

# Ozone Sensitivity Modeling with CMAQ: Evaluating Model Performance Using TEMPOv4 NO<sub>2</sub>

Jen Kaiser | Georgia Tech

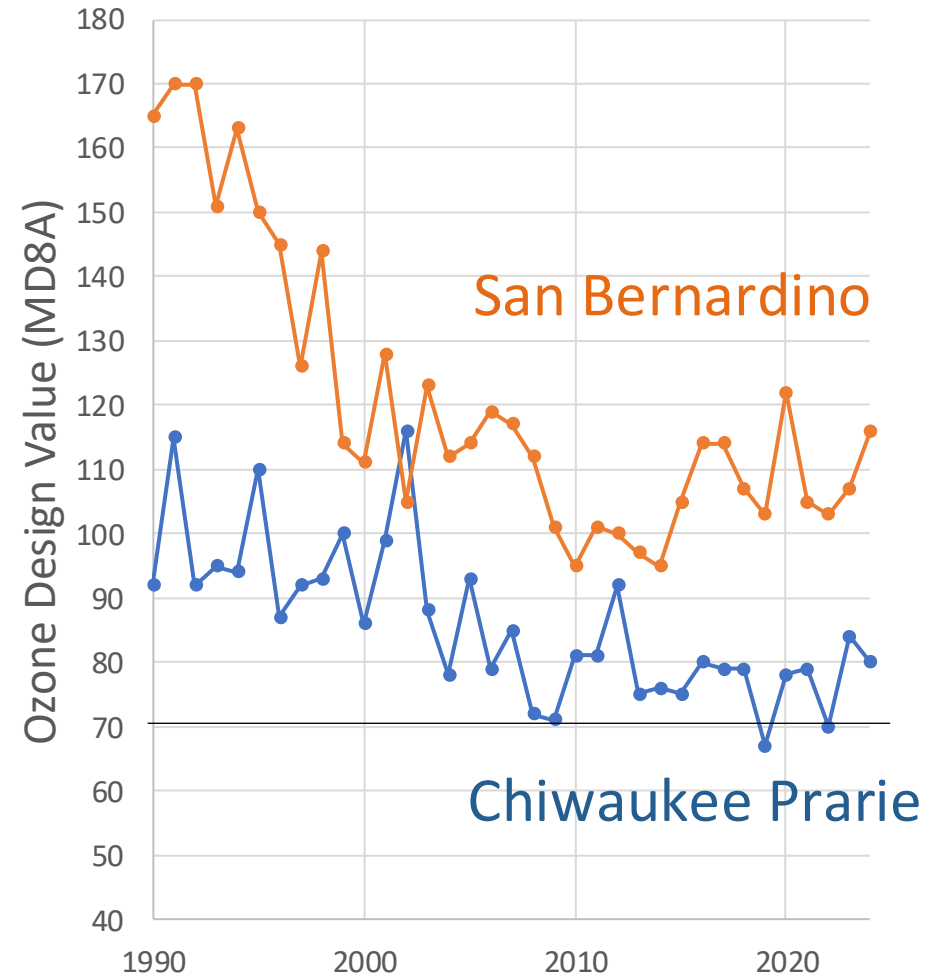
Aryiana Moore, Yongtao Hu, Talat Odman, and Ted Russell



# Ozone is not a solved problem in many US cities.

- Values are high, trends are flat.
- Years of emissions reduction programs have already lowered NO<sub>x</sub> and VOCs.
- What's knobs are left to turn?

Can we form effective control strategies by focusing on the timing of the emissions, or certain sectors?



Source: <https://gispub.epa.gov/air/trendsreport/2025/#naaq5>

# We use CMAQ-DDM to calculate sensitivity for each sector, time, and species (VOC or NOx)

Evaluate either NOx or VOC sensitivity

## 5 Anthropogenic NOx sectors:

- Onroad gasoline
- Onroad diesel
- Nonroad
- EGU point-source
- Non EGU-point source

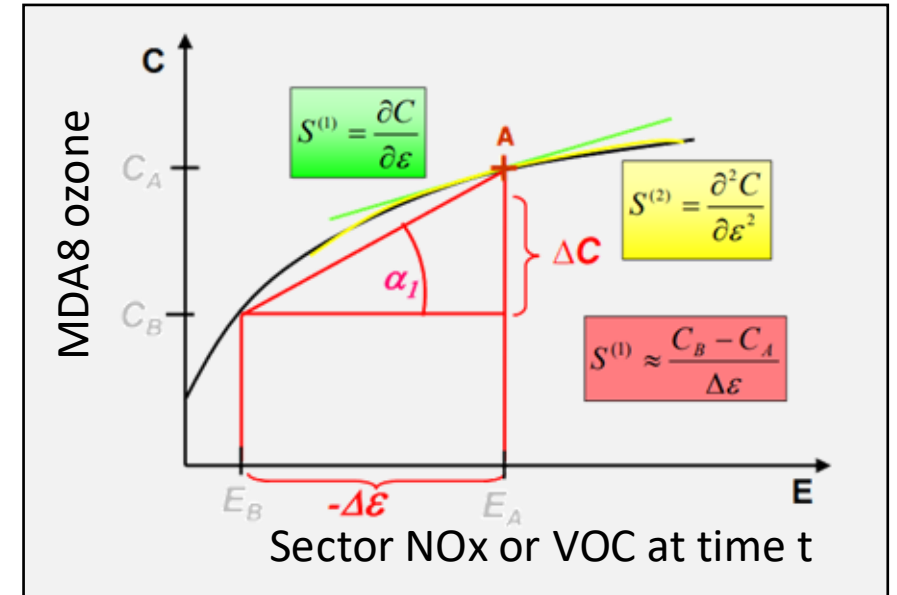
## 6 Anthropogenic VOC sectors:

- Onroad gasoline
- Onroad diesel
- Nonroad
- Volatile chemical products (VCPs)
- Other non-point VCPs
- Non EGU-point source

## Specify Timing

Time	(EDT)
Early AM	6-9
Late AM	10-12
Early PM	13-15
Late PM	16-19
Evening	20-22
Night	23-5

Sector-specific NOx or VOC impacts at a given monitor, on a given day

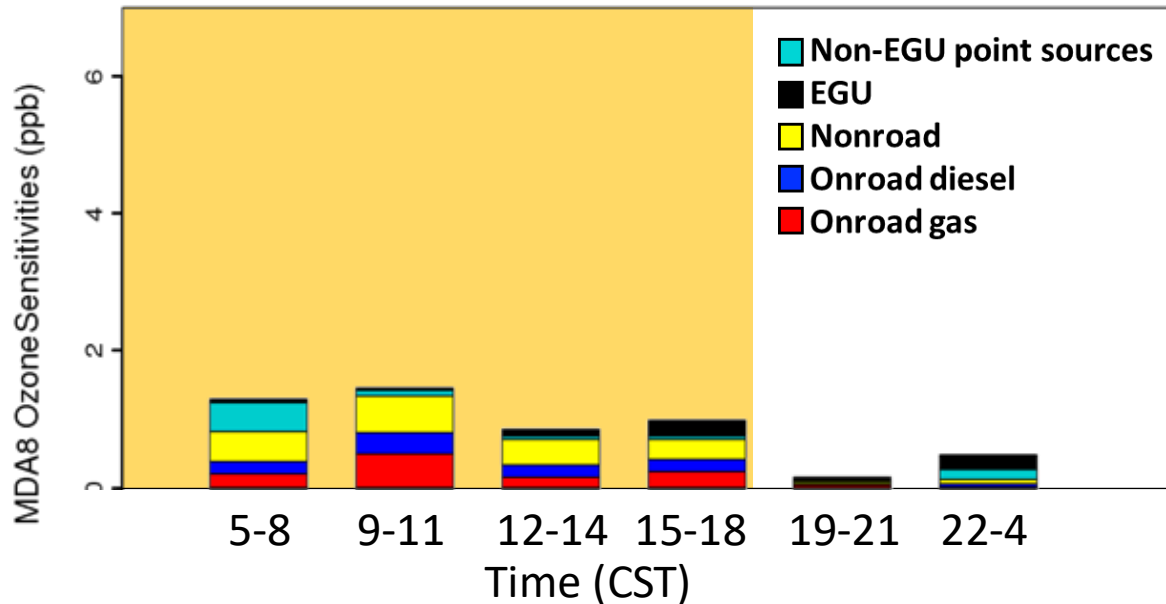


12 runs (2 DDM setups x 6 times)  
66 sectorized, timed sensitivities

# Building on Prior work with LADCO

## Chicago NOx sensitivities

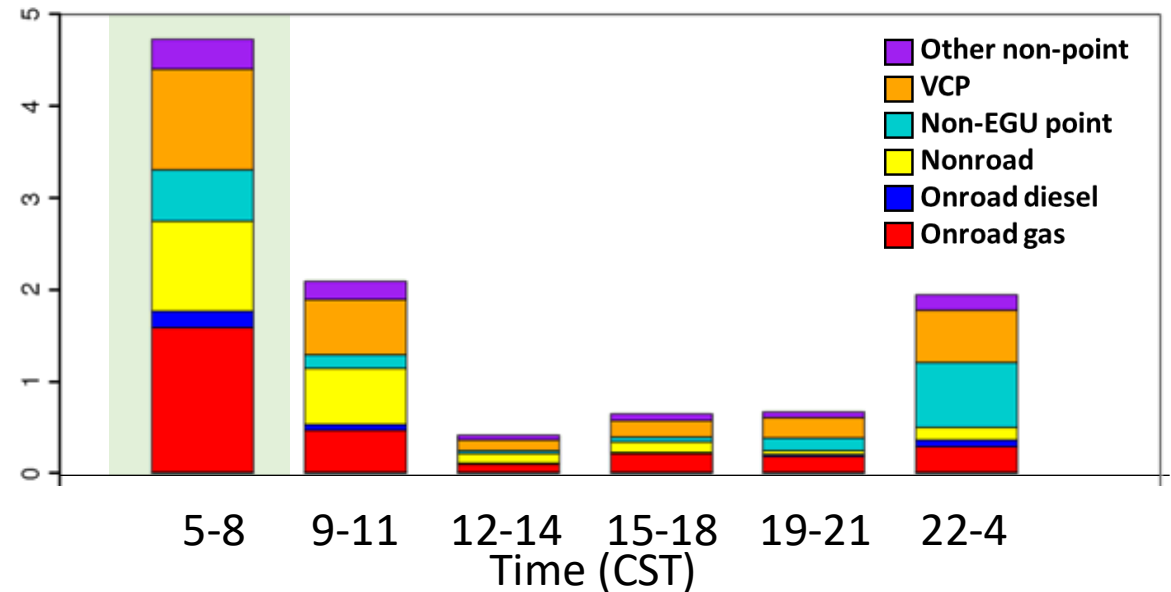
June 19, 2016 | Observed MDA8 O<sub>3</sub> = 74 ppb



Similar impact across daylight hours

## Milwaukee VOC sensitivities

July 20, 2016 | Observed MDA8 O<sub>3</sub> = 80 ppb



Consistently high impact of VOC emissions in early morning

# Building on Prior work with LADCO

Chicago (Water Plant)

Milwaukee (Harrington Beach Park)

## How reliable is this modeling framework?

- Run current years
- Evaluate against TEMPOv4
- Expand area of focus

Similar impact across daylight hours

Consistently high impact of VOC emissions in early morning

MDA8 Ozone Sensitivities (ppb)

point  
point  
sel

# TEMPO v4 appears to fix biases in prior versions

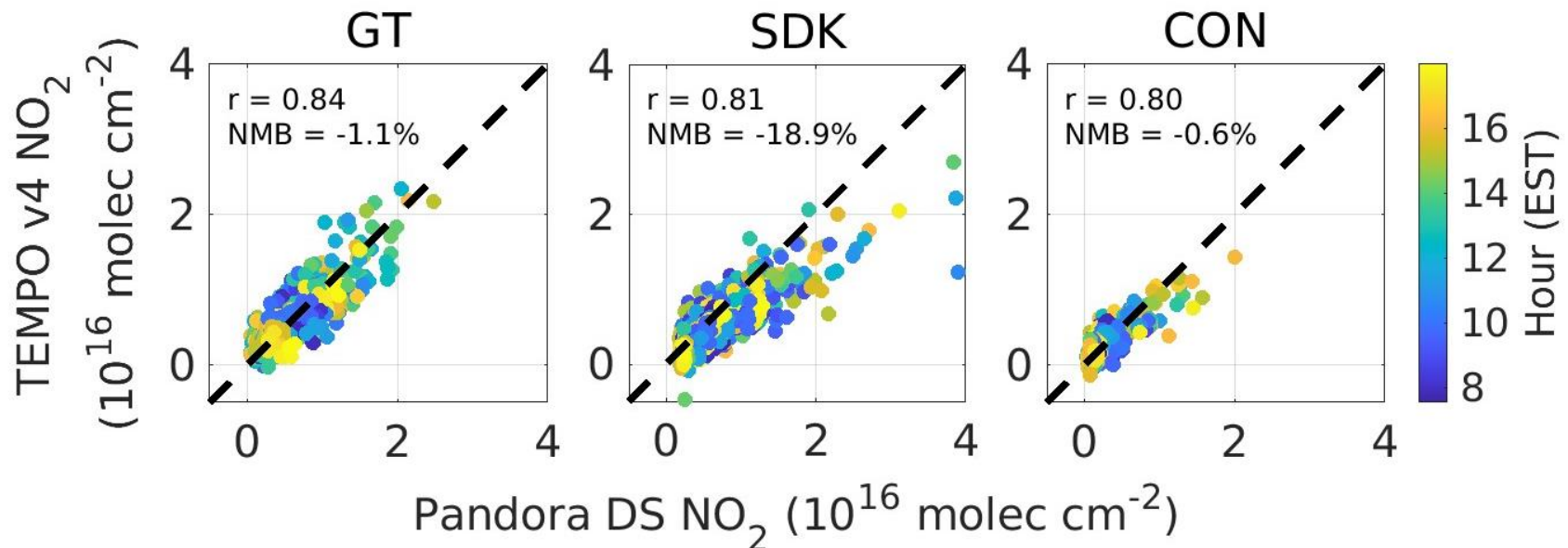
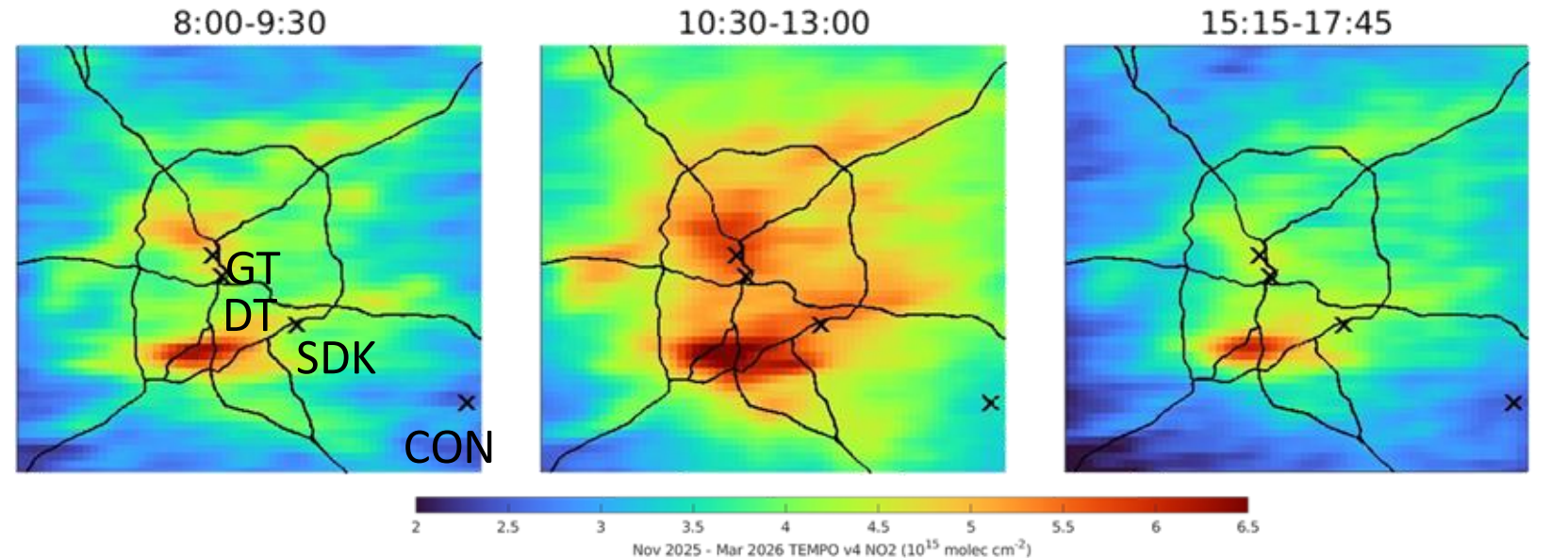
No time-dependent bias

No urban/rural bias

Strong starting point for model evaluation!

*Disclaimer:*

City-specific validation is required.

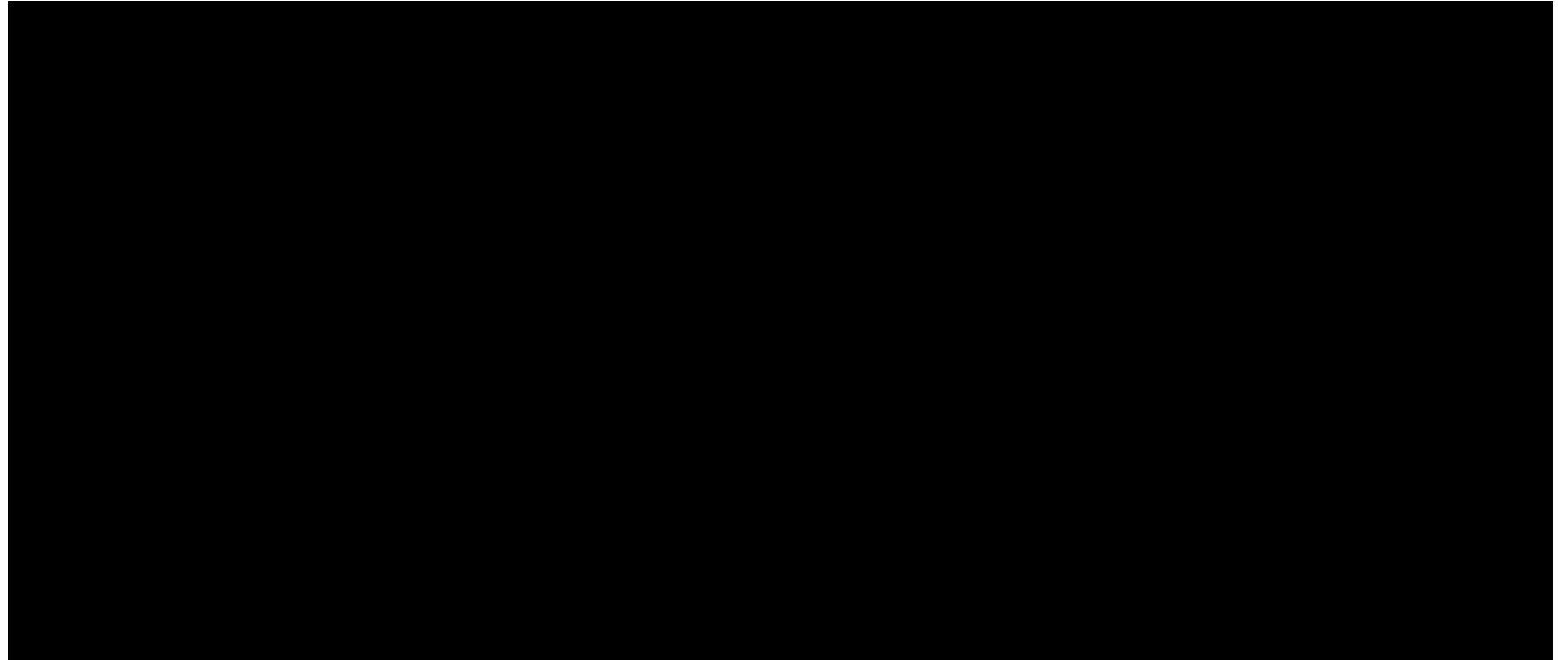


# We use hourly average TEMPOv4 to evaluate August 2023 CMAQ performance

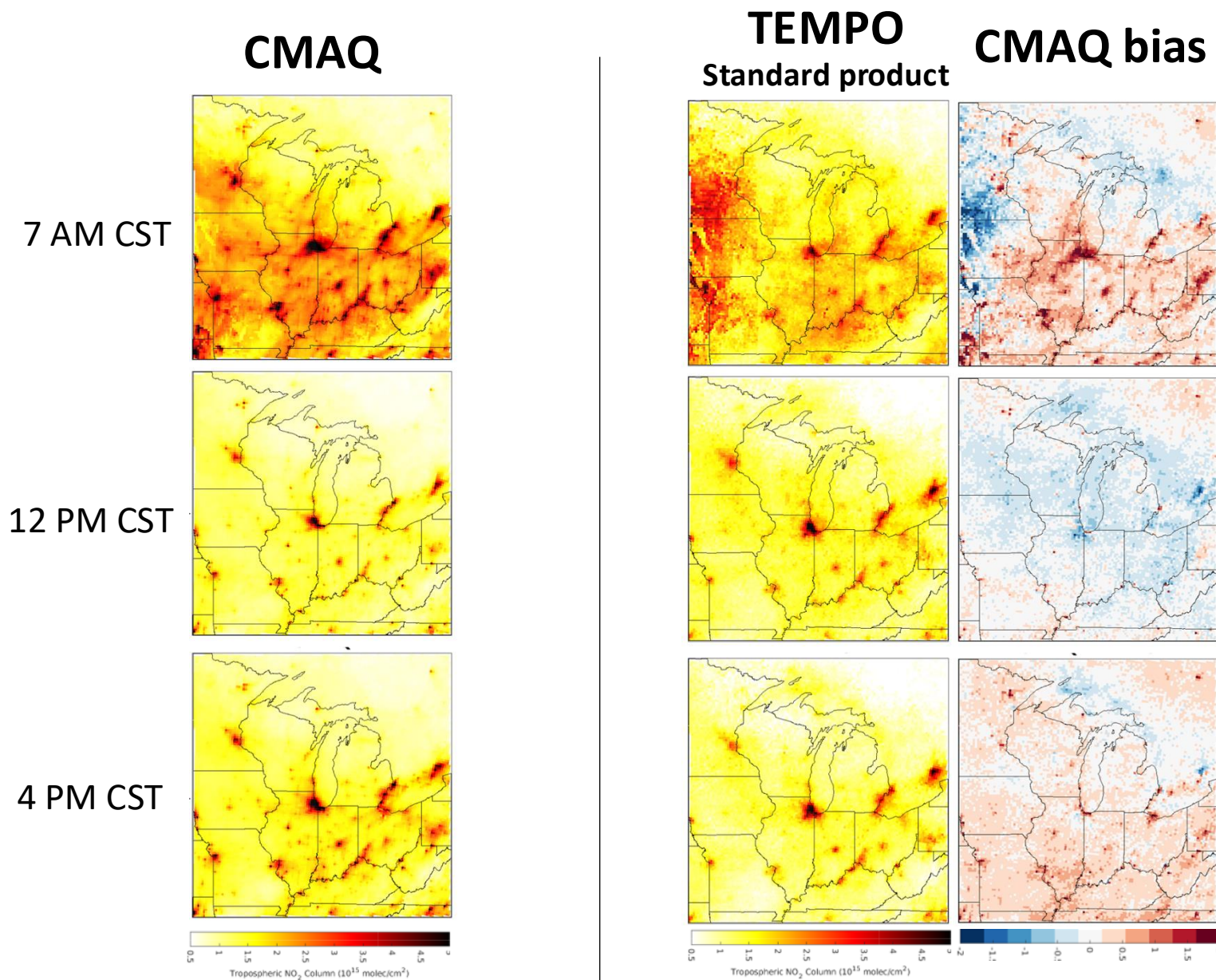
Spatial variability is well captured

Biases low mid-day

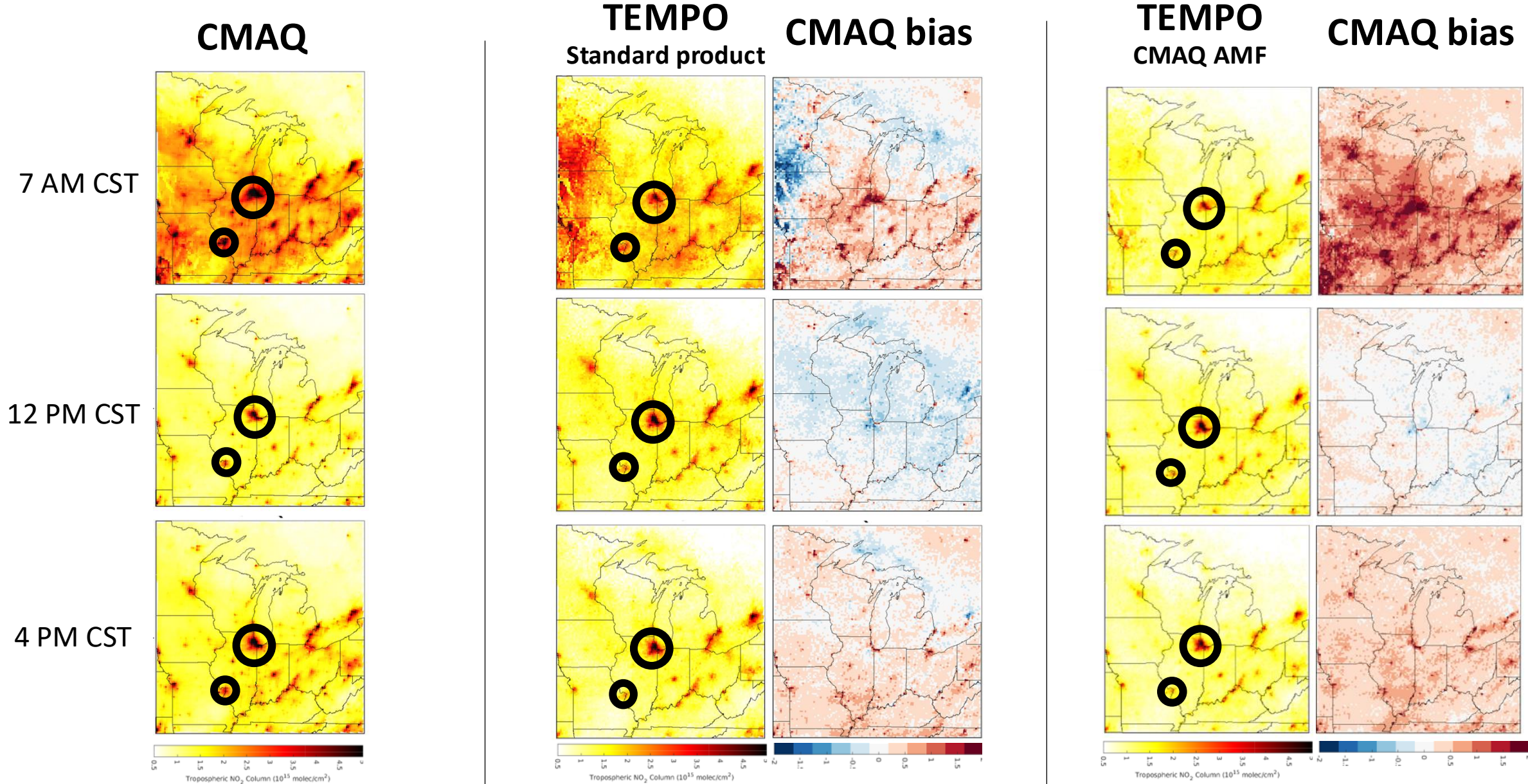
Biases higher in AM and PM



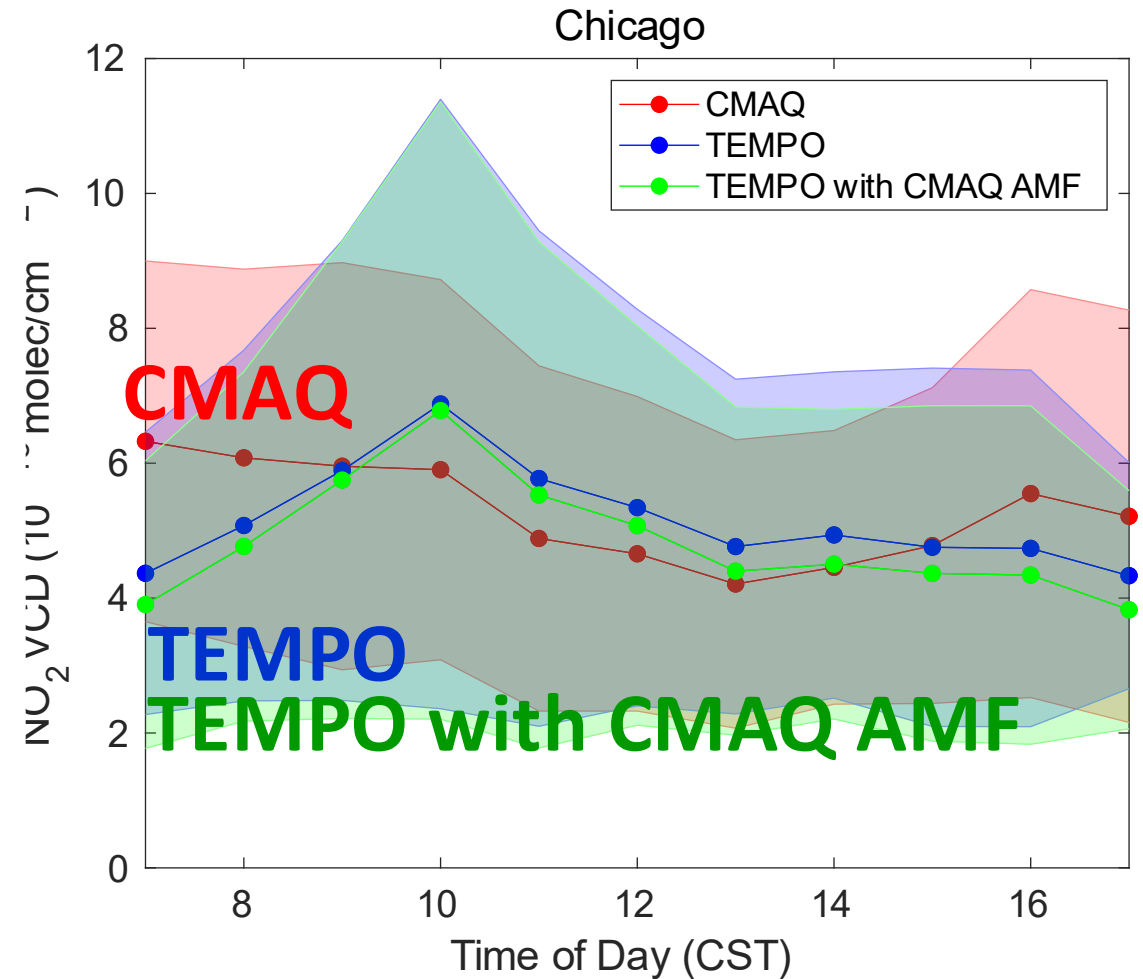
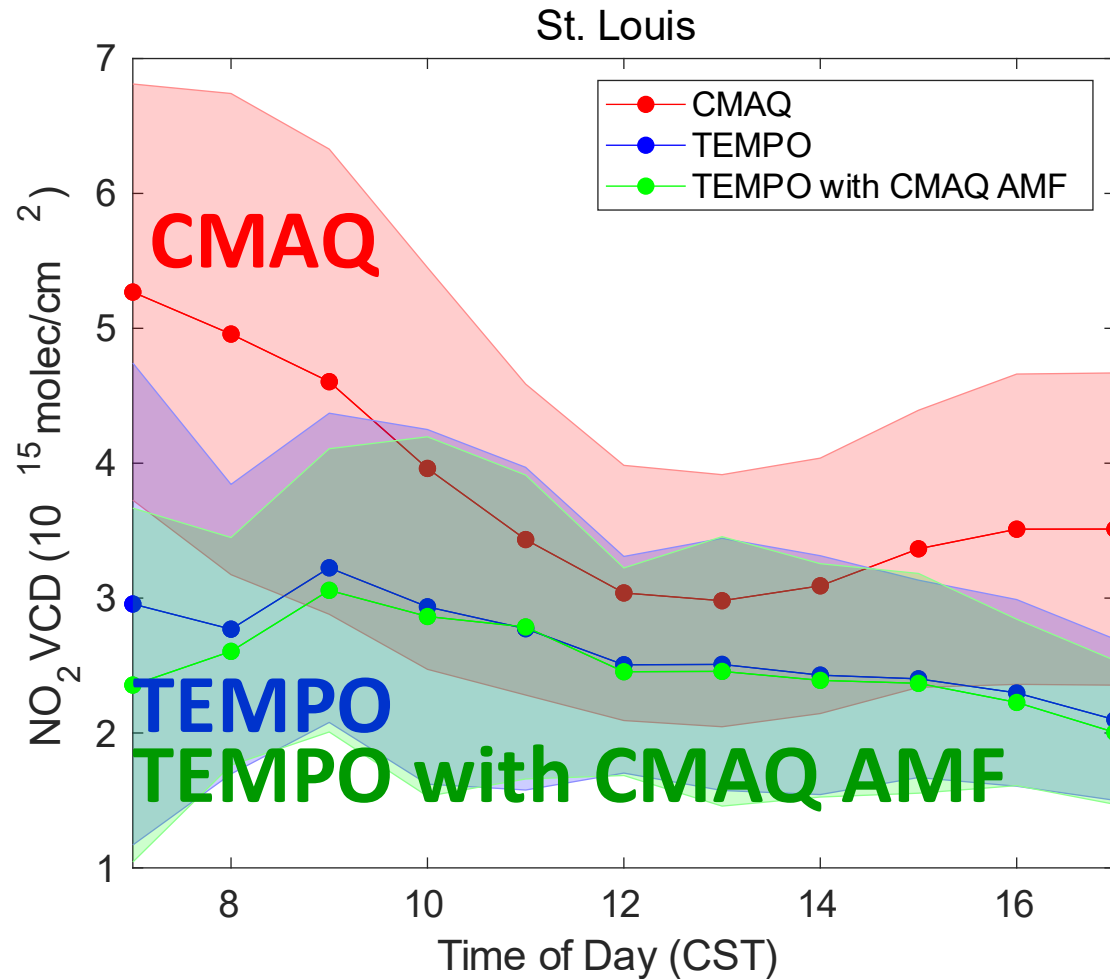
# We find low bias mid-day, higher bias in AM and PM



# CMAQ AMF does not improve comparison



# CMAQ and TEMPO show different temporal patterns (Regardless of AMF)



May suggest need to refine emissions

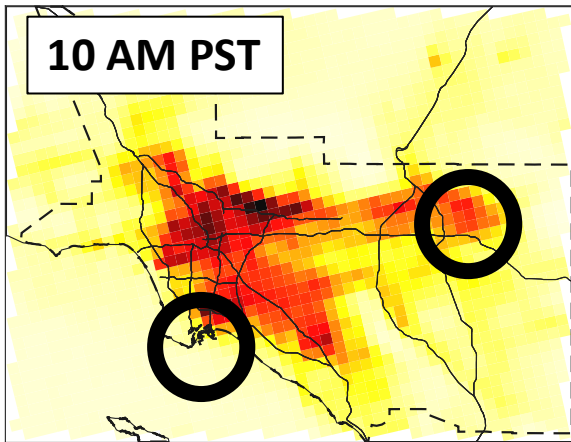


# SOCAB, July 2024, 4 km resolution

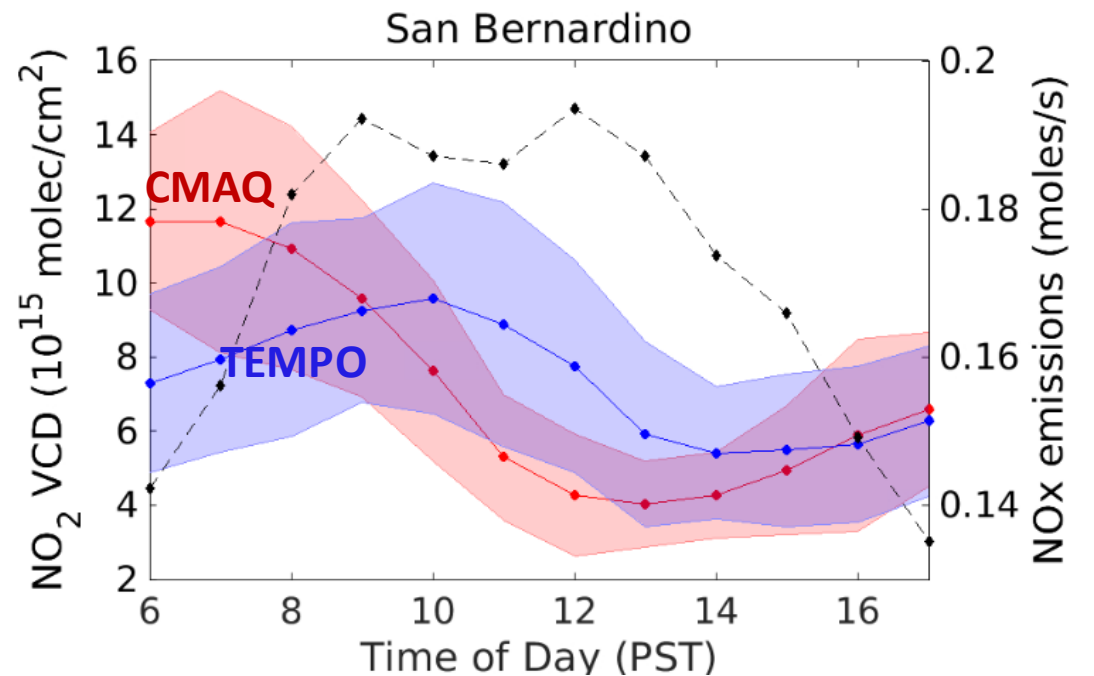
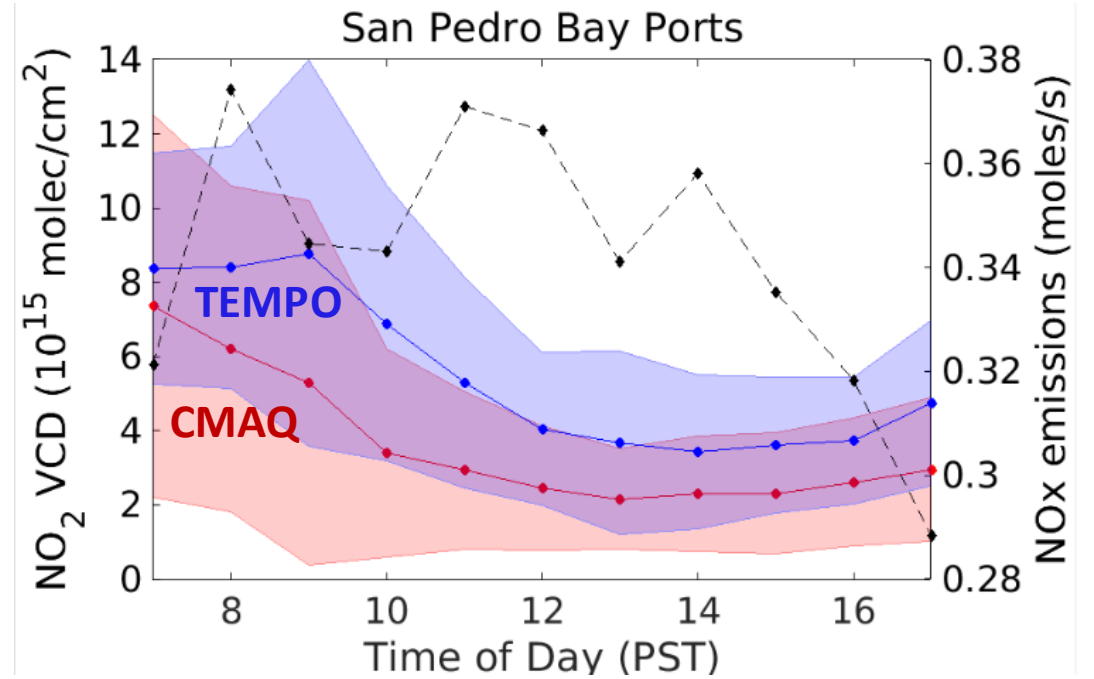
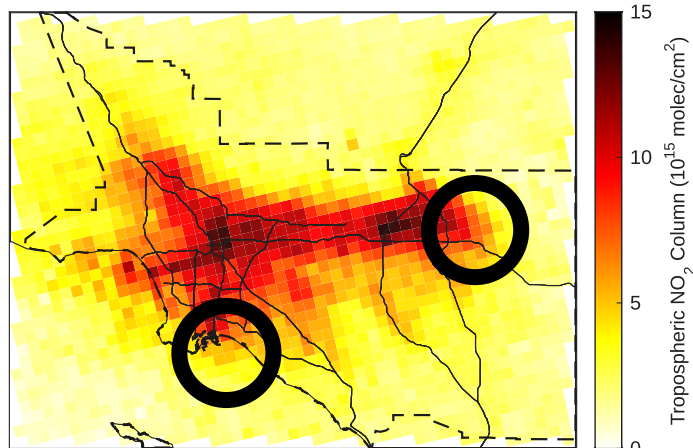
- Different biases than LADCO region: Biases are location-dependent
- At high resolution, differences can potential reflect errors in modeled transport

CMAQ and TEMPO have similar diel cycles near ports, but differ inland.

**CMAQ**



**TEMPO**



# Take-aways and next steps

- Ideally, CMAQ-DDM sensitivities can help decision makers understand potential effectiveness and impact of emissions controls.
- Are these sensitivities accurate? TEMPOv4 and CMAQ agreement would boost confidence in model results.
- Looking forward: VOCs are harder to track and may be an important lever: new Tiger Team will push towards using TEMPO HCHO.



