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

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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]

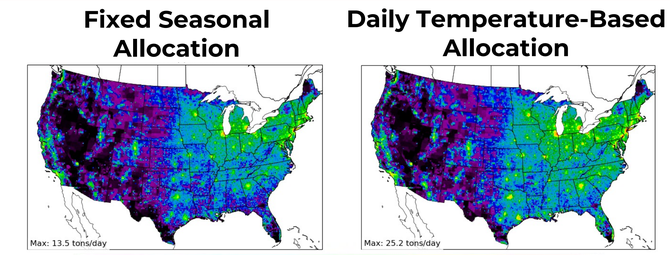
↑ or ↓ NOx lifetime (depending on oxidative capacity)[6]

Research Aim

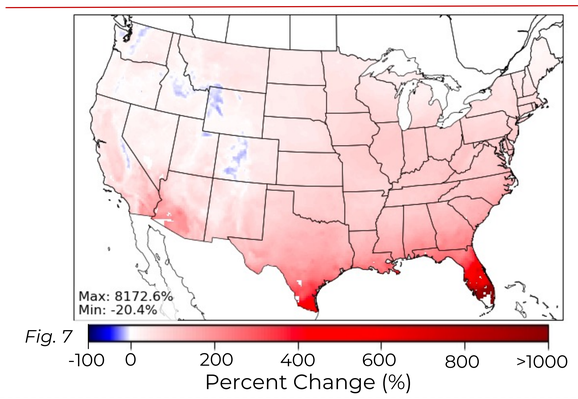
Develop and evaluate an hourly emissions inventory (EI) for **residential heating emissions** that reflects **daily temperature-based changes in heating demand.**

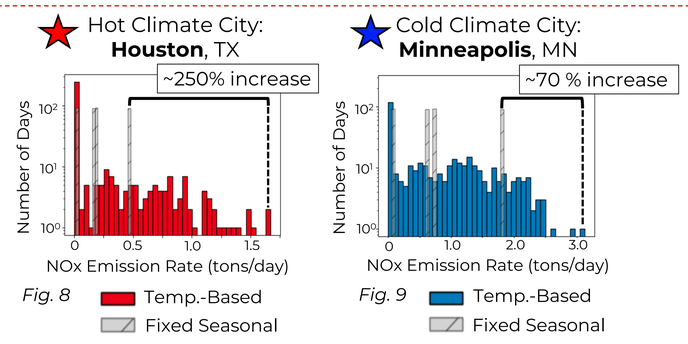
Key Result 1: Increase in maximum NOx emission rates

Maximum Daily NOx Emission Rate (tons/day)



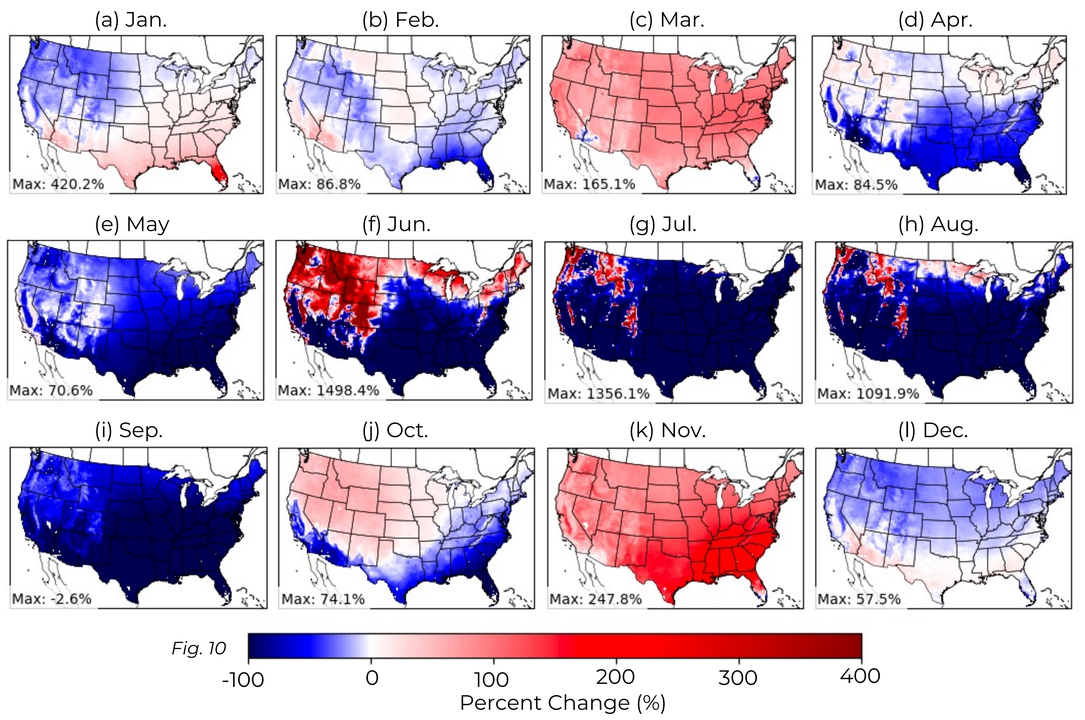
% Change in Maximum Daily NOx Emission Rate





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

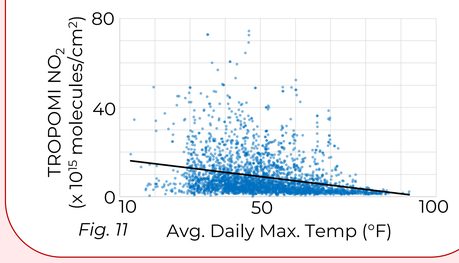
% Change in Monthly Total NOx (Temp.-Based – Fixed Seasonal)



Implications and Ongoing Work

- We will use our temperature-based 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



- We will use the model simulations to identify the contribution of heating to NO_2 concentrations observed by satellites (e.g., TROPOI, TEMPO).

Model 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

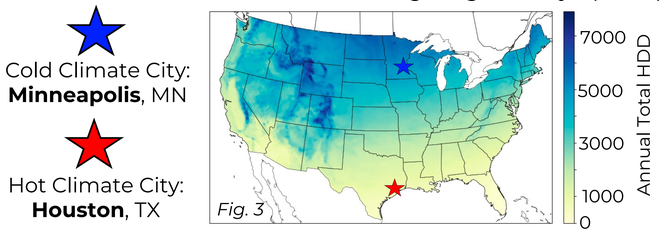
Temporal Allocation Methods:

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

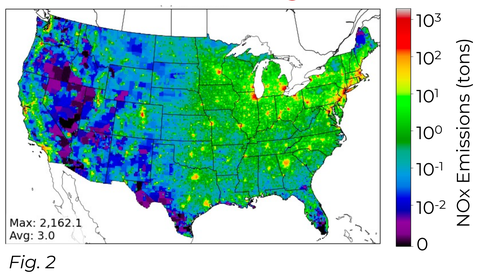
Our Approach: ***Temperature-Dependent*** Daily NOx
= **NEI Annual NOx** * **Temp.-Based Scaling Factor**

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

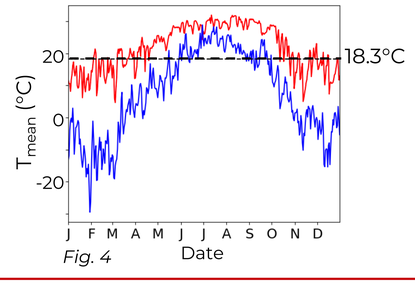
Annual Sum of Heating Degree Days (HDD)



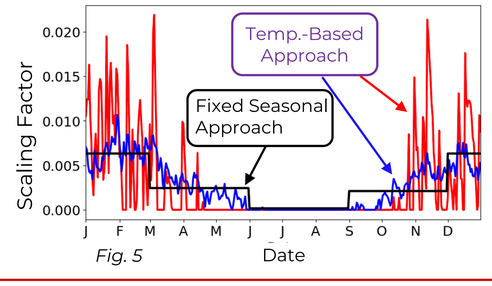
NEI Annual Heating NOx



Daily Mean Temp.



Temporal Scaling Factors



Acknowledgements

Scan for references

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