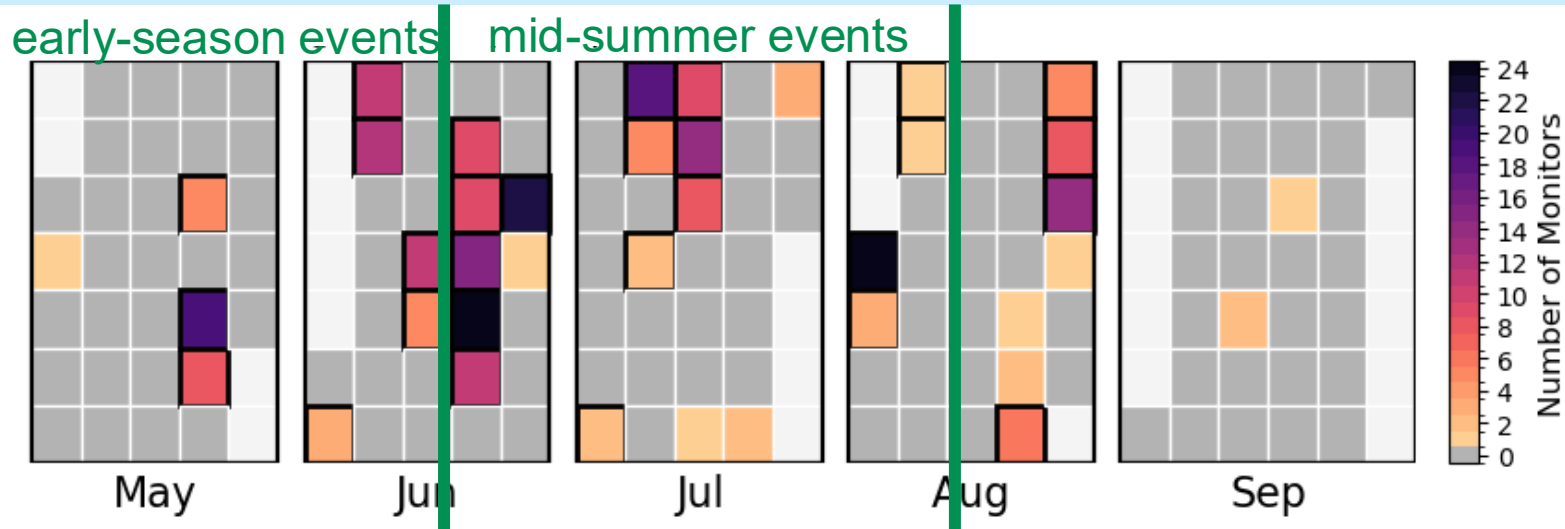
Data source: U.S. EPA 2014 National Emissions Inventory

Key challenge: Air quality management requires source apportionment, especially on days exceeding the ground-level O₃ NAAQS threshold

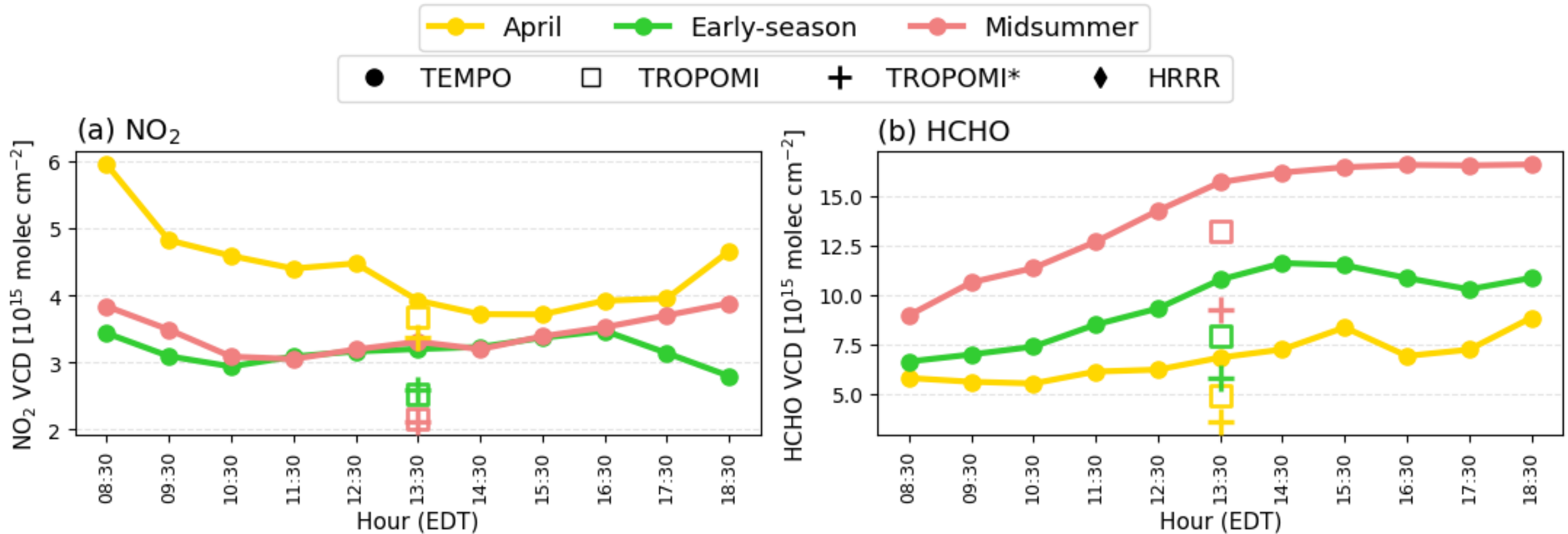
Our focus is on the "Ozone Transport Region" during the 2024 ozone season (the first full ozone season with TEMPO products available)



*none occur in April

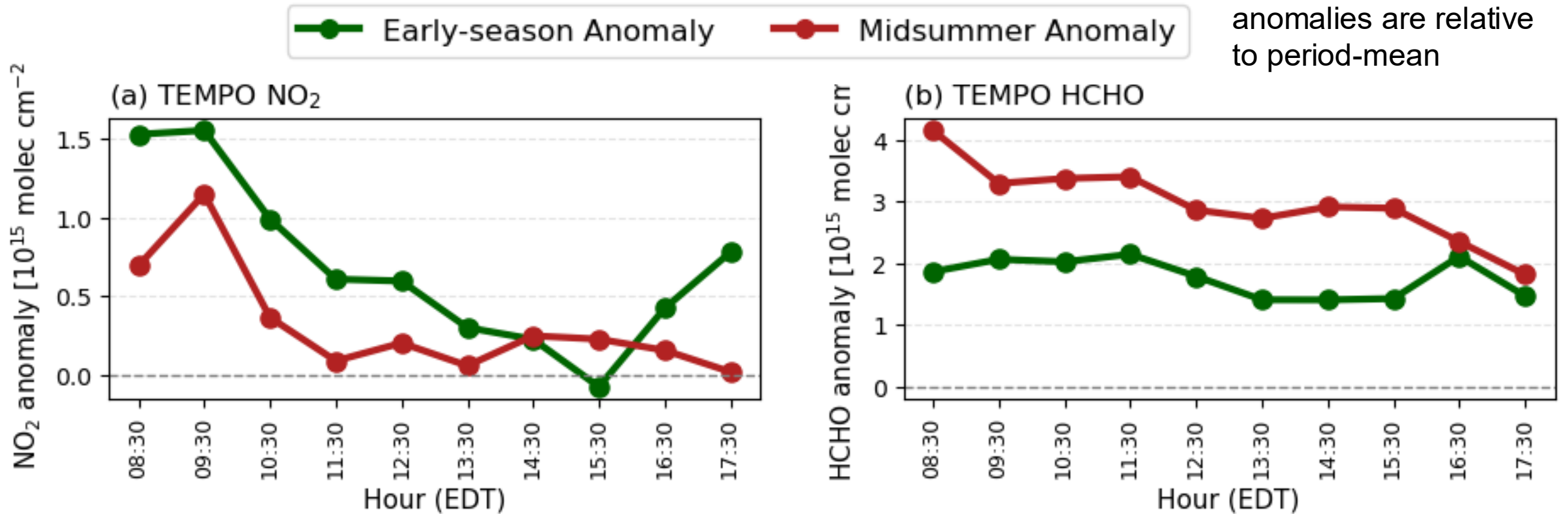


TEMPO (and TROPOMI) sense expected seasonal transition in NO₂ and HCHO over the Northeast Corridor



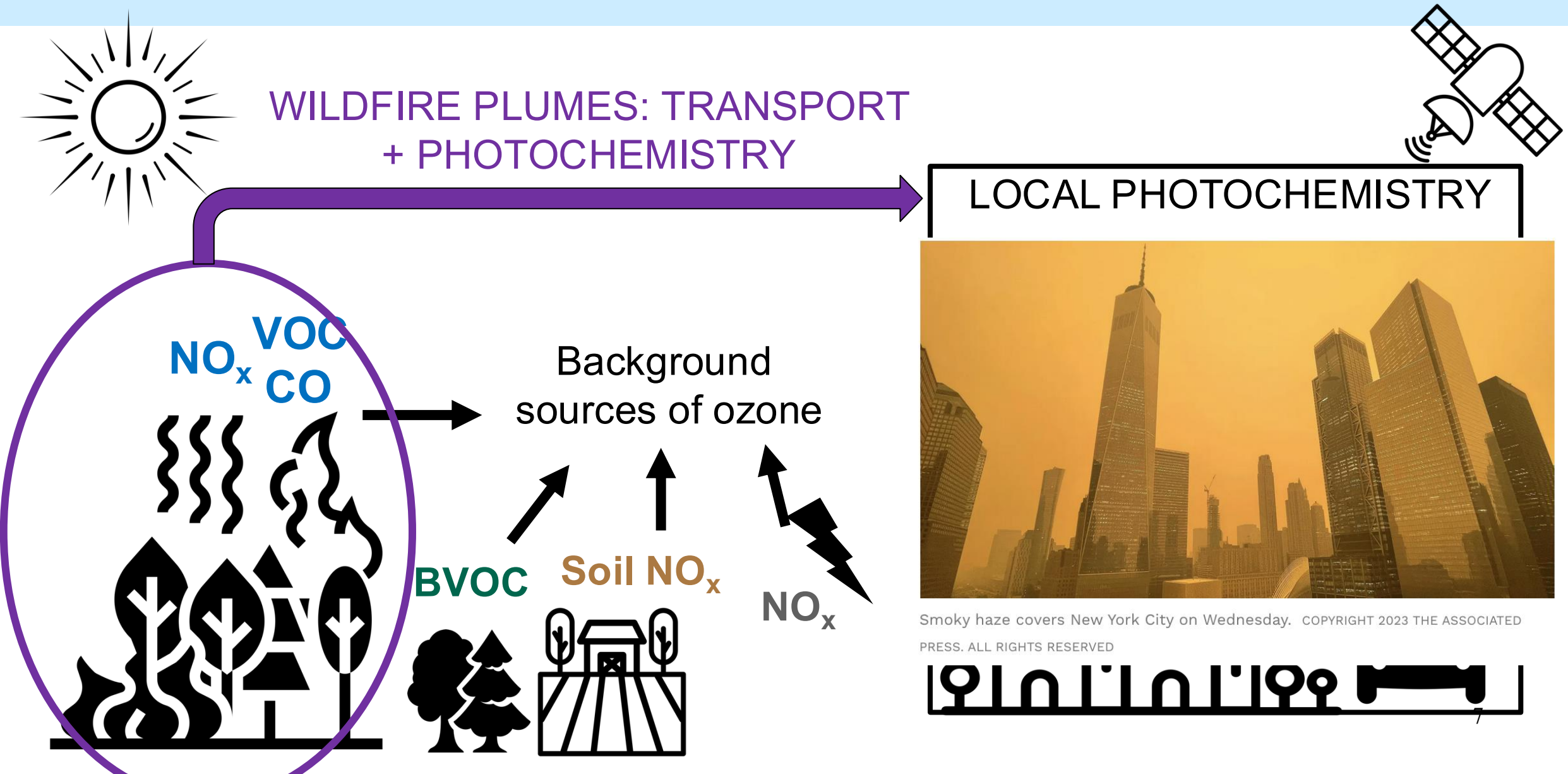
- New top-down view of seasonal differences by time of day:
 - flattening of NO₂ diurnal amplitude
 - steepening of morning to early-afternoon rise in formaldehyde
- Comparison to ground-based monitors & Pandora spectrometers in progress

During high-ozone events, how does the chemical environment differ on days occurring in the **early-season** versus **midsummer**?

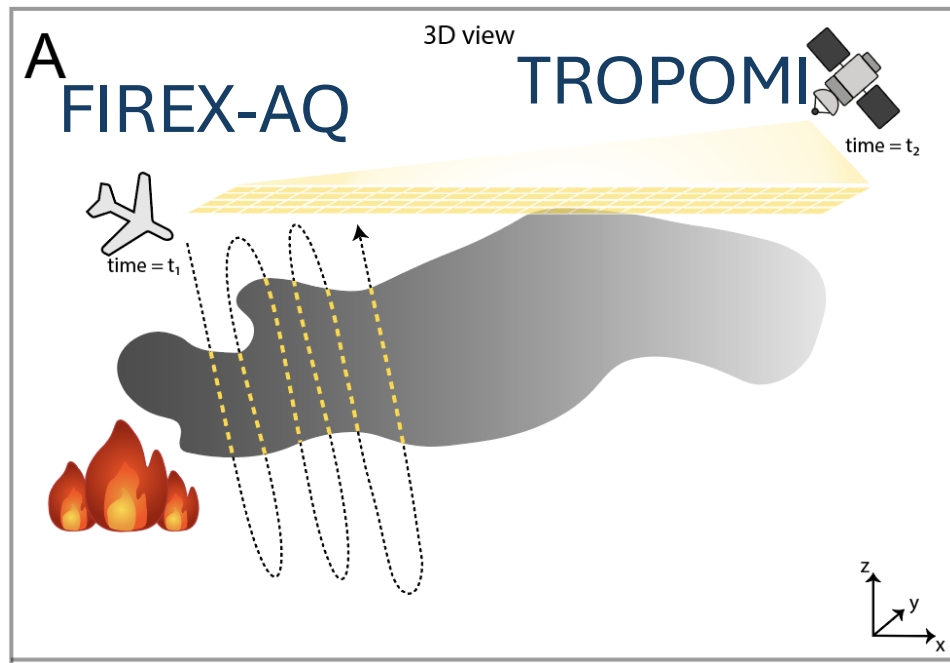


- Averaged over the Northeast Corridor, TEMPO suggests higher morning tropospheric NO₂ but lower HCHO during **early-season high-ozone events** relative to **midsummer high-ozone events**
- Comparison to ground-based monitors & Pandora spectrometers in progress

How much ozone is produced by wildfires? Is the ozone transported, or produced when urban emissions mix with transported smoke?



New approaches to diagnose ozone-forming chemistry in wildfire plumes

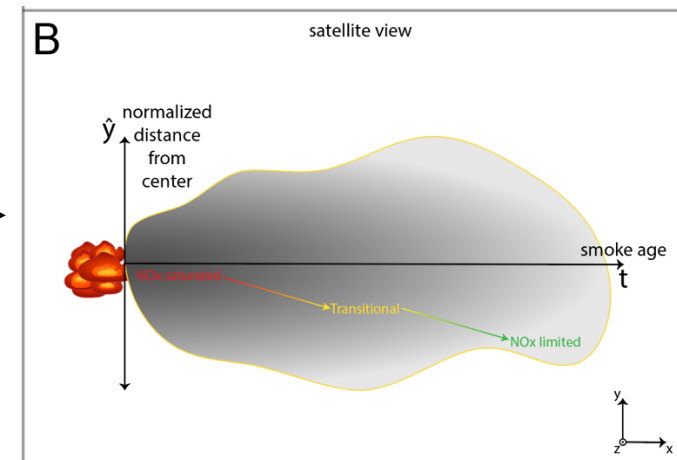


Machine-learning
(neural net)

Ozone Production

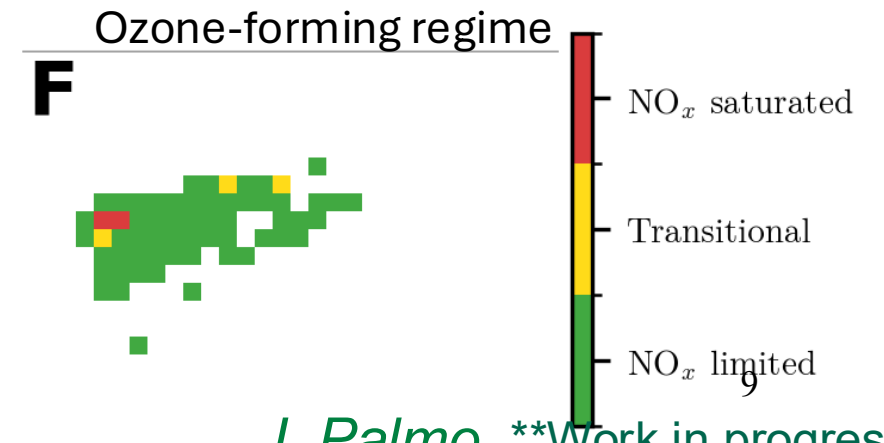
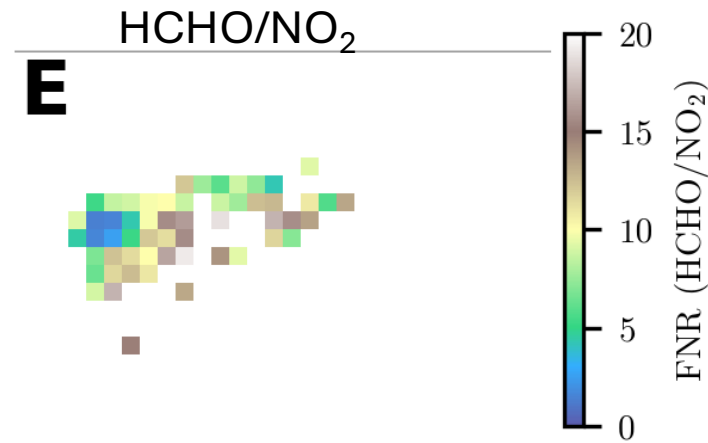
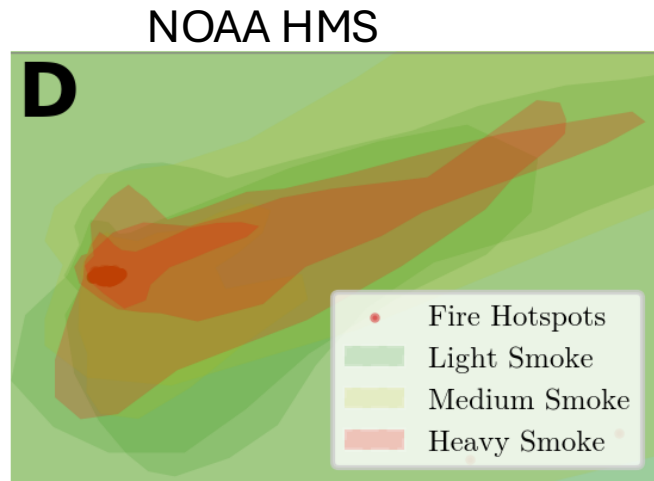
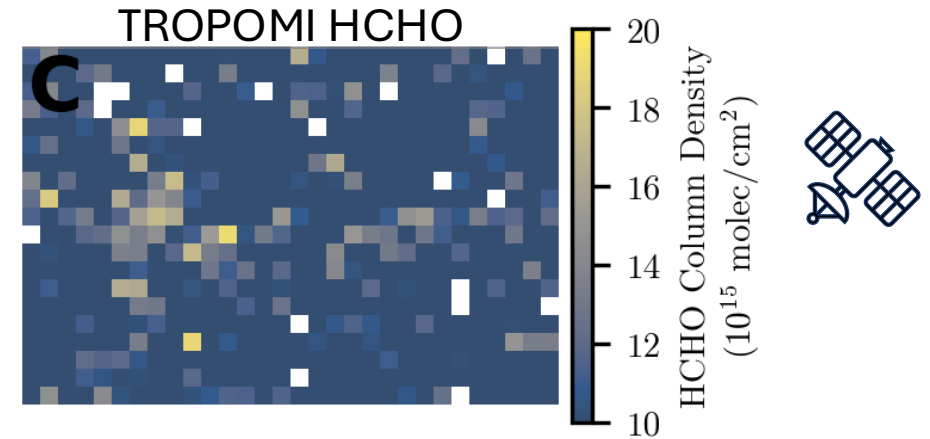
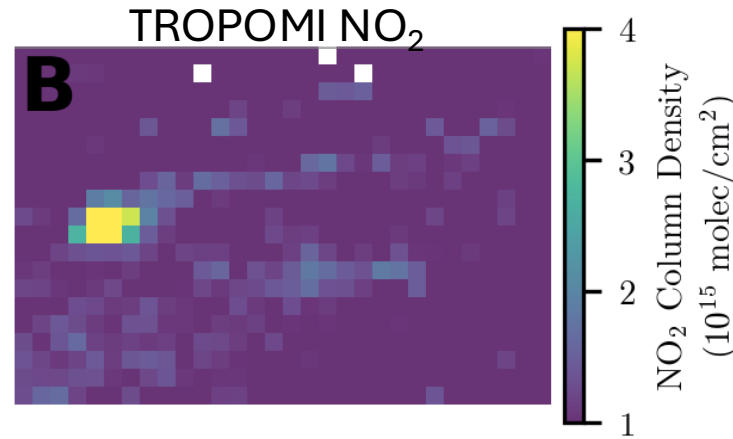
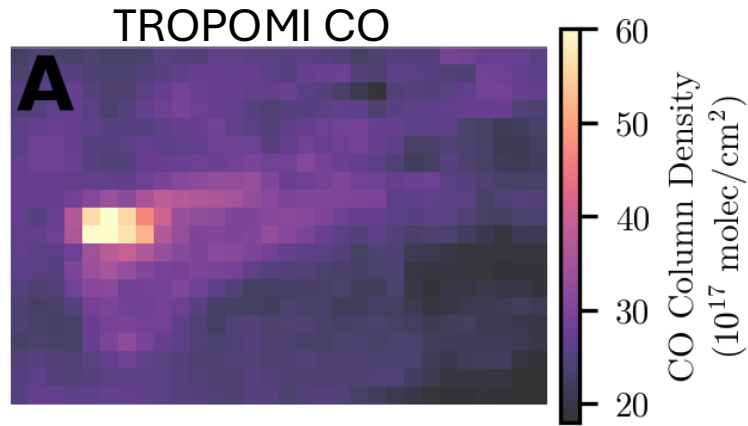
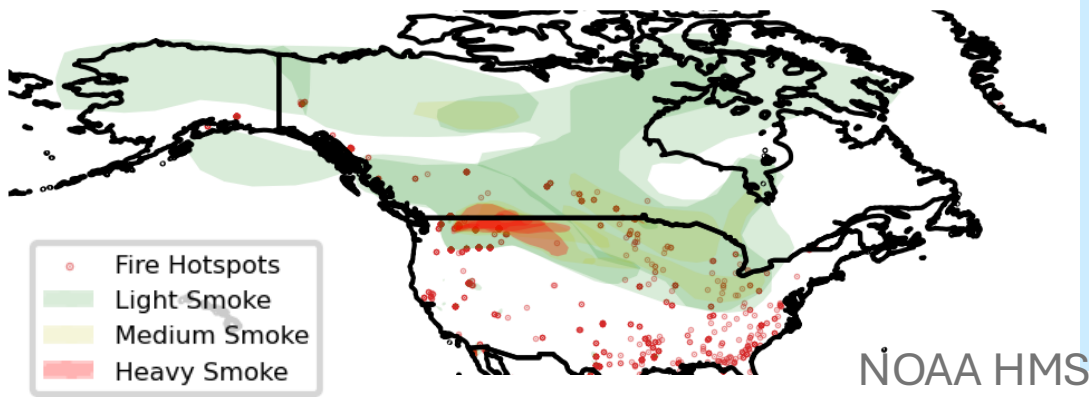
(builds on
Souri et al., 2025;
2026)

steady-state
 $\text{HO}_x\text{-NO}_x\text{-VOC-O}_3$
model



(builds on *Jin et al., 2020; 2023; 2025*)

Case study: Williams Flats Fire (WA) August 8, 2019



Evaluating hourly PM_{2.5} forecasts from the perspective of an individual aiming to minimize exposure: Is it safe to go out today? When should I go running?

BAMS Article

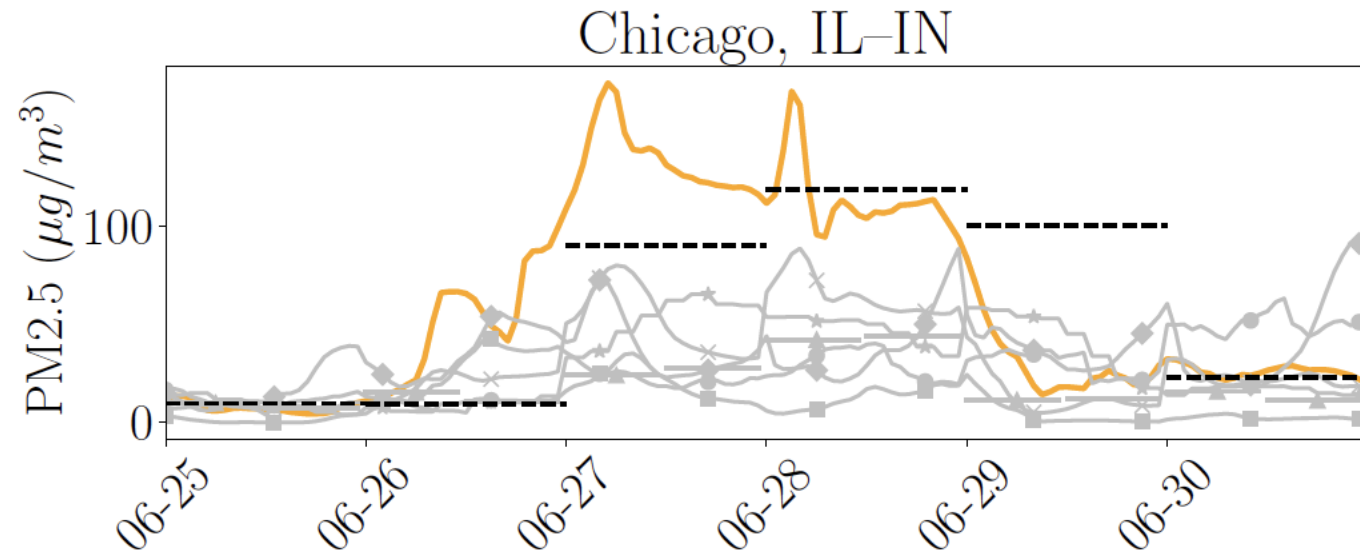
Are Hourly PM_{2.5} Forecasts Sufficiently Accurate to Plan Your Day? Individual Decision-Making in the Face of Increasing Wildfire Smoke

Renato Berlinghieri^{a,b}, David R. Burt^{a,b}, Paolo Giani^c, Arlene M. Fiore^c, and Tamara Broderick^{a,b}

DOI: [10.1175/BAMS-D-24-0291.1](https://doi.org/10.1175/BAMS-D-24-0291.1)

Corresponding author: Renato Berlinghieri, renb@mit.edu

Renato Berlinghieri and David R. Burt contributed equally to the work.



- Evaluated whether existing forecasts are reliable for these personal decisions
- Outlined development paths to better forecasts
- Recommended new metrics to assess skill and benchmark future improvements in PM_{2.5} forecasts.

Overarching questions guiding our HAQAST “Investigator Project” & an introduction to our team

- *What controls “early-season” high-ozone events in the NEUS?*



Kevin Civerolo
Ruby Tian



Alexandra Karambelas
Paul Miller

- *What is the relationship between smoke and high-ozone events?*



Temilayo Adeyeye



- *How does exposure to air pollution intersect with other cross-sectoral risk factors regionally and globally and how are these risks co-evolving over time? [Co-I Adam Schlosser (MIT)]*



Rohini Sampooram Swaminathan



Pallavi Pant

Technical collaborators:

Xiong Liu
Gonzalo González Abad
Caroline Nowlan



Xiaomeng Jin

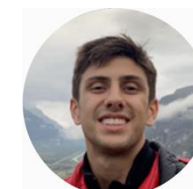


Alex de Sherbinin
COLUMBIA CLIMATE SCHOOL
CENTER FOR INTEGRATED
EARTH SYSTEM INFORMATION

Marianthi-Anna
Kioumourtzoglou



Lukas Valin

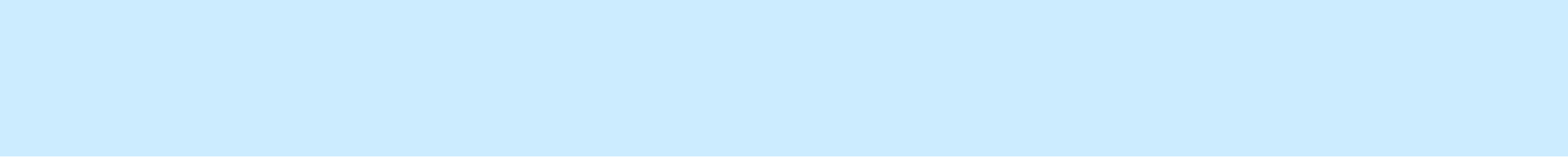


Joe Palmo



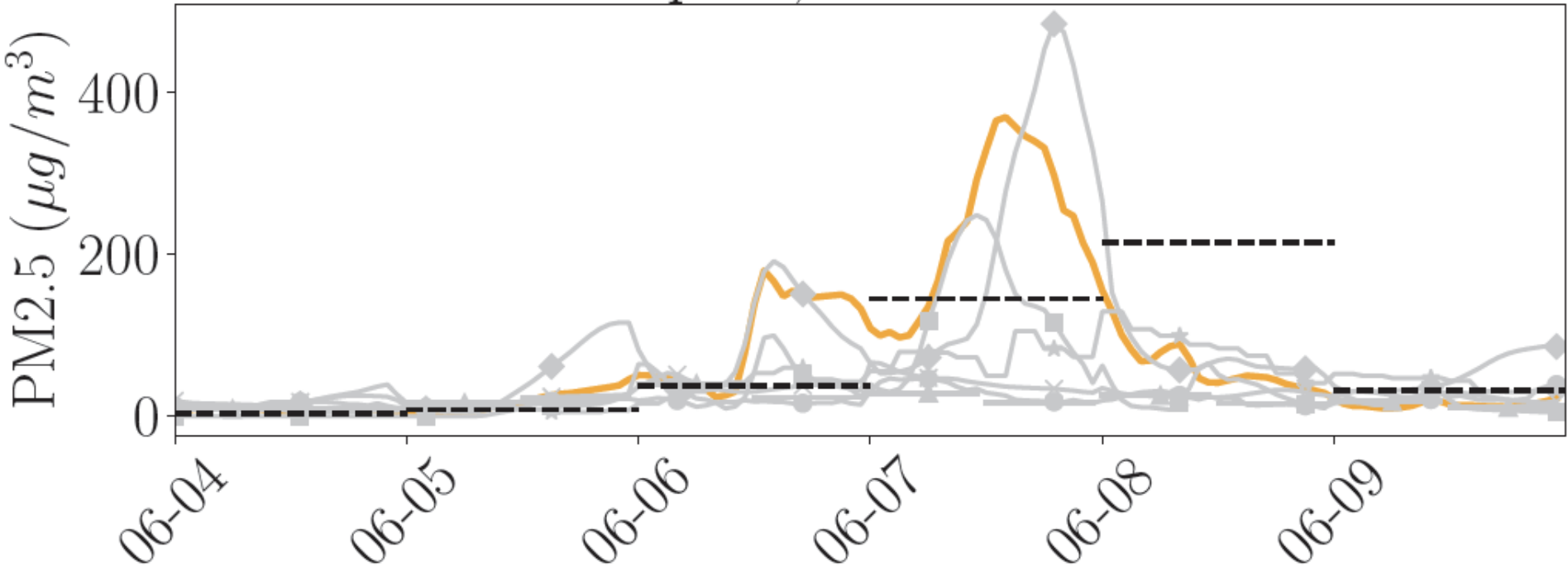
Madankui Tao





Philadelphia, PA-NJ-DE-MD

- AirNow
- NAQFC
- HRRR
- ◆ GEOS-CF
- × CAMS
- ▲ Aurora
- ★ HAQES
- - - Persistence



Interested to learn more about satellite products for ground-level ozone? Please check out TEMPO-related HAQAST materials

<https://haqast.org/tempo-applications-for-surface-ozone-tiger-team/>

“Clickable” Table

Satellite Table




Summary of satellite instruments for atmospheric trace gas monitoring that measure column densities of O₃, HCHO, and NO₂. This table contains information on satellite instruments, including name, orbit type, launch year, operation period, spectral range, spatial and temporal resolution, and monitoring region. ESA stands for European Space Agency, NASA for National Aeronautics and Space Administration, EUMETSAT for European Organization for the Exploitation of Meteorological Satellites, and KARI for the Korea Aerospace Research Institute. This table draws insights from a previous summary table in Gonzalez Abad et al. (2019). Please access table references [here](#).

Print Excel CSV Copy



Show 5 entries Search:

"Instrument/Satellite" ▲	Orbit ▲	Launch Year ▲	Operational Period ▲	Spectral Range ▲	Finest Spatial Resolution ▲	Temporal Resolution (Overpass in LT) ▲	Regional Coverage ▲	Reference ▲
Ozone Monitoring Instrument (OMI)/ NASA's Aura	Low-Earth	2004	2004-Present	"UV-VIS (270-500 nm)"	"13 km x 24 km (At nadir)"	Daily at 1:45 PM	Global	Levelt et al., 2018



1-Page Plain Language Summaries

Quick Guide: Use PGN to validate satellite products & model simulations

Quick Guide: Understanding Uncertainty in TEMPO Data

Quick Guide: Comparing Satellite NO₂ versus Ground Level Measurements

& Video Tutorials & Trainings Focused on TEMPO data

[produced by HAQAST3 TEMPO Applications for Surface Ozone Tiger Team]

