

Heatwave Effects on NO₂ Concentrations and Populations in Houston, TX

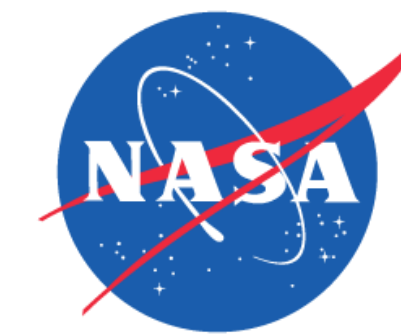
Heatwaves Influence Local NO₂ Pollution and its Communities



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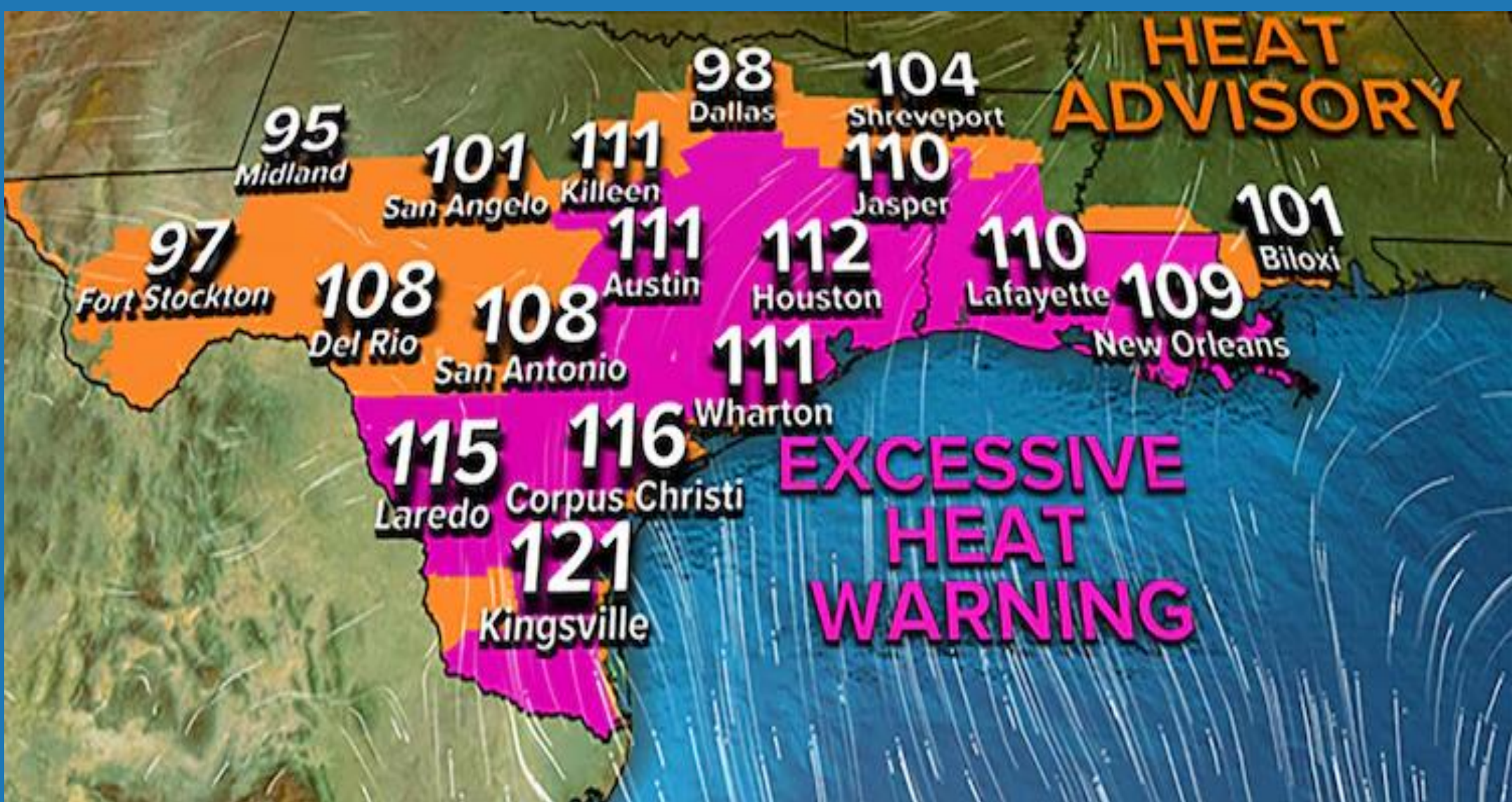
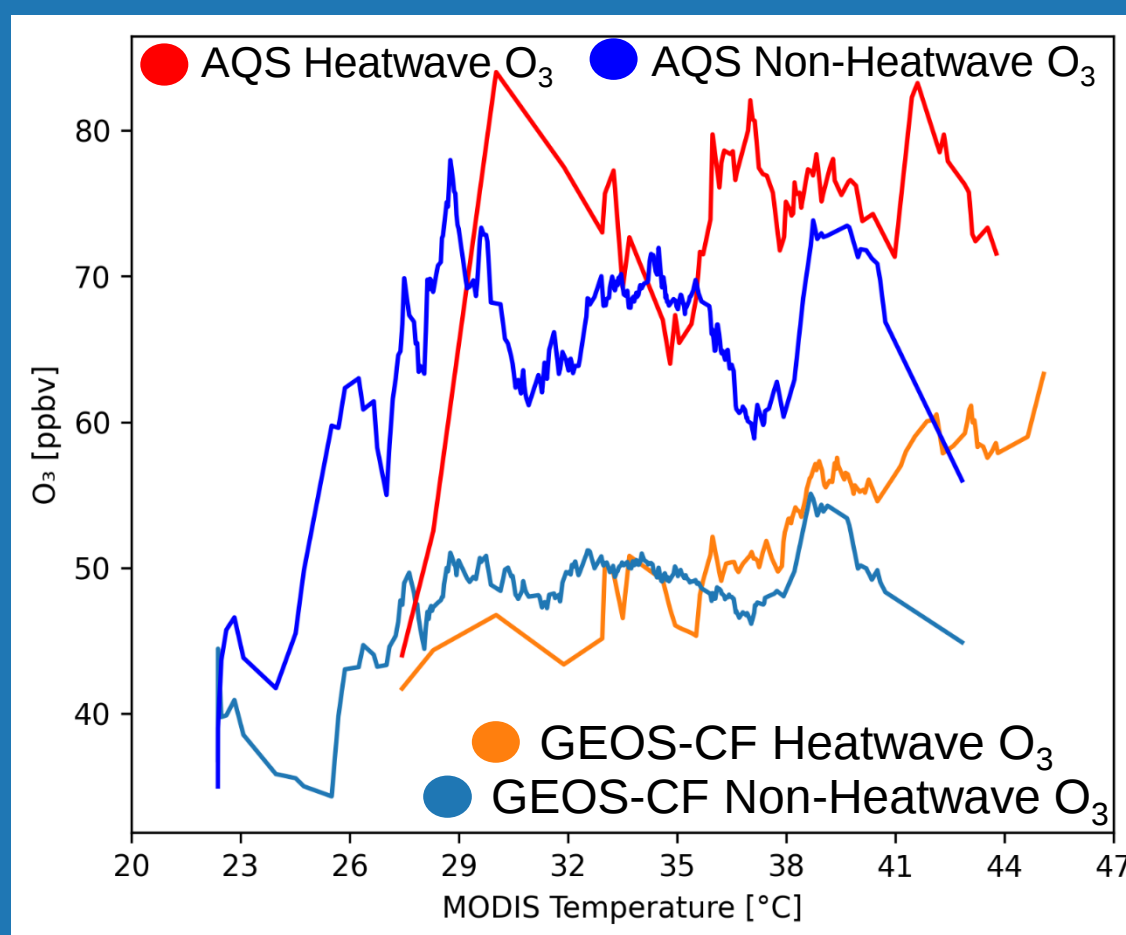
Key Observation

- Summer of 2023 was the hottest on record with almost every type of heat record possible broken in Houston

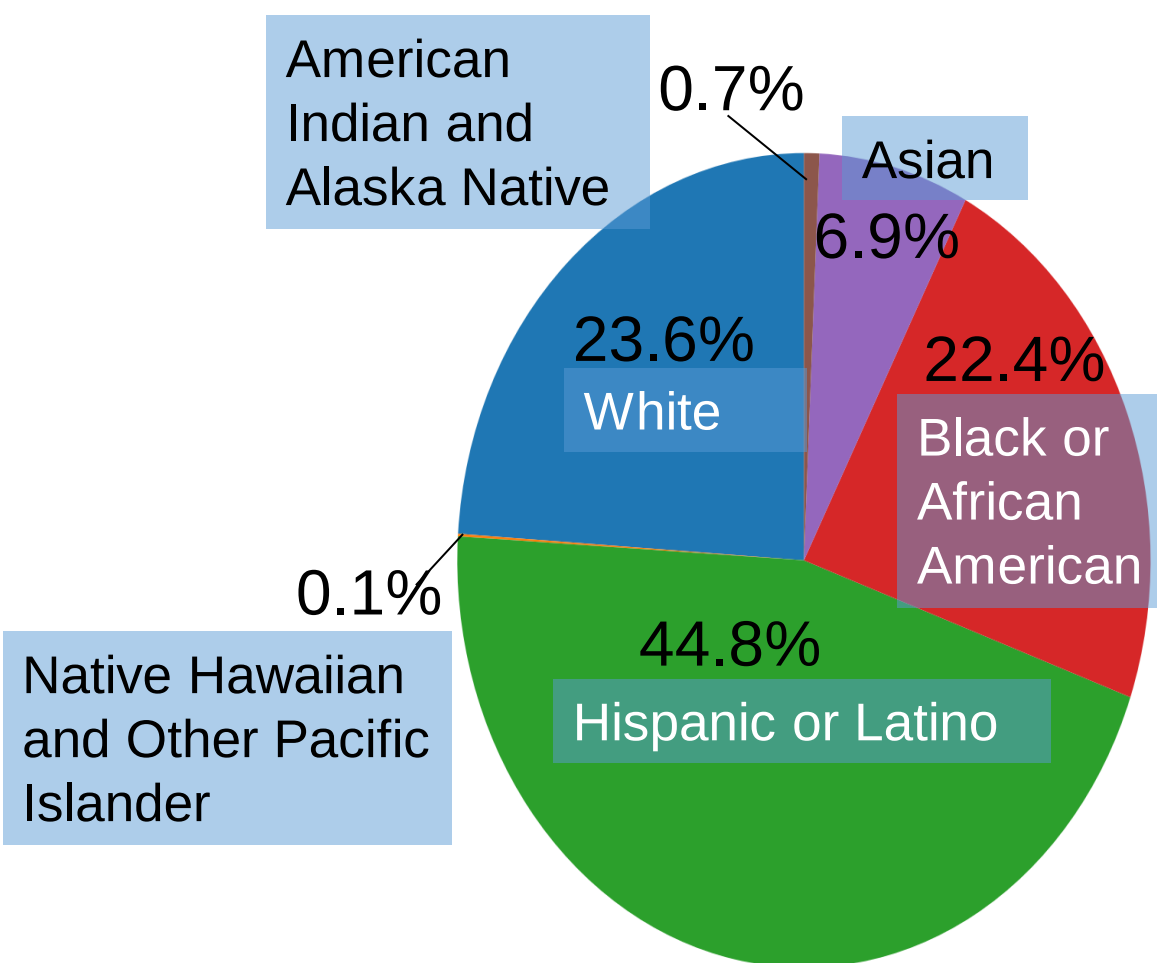
Motivating Questions

- How do NO₂ disproportions change in heatwave conditions?
- How do heatwaves affect O₃?

Ozone increases with temperatures in heatwave conditions but experiences a “suppression” type feature at maximum temperatures in in-situ observations, not captured by GEOS-CF

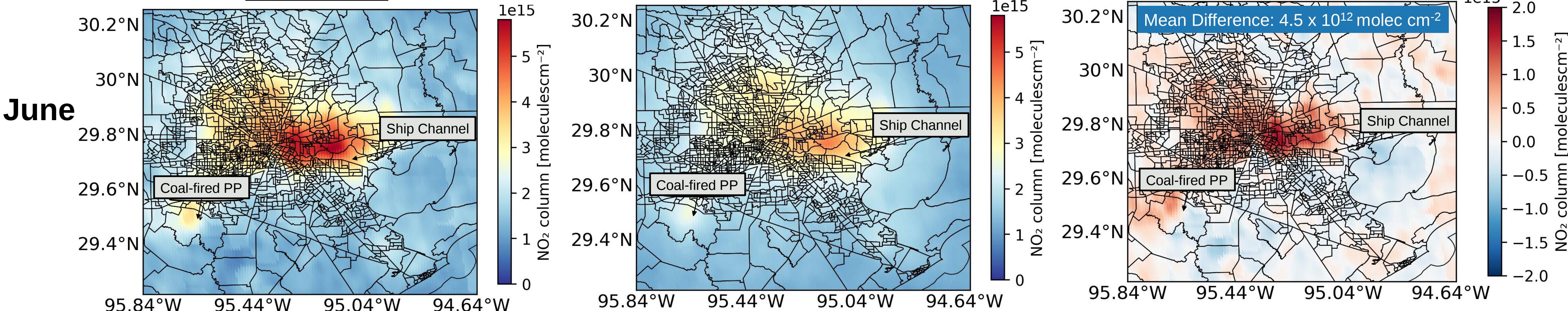


Heatwave Definition:
Average of total stations maximum temperature greater or equal to 100 °F (37.78 °C) for more than 3 days



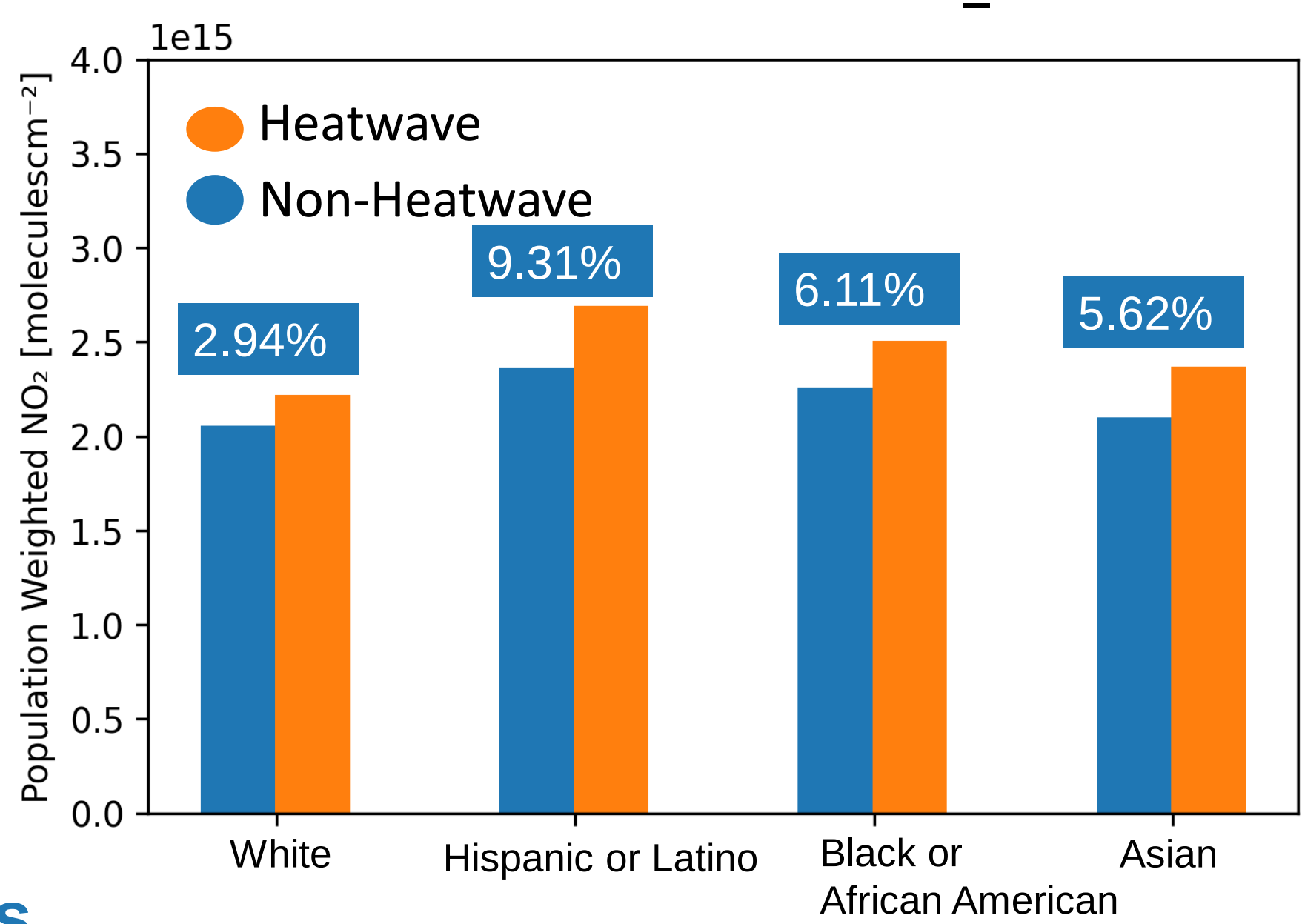
- Houston experiences many Heat Waves throughout 2018 – 2023
 - 2018 – 2023: 101 Heatwave Occurrences
- Houston is severely unequal in feeling heat and the urban heat island effect extends disparities
- MODIS Land Surface Temperature (LST) reflects temperatures experienced by populations in Houston
- TROPOMI observed NO₂ changes in Heatwave conditions between 2018 – 2023 on a monthly mean scale
 - June: 4.5×10^{12} molec cm⁻²
 - July: -2.71×10^{13} molec cm⁻²
 - August: 2.10×10^{13} molec cm⁻²

2018 – 2023 TROPOMI Tropospheric NO₂ Column Average

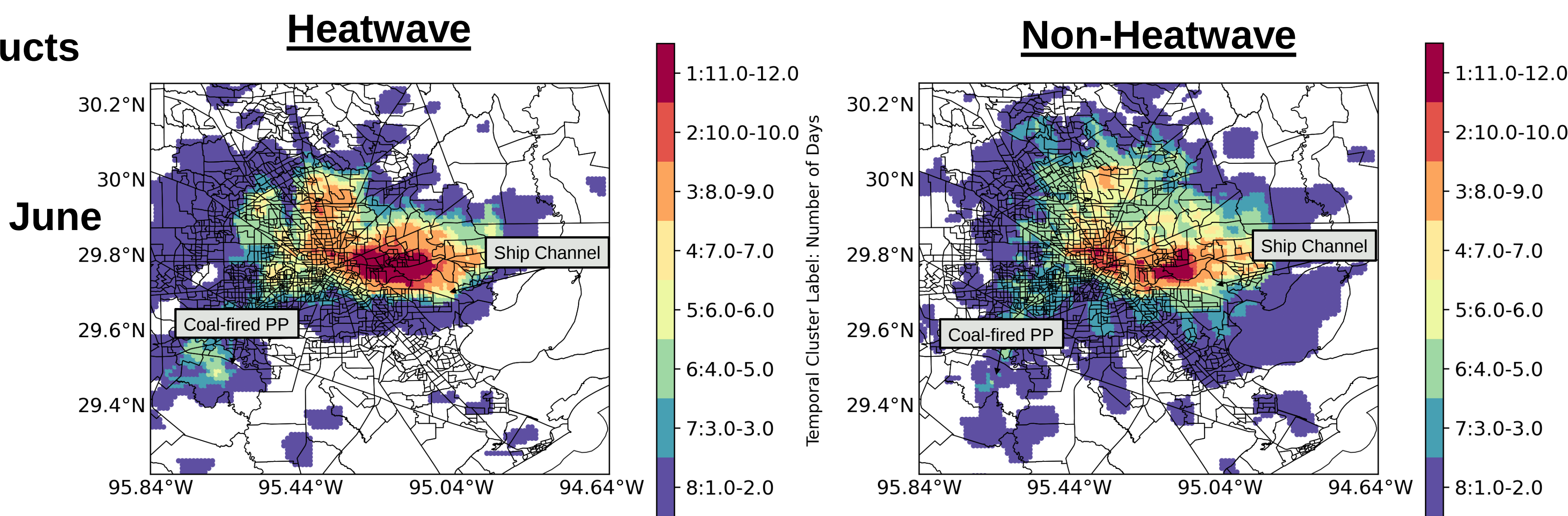
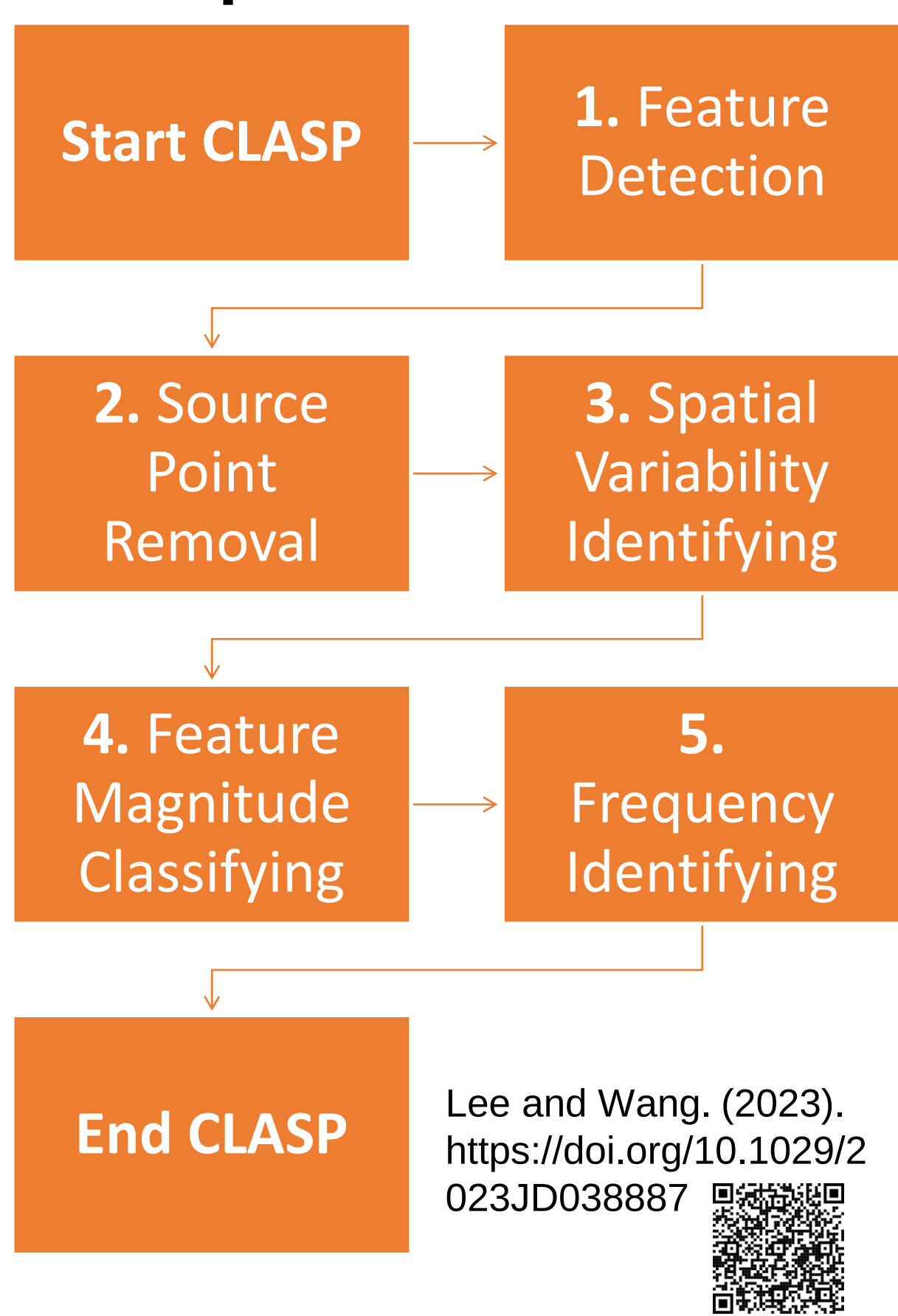


Population-weighted NO₂ columns is increased in Heatwave conditions

Population-weighted NO₂ columns



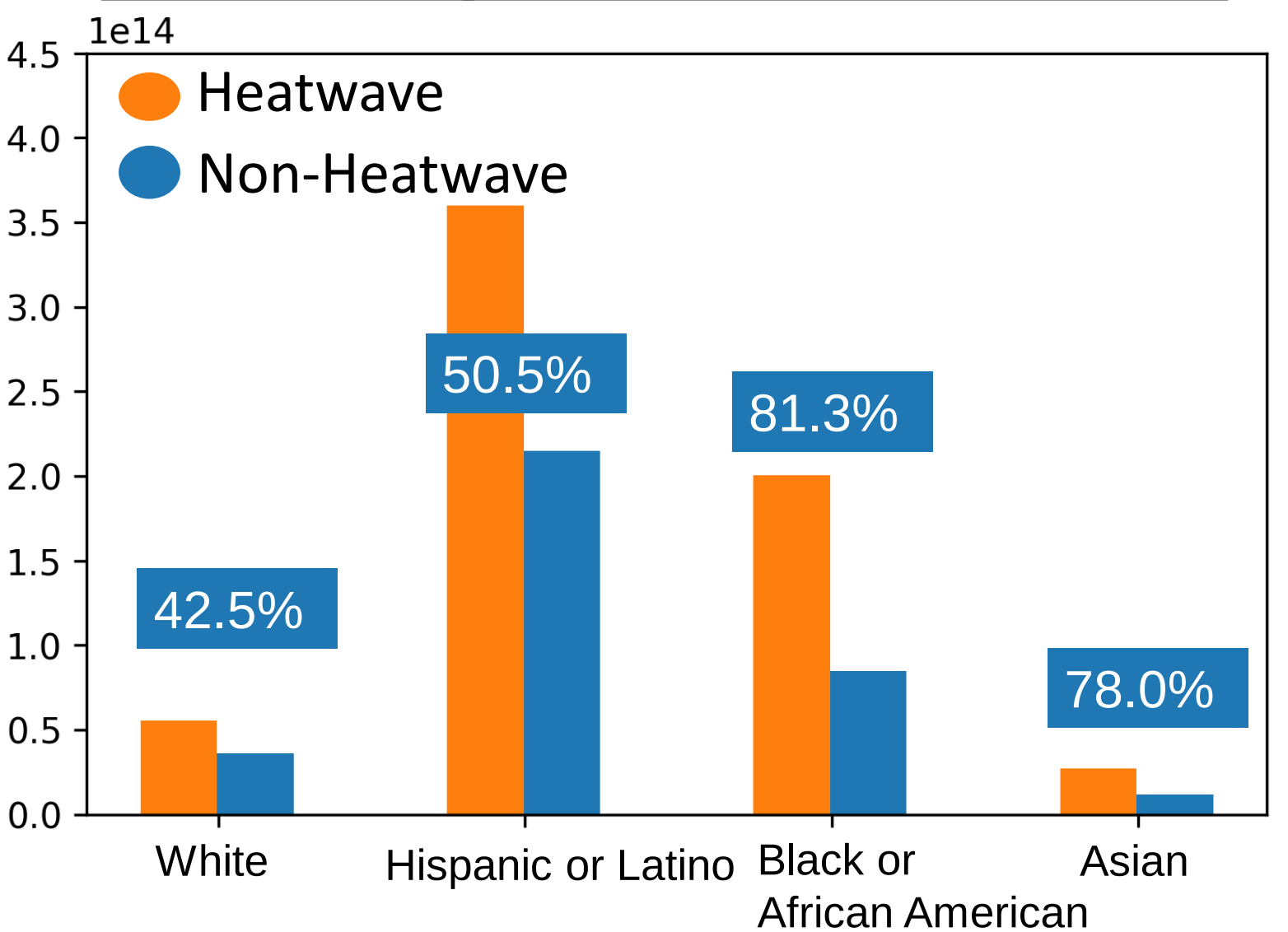
CLASP: CLustering of Atmospheric Satellite Products



Heatwaves increase NO₂ frequency in Houston's high-polluting regions

- Traditional averaging can dampen plume spatial and temporal variability
- CLASP Temporal Clusters capture variability in Heatwave and Non-Heatwave conditions
- CLASP observes how TROPOMI high-magnitude plumes change in conditions, where there is an increase in spatial area of plumes in areas near the Houston Ship Channel and a Coal-fired Power Plant in Heatwave conditions

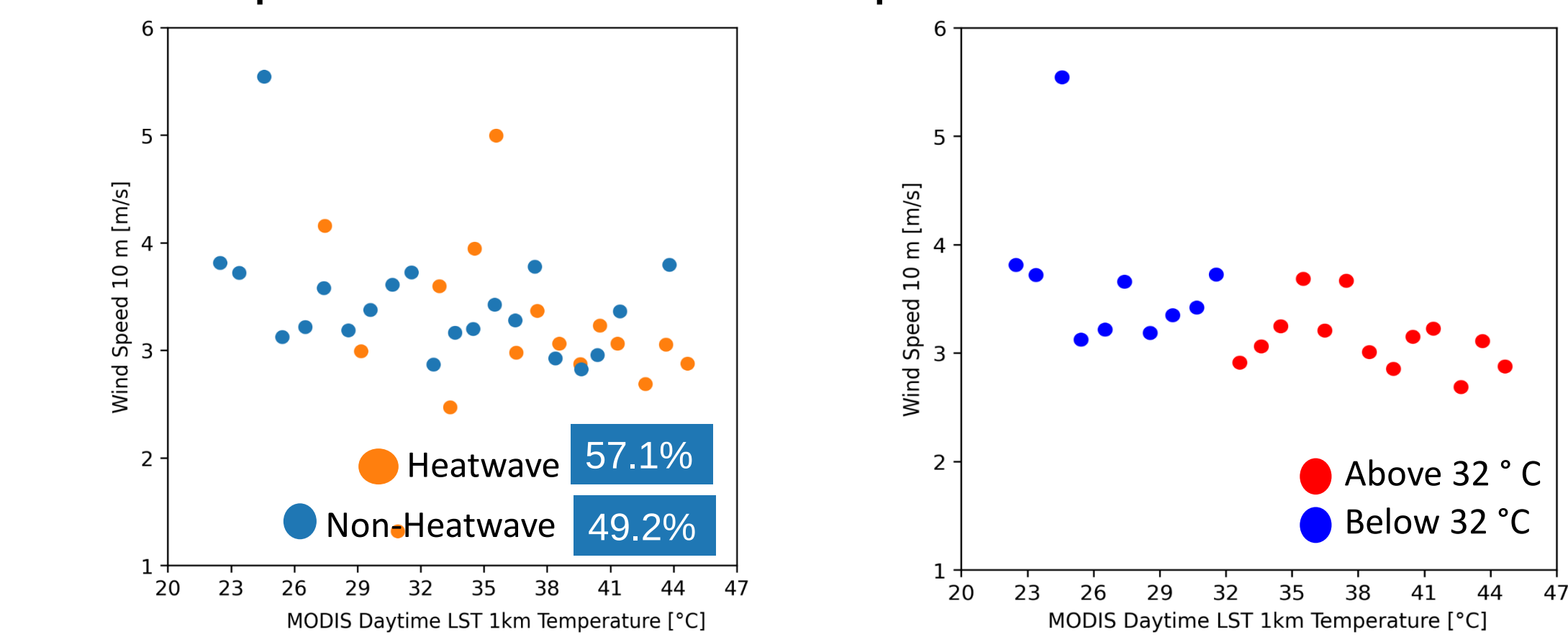
Population-weighted NO₂ columns



Communities see higher frequency of NO₂ and increased magnitudes in Heatwave conditions

Stagnation:

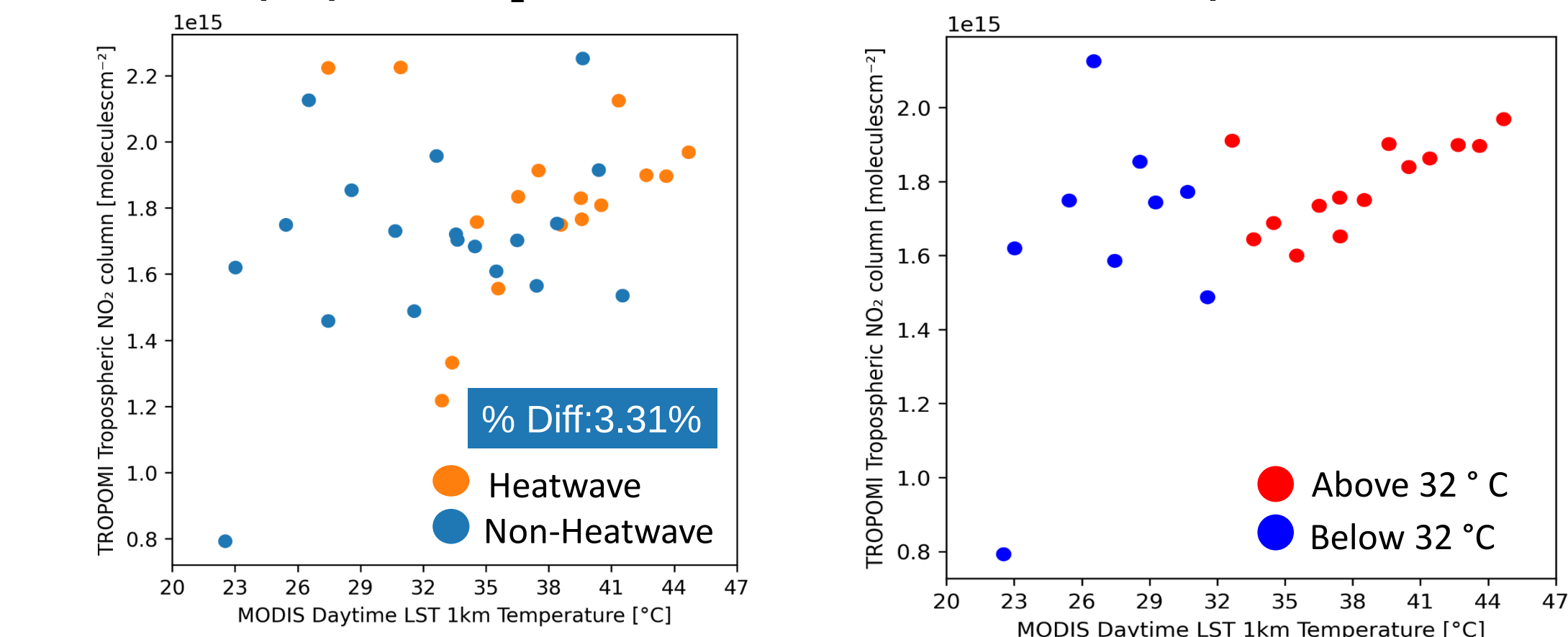
HRRR Wind Speed vs MODIS Land Surface Temperature



Stagnation increases in Heatwave conditions

NO₂ Column Concentration:

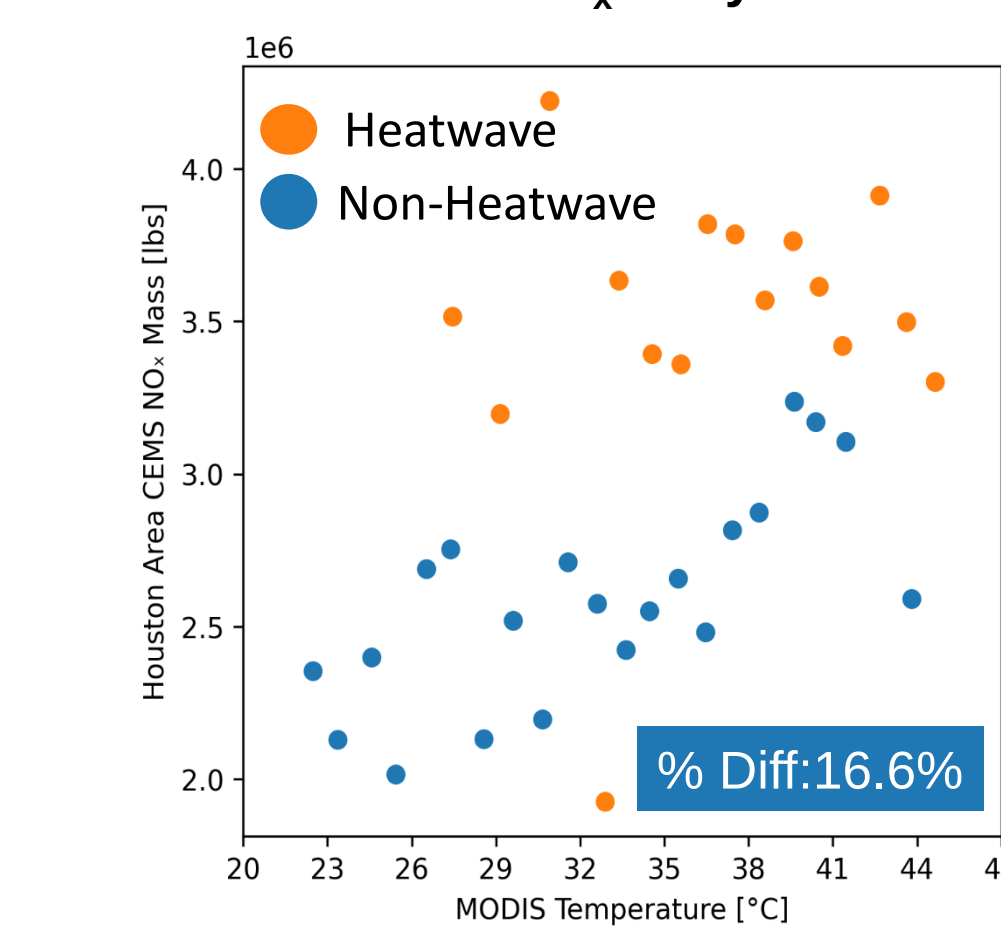
TROPOMI Tropospheric NO₂ Column vs MODIS Land Surface Temperature



NO₂ column concentration increases in Heatwave conditions

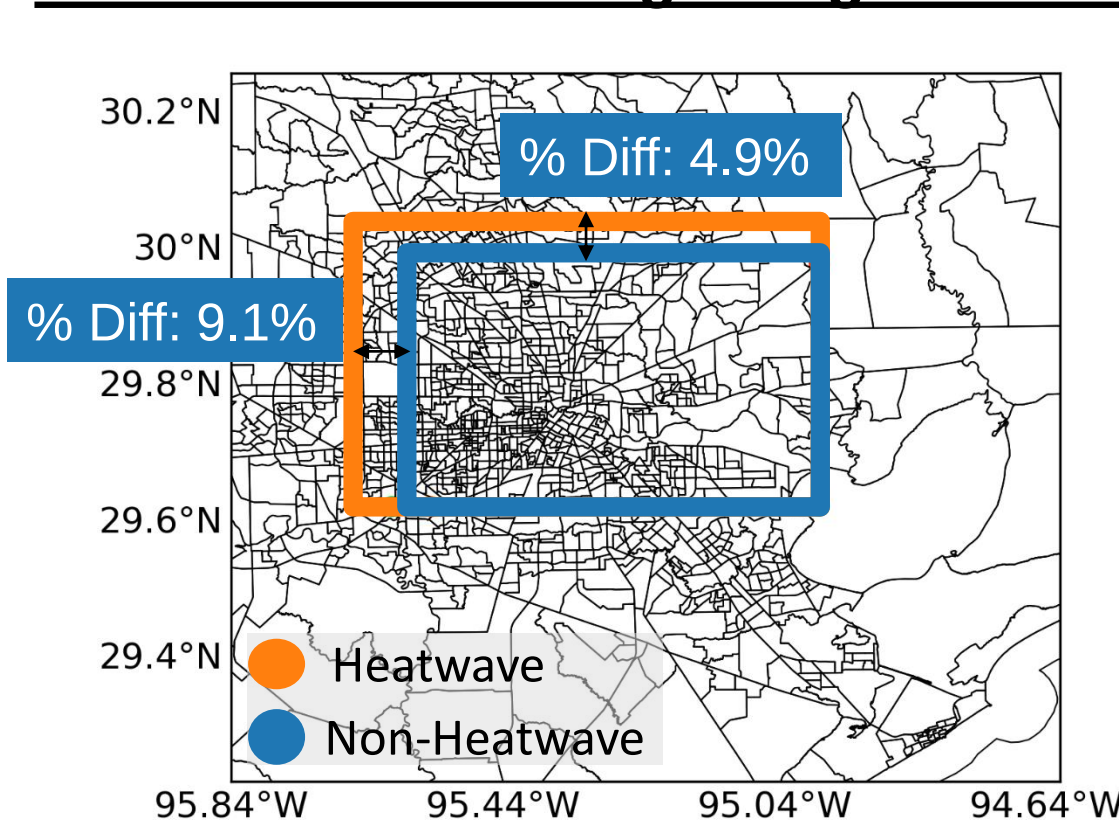
Anthropogenic NO_x Emissions:

CEMS Power Plant NO_x Daily Sums vs MODIS Land Surface Temperature



CEMS Area Power Plants produce more NO_x in Heatwave conditions

Size of TROPOMI High-Magnitude Plumes:



TROPOMI High-Magnitude Plumes increase in width and length in Heatwave conditions

Implications

- Heatwaves increase the observed column density of NO₂ and air pollution inequalities
- Heatwaves can affect local air quality and communities, using CLASP and space-based observations we can gain a better understanding of their impact

Acknowledgments
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References
1. Lee and Wang, (2024), Heatwave Effects on NO₂ Concentrations and Populations in Houston, TX. (In Prep)
2. GitHub: <https://github.com/tabitha-lee/CLASP>