

Evaluating the Impact of Resolving Hourly Anthropogenic Emissions on Air Pollutant Simulations in the United States Using the MUSICAv0 Model

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Winter Working Group Meeting
AMWG/CCWG/WAWG Joint Session

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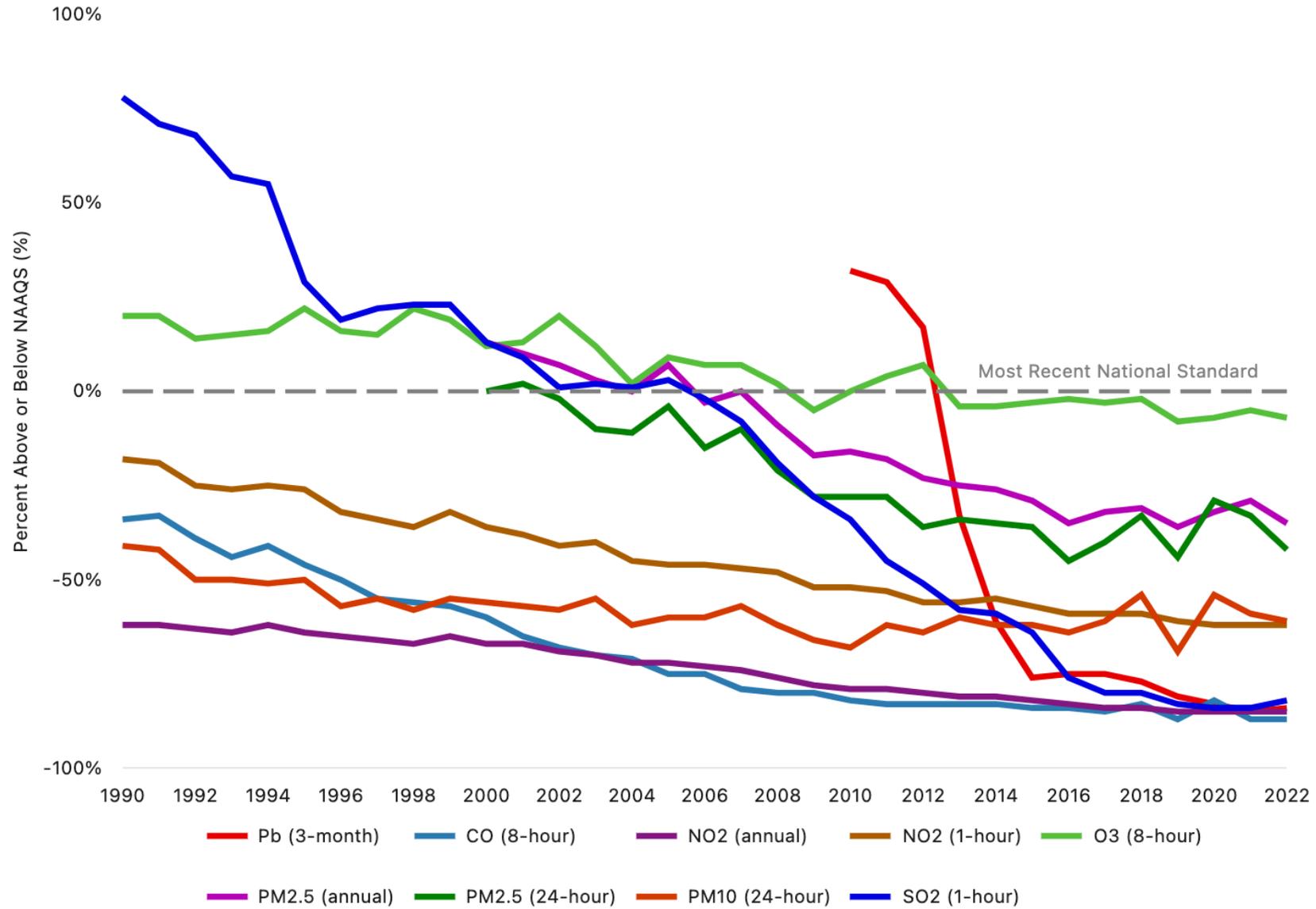


 COLUMBIA CLIMATE SCHOOL
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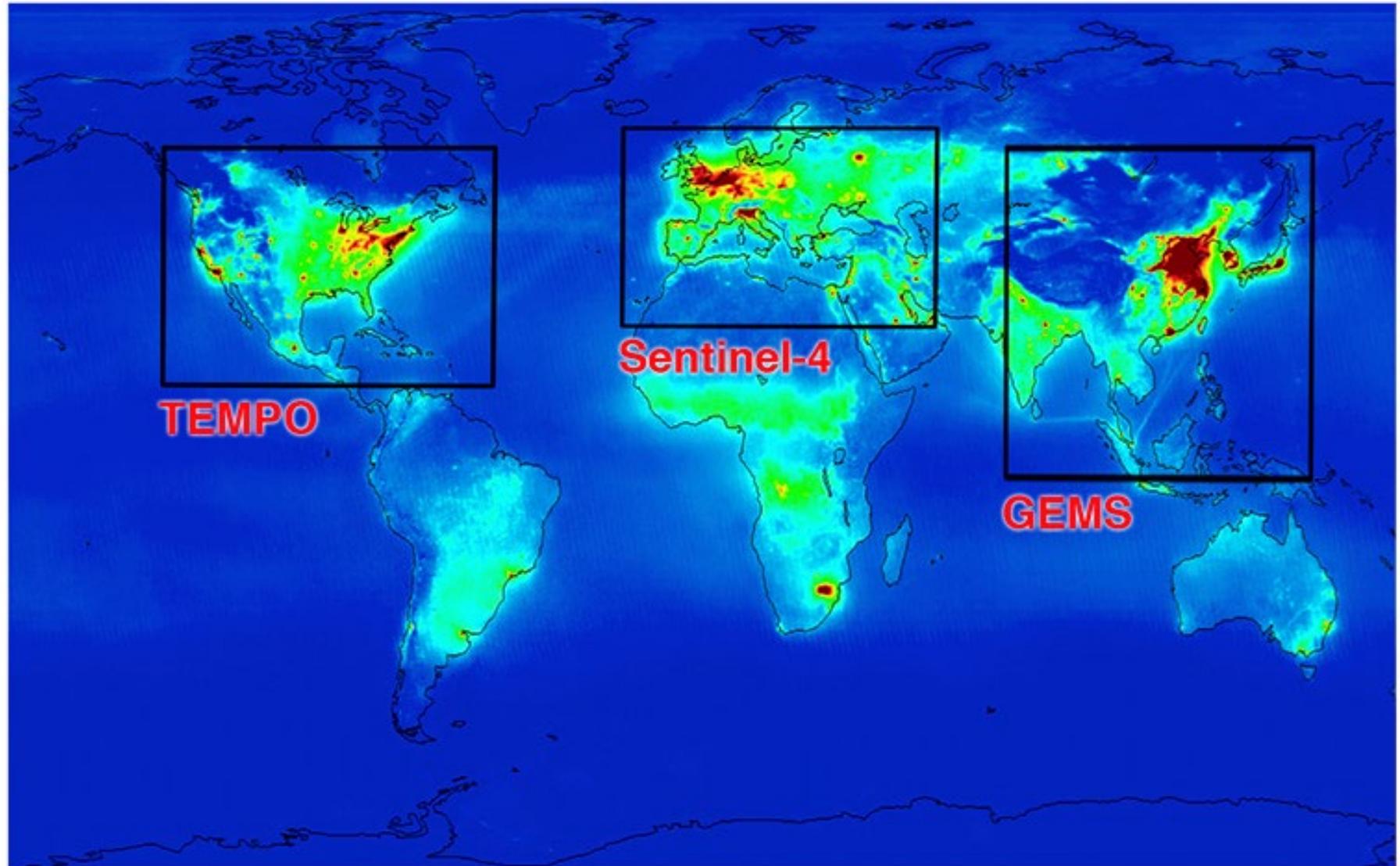
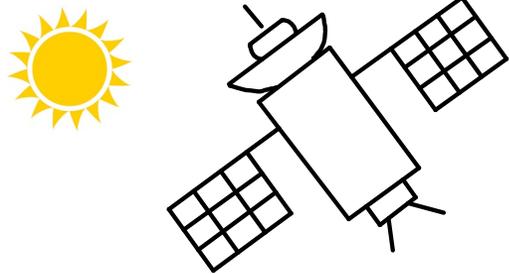
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U.S. Air Quality Trends



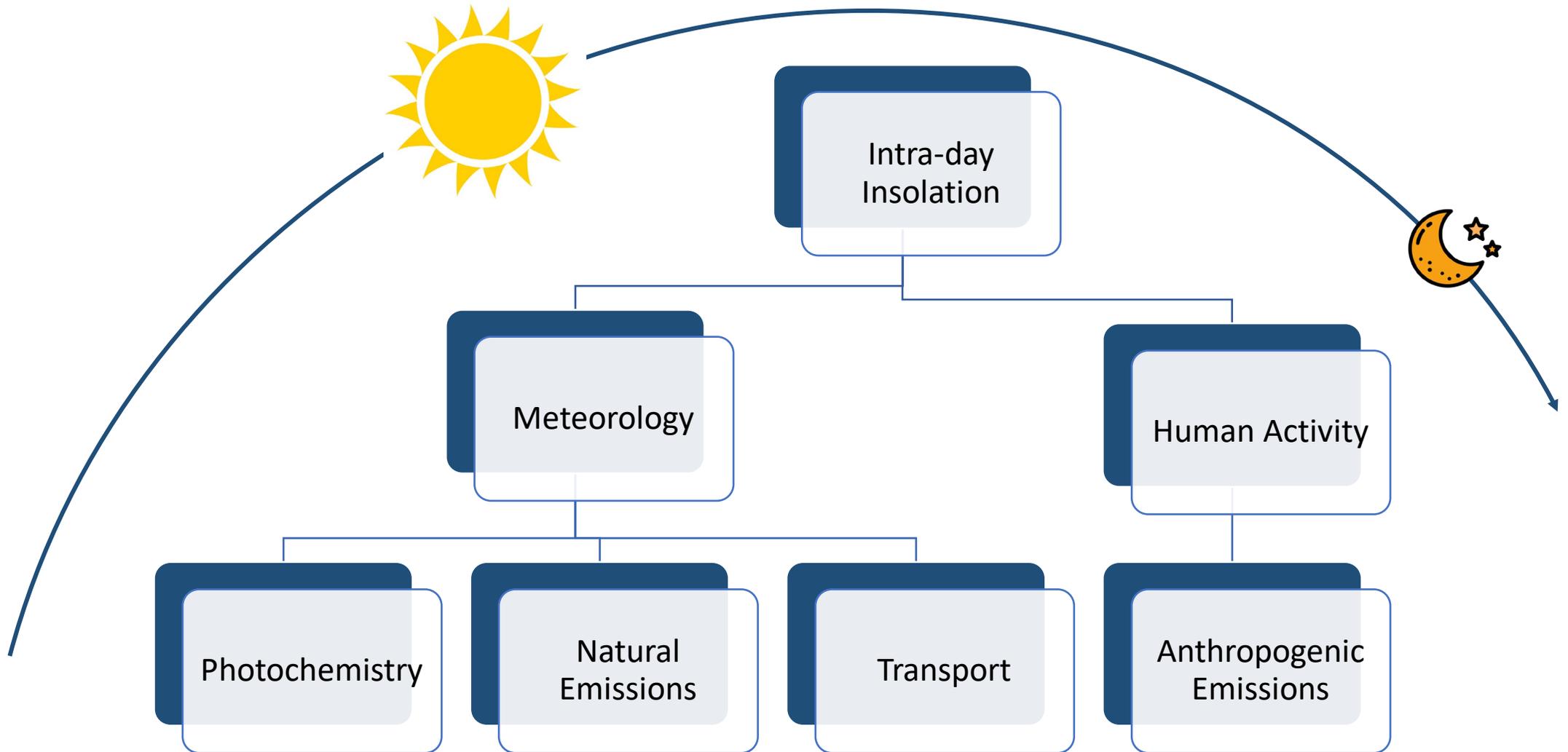
2023 EPA Air Trends Report (https://gispub.epa.gov/air/trendsreport/2023/#air_trends)

Geostationary Satellites with Daylight Hourly Retrievals



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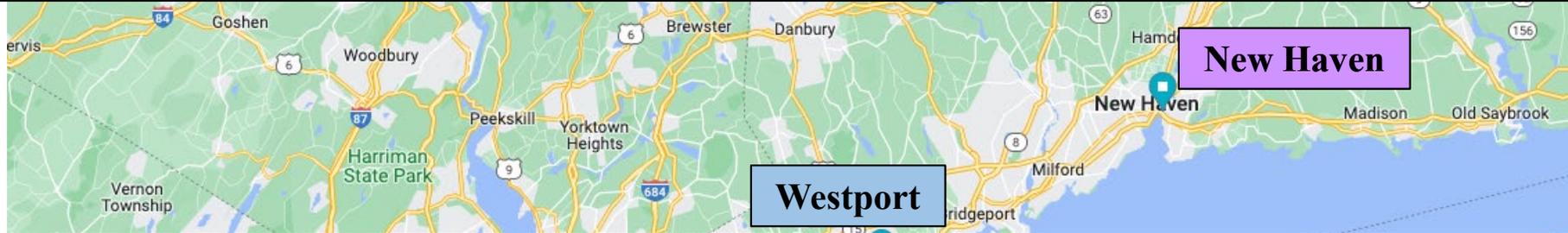
Key Factors Shaping Diurnal Variability of Air Pollutants



Formaldehyde and Nitrogen Dioxide Diurnal Cycles in New York: Insights into Surface Ozone Formation

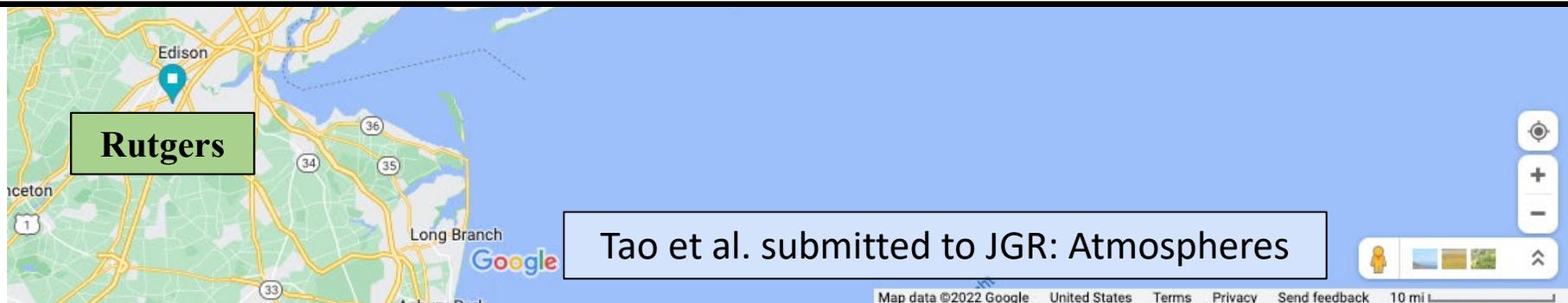


Formaldehyde and Nitrogen Dioxide Diurnal Cycles in New York: Insights into Surface Ozone Formation



For June-August 2018 over NYC and Long Island Sound:

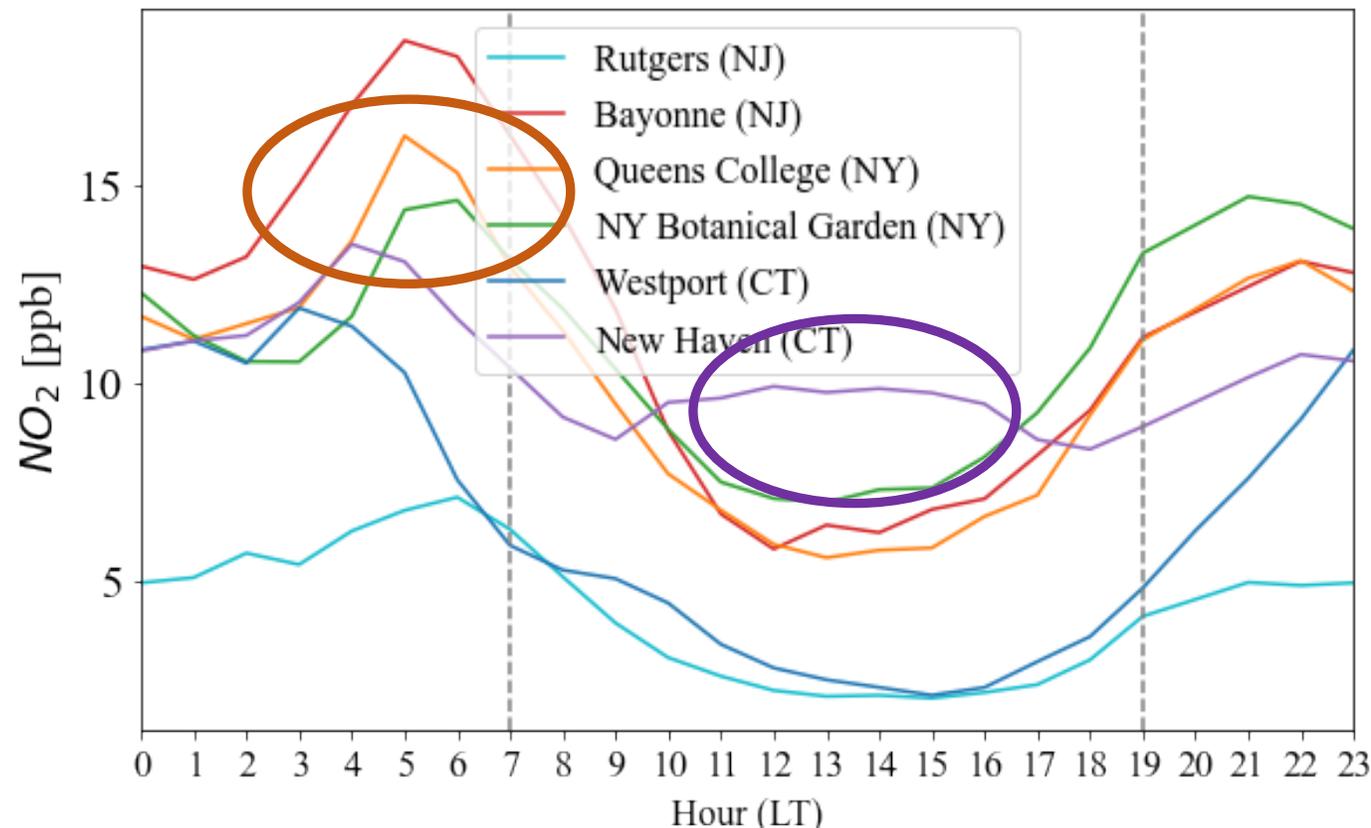
1. How do diurnal cycles in HCHO and NO₂ concentrations vary over urban-rural gradients?
2. What is the relationship between variations in near-surface concentrations and tropospheric vertical column densities?



Variations in the diurnal changes of surface NO_2 across NYC in:

- Diurnal range
- Timing of the daily maximum and minimum concentrations

Observed Surface NO_2 Concentrations (June-August 2018)

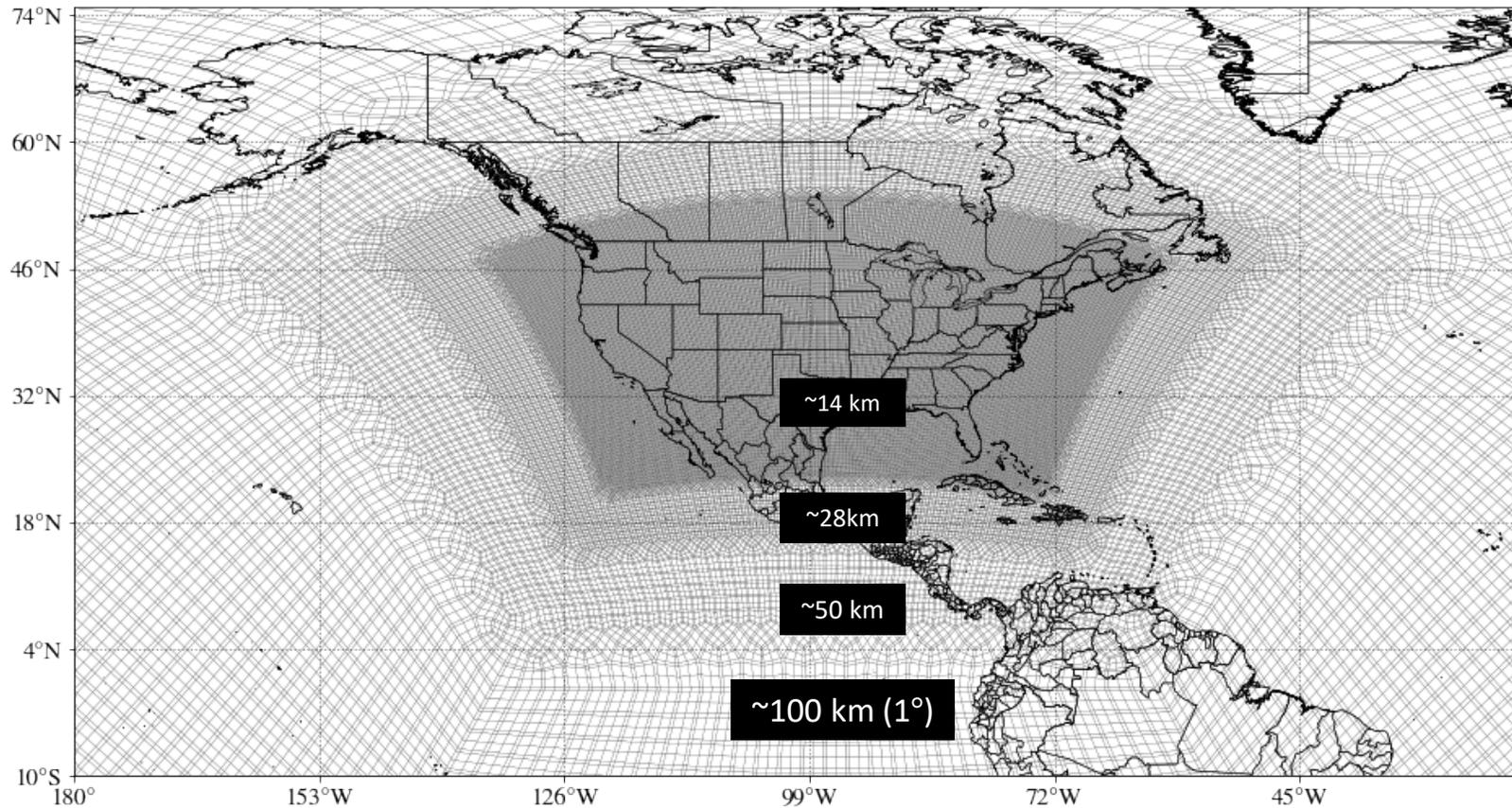


Research Objectives

For July 2018 over CONUS:

1. How do simulated trace gas concentrations and their diurnal variations differ when using CAMS-GLOB-ANT v5.17 emissions compared to the 2017 U.S. NEI?
2. How does using hourly instead of monthly anthropogenic emissions data affect simulations of trace gas concentrations and their diurnal variations?

Multi-Scale Infrastructure for Chemistry and Aerosols (MUSICAv0)



= CESM/CAM-chem-SE with ne0CONUSne30x8
(Pfister et al., *BAMS*, 2020, Schwantes et al., *JAMES*, 2022)

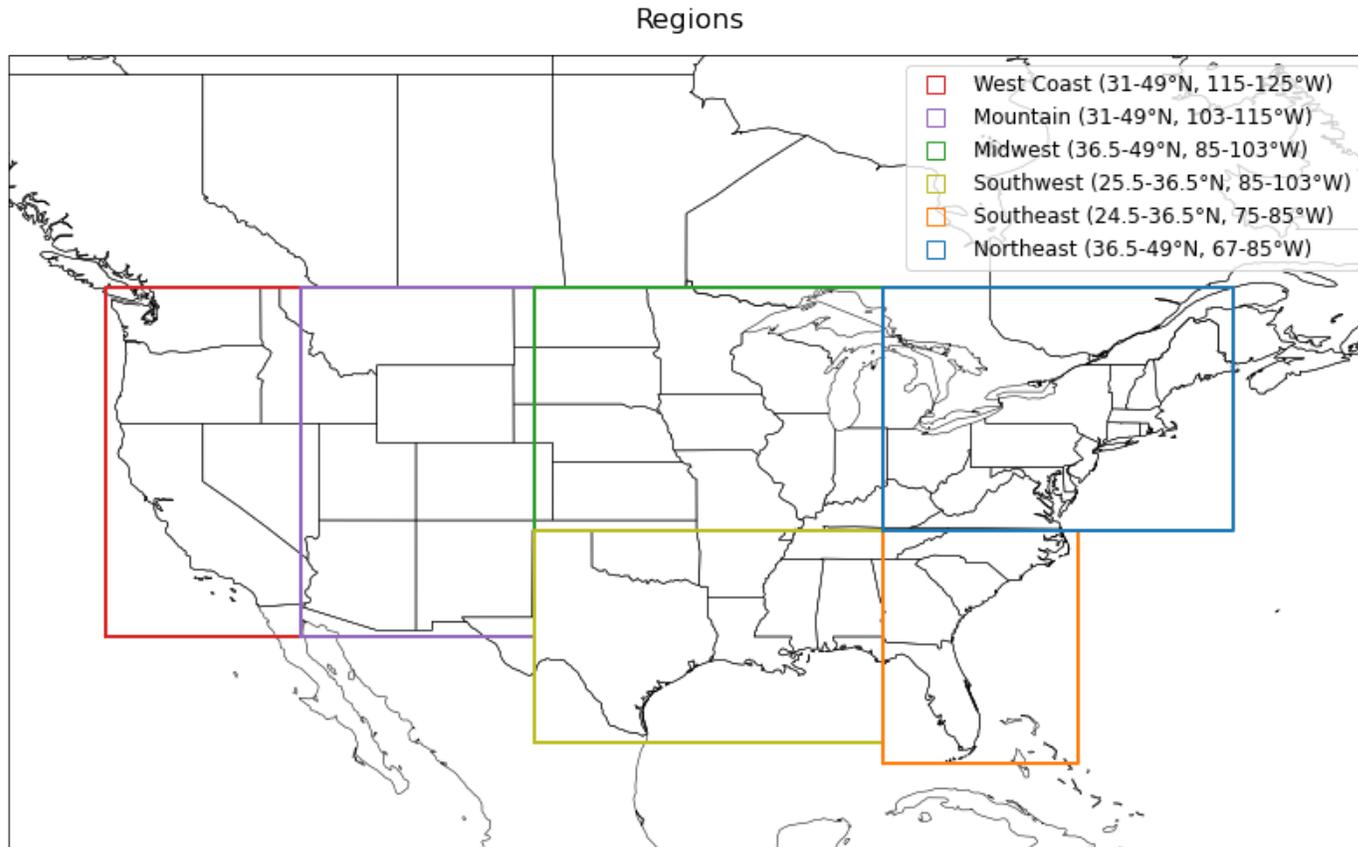
Base Case Simulation

Configuration Item	Description
Resolution	ne0CONUSne30x8_ne0CONUSne30x8_mt12 (0.125 (~14km) degree over CONUS + 1 degree global)
CompSet	FCnudged (F: for specified sea surface temperature and sea ice instead of fully coupled)
Chemical Mechanism	MOZART-TS1 troposphere-stratosphere chemistry
Meteorology	Nudged to Modern-Era Retrospective analysis for Research and Applications Version 2 (MERRA2) reanalysis
Emissions	<u>Anthropogenic</u> : Copernicus Atmosphere Monitoring Service for global anthropogenic emissions (CAM5-GLOB-ANT) v5.1
	<u>Biomass burning</u> : Fire INventory from NCAR (FINN) v2.5
	<u>Biogenic</u> : : Calculated online in the land component of CESM based on Model of Emissions of Gases and Aerosols from Nature (MEGAN) v2.1
Simulated time	Jan 1, 2018 – August 31, 2018
Output dimension	ncol = 174098; lev = 32; [hybrid level at midpoints (1000*(A+B))] ilev = 33. [hybrid level at interfaces (1000*(A+B))]

Sensitivity Simulations

Simulation Name	Period	Chemical Mechanism	Emission Perturbation
Base	January-August, 2018	MOZART-TS1	No
TS2base	July 1-6, 2018	MOZART-TS2	No
TS1Anthro70Perct	July 1-6, 2018	MOZART-TS1	-30% total anthropogenic emissions
TS1BioEmis70Perct	July 1-6, 2018	MOZART-TS1	-30% total biogenic emissions
TS1MonthlyNEI2017	July, 2018	MOZART-TS1	replaces monthly 2017 NEI over the CONUS but retains CAMS elsewhere
TS1HourlyNEI2017	July, 2018	MOZART-TS1	replaces hourly 2017 NEI over the CONUS but retains CAMS elsewhere

“Base” Case Evaluation



Daily Mean Surface Simulations vs. surface observations (**SLAMS**)

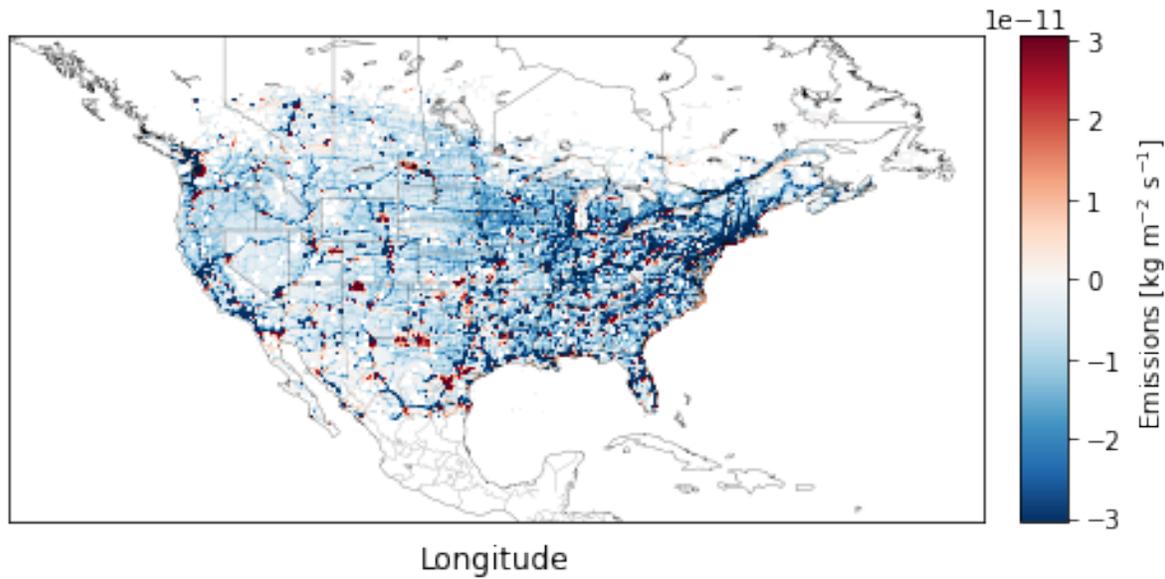
- NO₂: 23-40% (1-3 ppb) in all but the Mountain region -18% (-1 ppb)
- O₃: 11-28% (6-13 ppb)
- CO: -21% to -80% (10-60 ppb)

Daily Tropospheric VCD Comparisons vs. **TROPOMI** Satellite at 1:30 LT

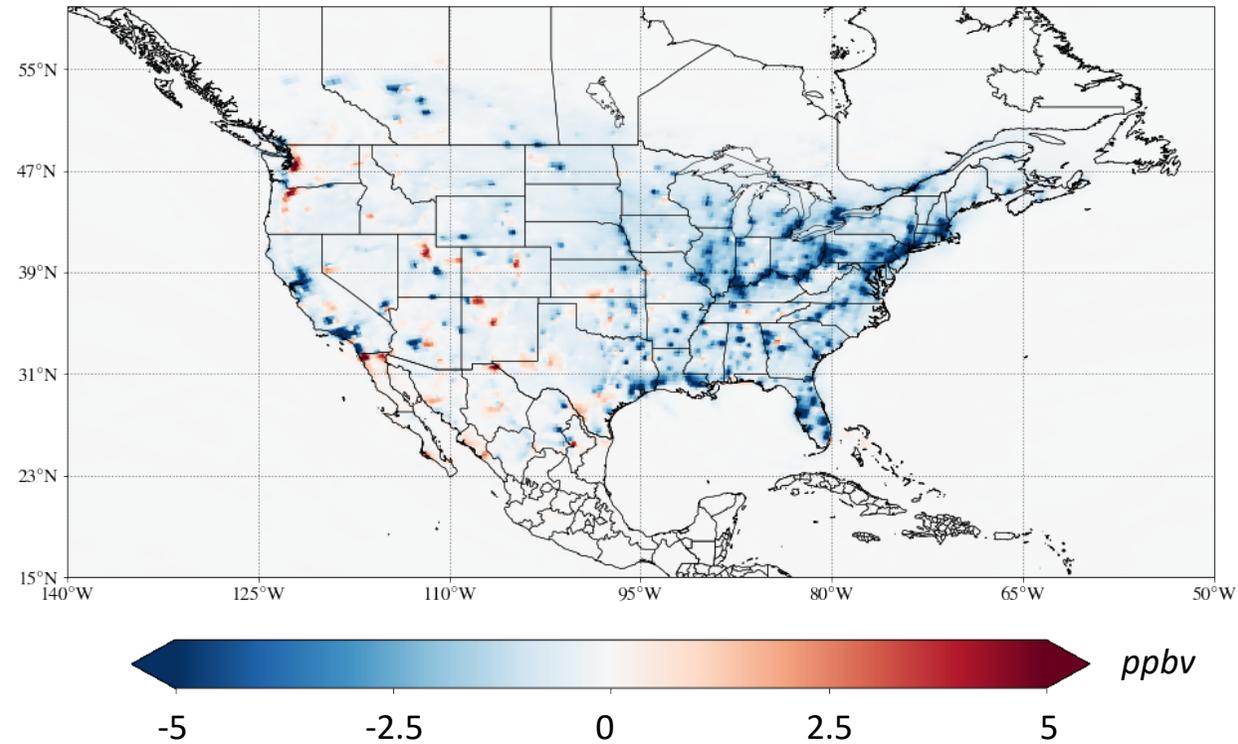
- NO₂: -35% to -52%
- HCHO: 14-24%

The 2017 NEI data shows reduced NO_x emissions leading to lower surface NO_2 concentrations

Difference in 2018-07 Monthly NO_x Emissions
2017NEI vs. CAMS-GLOB-ANT5.1)

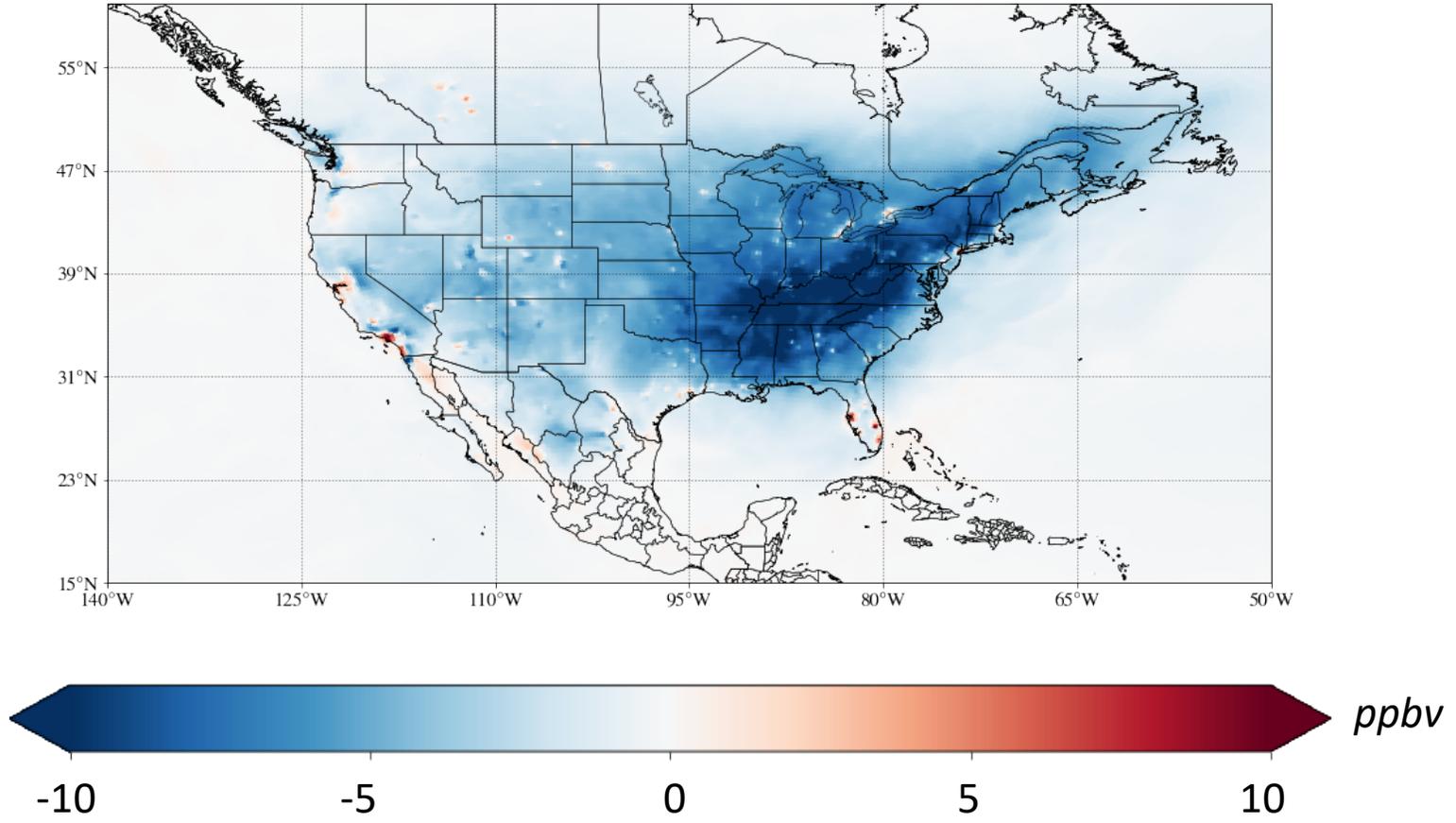


Difference in 2018-07 Monthly Mean NO_2 concentration
CONUSHourly2017NEI vs. Base (CAMS-GLOB-ANT5.1)



Integration of NEI emissions lowers high bias in surface O_3 model predictions

Difference in 2018-07 Monthly Mean O_3 concentration
CONUSHourly2017NEI vs. Base (CAM5-GLOB-ANT5.1)



Preliminary Takeaways

For July 2018 over CONUS:

- Biases in modeled concentrations
- Improved agreement in surface concentrations and HCHO columns using NEI emissions, but increased model bias in NO₂ column.
- Emissions inventory selection influences simulated daily mean concentrations more than NEI's temporal resolution.
- Notable regional variability.

Next Steps

- Analyze diurnal changes of simulated concentrations
- Group sites by location settings

A black and white photograph of a bird perched on a branch, with the text "Thank You!!" overlaid in the center. The background shows a dense forest of bare trees, suggesting a winter or late autumn setting. The lighting is soft, creating a serene atmosphere.

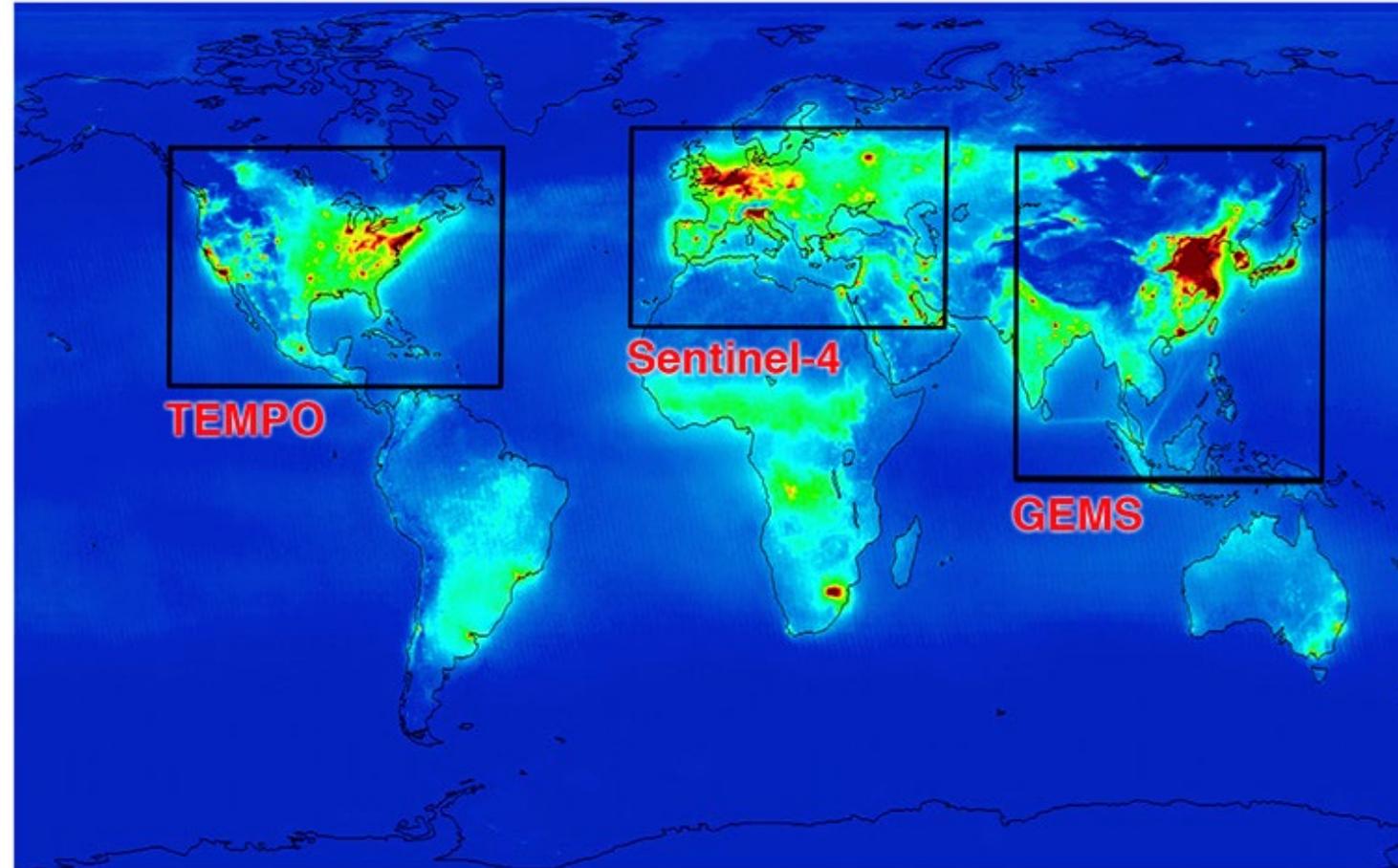
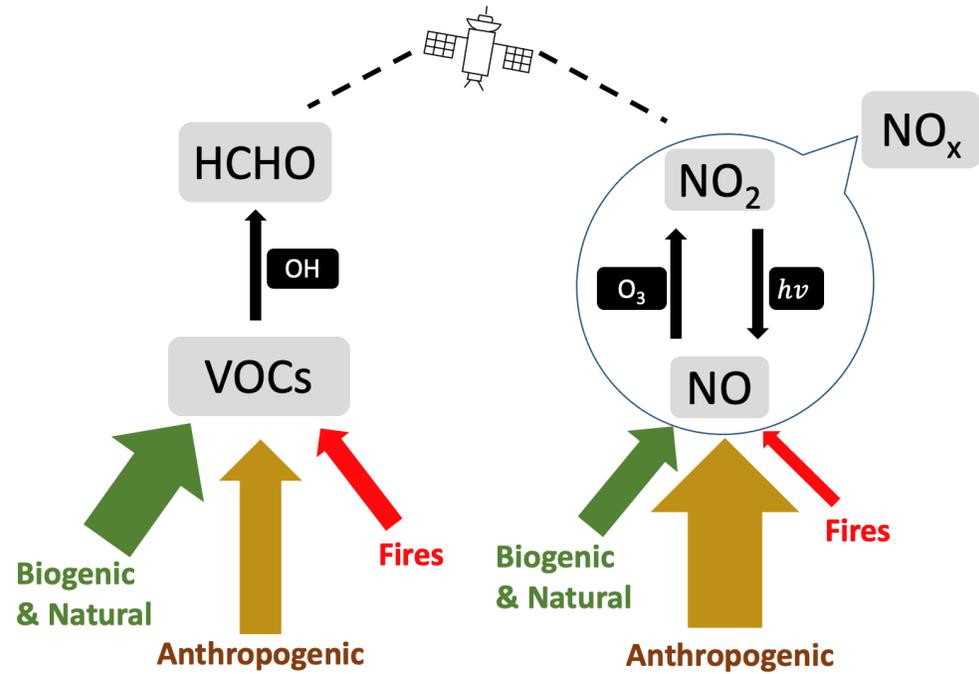
Thank You!!

Contact: mt3388@columbia.edu



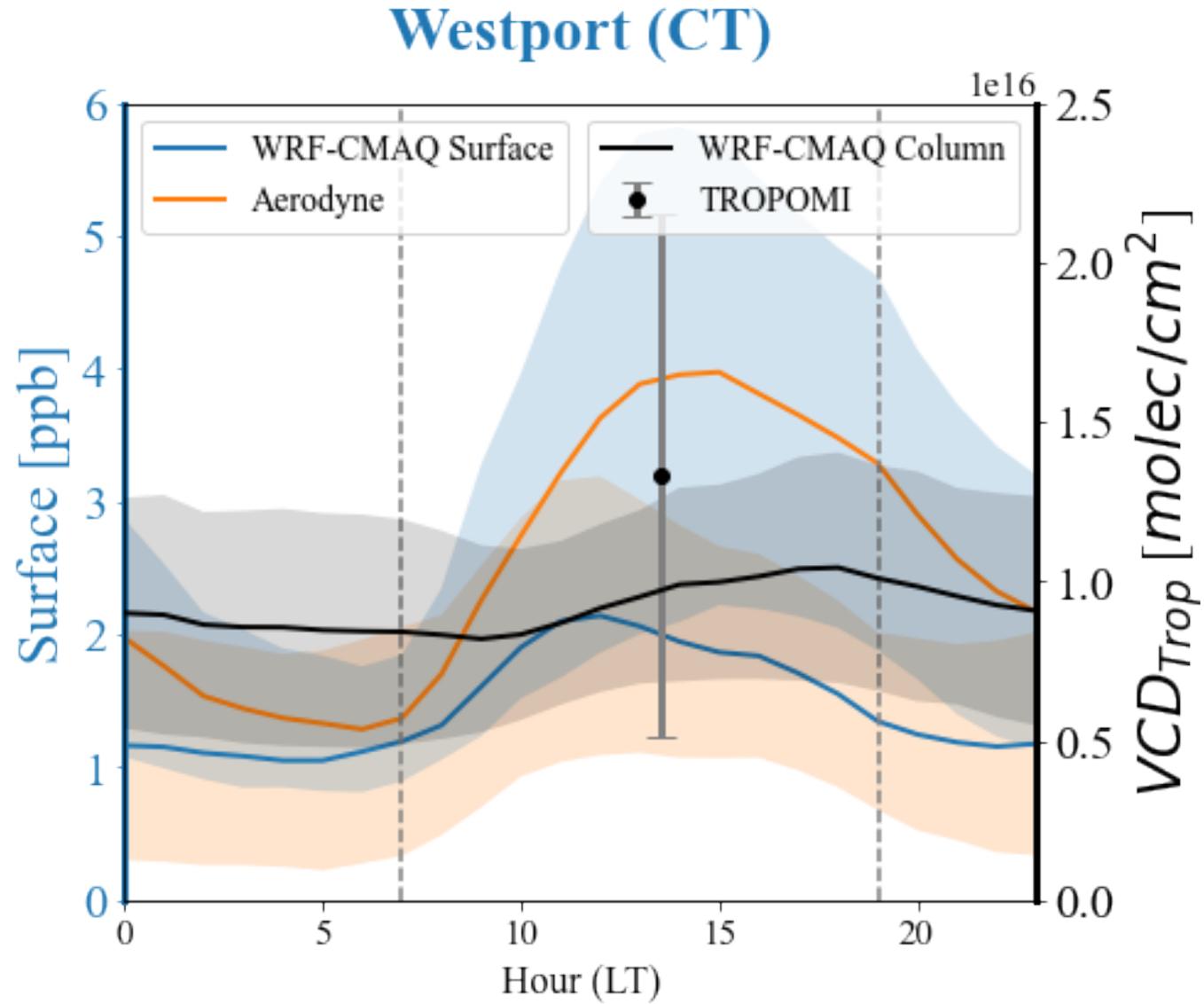
Complimentary Slides

Geostationary Satellites with Daylight Hourly Retrievals



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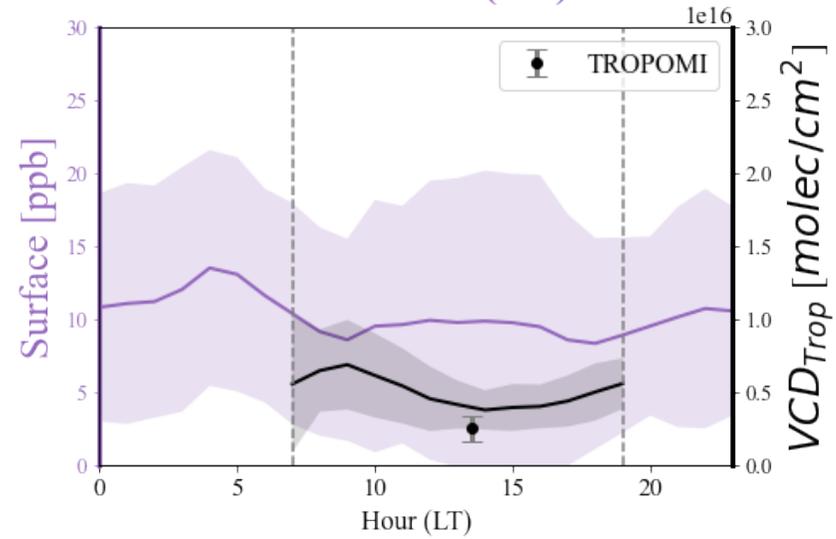
HCHO Column densities show a delay compared to peak surface concentrations



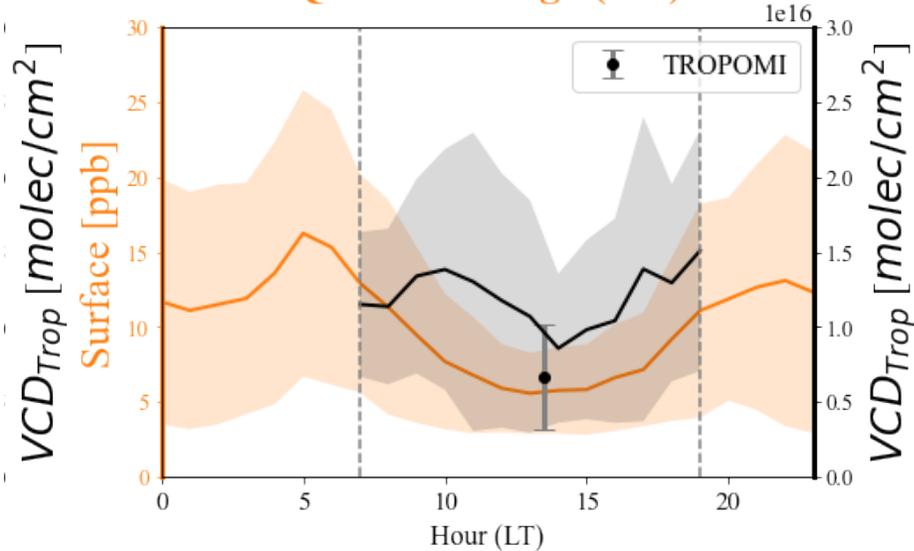
Observed **Surface** versus Column (Pandora, TROPOMI VCD_{Trop}) NO_2



New Haven (CT)



Queens College (NY)



Westport (CT)

