Understanding Wintertime Air Pollution: the Roles of Building Heating Emissions and Temperature

Atmospheric & Oceanic Sciences
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Background

- Nitrogen oxides (NOx = NO + NO_2) and particulate nitrate (pNO_3^-, formed from NOx) harm human health, and often have **peak concentrations in cold weather months**.[1,2]
- **Burning fuels to heat homes emits NOx**, and heating demand increases with decreasing temperatures.

- Home heating represent an important control on wintertime air quality, which covaries with changes in **atmospheric properties** and **chemistry**:

↓ temperature, ↑ NOx lifetime[3,4] and ↑ heating emissions

↓ daylight, ↓ photolysis and ↑ nocturnal chemistry[4]

↑ stagnation and ↓ boundary layer height,
↑ concentrations[5]
↑ or ↓ NOx lifetime (depending on oxidative capacity)[6]

Research Aim

Develop and evaluate an hourly emissions inventory (EI) for **residential heating emissions** that reflects **daily temperature-based changes in heating demand.**

Key Result 1: Increase in maximum NOx emission rates

Maximum Daily NOx Emission Rate (tons/day)

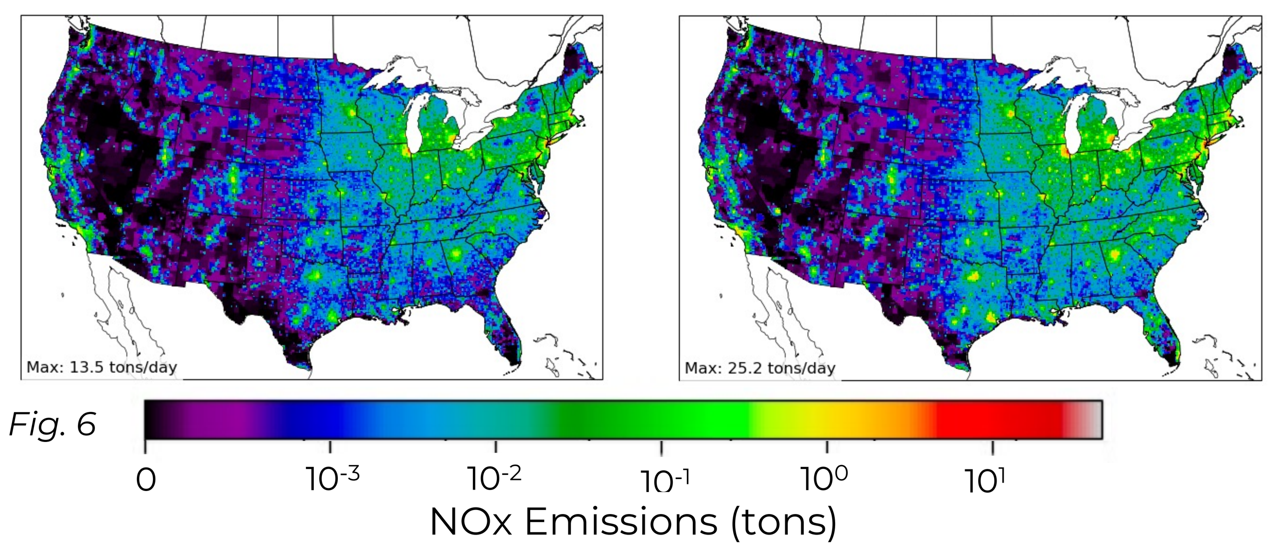

Fig. 6

% Change in Maximum Daily NOx Emission Rate

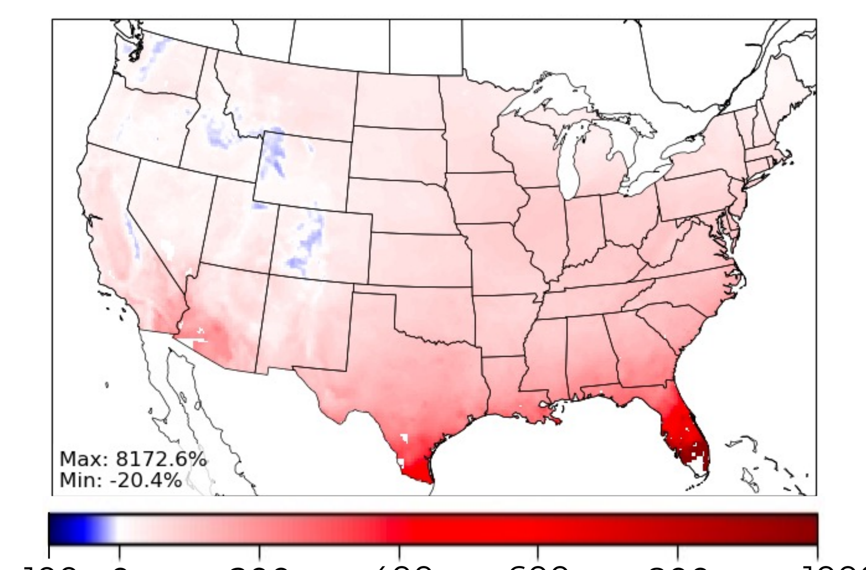

Fig. 7

Hot Climate City: **Houston**, TX

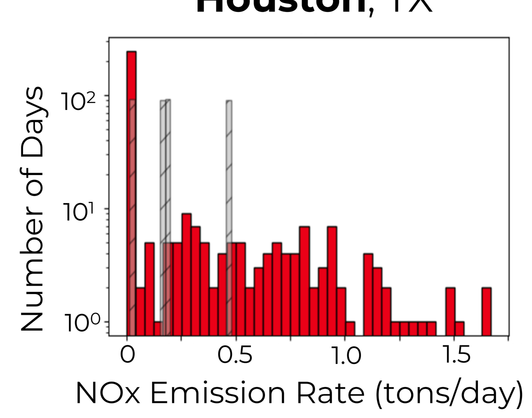

Fig. 8

Cold Climate City: **Minneapolis**, MN

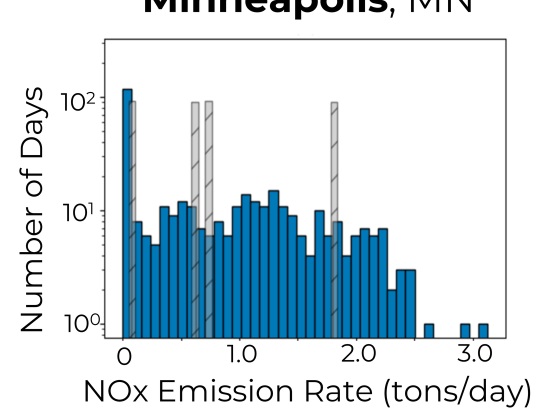

Fig. 9

Key Result 2: Shift in monthly emissions to reflect local heating season

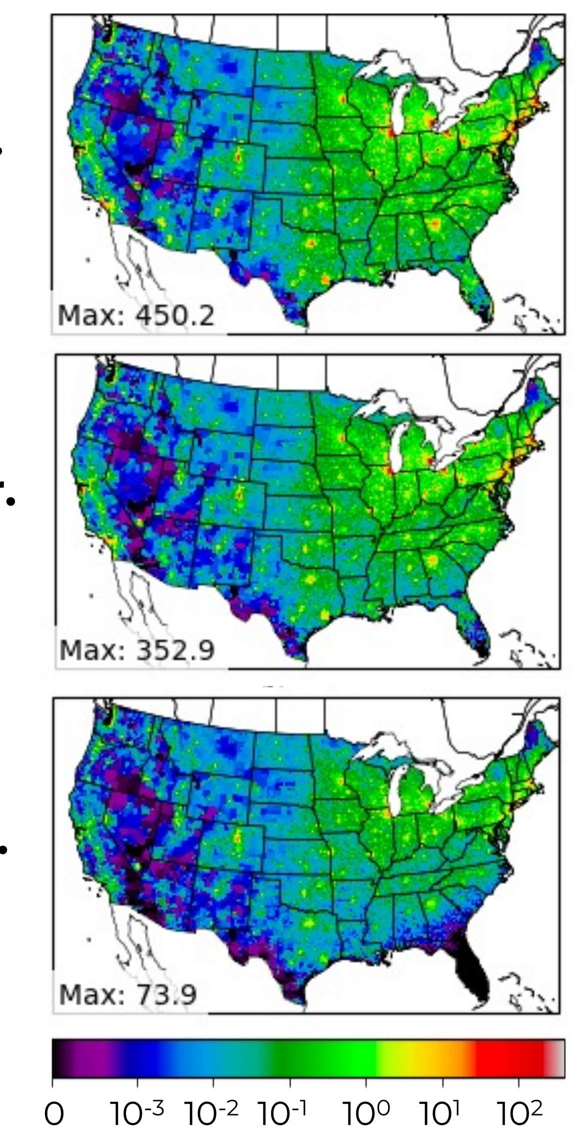

Fig. 10

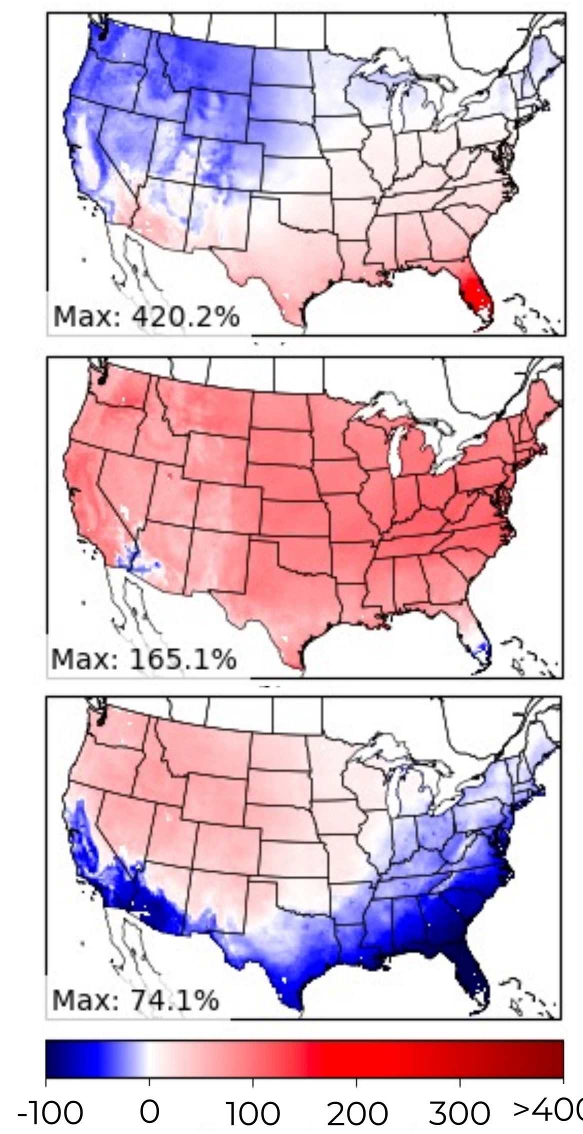

Fig. 11

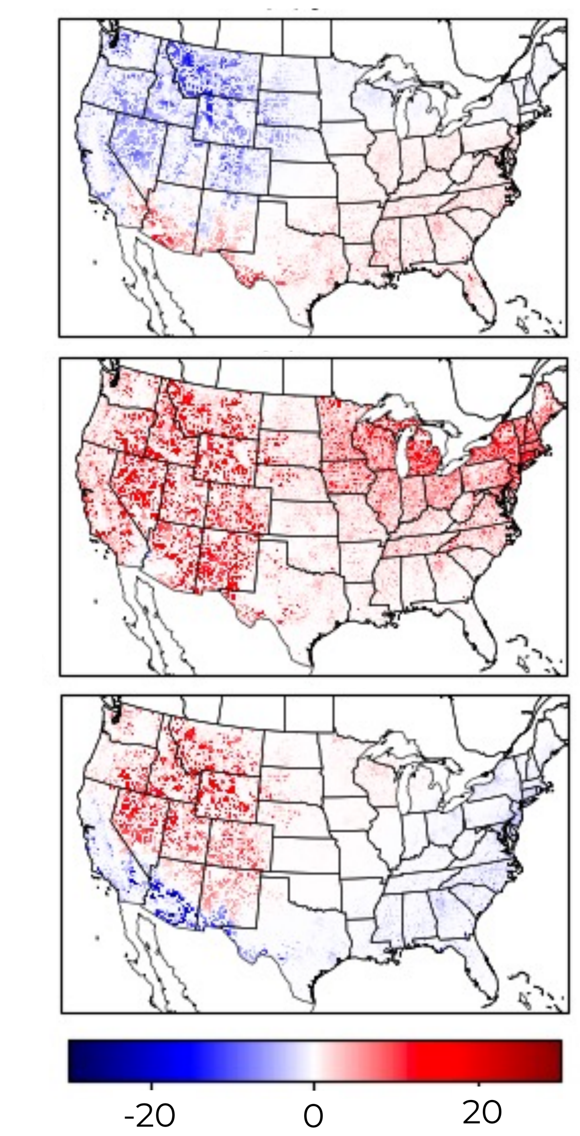

Fig. 12

Implications and Future Work

- We will use our temperature-dependent heating emissions inventory in chemical transport model simulations to **isolate the covariable factors of emissions, temperature, and chemistry on ambient wintertime NOx and pNO_3^-.**
- We expect our inventory to have the greatest impact to peak NOx concentrations during particularly cold days in urban areas.

TROPOMI NO_2 in counties with top-10 highest contribution of home heating

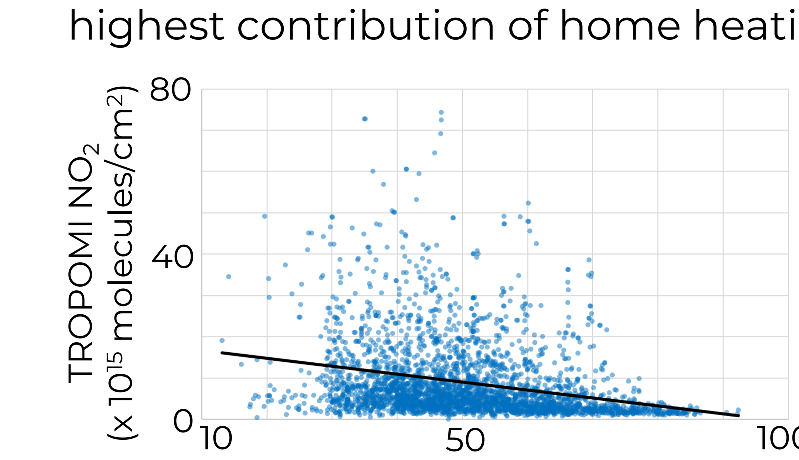

Fig. 13

CMAQ Scenario	Description	Emissions
Base Case	Default heating emissions	EQUATES 2019
HDD Case	Temperature-based residential heating	EQUATES 2019 with temperature-based EI
Zero Heating Case	Zero residential heating emissions	EQUATES 2019 with zeroed out heating emissions

Methods: Examples from Two Climates

Temporal Allocation Methods:

Default Approach: ***Seasonally-Fixed*** Daily NOx
= **NEI Annual NOx** * Seasonal Scaling Factor

Our Approach: ***Temperature-Dependent*** Daily NOx
= **NEI Annual NOx** * **Temp.-Based Scaling Factor**

$$\textbf{Temp.-Based Scaling} = \frac{\text{Daily Heating Degree Day (HDD)}}{\text{Annual Sum of HDDs}}$$

Annual Sum of Heating Degree Days (HDD)

Cold Climate City: **Minneapolis**, MN

Hot Climate City: **Houston**, TX

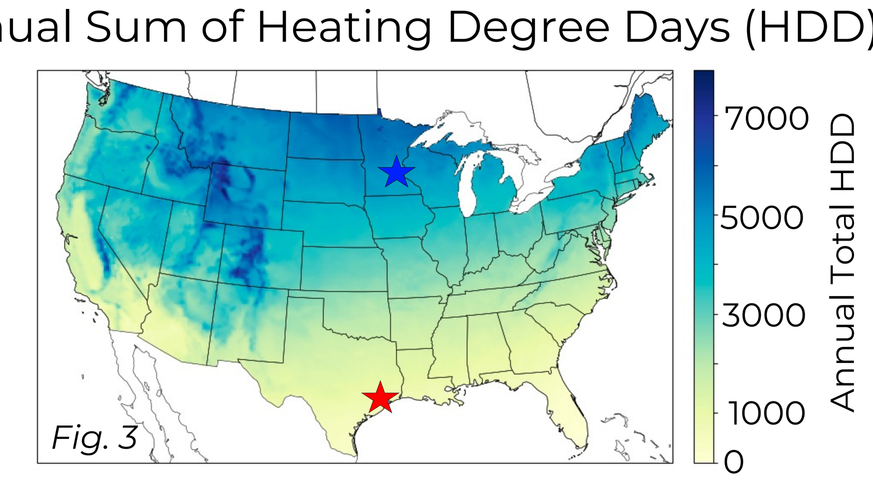

Fig. 3

NEI Annual Heating NOx

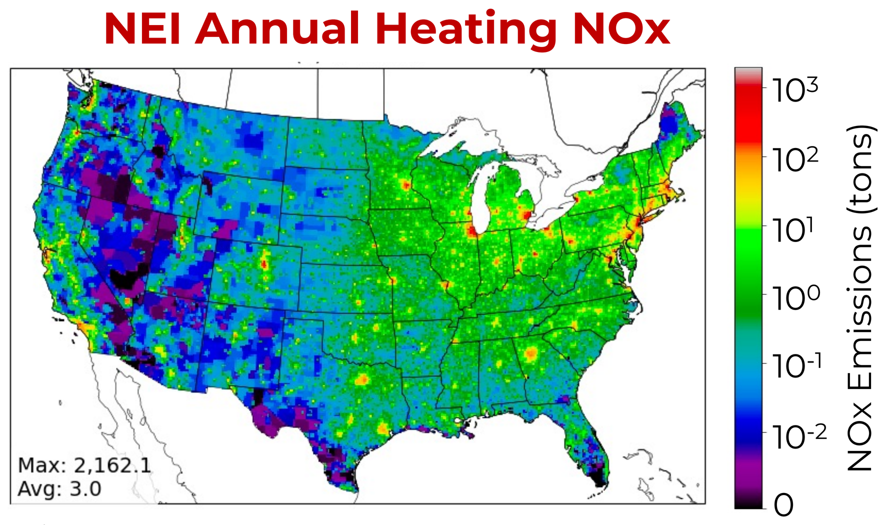

Fig. 2

Daily Mean Temp.

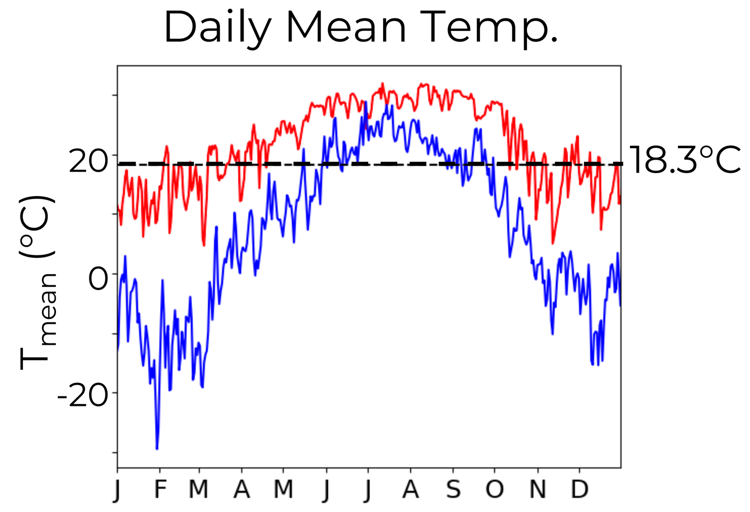

Fig. 4

Temporal Scaling Factors

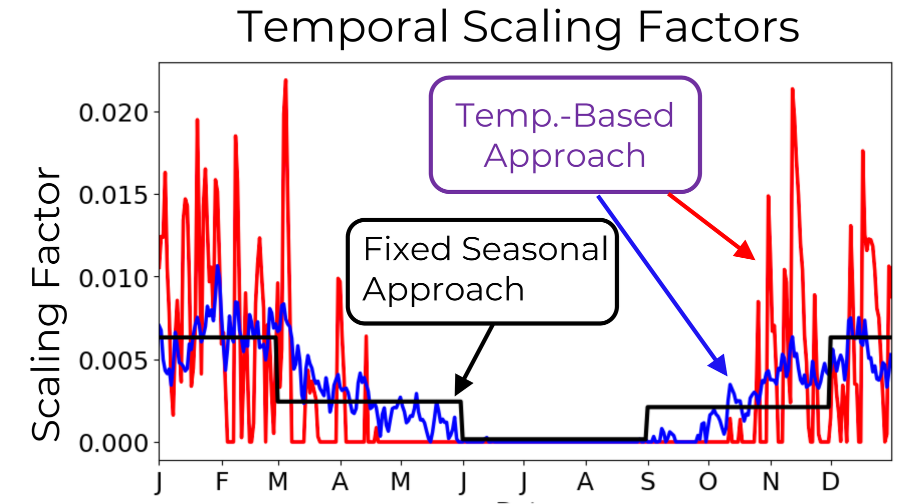

Fig. 5

Acknowledgements

Scan for references

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