Air quality monitoring and anthropogenic correlations in Northwest Indiana

Siobhan Cleveland, Phillip. Kirk, and Christopher Iceman

VALPARAISO UNIVERSITY

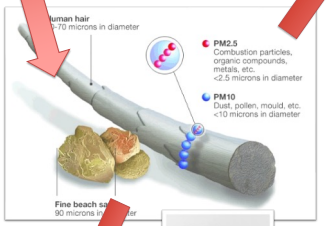
INSGC NASA

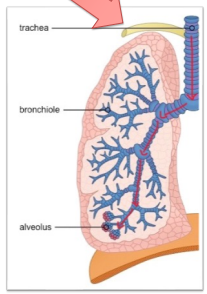
Introduction

Currently, there are seven PurpleAir sensors deployed throughout Lake and Porter counties in cities including Gary, Chesterton, Valparaiso, and Schererville as part of the North Lake County Environmental Partnership (NLCEP). More are on the way!

Communities have been partnering with Valparaiso University to set up and help maintain the PurpleAir sensors in their municipalities. In addition to setup and monitoring, communities are learning about their local air quality and the monitoring systems in place. Air quality is one of the most misunderstood and unknown metrics for human health!

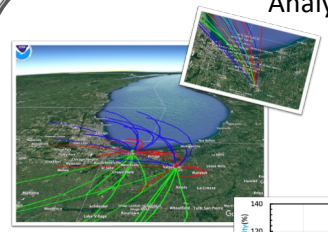
We observe air quality via these sensors with attention to particulate concentrations and compare to spatial and meteorological factors. Within the Gary and Valparaiso areas, sensors have qualitative trends. Relative to a 5-mile radius in the Gary area, the distributions of particulates are not the same within the 95% confidence interval.





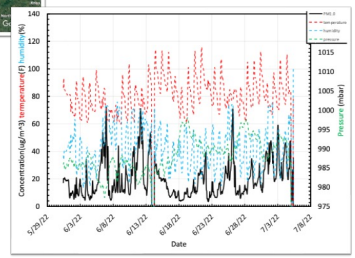
Meteorological factors like humidity and pressure have an effect on the particulate concentrations and trends in pressure where particulate concentrations data show a transposed relationship. Anthropogenic spikes in particulate matter (PM1.0) are modeled with meteorological data with the Hybrid Single-Particle Lagrangian Integrated Trajectory Model (HYSPLIT) to evaluate particulate origin. Deconvolution of particulate origin remains an aim of this work!

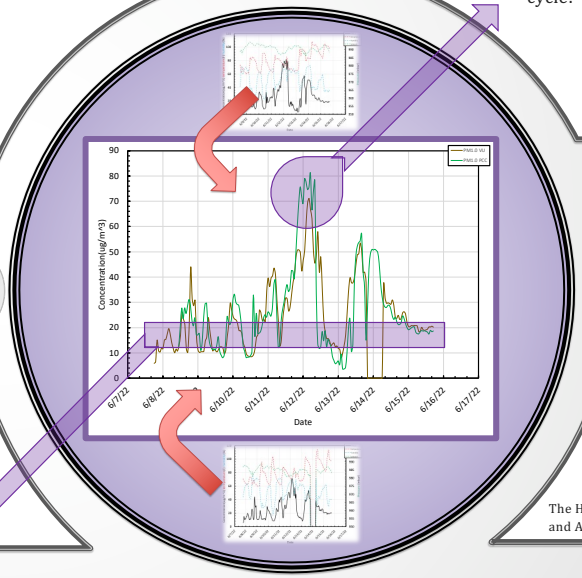
Analysis

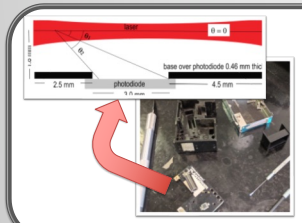


What is natural air quality degradation and what is anthropogenic? We still don't know! But we are trying to find trends by looking at spike shape, correlations, and HYSPLIT. Each spike is a potential source, but determining the nature of the source is not easy. Do other sensors see the same spike consistent with wind direction? Is the spike long lived? Each variable is an important co-factor.

The weather in NWI is interesting. Also notice the diurnal cycle!







- Particulates are gently introduced to the light scattering chamber via small fans
- The particles are measured by the light scattered from their surface
- Scattered light intensity is then correlated to particulate concentration when detected at the photodiode
- Best performance obtained at <50% humidity for particles <1.0μm effective diameter[1, 2]
- Information is uploaded and viewed via PurpleAir.com and publicly available
- Sensors can unfortunately be degraded by deposited dust and local flora/fauna

PurpleAir

HYSPLIT NOAA

What is HYSLPLIT? The Hybrid Single-Particle Lagrangian Integrated Trajectory model uses meteorological datasets, such as the Global Data Assimilation System (GDAS), to forecast or backcast air mass vectors to model where air particles came from. Typically the resolution for GDAS is ~25 km grid updated every 3 hrs and interpolated for the predictive models in use above.

Additionally the trajectories now have the ability to be imported into GoogleEarth and mapped with terrain. The HYSPLIT model is limited in many ways for ground based observations, but is at least a qualitative source estimate.

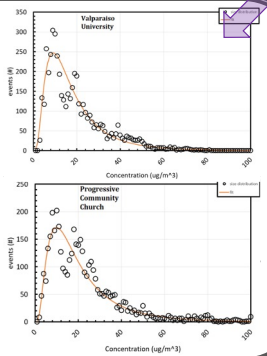
The HYSPLIT tool is freely available thanks to the National Oceanic and Atmospheric Administration and can be found online!

Analysis

We aren't quite sure yet if we have a normal distribution of particulate data, but we are collecting more data fast! The log normal distributions shown here represent thousands of data points each in the month of June. These data have some lumps but so far the average particulate concentrations between different locations show significance at the 95% confidence limit. In fact, with more data, our confidence limit may even increase!

We do not yet know what each month or the yearly total may represent, but we are paying attention to distribution normality and consistency.

Location	Mean concentration (ug/m3)	σ	N
Valparaiso University	19.0	15.1	5037
Progressive Community Church	22.4	19.0	4218
Miller Beach	23.1	20.3	5616
East Side Chicago	28.1	28.9	3460



Conclusions

Currently datasets are being collected and compiled for the forthcoming year to begin to observe correlations that prescribe to seasonal, spatial, meteorological, and industrial trends. All data is observable via a publicly accessible website to assist with community engagement and education for livetime hourly air quality data. We are proud to be part of the PurpleAir network of citizen and research scientists!

We are concerned with some things that we have learned so far, such as the sensor susceptibility to contamination from insects and spiders, as well as sensor reliability in remote locations that can not be checked daily. Additionally the advertised PM2.5 – PM10 measures are likely overestimates of the sensor design and function, only PM1.0 values are reported as a result. Though these particles are the most harmful to human health, this limits true metrics of air quality that span larger particulate morphology.

Future work will include the use of cascade impactors and filter samplers to collect particulates from PM1 – PM10 and use these substrates for chemical analysis. We anticipate being able to further correlate air quality events and trace sources with these tools.

Indoor air quality and drones are other topics for future study to monitor the correlations between outdoor and indoor air.

We would like to thank the INSGC, NASA, and Valparaiso University for funding support.

References: [1] Ouimette, James R., et al. "Evaluating the PurpleAir monitor as an aerosol light scattering instrument." *Atmospheric Measurement Techniques* 15.3 (2022): 655-676. [2] Hagan, David H., and Jesse H. Kroll. "Assessing the accuracy of low-cost optical particle sensors using a physics-based approach." *Atmospheric measurement techniques* 13.11 (2020): 6343-6355.