Near-Road Nitrogen Dioxide Monitoring Stations: Are We Capturing the Variability to Estimate Population Exposure in Urban Areas?

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Introduction

- Nitrogen dioxide (NO_2) is a gaseous air pollutant that causes a range of harmful effects on human health.
- Motor vehicles are a leading source of NO_2.

The Clean Air Act requires the U.S. Environmental Protection Agency (EPA) to monitor and regulate the ambient NO_2 concentrations.

- In 2010, EPA promulgated minimum near-road NO_2 monitoring requirements.
- Six years later, however, they removed the requirement in areas with populations between 500,000 and 1,000,000 persons (40 CFR 58).

- Ambient NO_2 concentrations collected at the existing near-road monitoring sites are below the NAAQS (National Ambient Air Quality Standards) levels.
- However, many studies and satellite measurements have demonstrated intra-urban variability of nitrogen dioxide.
- This study compared air quality model predictions of NO_2 concentrations with monitoring measurements in two urban areas in Texas.

Methodology

[Study Sites]

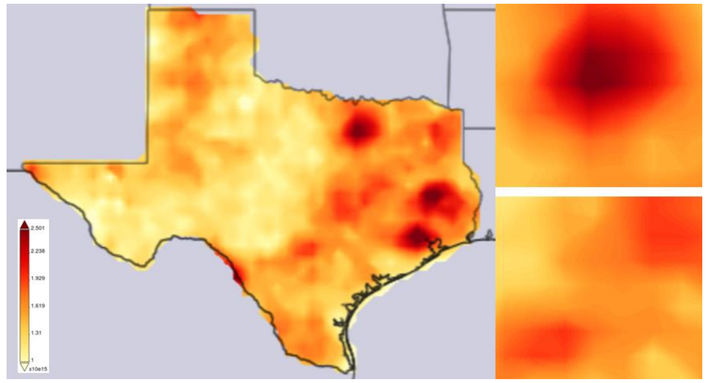
Austin and Dallas were chosen for this analysis because:

- Texas is ranked 2 in total number of registered vehicles.
- Both are ozone non-attainment areas.
- They can represent different groups:
  - Austin
    - Population (2011): < 1,000,000 (~800,000)
    - 2 near-road NO_2 monitoring stations
  - Dallas
    - Population (2011): > 1,000,000
    - 13 near-road NO_2 monitoring stations

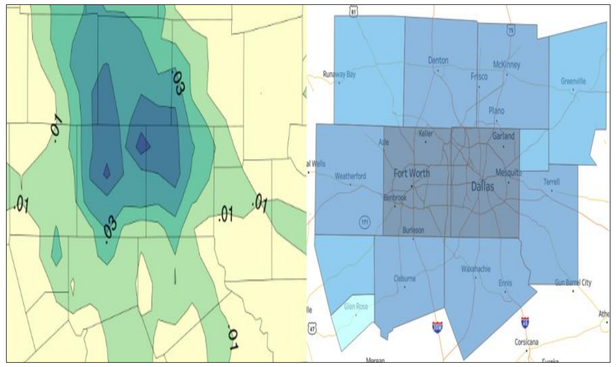
Summer months (June-August) whose ozone levels are typically highest were selected (NO_2 is a main ingredient of ground-level ozone).

[Data & Plots]

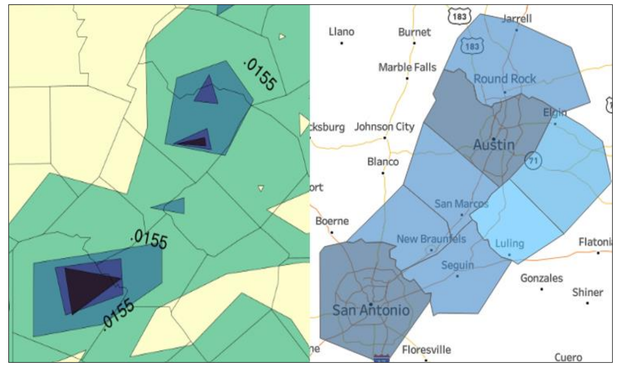
- Hourly NO_2 concentration predictions were taken from CMAQ (Community Multiscale Air Quality Modeling System), a widely used air quality model.
- Using NCAR Command Language (NCL), daily max NO_2 concentration predictions of CMAQ in Austin and Dallas areas were plotted on a map, respectively.
- NO_2 measurements were taken from the EPA Air Quality System (AQS) database (daily max 1-hour NO_2 concentrations in each monitoring station).
- Using NCL, correlation plots between AQS measurements and model predictions were created with monitor measurements on the x-axis and CMAQ predictions on the y-axis (unit: parts per million).



NO_2 Satellite Measurements for June 2011: Texas (left), Dallas (top right), and Austin (bottom right) (Source: NASA Giovanni)



Dallas. NO_2 Concentration Predictions of CMAQ on June 6, 2011 (left), Map of Roads and Population Density in Dallas Counties (right)

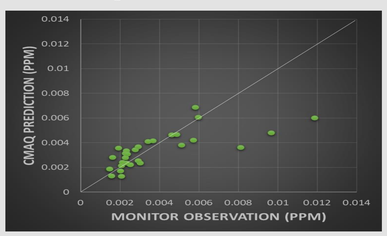


Austin. NO_2 Concentration Predictions of CMAQ on June 6, 2011 (left), Map of Roads and Population Density in Austin Counties (right)

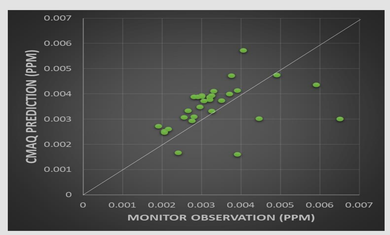
Results

- Maps of NO_2 predictions in Austin and Dallas showed variability (higher concentrations near roads and areas with more people).
- Austin and Dallas did not show 1:1 agreement between measurements and predictions.
  - Austin shown in (a)-(c):
    - Datasets were scattered although they showed some positive correlations.
    - July showed higher model predictions, whereas August showed higher measurements.
  - Dallas shown in (d)-(f):
    - Datasets scattered away from the 1:1 line.
    - Most data showed higher model predictions.

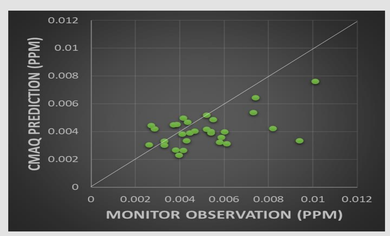
Ambient NO_2 Concentrations: CMAQ Predictions vs. Monitor Measurements



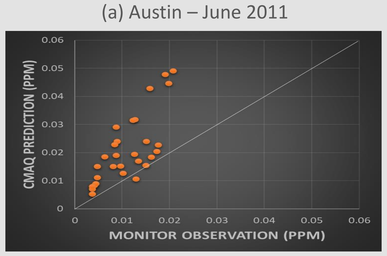
(a) Austin – June 2011



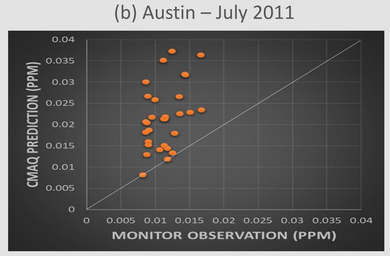
(b) Austin – July 2011



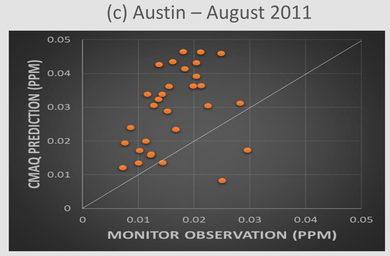
(c) Austin – August 2011



(d) Dallas – June 2011



(e) Dallas – July 2011



(f) Dallas – August 2011

Conclusion

- The number of installed near-road NO_2 monitoring stations varies by region.
- Many studies and satellite measurements have demonstrated the variability of NO_2 concentrations.
- CMAQ predictions in Austin and Dallas also showed the variability of NO_2 concentrations.
- In both Austin and Dallas, model predictions did not show 1:1 agreement with monitor measurements.
  - Dallas that has > 1M populations and 13 monitoring stations mostly showed higher model predictions.
  - Austin that has fewer populations and monitoring stations showed inconsistency – higher model predictions or higher monitor measurements.
- This result concludes that current near-road NO_2 monitoring stations may not appropriately estimate population exposure in urban areas.

Given that policies and other decision-makings are primarily based on measurements, it is important to evaluate how adequately the monitoring stations currently record the ambient NO_2 concentrations and thus represent population exposure in urban areas.

Limitations:

- This study investigated only two urban areas in Texas for three months of a single year.
- Factors that may influence either monitor measurements or model predictions may vary both spatially and temporally.
- Further research is required to find how well near-road NO_2 monitoring stations capture the variability of nitrogen dioxide in various urban areas.

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