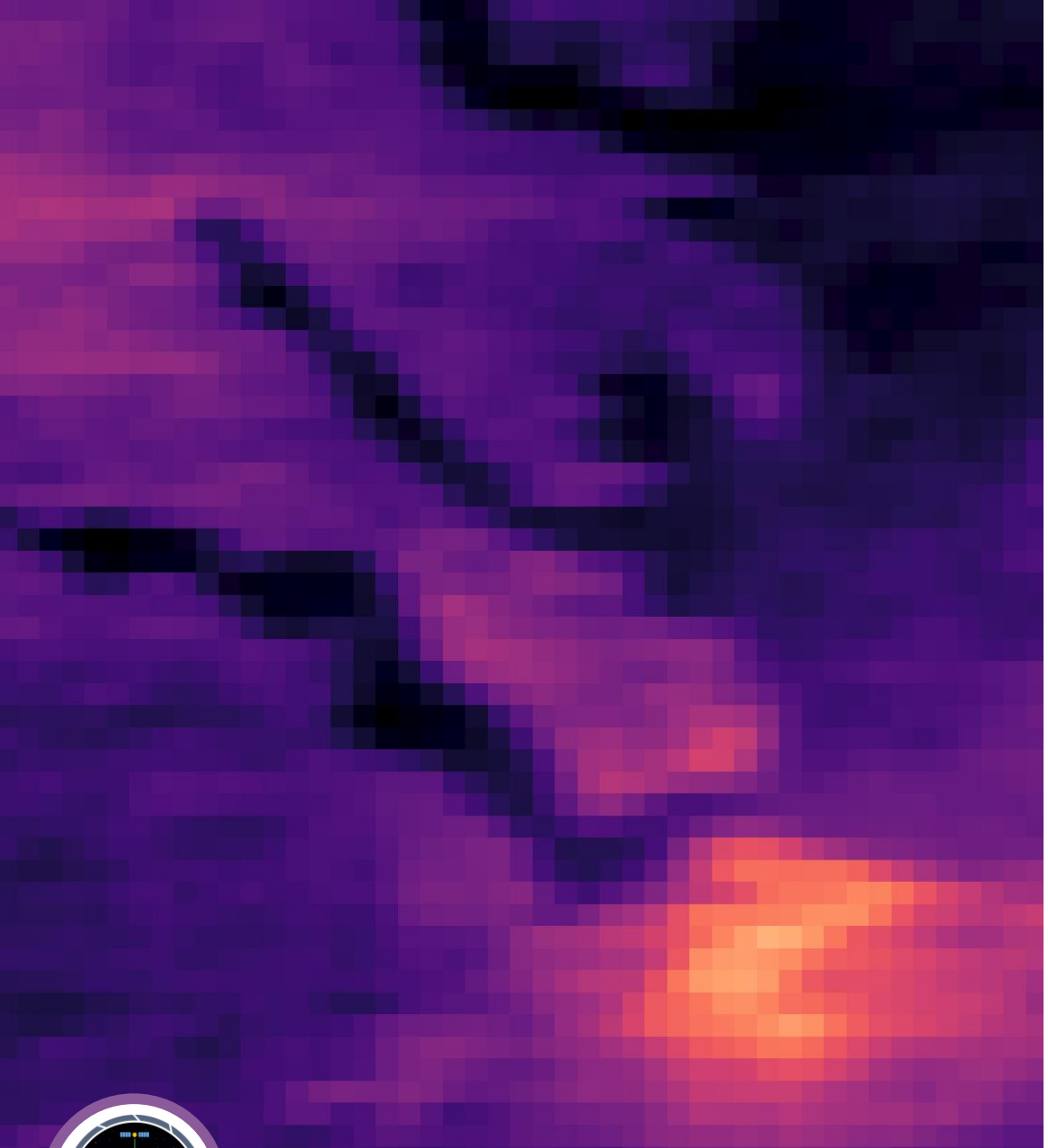


National Aeronautics and Space Administration

HAMPTON ROADS HEALTH & AIR QUALITY II

Monitoring Air Quality using TEMPO and TROPOMI Data in Conjunction with Socioeconomic Data to Map Air Pollution in Hampton Roads Virginia

Briana Johnson

Molly Gill

Lorryn Andrade

Joseph Horan

MEET THE TEAM

Briana Johnson
(Project Lead)

Molly Gill

Lorryn Andrade

Joseph Horan

OUTLINE

Project Origins

- Pollutants of Interest
- Study Area
- Partner
- Community Concerns

Objectives & Methods

- Objectives
- Earth Observations
- Study Period
- Methodologies

Outcomes

- Results
- Errors & Uncertainties
- Limitations

Conclusions

- Feasibility
- Partner Implementation
- Conclusions
- Contributions

PARTNER

Virginia Department of Environmental Quality (VDEQ)

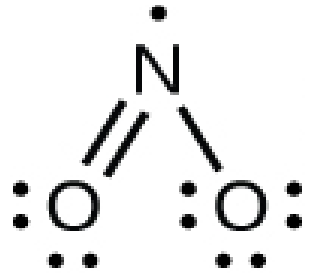
"DEQ carries out its mission to protect and improve the environment for the health, well-being and quality of life of all Virginians"

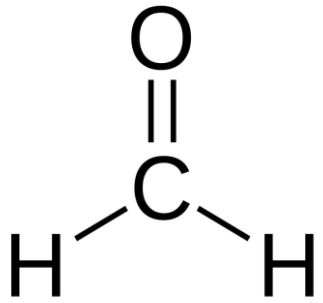
-Virginia Department of Environmental Quality

Image Credits (left to right): Will Parson, Scott Teresi, ForestWander

POLLUTANTS OF INTEREST

Nitrogen dioxide (NO_2) is a highly reactive gas. NO_2 in the atmosphere is primarily due to **emissions** from **vehicles, power plants, and other machinery**.





Formaldehyde (HCHO) is a byproduct of combustion and has both natural and artificial methods of production. The main artificial sources of emission are **power plants, industrial machinery and vehicle exhaust**.

Both pollutants produce **acute and chronic effects in the respiratory system** and increase risk for respiratory disease.

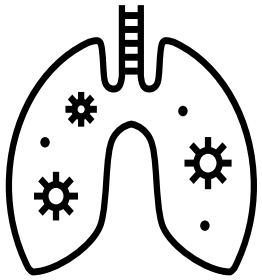


Image Credit (Top & Middle): Chem Sim 2001, OSCRiceUniversity

COMMUNITY CONCERNS

Community concern over coal dust in **at-risk communities** inspired the first study, which is being expanded with a **focus on exhaust pollutants**

Atmospheric **NO_2** is linked primarily to vehicle exhaust, while **HCHO** is linked to combustion and fuel-burning machinery.

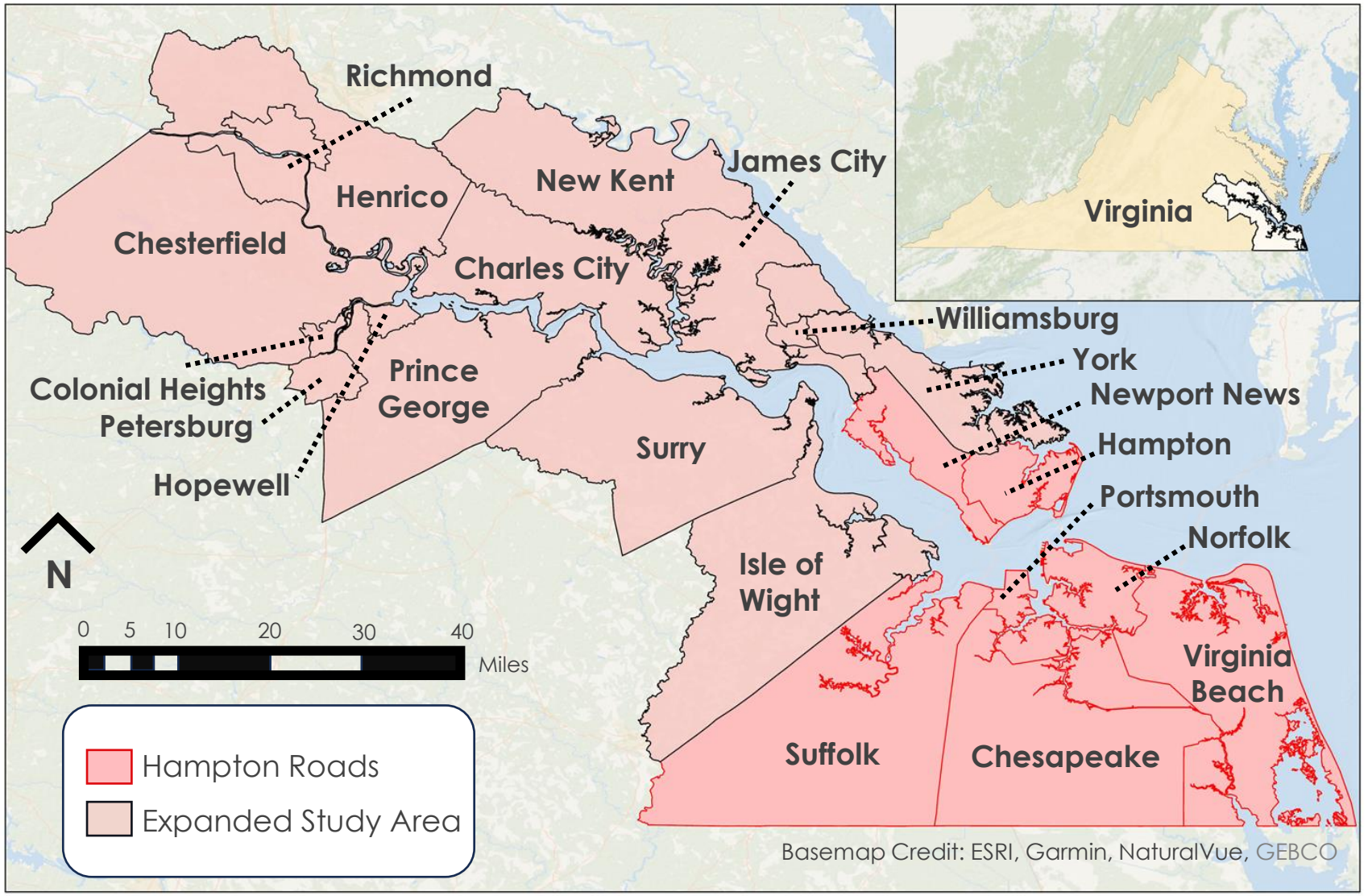
Image Credit: Missy Schmidt (left), Virginia Dept. Of Transportation (middle & right)

STUDY AREA

~1.8 million Residents

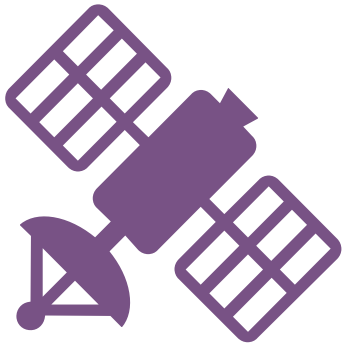
~6.7 million gas vehicles registered statewide

Contains the 9th busiest port in the U.S.



OBJECTIVES

Determine the feasibility of using NASA Earth observations to improve air quality monitoring in the Hampton Roads area



Analyze trends in nitrogen dioxide and formaldehyde in the past year

Visualize health risks to the community in conjunction with pollutant concentration

Differentiate between measurements based on season, month, and time of day to provide a complete picture of a pollutant's concentration over time

Inform the Virginia Department of Environmental Quality on future decisions regarding air quality policy and pollution mitigation efforts

Image Credit: AI Emojis

EARTH OBSERVATIONS

Satellite Instruments TEMPO and TROPOMI can both detect levels of Nitrogen Dioxide and Formaldehyde using spectroscopy

TEMPO – NASA

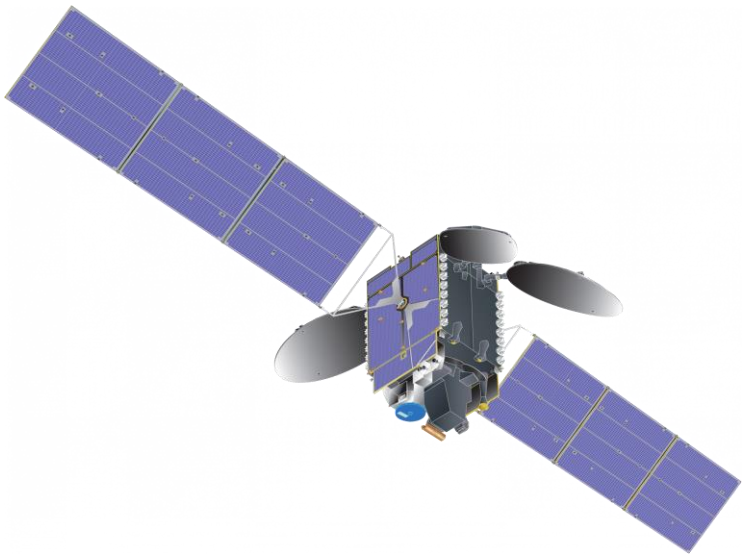


Image Credit: NASA

TROPOMI – ESA

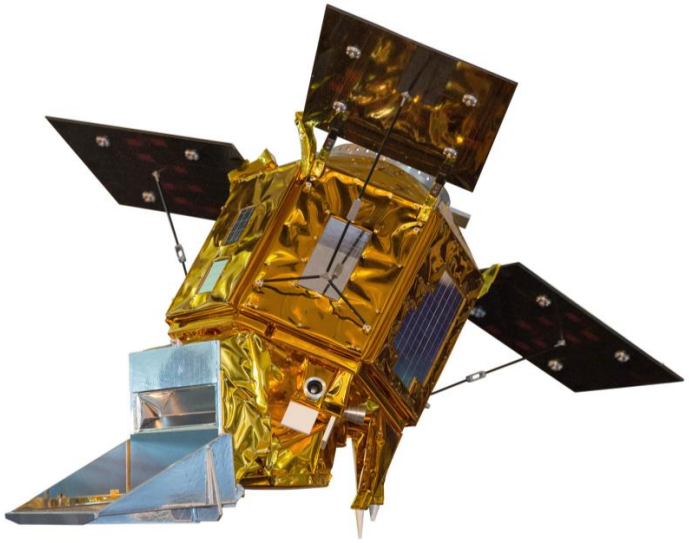


Image Credit: SkywalkerPL

Sampling Frequency	Hourly	Daily
Orbit Type	Geostationary	Low Earth
Spectral Resolution	0.6 nm	0.5 - 0.55nm

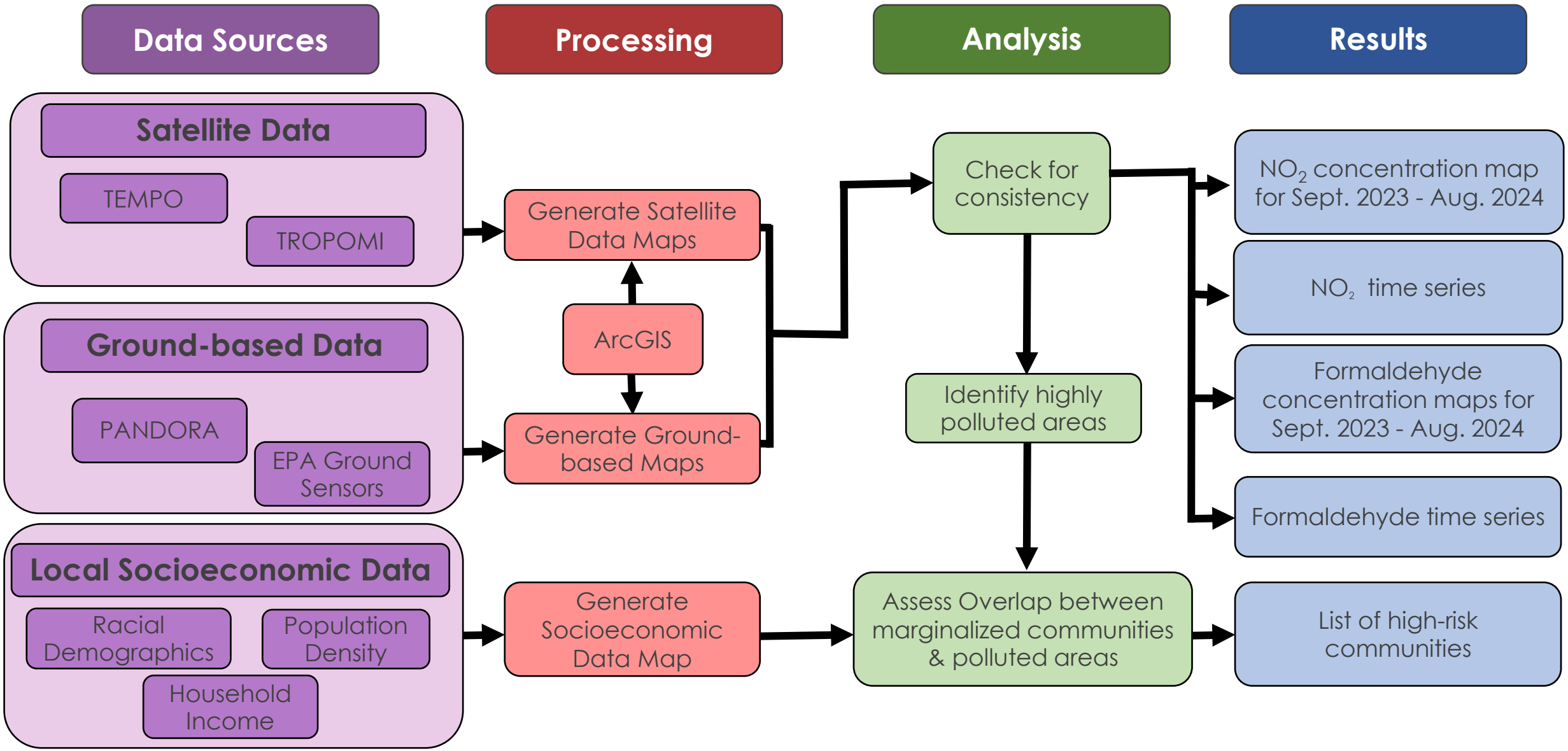
STUDY PERIOD

Sept. 1, 2023
to Aug. 31, 2024

TEMPO, one of the satellite instruments used in the study, was launched in Apr. 2023.

Image Credit: NASA

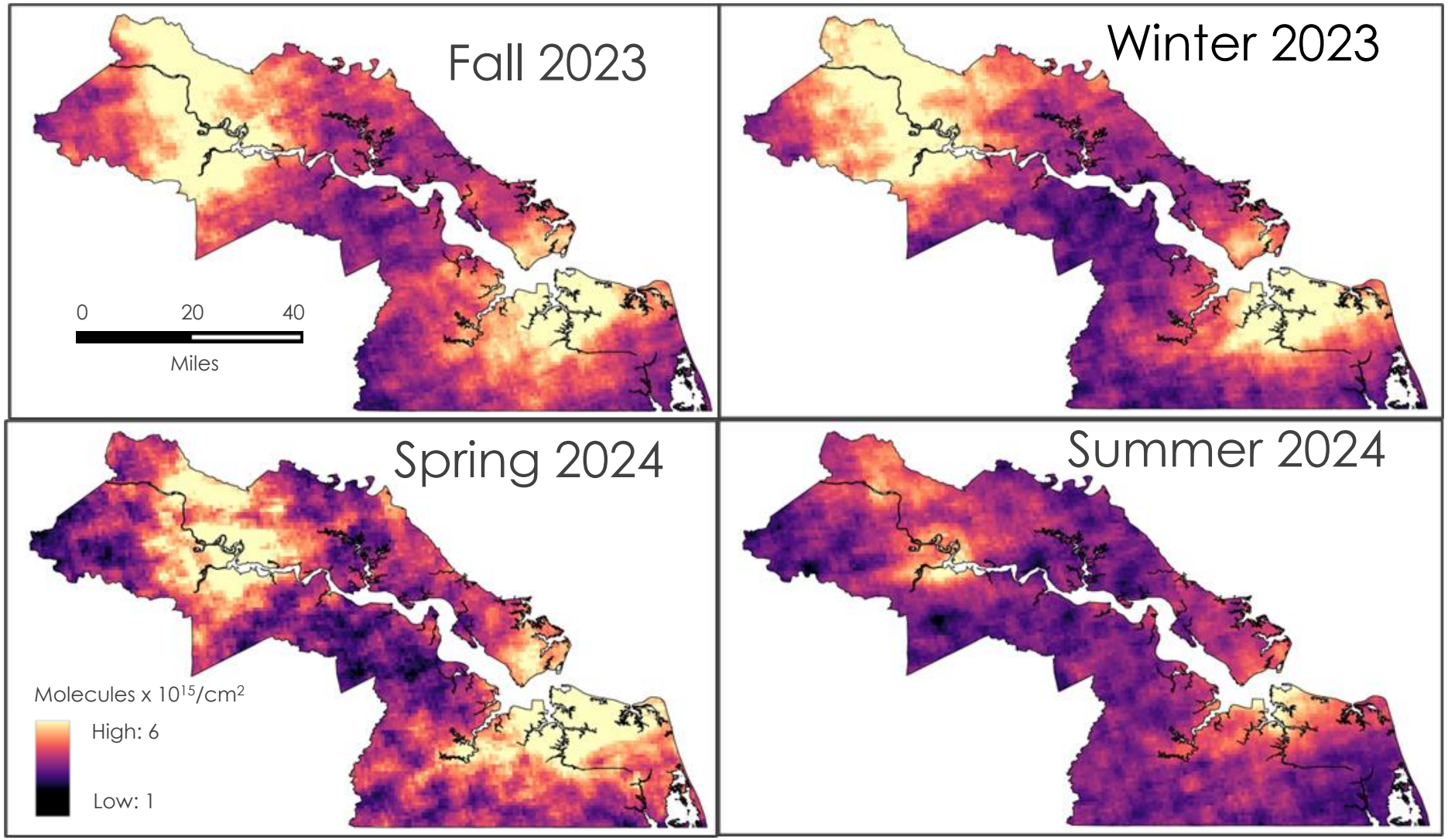
METHODOLOGY



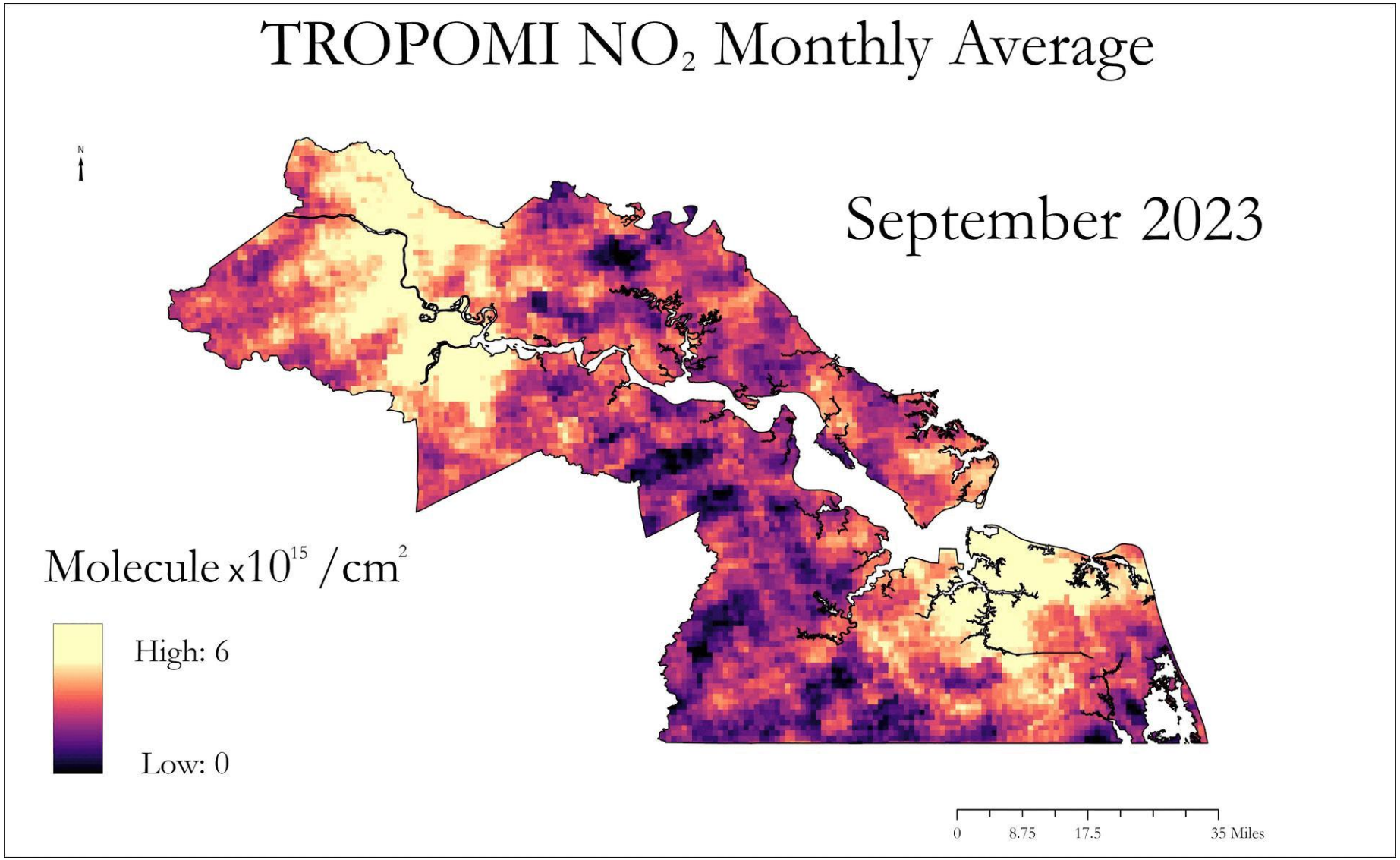
RESULTS – SEASONAL NO_2 MAPS FROM TROPOMI

Our results suggest an NO_2 concentration that peaks in Winter and Spring and sees a minimum during Summer and Fall

Seasonal NO_2 Maps (TROPOMI)



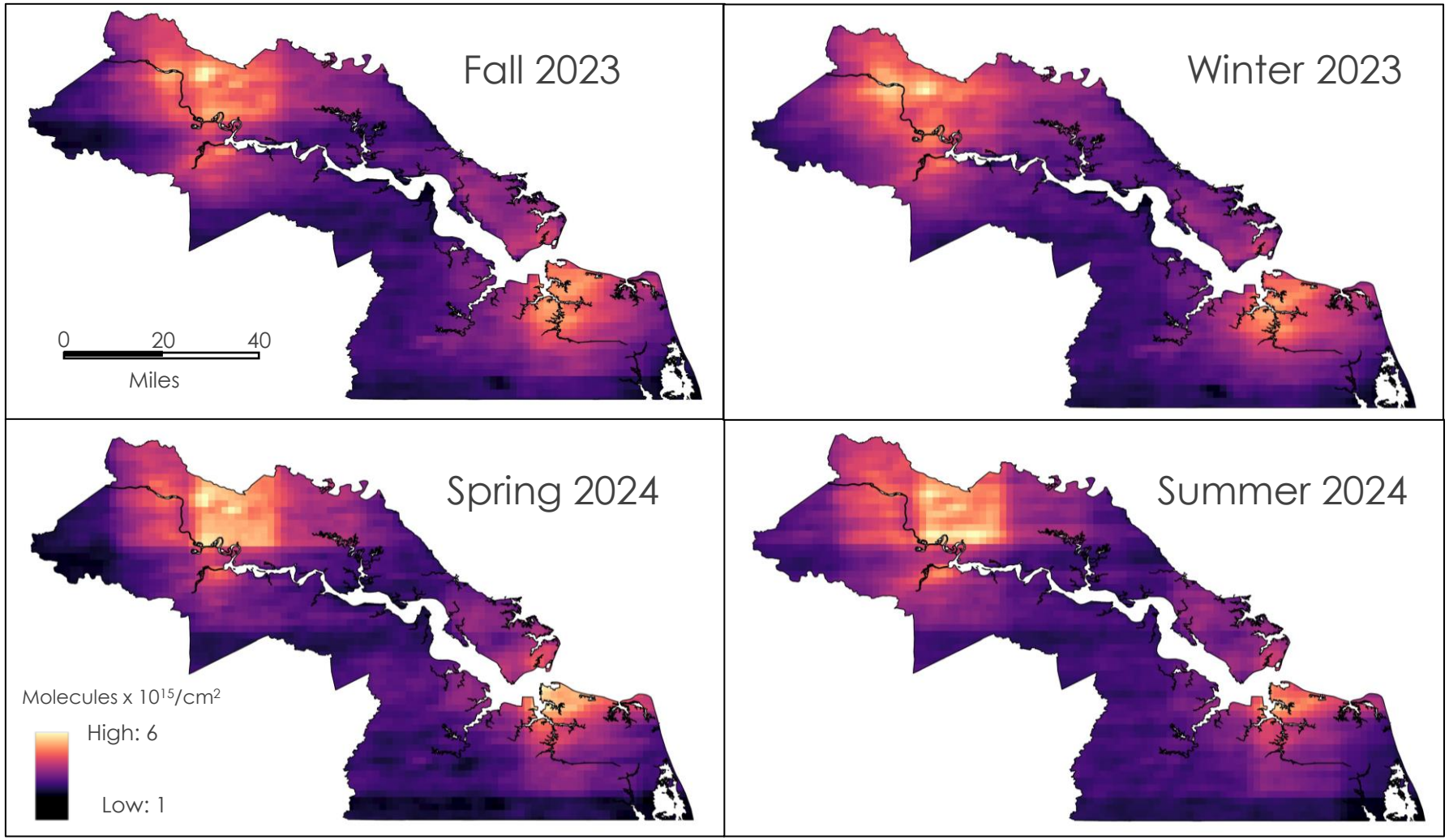
RESULTS-MONTHLY NO_2 MAPS FROM TROPOMI



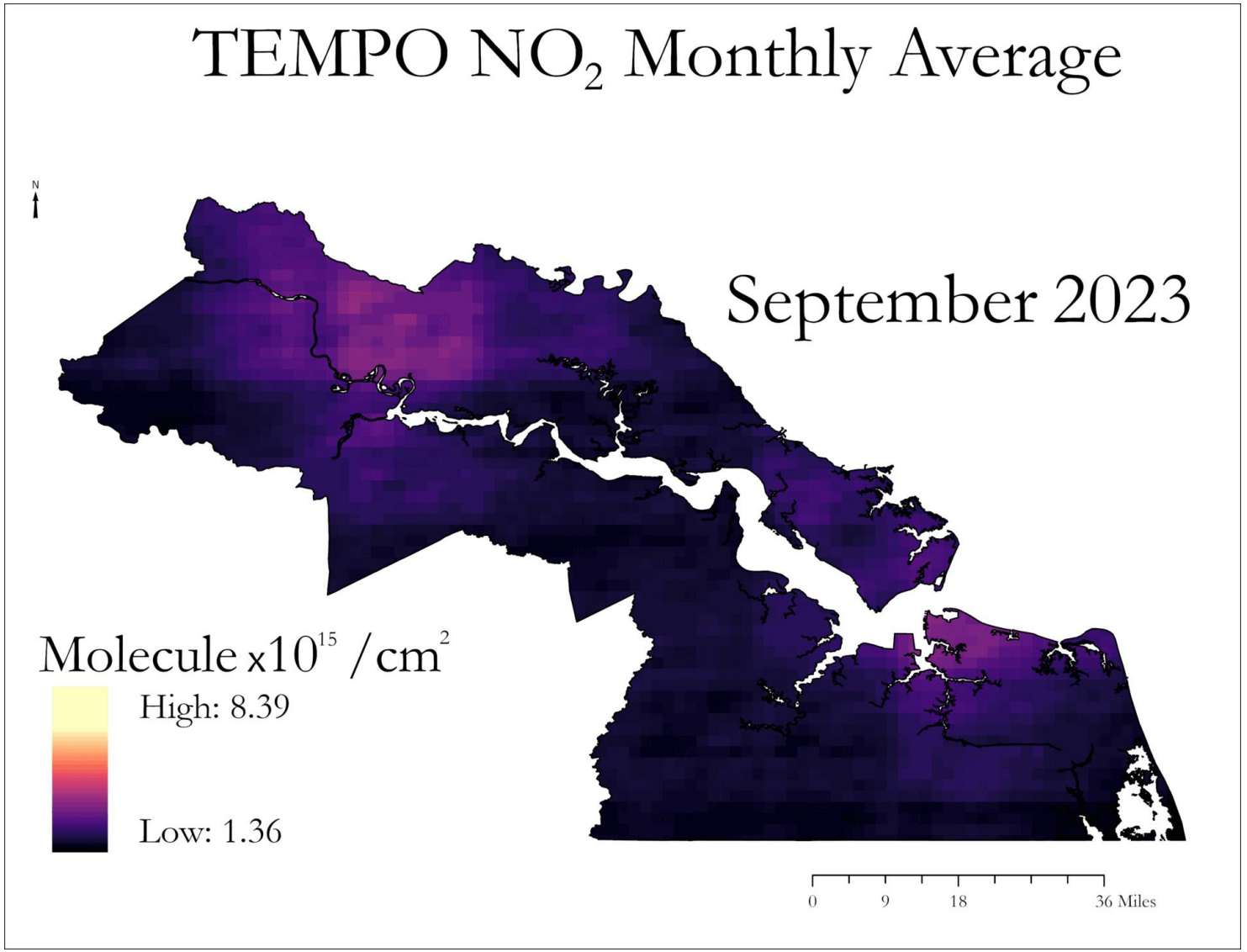
RESULTS - SEASONAL NO_2 MAPS FROM TEMPO

Our results suggest an NO_2 concentration that peaks in Winter and Spring and sees a minimum during Summer and Fall

Seasonal NO_2 Maps (TEMPO)



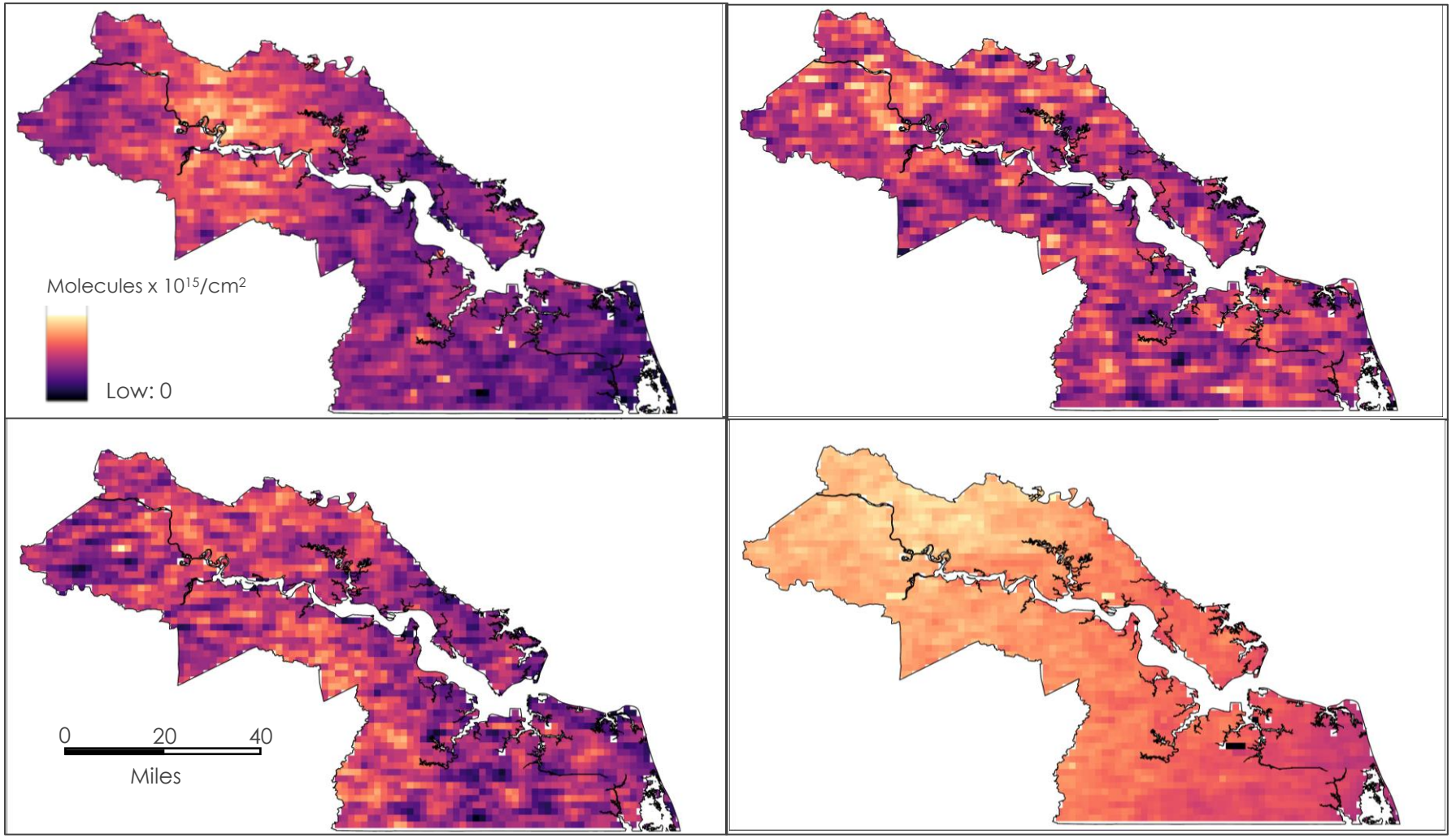
RESULTS - MONTHLY NO_2 MAPS FROM TEMPO



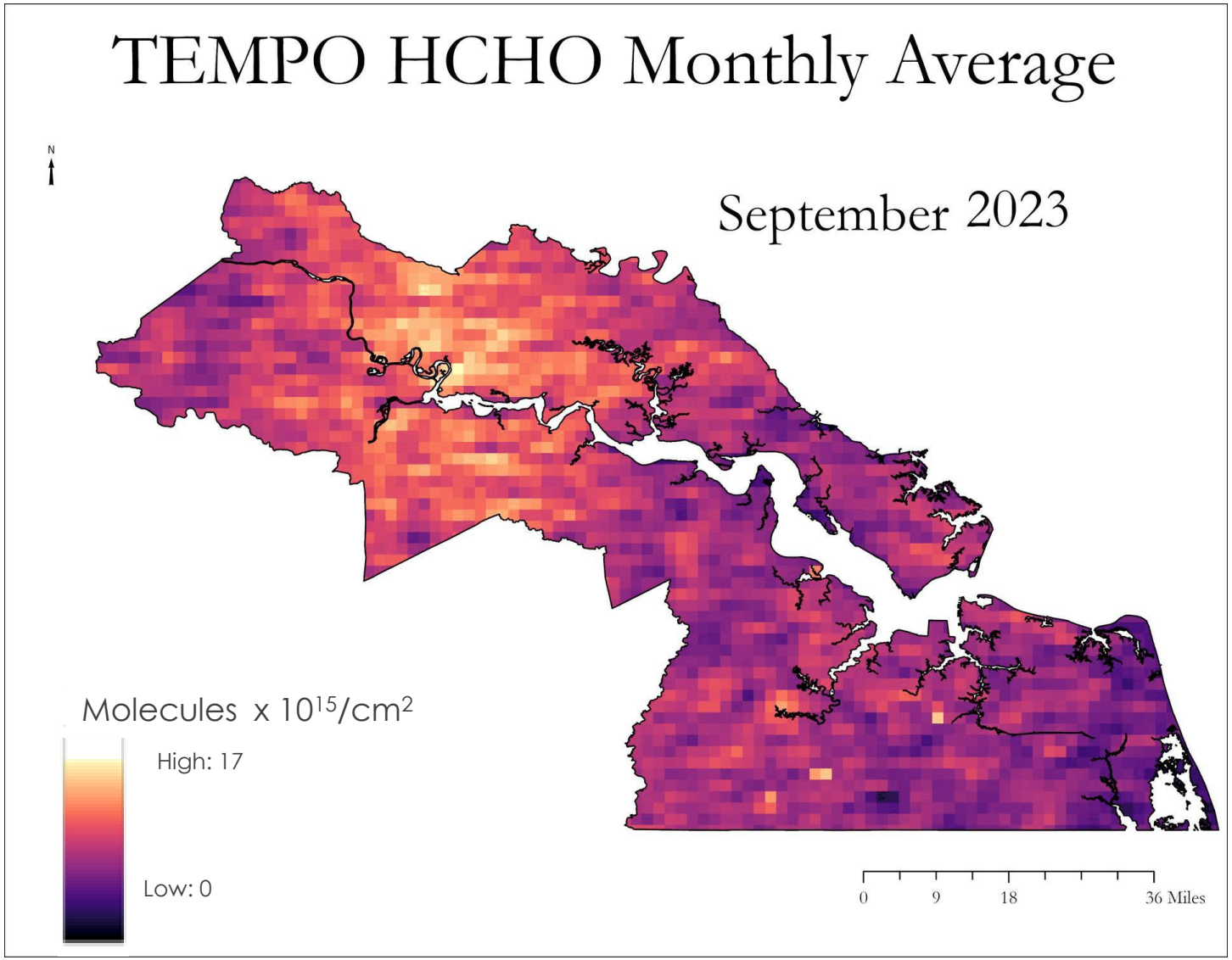
RESULTS – SEASONAL HCHO MAPS FROM TEMPO

Our results depict HCHO distributions that change primarily with the seasons, peaking in the Summer

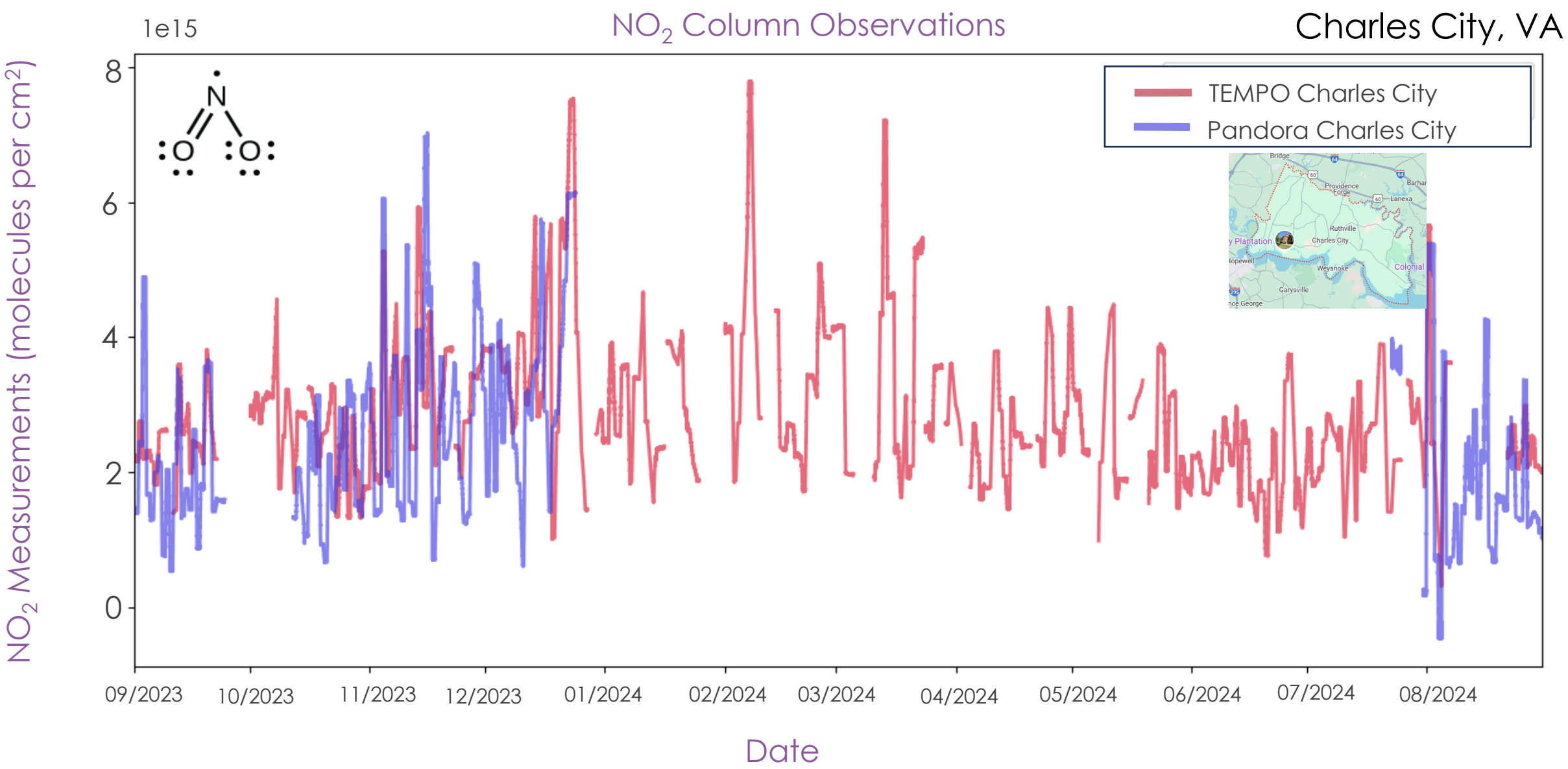
Seasonal HCHO Maps (TEMPO)



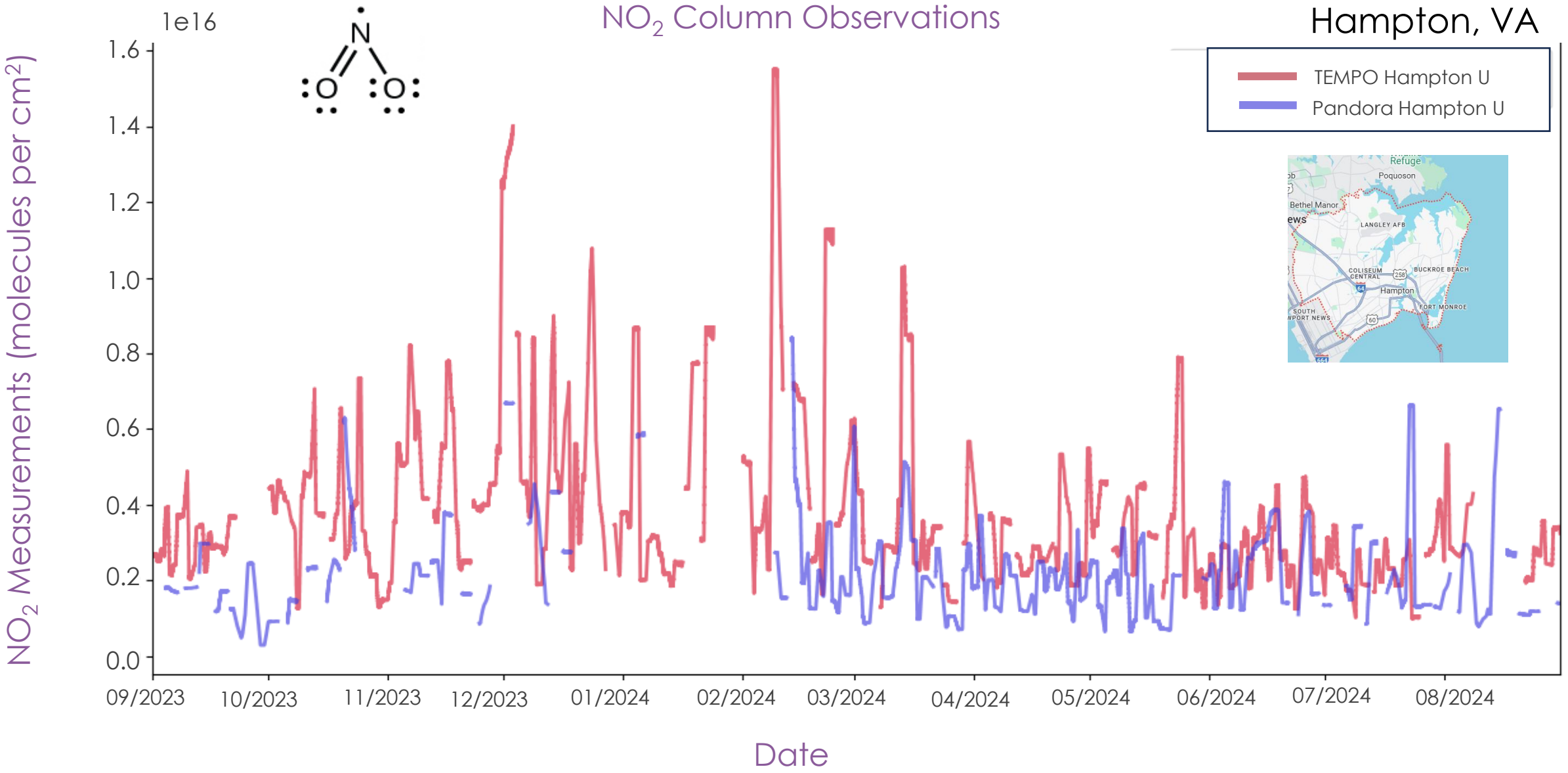
RESULTS – MONTHLY HCHO MAPS FROM TEMPO



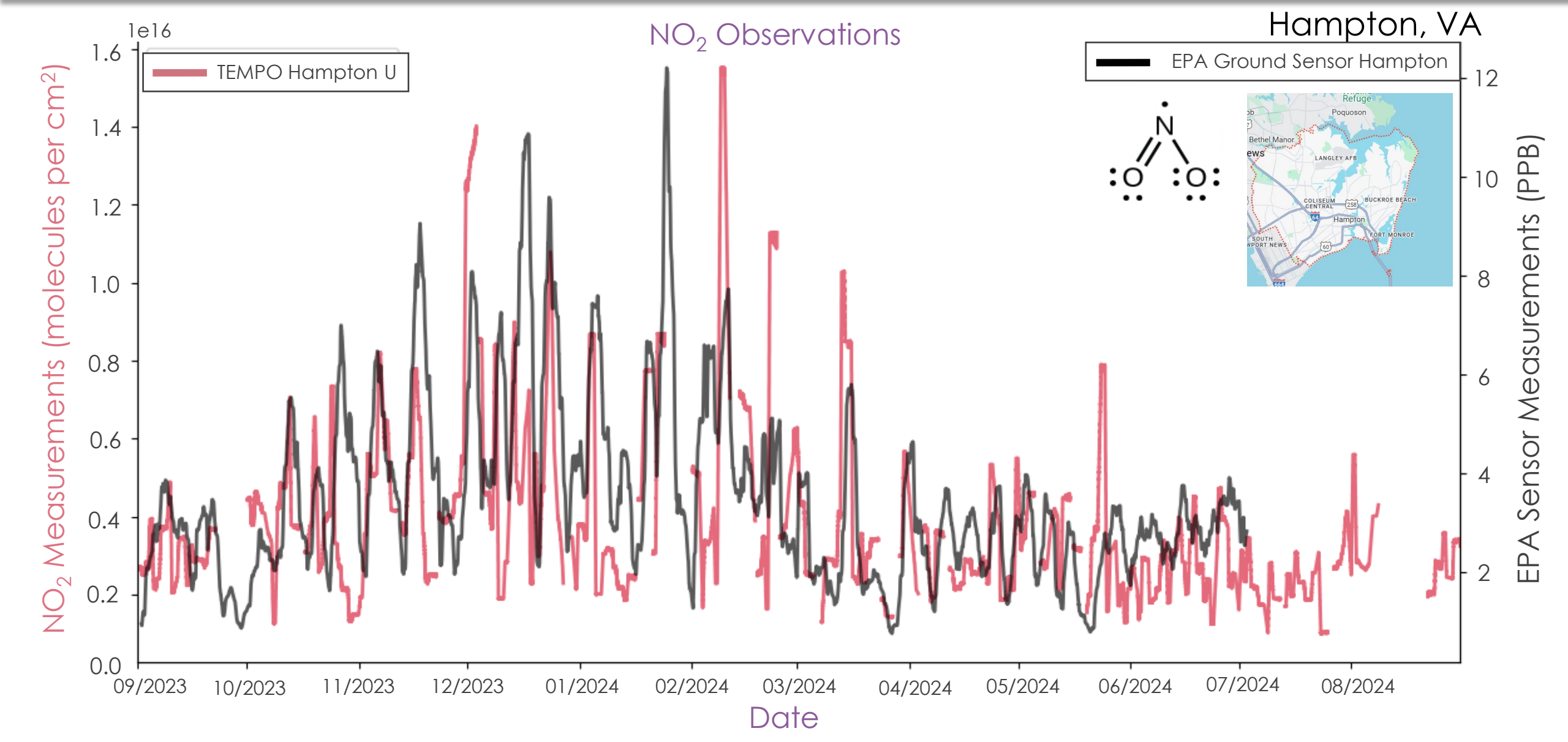
RESULTS – VALIDATE TEMPO WITH PANDORA



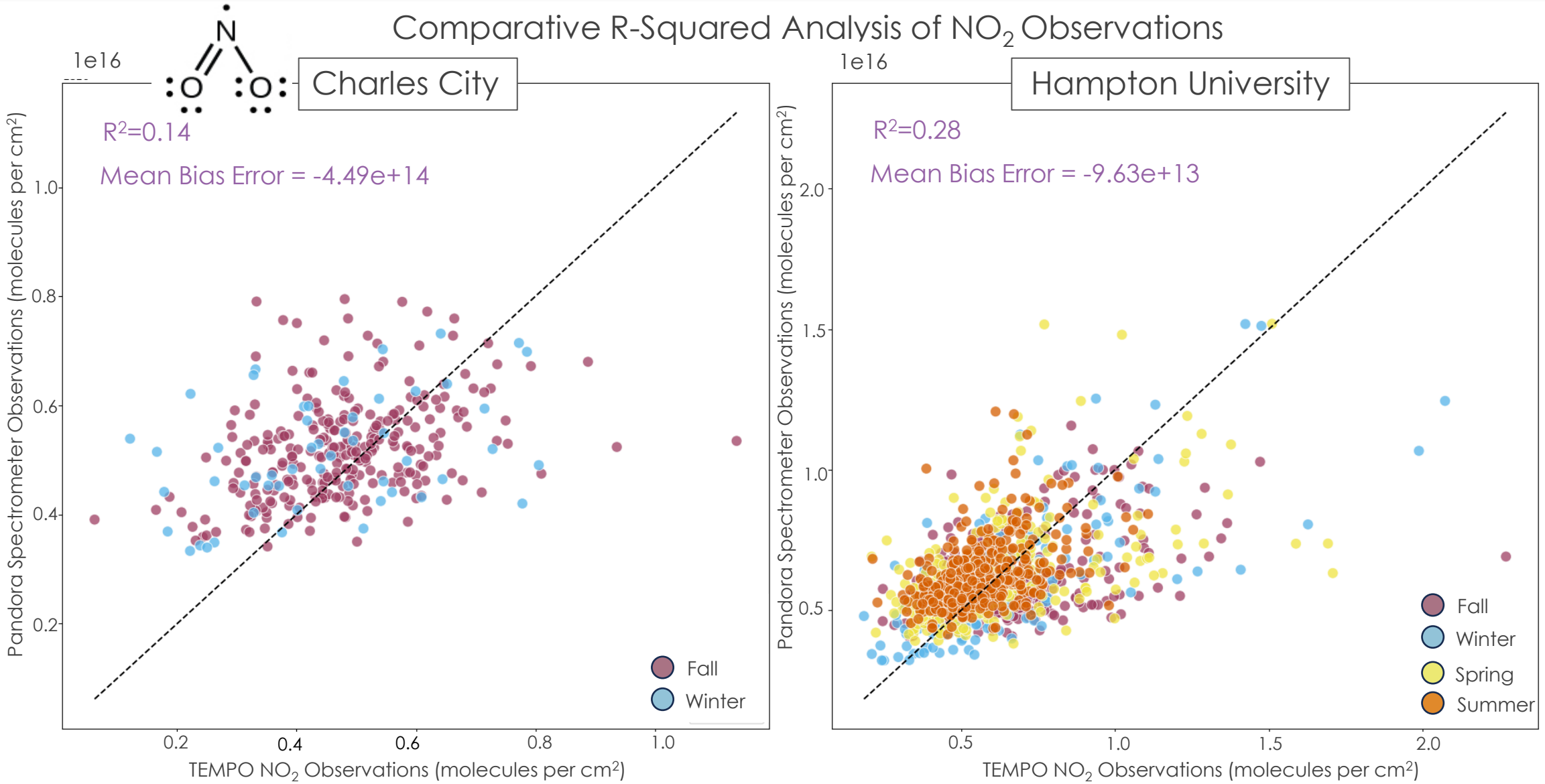
RESULTS – VALIDATE TEMPO WITH PANDORA



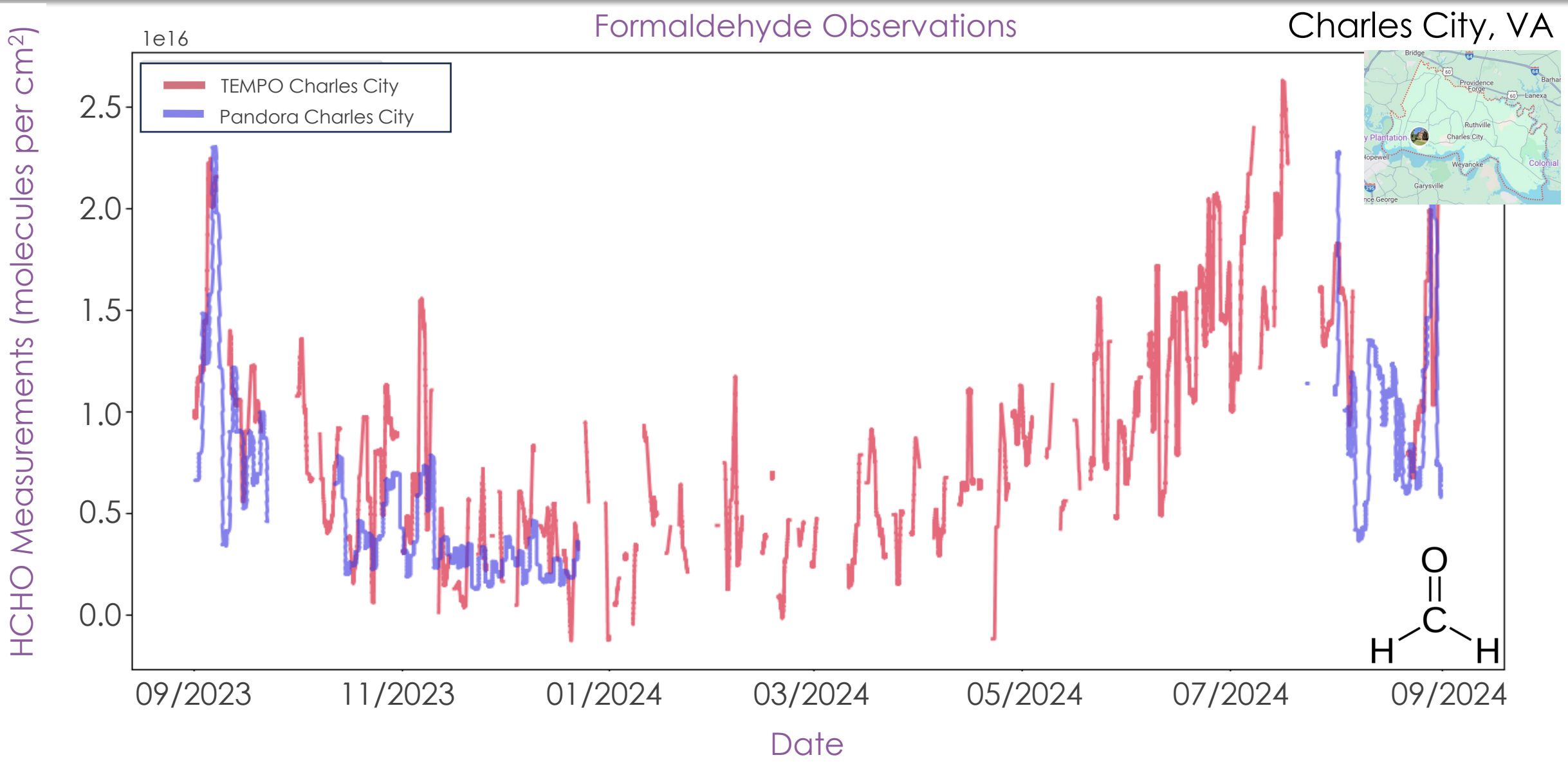
RESULTS – VALIDATE TEMPO WITH EPA SENSOR



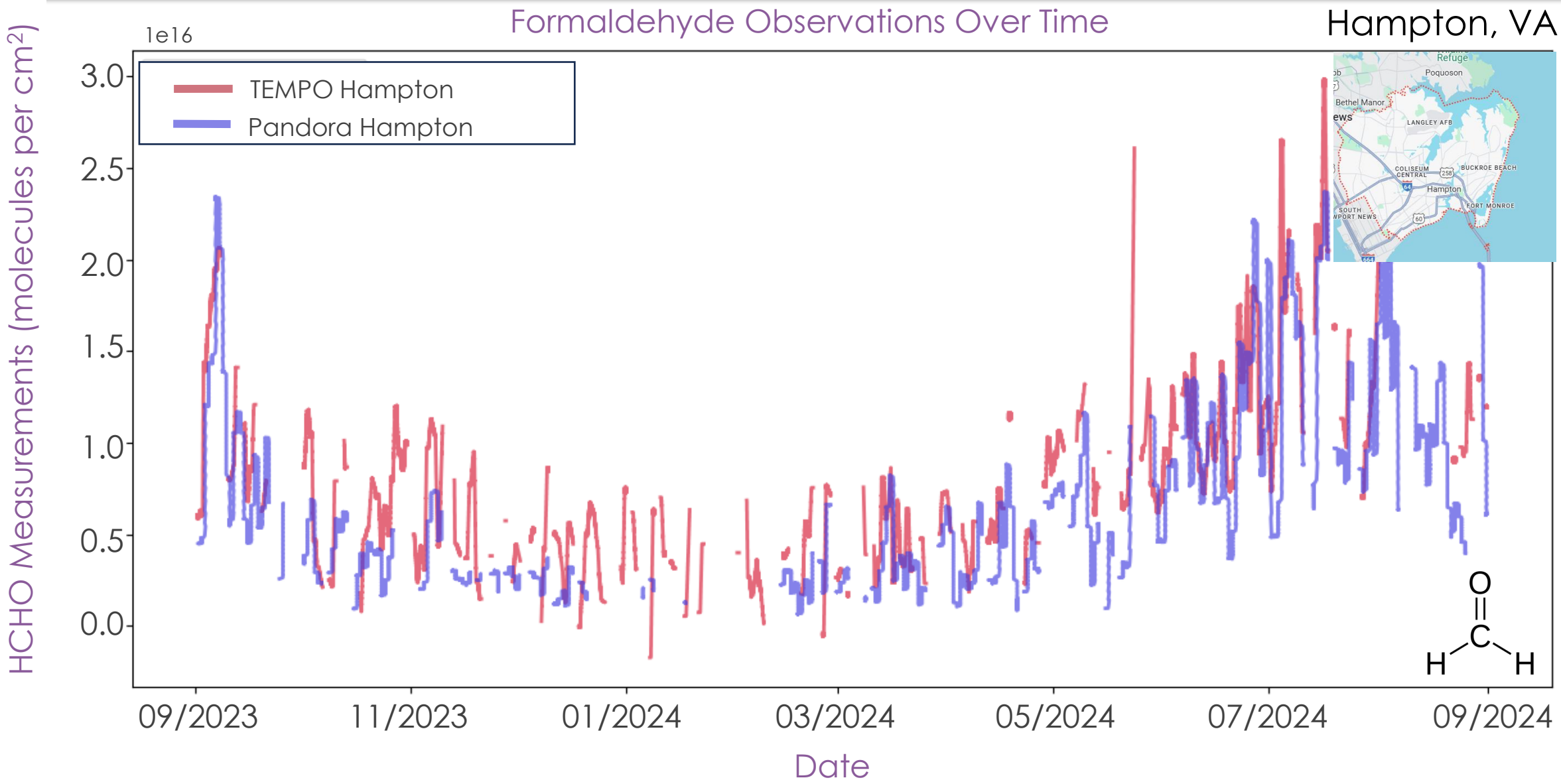
RESULTS – VALIDATE TEMPO WITH PANDORA



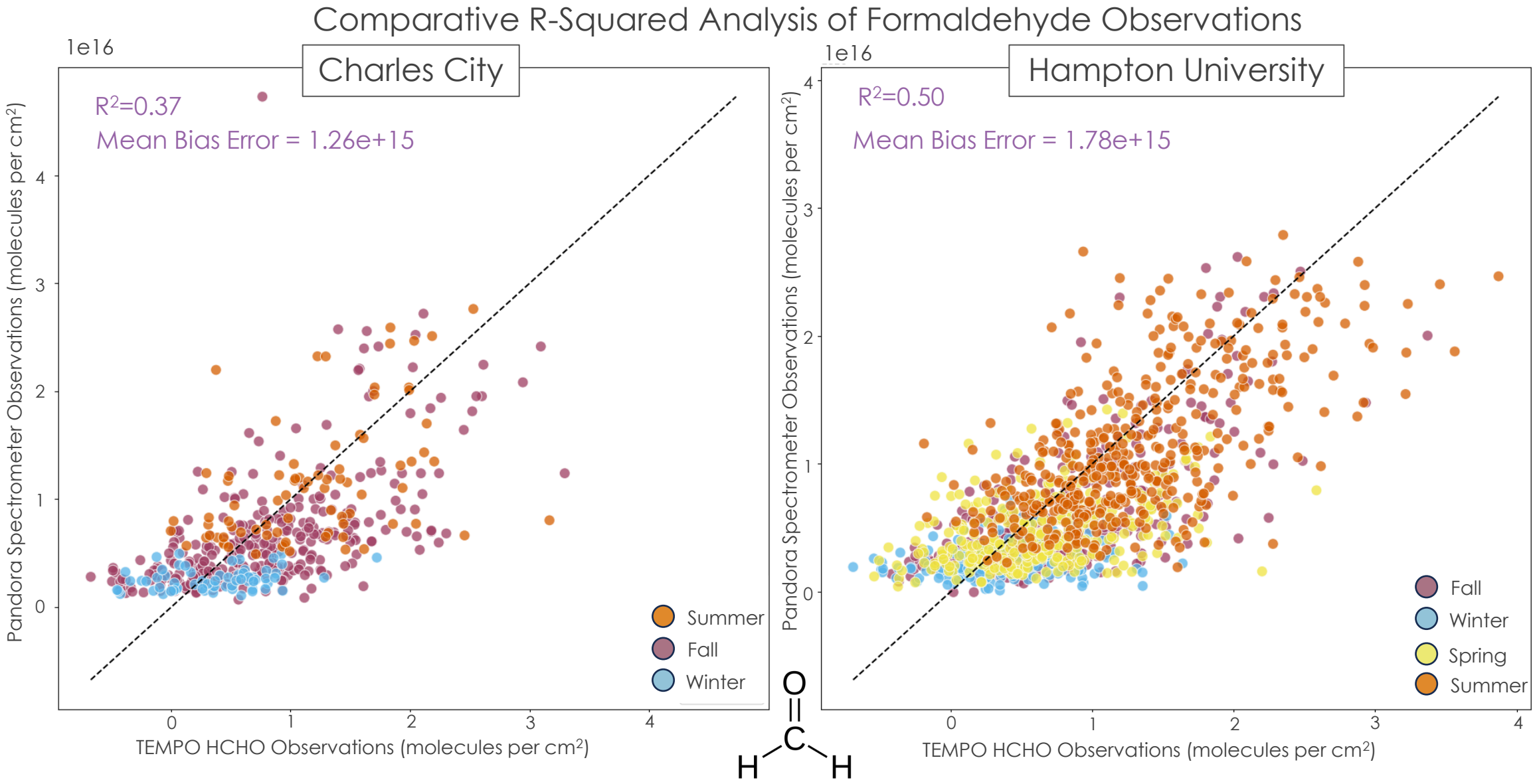
RESULTS – VALIDATE TEMPO WITH PANDORA



RESULTS – VALIDATE TEMPO WITH PANDORA

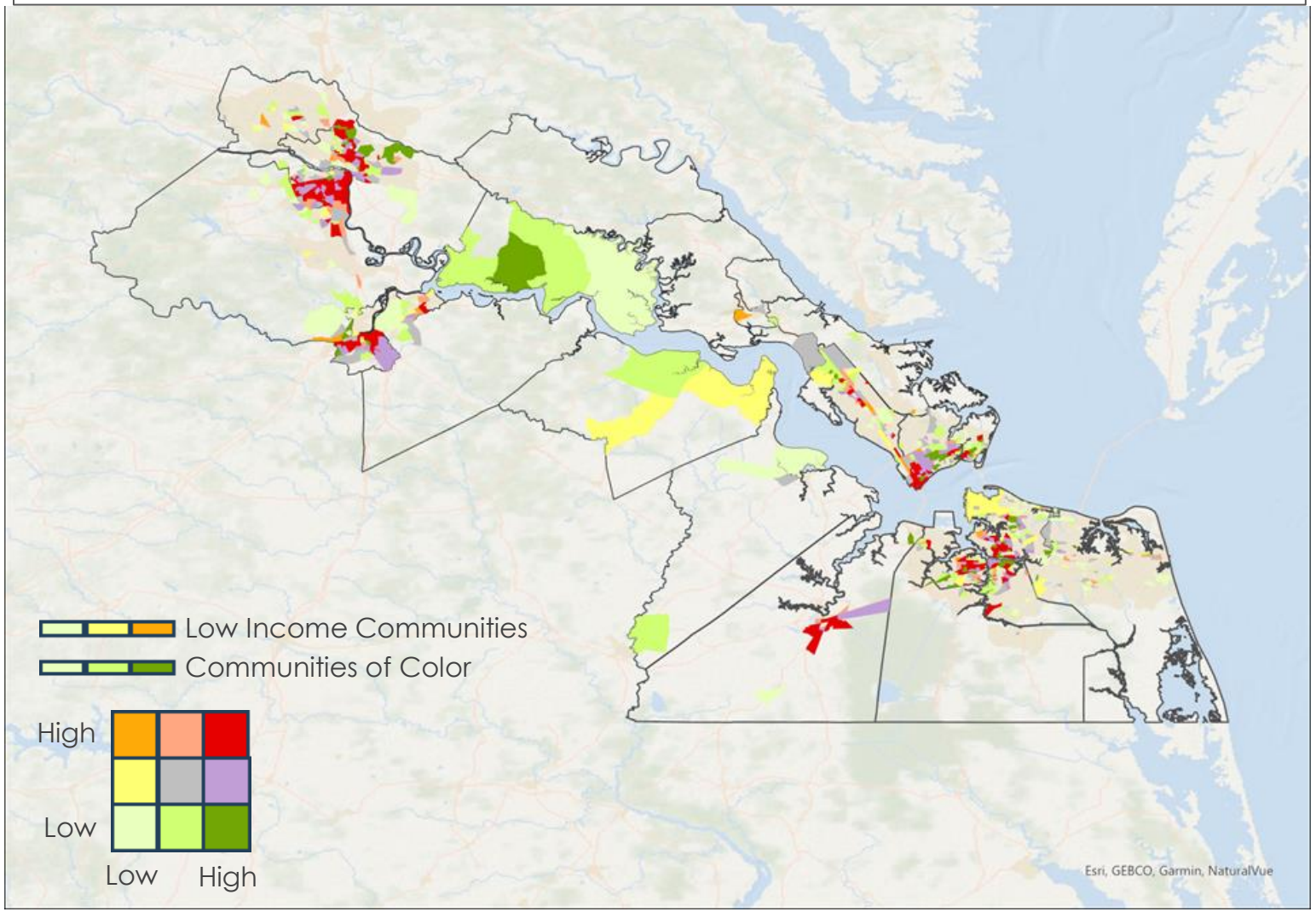


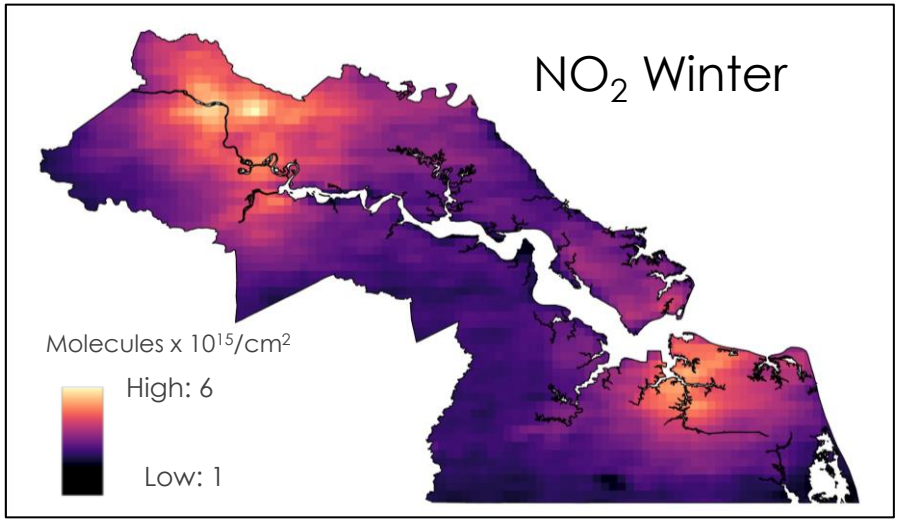
RESULTS – VALIDATE TEMPO WITH PANDORA

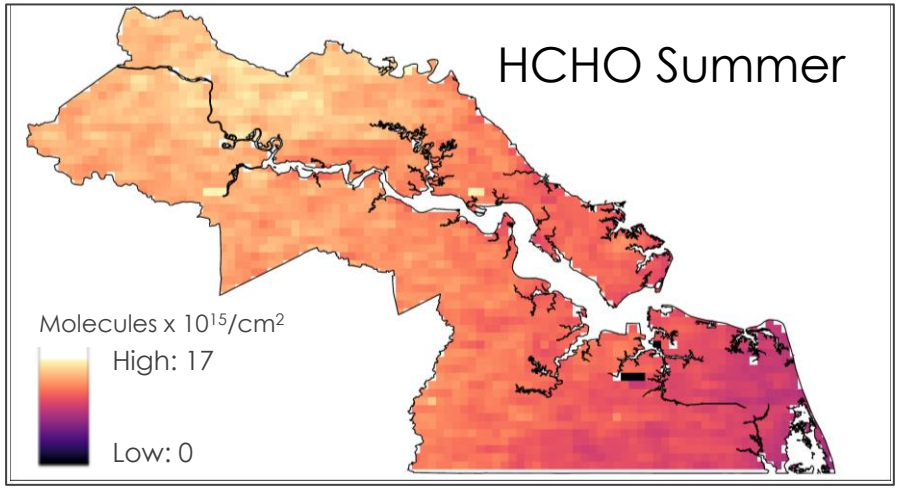


SOCIOECONOMIC VARIABILITY

Socioeconomic Vulnerability Map



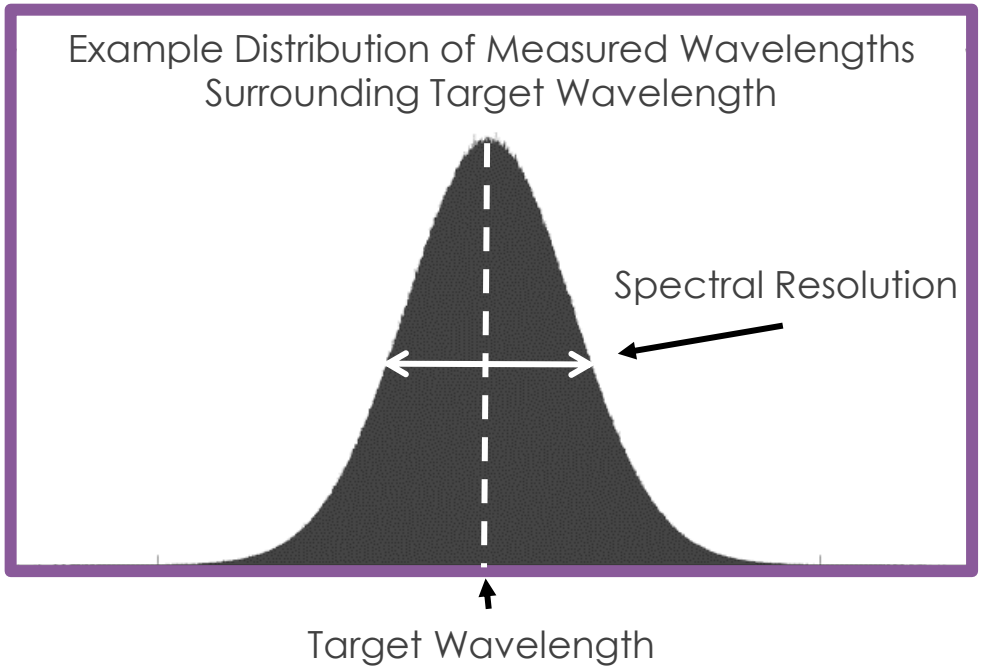


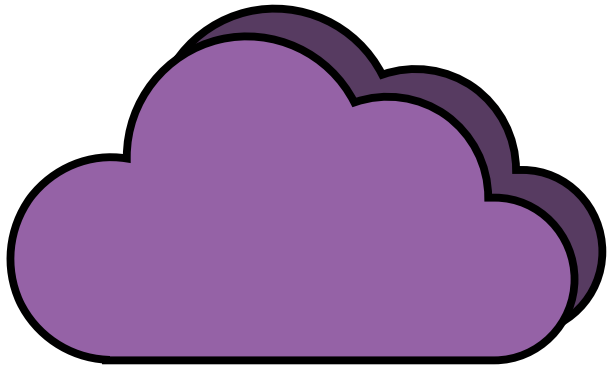


ERROR AND UNCERTAINTIES

Uncertainties native to the instruments

- Spectral resolutions
  - 0.6 nm for TEMPO
  - 0.50 - 0.55 nm for TROPOMI





Uncertainties due to circumstance

- Missing measurements due to cloud cover
- Translating between slant and vertical column densities

Image Credit: Sss41

LIMITATIONS

Data availability

- Ground-sensors in the area present large data gaps (5-7 months of missing data).
- Technical issues with data access

Correlation

- Unable to directly compare satellite data with EPA ground data.

Additional factors

- Presence of industrial plumes

FEASIBILITY

TEMPO and TROPOMI show promise for monitoring levels of NO_2 and HCHO in Hampton Roads and surrounding regions

TEMPO and TROPOMI measurements can be used with socioeconomic data to identify at-risk communities and inform decision-making regarding resource delegation

TEMPO is moderately feasible for supplementing ground-based measurements and informing future instrument locations

CONCLUSIONS

Similar to TROPOMI, TEMPO provides seasonal and spatial patterns of distribution of gaseous pollutants (NO_2 and HCHO) at high spatial resolution in Hampton Roads. Due to its hourly measurements, TEMPO is capable of monitoring diurnal patterns of these pollutants

Although TEMPO and TROPOMI column density of NO_2 and HCHO have moderate correlations with ground-based surface concentrations, they reveal similar patterns, confirming that their measurements can help fill gaps in ground sensor data.

Measurements from TEMPO in addition with socioeconomic indicators, can be used to inform placement location of future air monitors. This study identified certain areas in Richmond, Newport News, Portsmouth, Norfolk, and Hopewell as high-risk areas.

PARTNER IMPLEMENTATION

1. **Public Information:** DEQ can use this information to inform the public on important air quality concerns

2. **Community Engagement:** DEQ can encourage community members to install air quality sensors in their communities

3. **Sensor Usage:** DEQ can use satellite data to fill data gaps of ground air sensors and monitor air pollution at regional scale

Acknowledgments

Project Partners:

Chuck Turner - Director, Office of Air Quality Monitoring, Virginia DEQ
James Barringer – Office of Air Quality Monitoring, Virginia DEQ

Science Advisors:

Dr. Laura Judd - Langley Research Center
David Young - Langley Research Center
Dr. Xia Cai – Langley Research Center
Dr. Travis Toth - Langley Research Center

Previous Contributors

Marilee Karinshak – Participant, Team Lead
Sidney Hipp - DEVELOP Participant
Brooklyn Appling- DEVELOP Participant
Piper Coleman- DEVELOP Participant

Special Thanks

Alyson Bergamini – NASA DEVELOP Center Lead, Langley Research Center
ASDC and GESDISC Teams – Data centers containing TEMPO and TROPOMI data

This material contains modified Copernicus Sentinel data (2023-2024), processed by ESA.

This material is based upon work supported by NASA through contract 80LARC23FA024. Any mention of a commercial product, service, or activity in this material does not constitute NASA endorsement. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Aeronautics and Space Administration and partner organizations.

Backup Slides

EARTH OBSERVATIONS

Satellite Instruments TEMPO and TROPOMI can both detect Nitrogen Dioxide and Formaldehyde using spectroscopy

TEMPO

Image Credit: NASA

TROPOMI

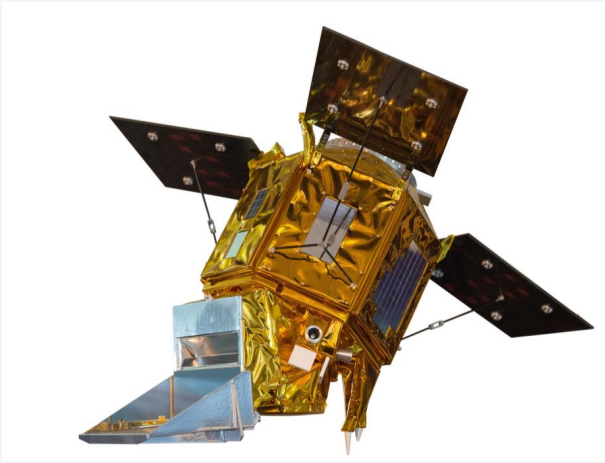
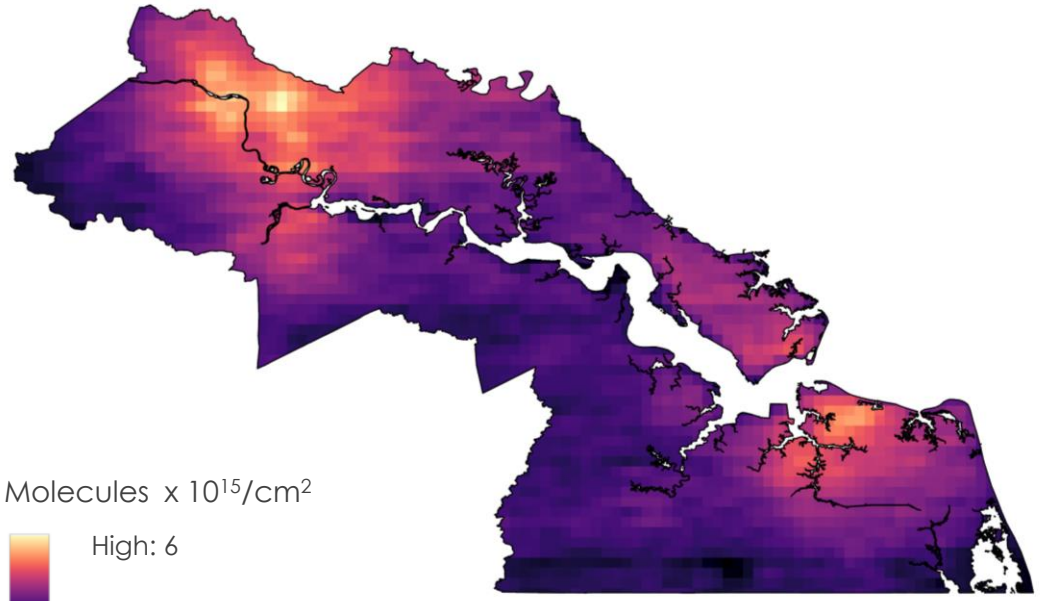


Image Credit: SkywalkerPL

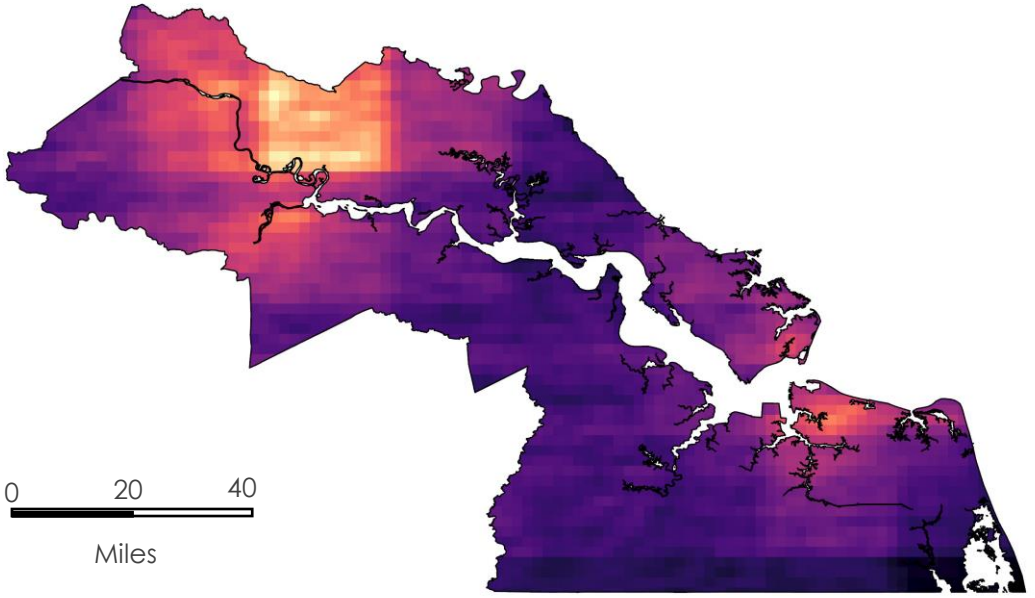
Instrument	TEMPO	TROPOMI
Instrument Type	Grating Spectrometer	Optical Absorbtion Spectrometer
Spatial Resolution (sources vary slightly)	2km N/S x 4.5 km E/W	7km x 7km
Spectral Resolution	0.57 nm	0.5 nm
Sampling Frequency	Hourly	Daily
Orbit	Geostationary Orbit (GEO)	Low Earth Orbit (LEO)

RESULTS – MID-DAY NO_2 MAPS FROM TEMPO

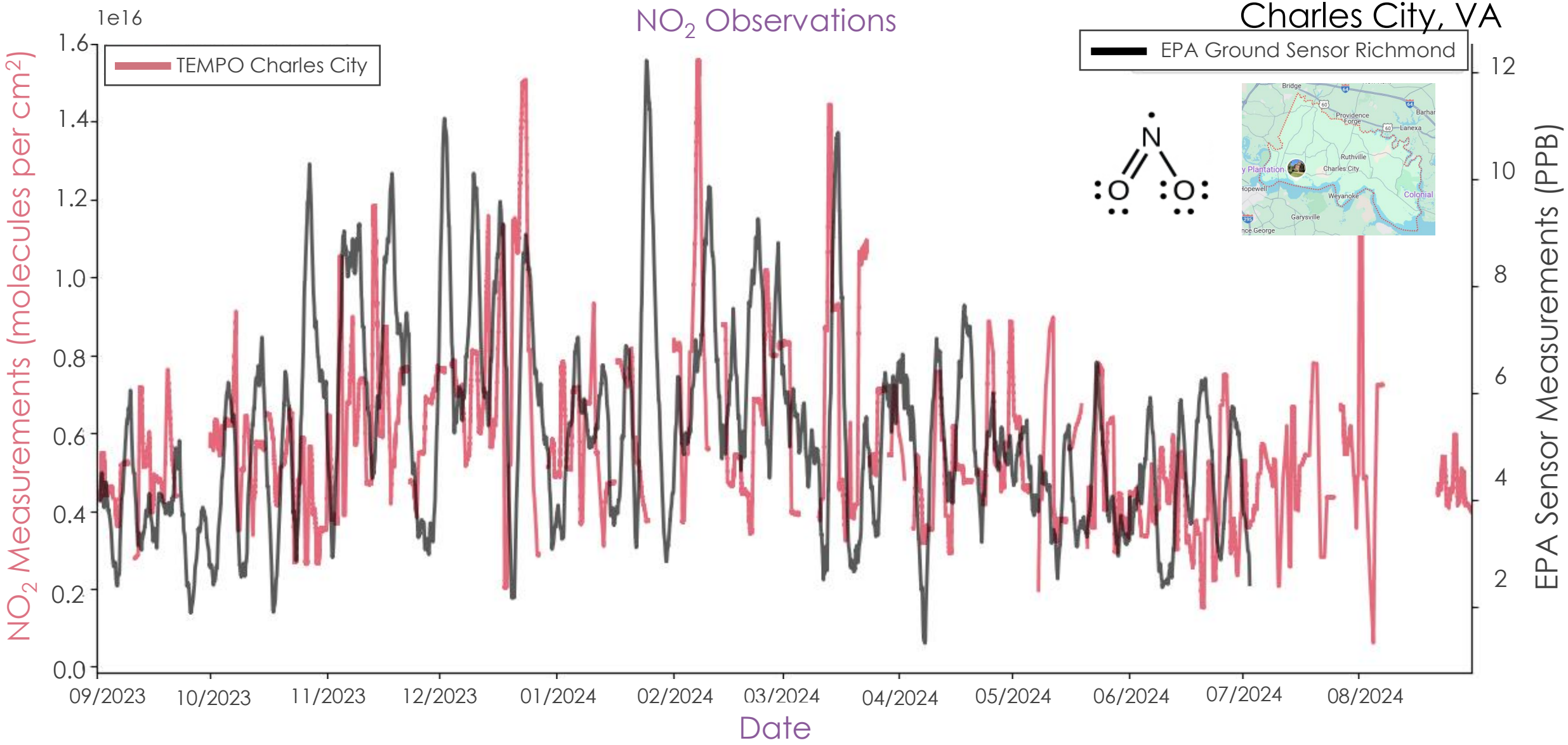
Winter



Summer



RESULTS – VALIDATE TEMPO WITH EPA SENSOR



EARTH OBSERVATIONS

Satellite Instruments TEMPO and TROPOMI can both detect levels of Nitrogen Dioxide and Formaldehyde using spectroscopy

TEMPO

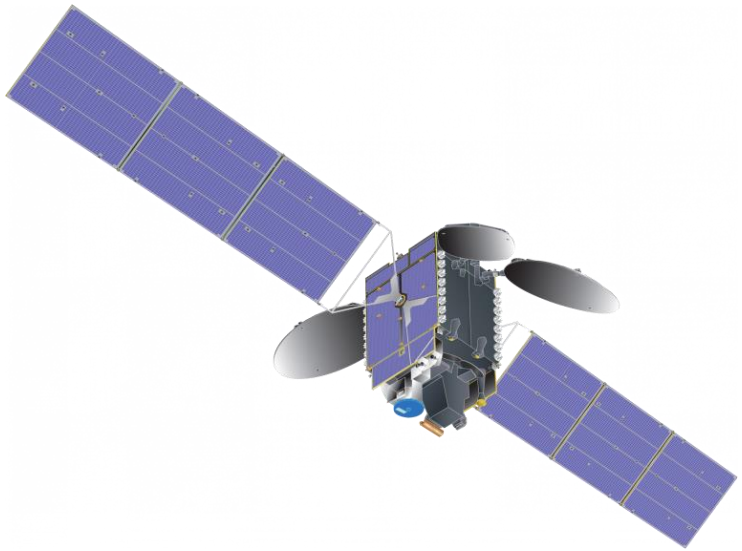


Image Credit: NASA

- **Hourly sampling frequency**
- **Geostationary orbit**
- **0.57nm spectral resolution**

TROPOMI

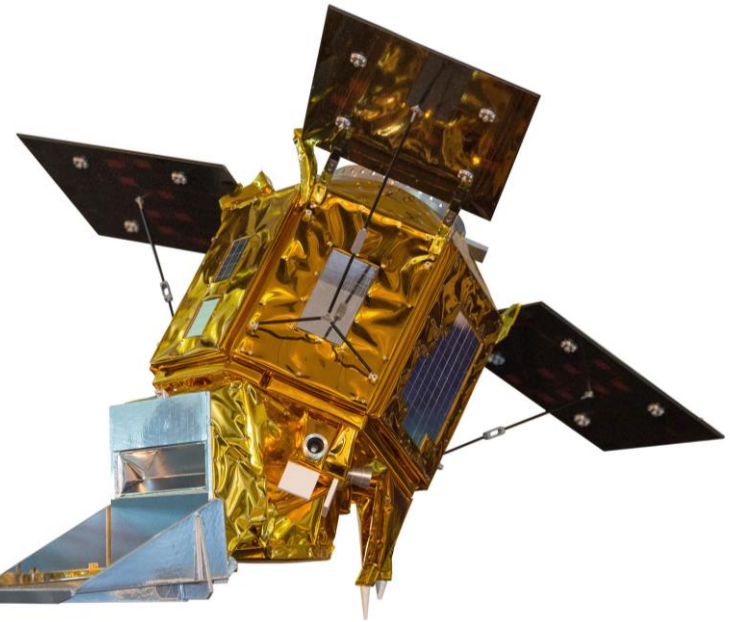


Image Credit: SkywalkerPL

- **Daily sampling frequency**
- **Low Earth orbit**
- **0.5nm spectral resolution**