Fusing Observational Data and Chemical Transport Model Simulations to Create Spatiotemporally Resolved Ambient Air Pollution Fields for Health Analysis

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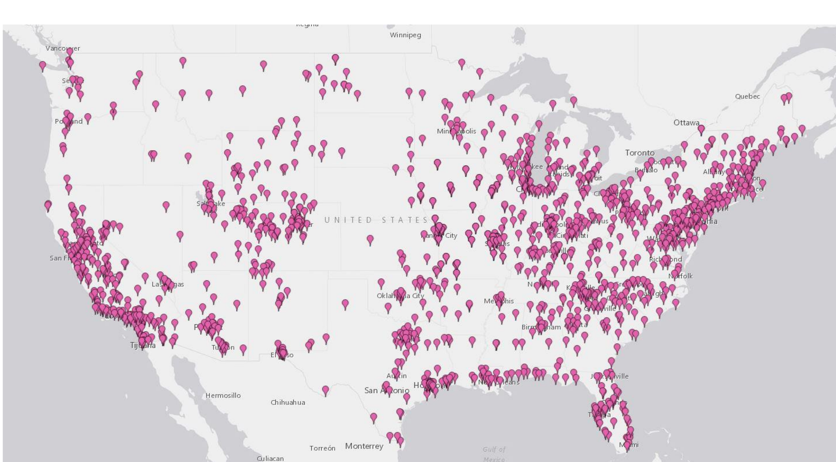
OBJECTIVES

Combine observational (OBS) and chemical transport model (CMAQ) simulations to create accurate and complete air pollution fields

- Domain: Contiguous U.S., 12km resolution, 2005-2014
- Pollutants: 1h maxNO_2, NO_x, CO, SO_2; 8h max O_3; 24h PM_{10}, $PM_{2.5}$, EC, OC, NH_4^+, SO_4^{2-}, NO_3^-
- Evaluate model through data withholding

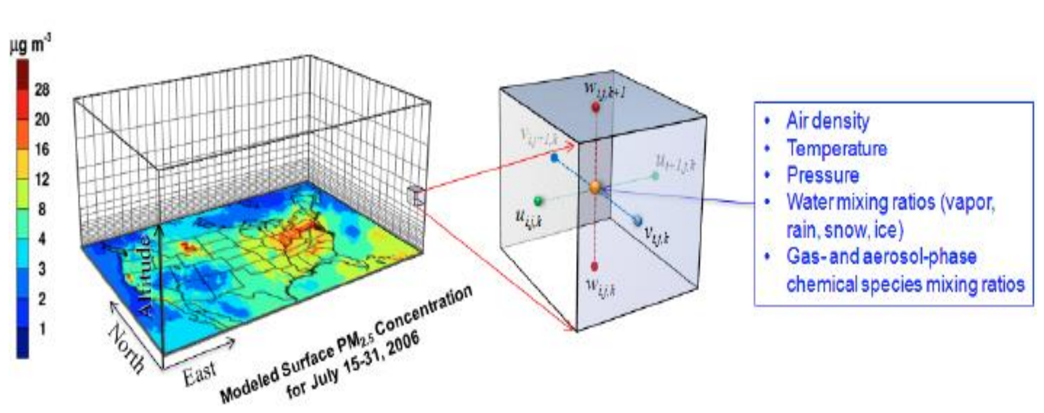
INTRODUCTION

- Need spatially and temporally resolved air quality for acute health effects studies
- Monitoring networks provide accurate measurements but limited spatial information



U.S. Ozone Monitoring Network for 2011

- EPA and CDC have collaborated to provide air pollution concentration fields for 2005-2014 at a 12km resolution across the U.S.



Processes calculated in the CMAQ chemical transport model simulation.

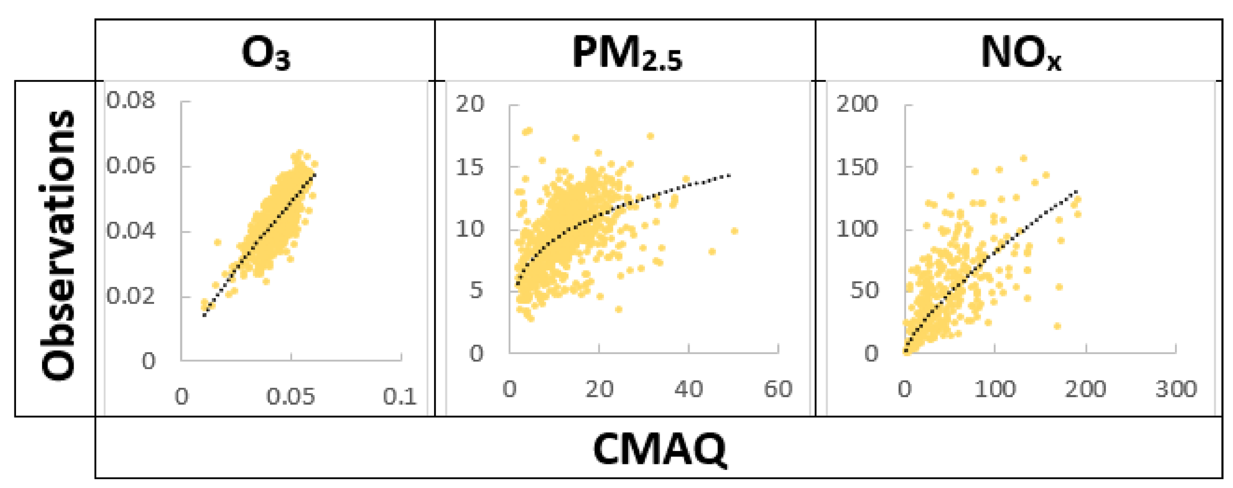
- Data Fusion combines measurements with chemical transport model simulations to create spatiotemporally complete air pollution fields

METHODS

Annual Average OBS-CMAQ Regression

- Yearly average CMAQ and monitor concentrations
- Perform power regression

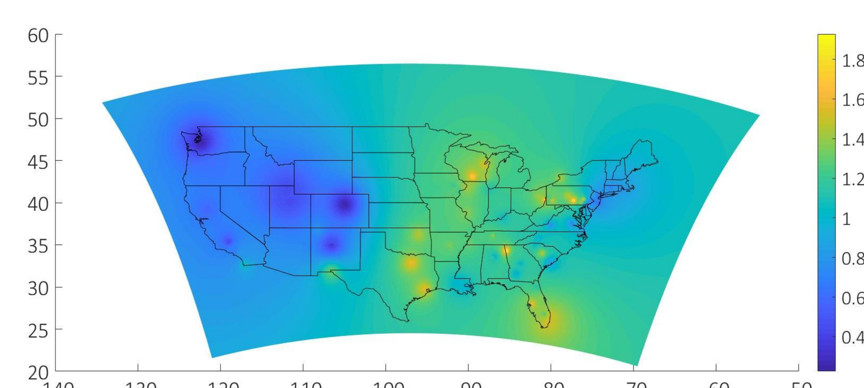
$$\overline{OBS} = \alpha \overline{CMAQ}^{\beta}$$



$OBS = 0.51\,(CMAQ)^{0.78}$ $OBS = 4.85\,(CMAQ)^{0.23}$ $OBS = 2.67(CMAQ)^{0.74}$

OBS/CMAQ Ratio Interpolation

- Ratio of normalized observation to normalized CMAQ
- Inverse Distance Weight (IDW) ratio



Interpolated dimension-less ratio for PM25 for 2011.

Using Inverse Distance Weighted field, and the CMAQ field adjusted with the regression Parameters we can generate C^*

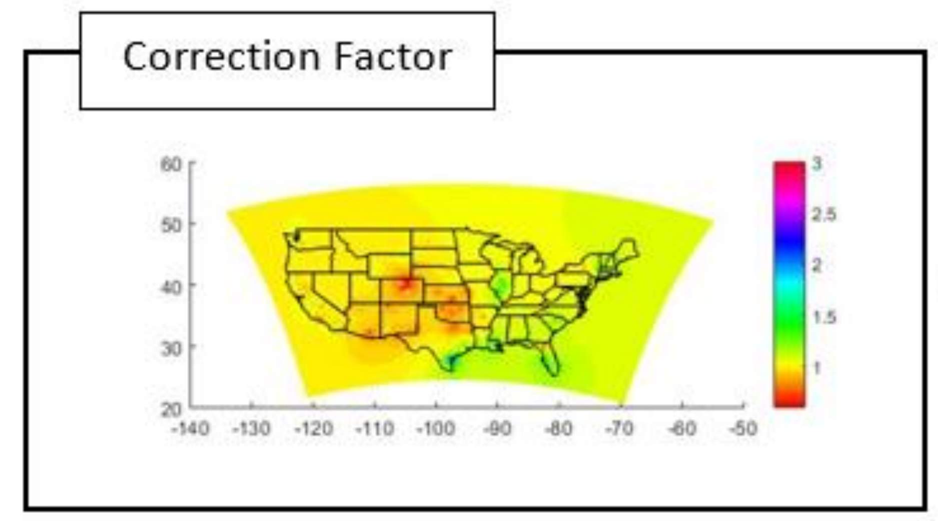
Fused Field Generation

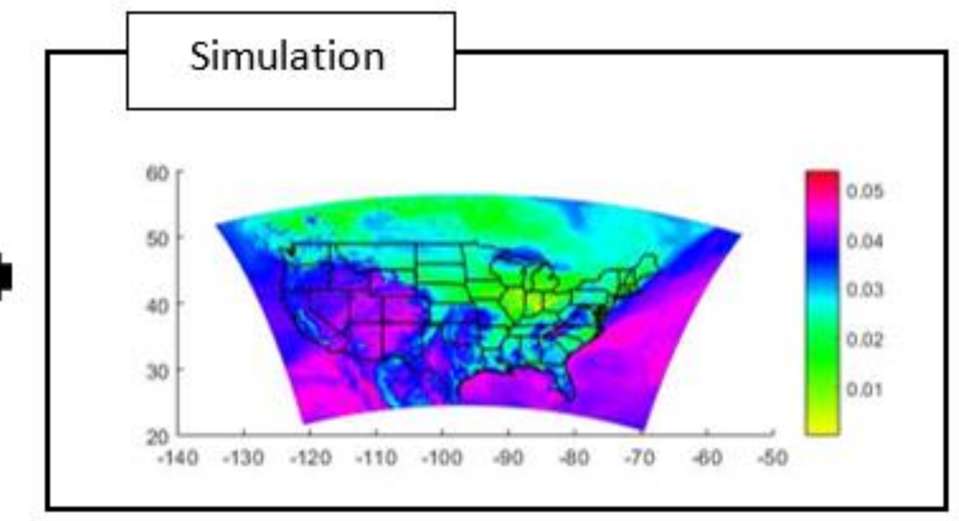
- Multiply IDW ratio field by CMAQ concentration in each cell

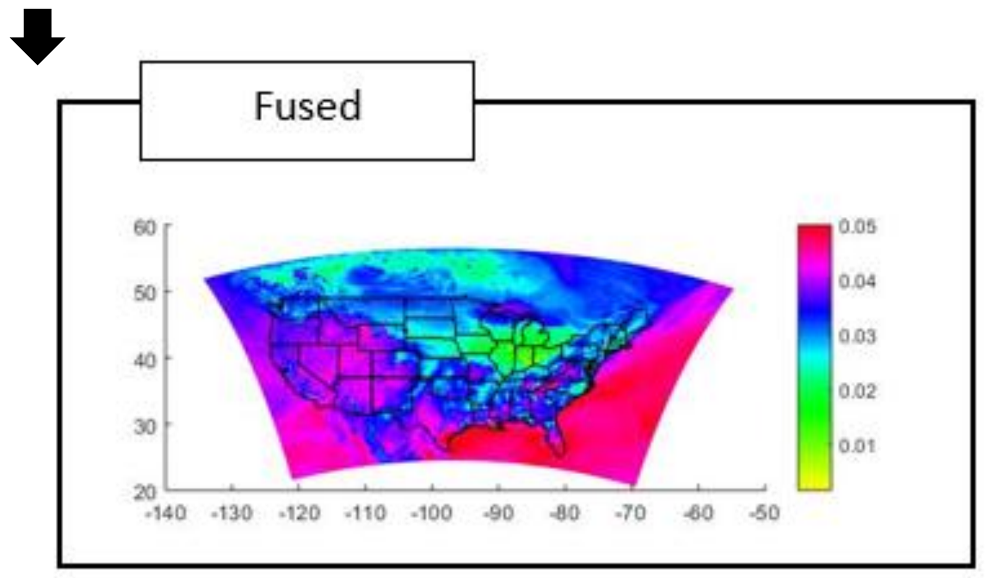
$$C^* = \left(\frac{OBS}{\alpha CMAQ^{\beta}} \times \frac{\alpha \overline{CMAQ}^{\beta}}{\overline{OBS}}\right)_{IDW} \times \alpha CMAQ^{\beta}$$

C^*	Fused Concentration Field
OBS	Observational Value
$CMAQ$	Simulated Model Value
$\overline{OBS}$	Yearly Averaged Observational Value
$\overline{CMAQ}$	Yearly Averaged CMAQ
α	Regression Parameter
β	Regression Parameter

RESULTS

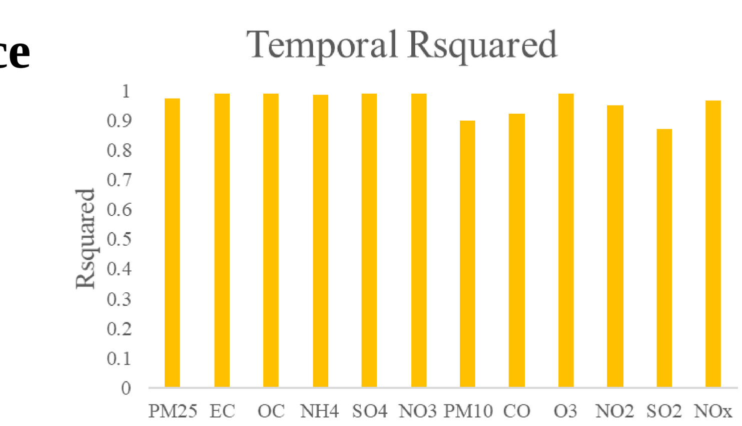


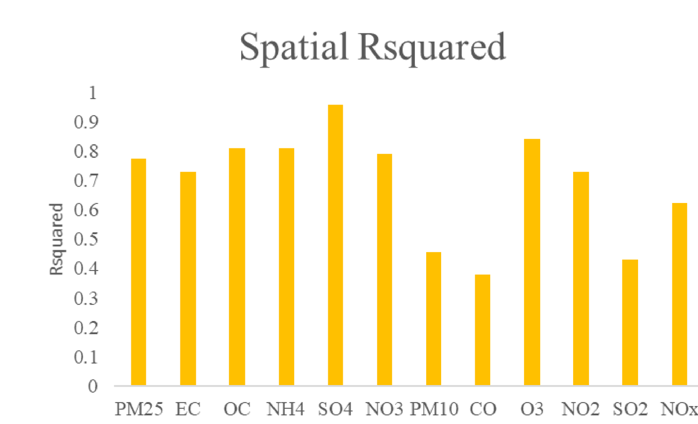




Concentration fields at each step of process. The fused concentration maintains spatial pattern of initial CMAQ field with adjusted scale based on observational data of that day.

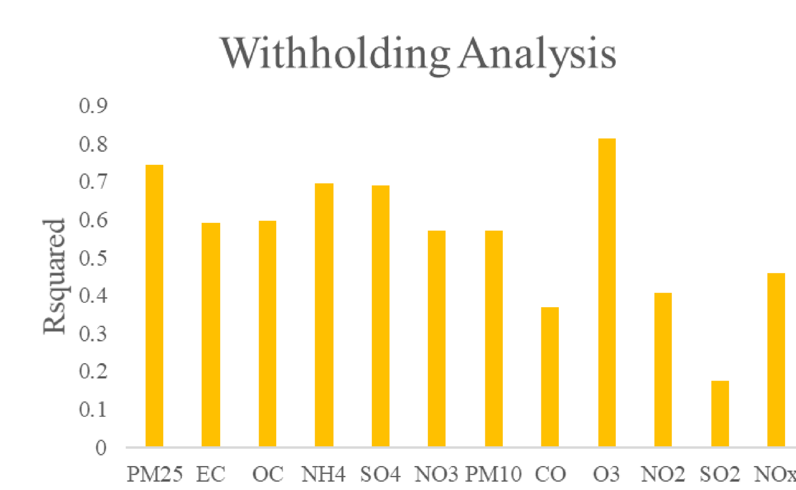
Performance





The fused field reproduces monitor temporal variation better than the monitor spatial variation.

Evaluation



Spatiotemporal R^2 values from 10% data withholding.
The R^2 indicates how well the model can predict variation at removed location.

Conclusion

- Fused Approach captures the temporal variability from the observational data while maintaining the spatial pattern of the CMAQ simulations.
- Ozone performs best, while sulfur dioxide performs worst. Ozone is a secondary pollutant with less spatial variation than primary pollutants. Sulfur dioxide concentrations are driven by coal combustion plumes that are difficult to capture through measurements or simulations.