Analysis of Air Quality in the Joliet Illinois Area Using Ground-based and Space-based Measurements

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Abstract

Nitrogen dioxide and small particulate matter (PM 2.5) are air pollutants with significant implications for public health and environmental quality. This study looks at ground-based and space-based measurements of air quality in communities in Joliet, Illinois, and the surrounding canal corridor. This is a region of interest due to its extensive industrial activity and the presence and large warehouse complexes that generate a substantial amount of diesel truck traffic, which is a major source of nitrogen dioxide and particulate matter. This study uses TEMPO satellite data obtained from NASA's Earthdata portal and ground-based data from a network of low-cost PurpleAir PM2.5 sensors to examine the distribution of nitrogen dioxide and PM 2.5 locally. The study highlights the impact of transportation emissions on air quality as well as the potential for monitoring the impact of local events like industrial fires.

NO2 and PM2.5

Sources

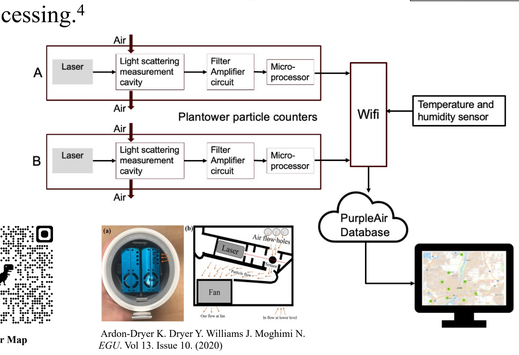
- Vehicle emissions, especially diesel emissions
- Power plants burning fossil fuels or biofuels
- Various industrial and agricultural processes
- Fires
- Windblown dust (PM2.5)

EPA PM2.5 and NO_2 Thresholds[1,2]

EPA Air Quality Index (AQI)	PM2.5 Concentration 24hr average (µg/m^3)	NO_2 Concentration 24hr average (ppb)
Good (0-50)	0.0-9.0	0.0-53
Moderate (51-100)	9.1-35.4	54-100
Unhealthy for Sensitive Groups (101-150)	35.5-55.4	101-360
Unhealthy (151-200)	55.5-125.4	361-649
Very Unhealthy (201-300)	125.5-225.4	650-1249
Hazardous (301-500)	225.5-325.4	1250-2049

PurpleAir Sensors

PurpleAir Sensors[3] are low cost (~$300) for measuring PM2.5, making them popular for citizen science air quality monitoring projects. The data are stored in the PurpleAir database and are accessible in real time on the PurpleAir map. EPA corrections are applied during preprocessing.[4]



PurpleAir Map

Ardon-Dryer K. Dryer Y. Williams J. Moghimi N. *EGU*. Vol 13. Issue 10. (2020)

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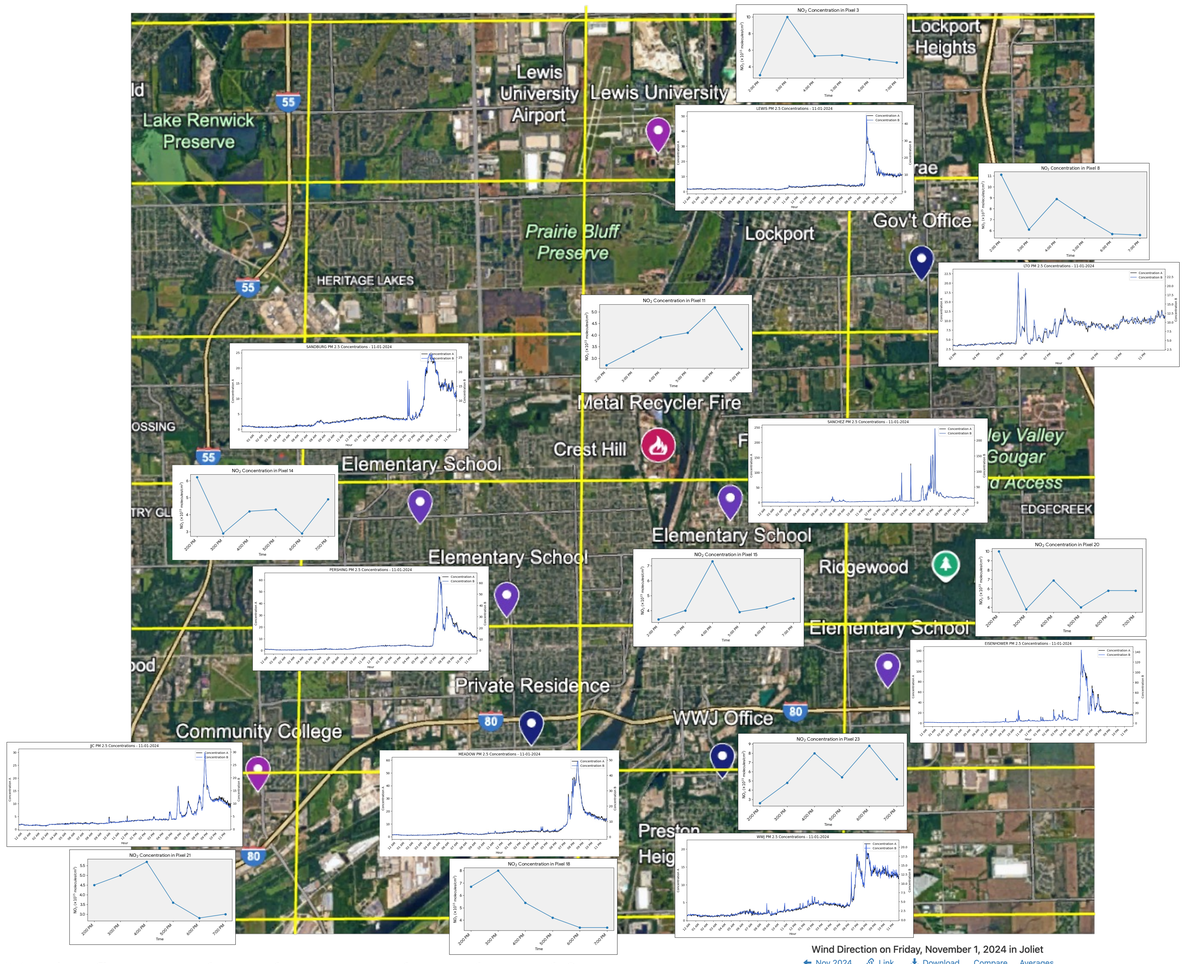
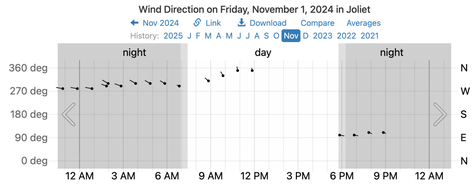
Case Study: Fire at Scrap Metal Yard on Nov. 1, 2024

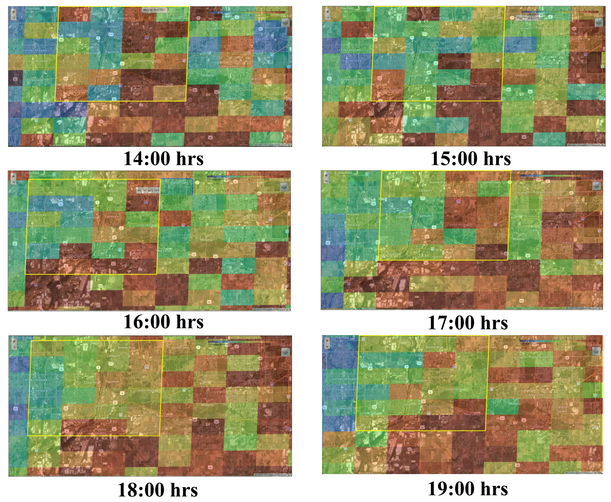


- Massive fire at metal recycler scrap yard started around 2 pm on November 1, 2024, Friday of the week we deployed our first 8 sensors.
- Firefighters had it under control by early evening but were putting out hotspots through the night.
- Winds were blowing from the NNW in the morning, calmed to under 5 mph for much of the afternoon, and then strengthened from the East around 6pm.



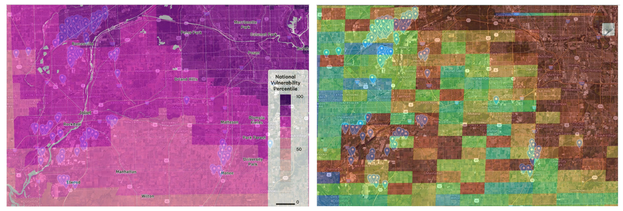
https://weatherspark.com/h/d/13345/2024/11/1/Historical-Weather-on-Friday-November-1-2024-in-Joliet-Illinois-United-States#Figures-WindDirection

NO_2 on November 1, 2025



Climate Vulnerability Index (CVI)

The Climate Vulnerability Index[5] is a mapping tool that incorporates 184 data sets that include health, socioeconomic, environmental, infrastructure, and climate data to provide an overall vulnerability ranking of more than 70,000 census tracts as well as grouped (e.g. "Health" or "Infrastructure") rankings and individual input rankings. The NO_2 data in the CVI is an annual average from TROPOMI, which does not have the resolution of TEMPO.

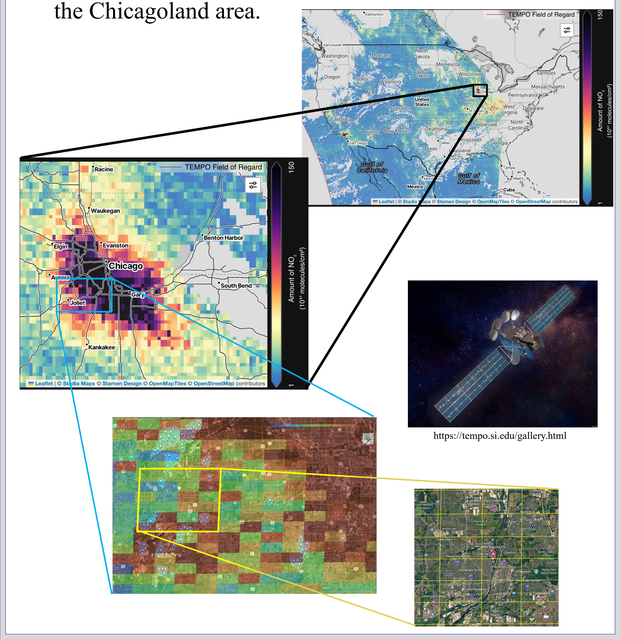


CVI NO_2 map (left) and TEMPO map from one slice (right) overlayed on a map of ground-truthed warehouses (pins) in Will County.

TEMPO

The TEMPO (Tropospheric Emission Monitoring of Pollution) Spectrometer, housed on a geostationary communications satellite, uses UV-VIS spectroscopy to measure NO_2 and other pollutants across the United States in hourly sweeps (during daylight hours). The NO_2 measurement resolution is 2 km N/S x 4.75 km E/W. TEMPO data started being released in Spring 2024.

- Resolution and frequency of scans allow for more localized, intraurban analysis of NO_2 concentrations
- Clouds result in missing data, which can be limiting in the Chicagoland area.



https://tempo.si.edu/gallery.html

Conclusions

- PM2.5 network can track particulate matter from local events like fires over time
- While NO_2 data are inconclusive regarding tracking local events like fires, higher NO_2 concentrations are observed around major highways and warehouse complexes.
- TEMPO data could also provide higher resolution information for Climate Vulnerability mapping.

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[1]Environmental Protection Agency, (2024) *Reconsideration of the National Ambient Air Quality Standards for Particulate Matter.* FR Doc. 2024-02637 https://www.federalregister.gov/documents/2024/03/06/2024-02637/reconsideration-of-the-national-ambient-air-quality-standards-for-particulate-matter

[2] Environmental Protection Agency, (2018) *Technical Assistance Document for the Reporting of Daily Air Quality – the Air Quality Index (AQI).* EPA 454/B-18-007 https://www.airnow.gov/sites/default/files/2020-05/aqi-technical-assistance-document-sept2018.pdf/

[3]*PurpleAir website.* https://www2.purpleair.com/

[4]Barkjohn KK, Holder AL, Frederick SG, Clements AL. *Correction and Accuracy of PurpleAir $PM_{2.5}$ Measurements for Extreme Wildfire Smoke.* Sensors (Basel). 2022 Dec 10;22(24):9669. doi: 10.3390/s22249669.

[5] Environmental Defense Fund (2018). *The US Climate Vulnerability Index.* https://climatevulnerabilityindex.org/