Assessment of Airport-Related Emissions and their Impact on Air Quality in Atlanta, GA using CMAQ and TROPOMI

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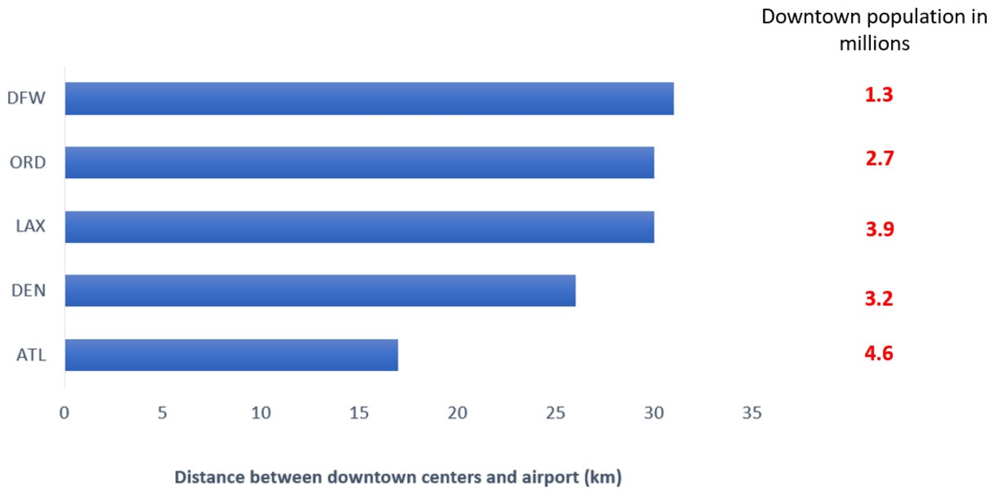
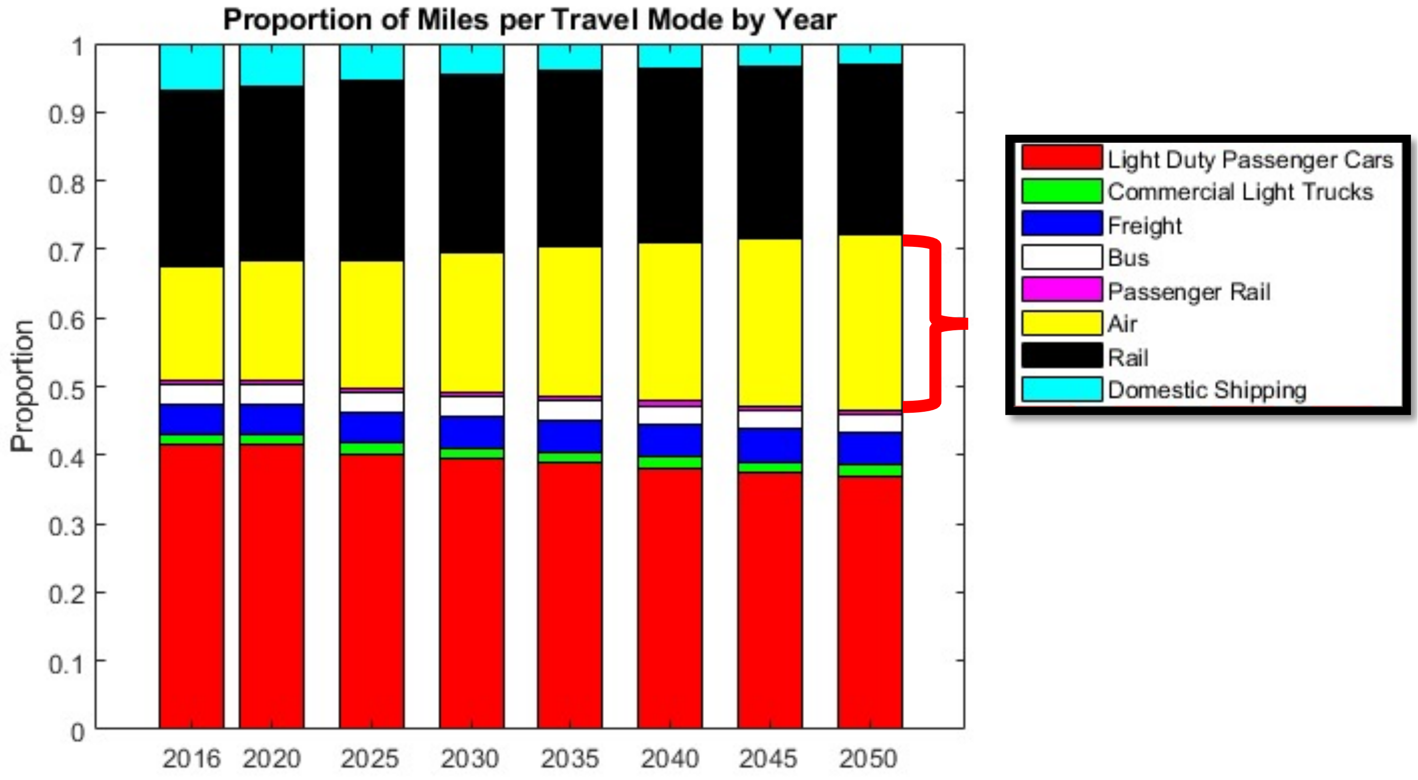
• Background: Why airports?

- They contribute to ground level pollution
  - Particulate matter, NOx and ozone formation.
- Airport travel is expected to continually increase and emissions along with it.
- Located near major downtown areas: health implications for urban populations

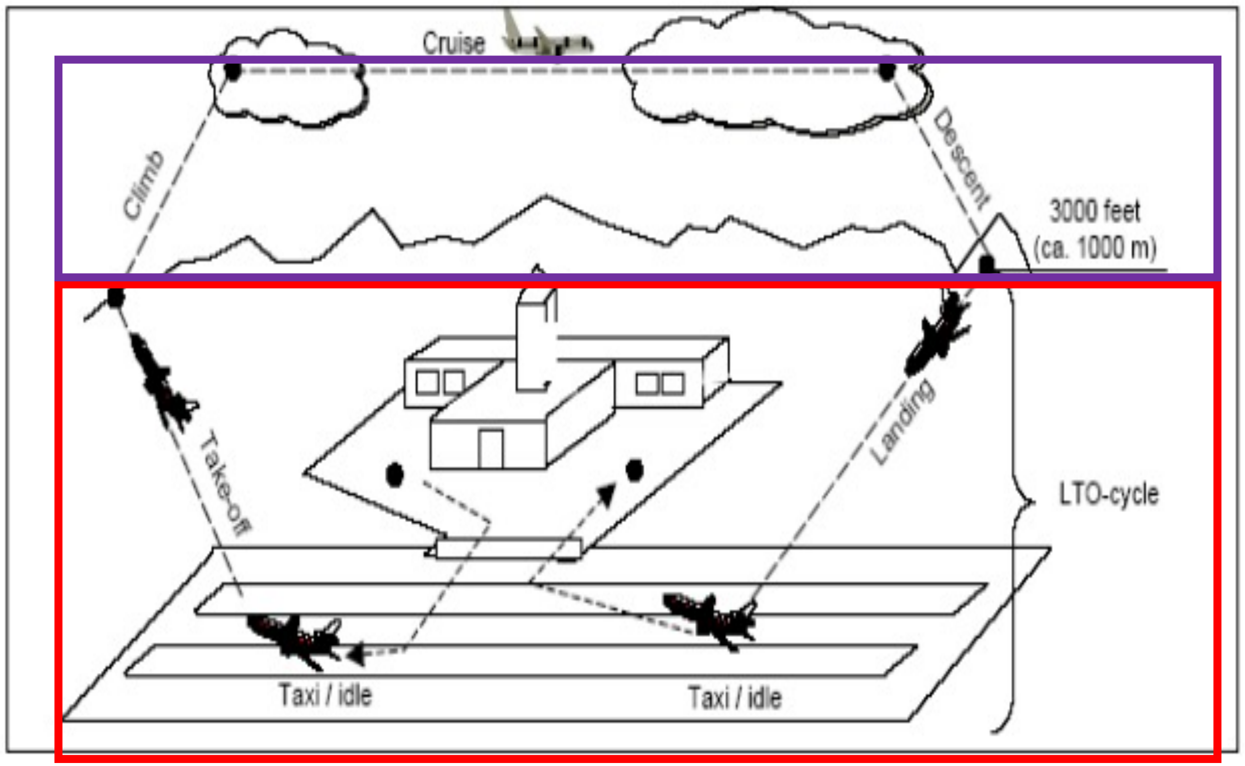




Airport emissions = Ground + Upper Layer operations

- Airport emissions come from:
  - **Ground Emissions (10%) < 1000 m**
    - Landing, take off, taxiing processes (LTO).
    - Also includes ground support vehicles
  - **Upper Emissions (90%) > 1000m**
    - Cruising, climb and descent

- Some modeling practices tend to:
  - Excluded emissions above ground level
  - Allocate all LTO processes to the same altitude as the airport **(Default inventory)**



Source: Environ

Figure 2-1. Landing and Takeoff Cycle

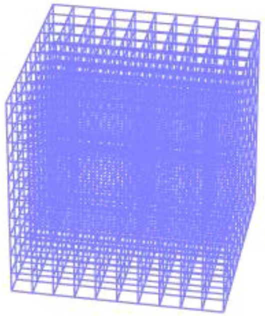
Objective:

- Evaluate the impact of a more representative (realistic inventory), by comparing differences between two airport inventories (i.e. Default vs 3D)

- Questions
  - What is the impact on airport emissions, when using a more realistic spatial representation of airport inventories?

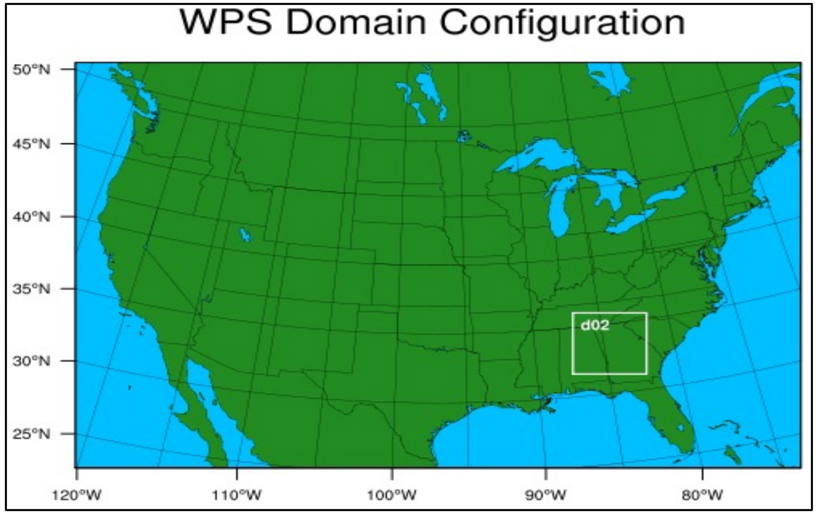
  - How are these differences be evaluated?

Overall approach: Focus on Atlanta Hartsfield-Jackson Airport (ATL)

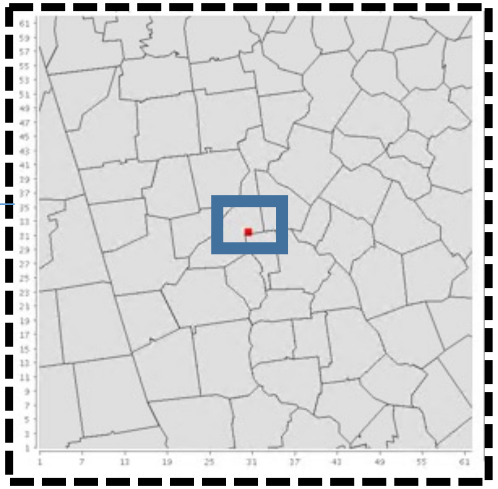


- Use Chemical Transport Model to estimate airport effects
- Evaluate airport impacts with 2 airport inventories
  - Default: LTO airport emissions are allocated at surface and at airport
  - Develop a 3D airport inventory: emissions allocated **vertically** and **horizontal** over a larger domain. Includes **cruise** emissions

CMAQ modeling



Modeling Domain
61 by 61 grid
Resolution: 4km
32 vertical layers
Airport in center



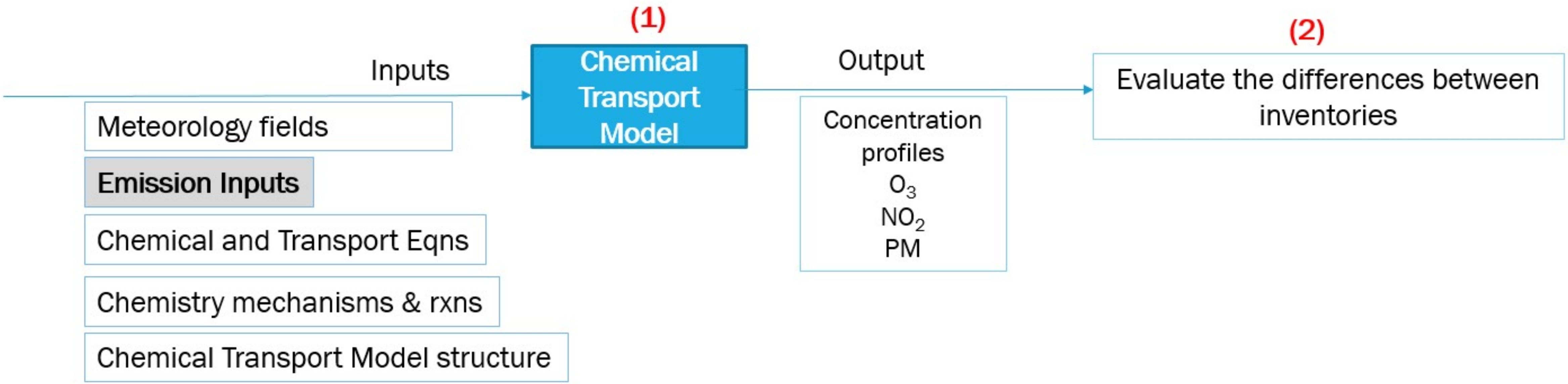
Time: August 2019

SMOKE: 2016 Modeling platform for inventory processing.

Chemical Transport Model
CMAQ: v5.3.2
Mechanism: CB6

Meteorology
WRF v 4.1
Nested domain with nudging

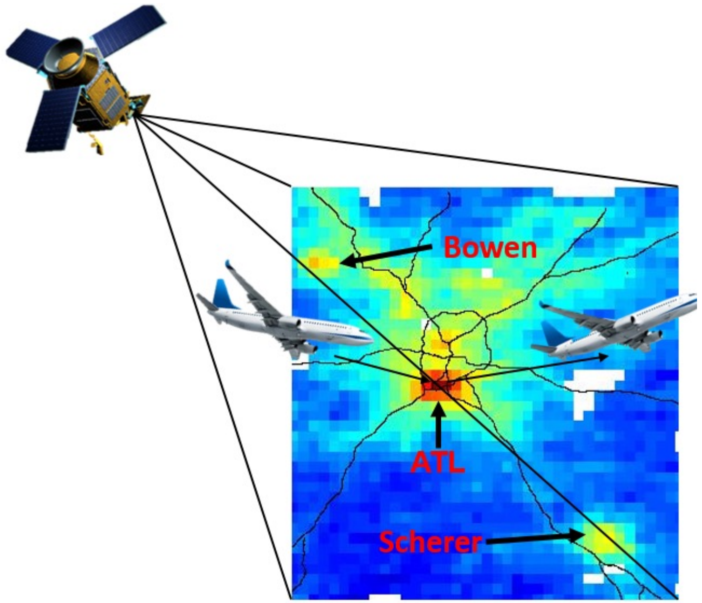
Process



How to evaluate the findings?

Observations: TROPOMI Retrievals

TROPOMI

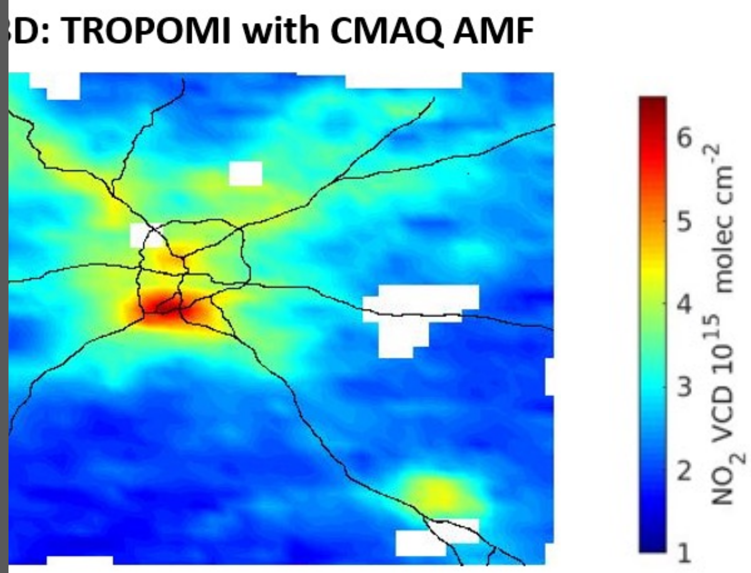


TROPOMI

(Tropospheric Monitoring Instrument)

Launched in 2017 by the European space agency on Sentinel-5 Precursor

- Low earth orbit satellite
- Higher resolution than OMI
- 5.5 by 3.5 km^2 vs 13 x 23 km^2
- It measures a wide range within the electromagnetic spectrum
  - UV and visible (270 – 500nm)
  - Near infrared (675 – 775 nm)
  - Shortwave infrared (2305 – 2385 nm)

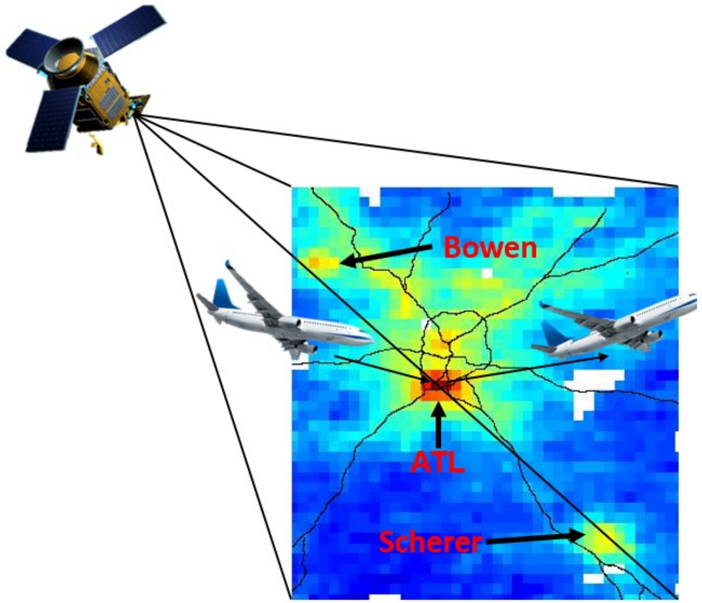


AMFs derived with vertical profiles from **higher** resolution model

Satellite products are converted to column densities using with **Air Mass Factors (AMFs)** vertical profiles of the atmosphere

Observations: TROPOMI, Power plants and air monitors

TROPOMI

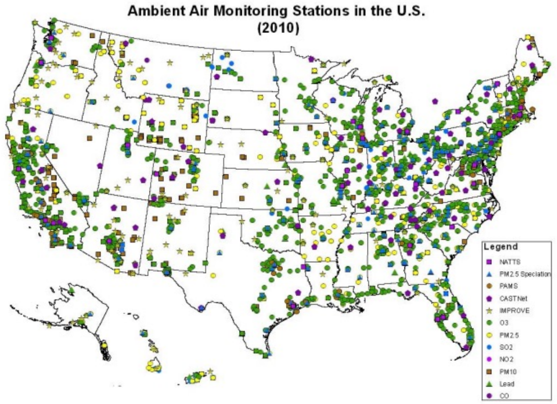


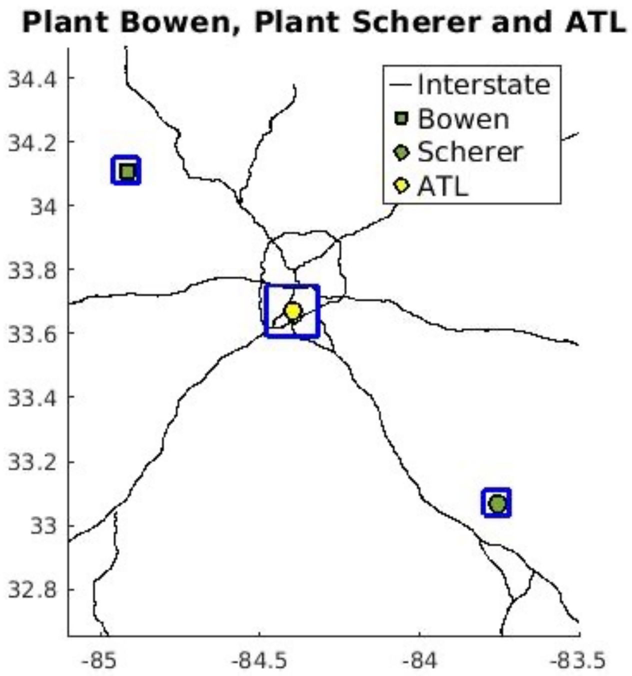
Three sets of observation comparison analysis of high emitting NOx

Compare TROPOMI with CMAQ: At ATL for both inventories

Compare TROPOMI detection with power plants (high NOx)

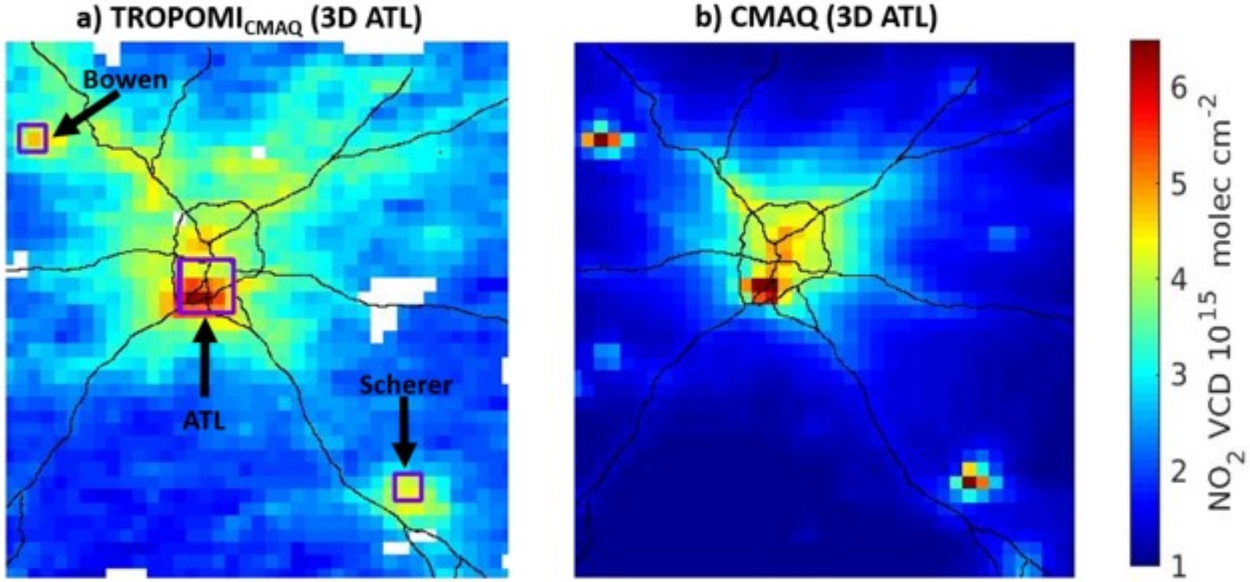
Compare CMAQ with near airport monitor





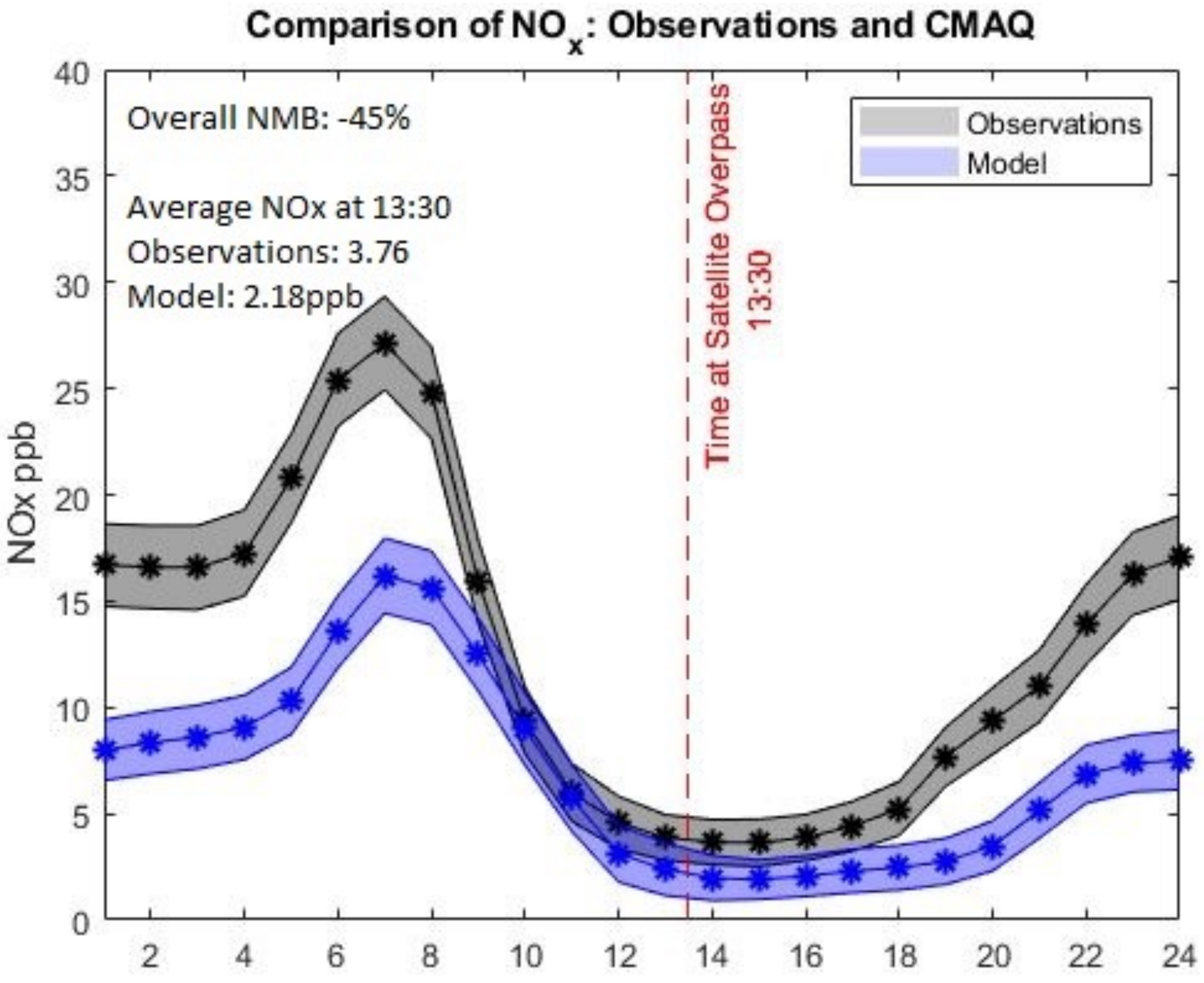
Results

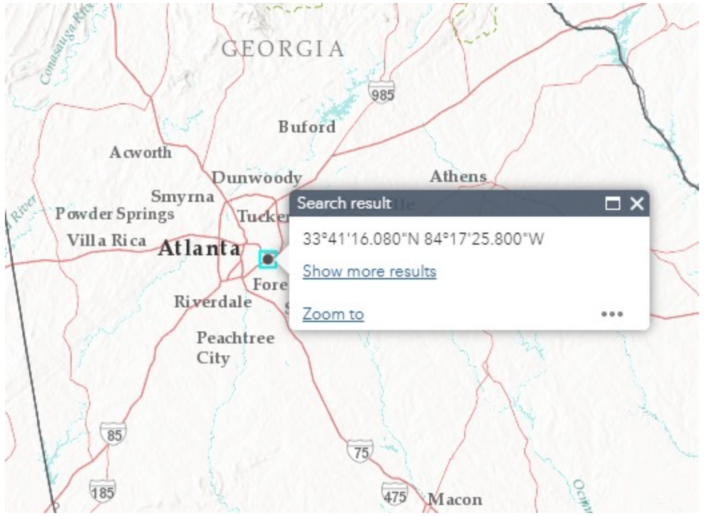
CMAQ MODEL COMPARED WITH TROPOMI



TROPOMI captures the airport and other high emitting NOx sources in the domain

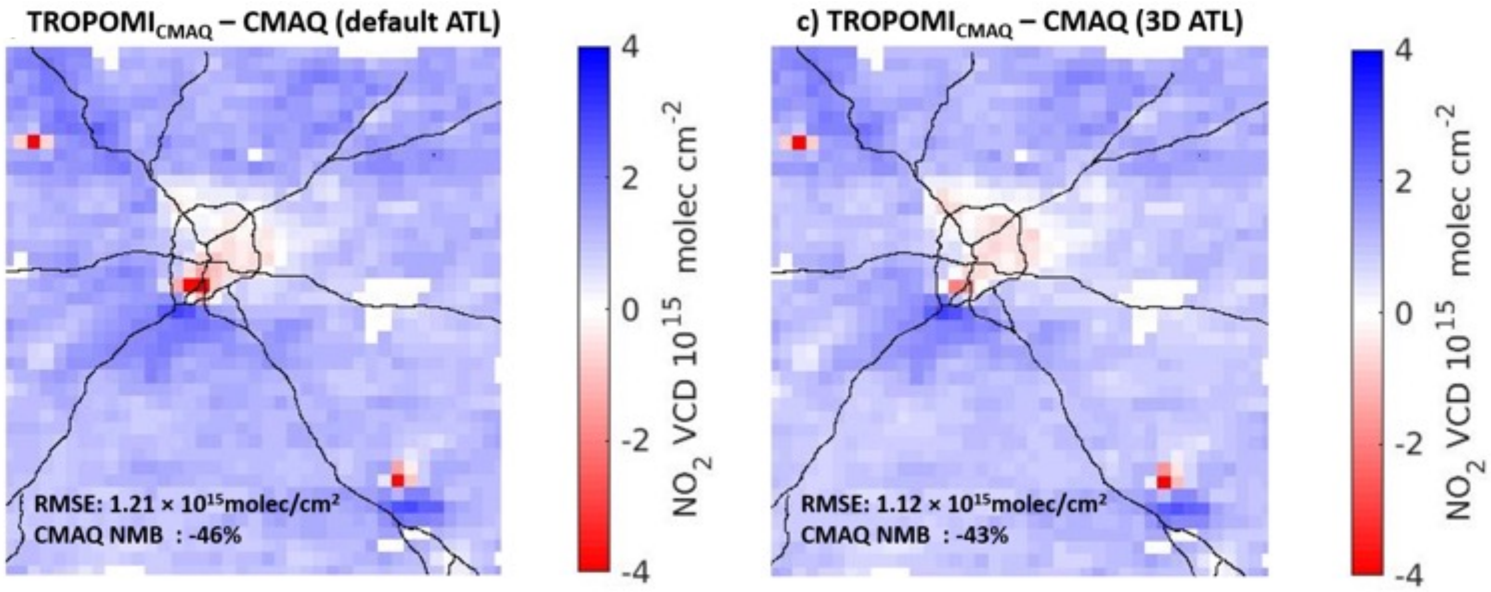
CMAQ MODEL AND AIR MONITORS COMPARE WELL FOR NO_X





Hour

CMAQ MODEL COMPARED WITH TROPOMI FOR BOTH INVENTORIES

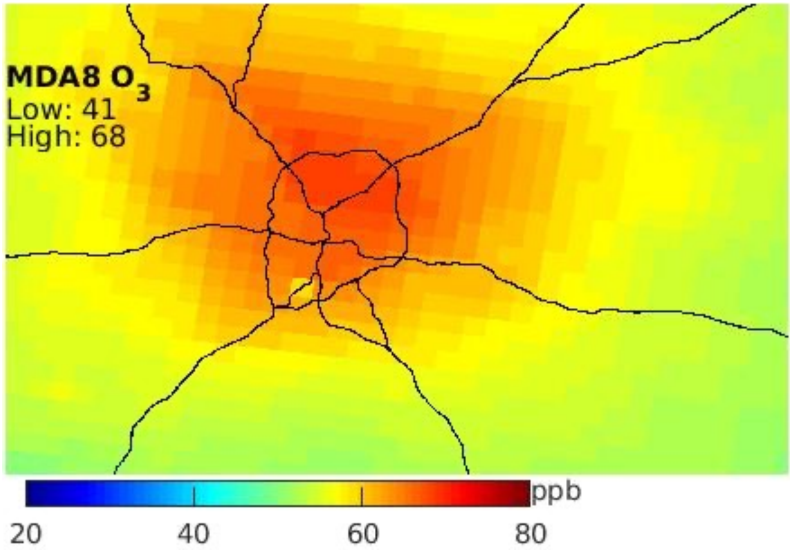


Not too much difference in spatial differences

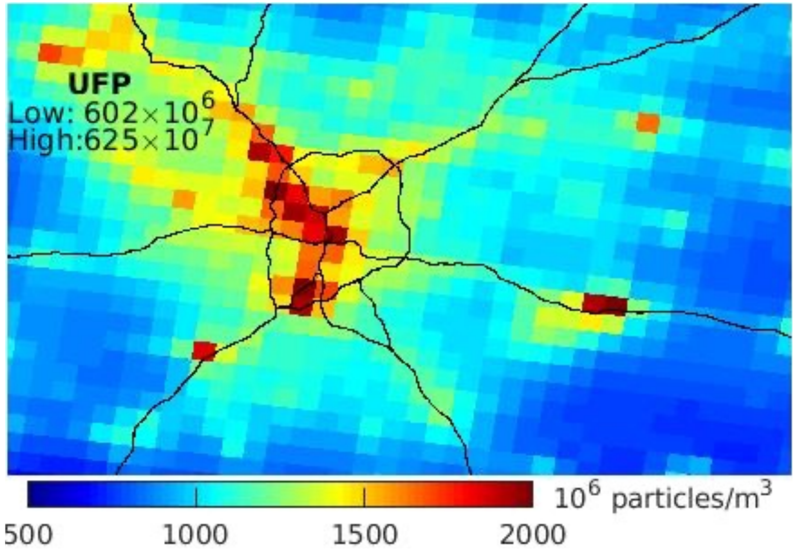
However, slightly lower bias with the modified (3D) inventory when compared with TROPOMI retrievals at airport grids

Airports impacts are varied for Ozone, Ultra fines and $PM_{2.5}$

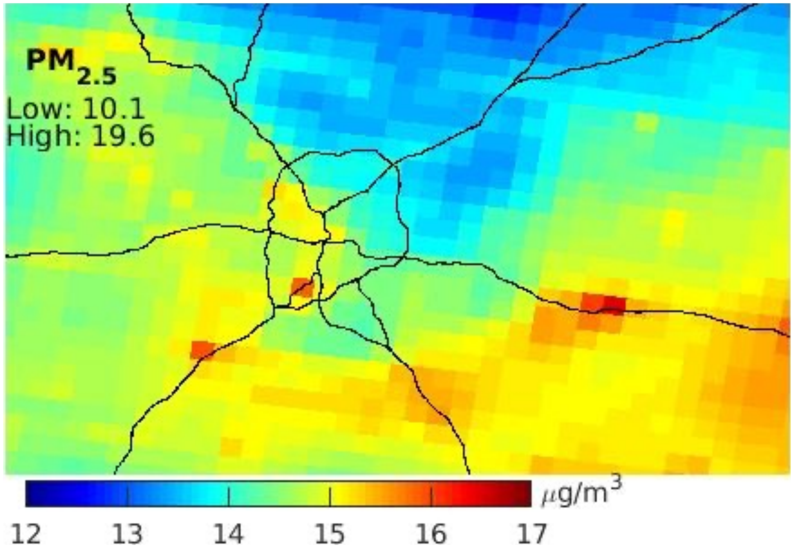
a) MDA8 O_3
Maximum Daily 8hr O_3 with 3D



b) Ultrafine Particulate
Particle Number Concentration with 3D



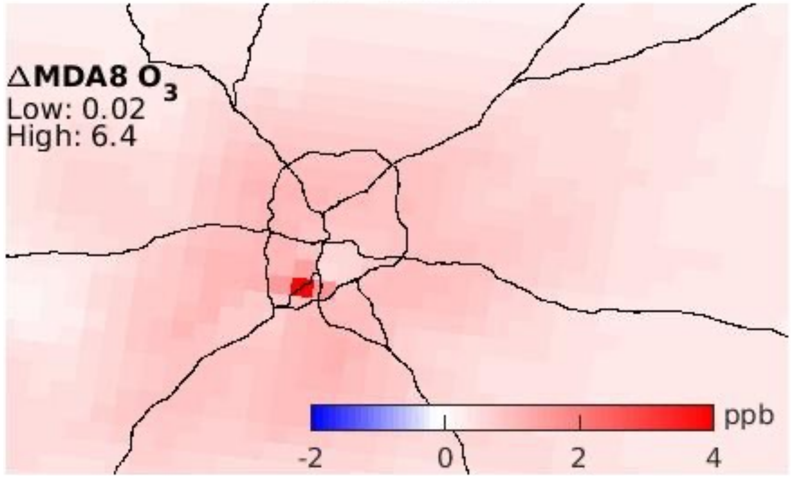
c) Fine Particulate Matter ($PM_{2.5}$)
Mass Concentration with 3D



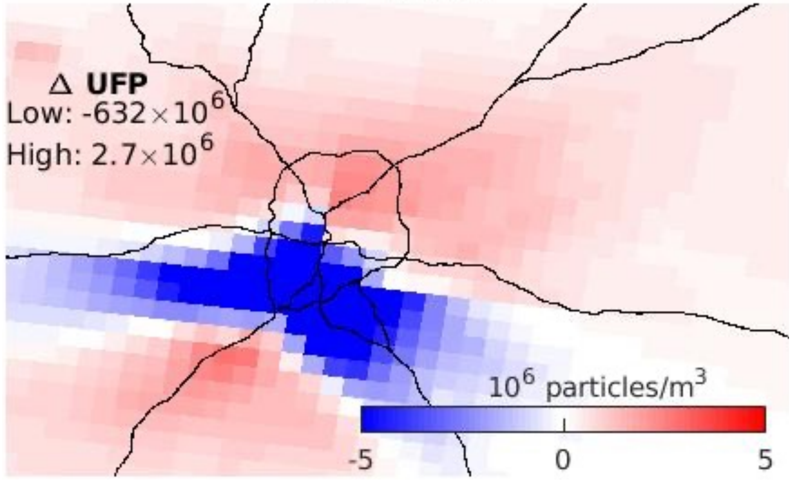
1. Ozone distribution is more regionally spread out than particulate matter
2. Particulate matter emissions: mobile and airport sources

Larger spatial impact seen with 3D inventory scenario

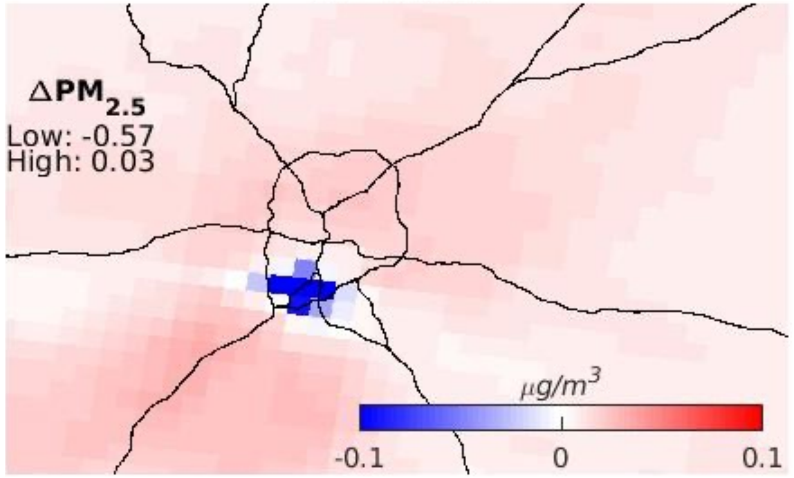
Δ MDA8 O_3
3D - Default



Δ Particle Number Concentration
3D - Default

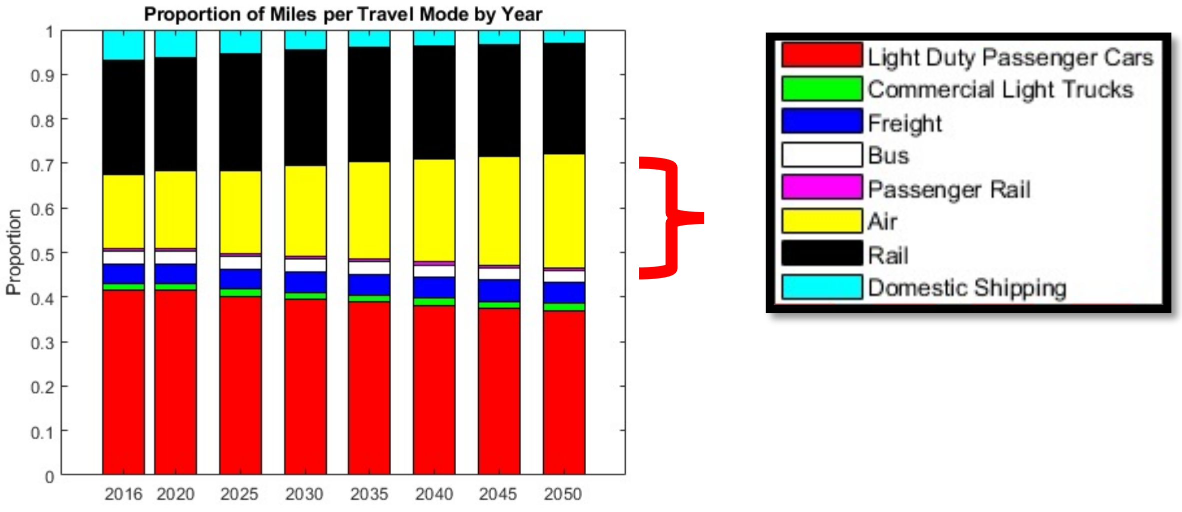


Δ Particulate Matter
3D - Default



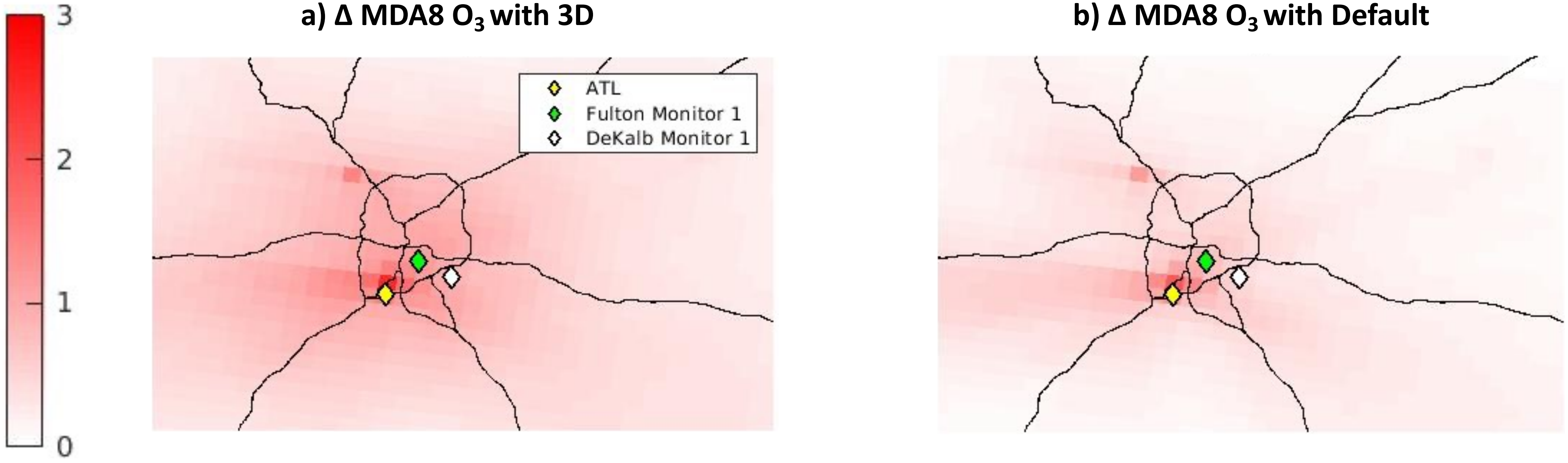
1. Ozone higher with 3D inventory over entire domain
2. Particulate matter emissions, lower with 3D (vertical allocation) at the airport, but spatial impact can be seen across the domain.

20YR PROJECTED IMPACTS: MAX 8HR O_3



a) Δ MDA8 O_3 with 3D

b) Δ MDA8 O_3 with Default



CONCLUSIONS

- TROPOMI captures NOx point sources at high resolution when used with AMFs derived from high resolution models.
- The model shows that airport's impact higher with 3D inventory
- Airport effects are not constrained to the airport.
- Highlights the need for better aviation inventories in 3D modeling.
- Airport effects could offset emission control gains with other sectors.

Abiola S. Lawal, Armistead G. Russell and Jennifer Kaiser. **Assessment of Airport-Related Emissions and their Impact on Air Quality in Atlanta, GA using CMAQ and TROPOMI.** Currently under review in Environmental Science & Technology

Thank you