Preliminary Seasonal Characterization of $PM_{2.5}$ and Ozone Small Sensors

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TEMPO

Tropospheric Emissions: Monitoring of Pollution (TEMPO) will be the first space-based geostationary satellite to collect hourly measurements to monitor air pollutants across North America. The small footprint (~2.1km N/S × 4.5km E/W at 36.5°N, 100°W) will allow for high spatial resolution readings of many parameters including ozone, nitrogen dioxide, and aerosol. Communities across the US have begun deploying dense networks of small sensors to measure spatial gradients of air pollutants, motivating this study to gain a better understanding of sensor performance. During the summer of 2019, $PM_{2.5}$ and ozone small sensors were evaluated for feasibility of use in the TEMPO validation network.

Tropospheric Ozone

Tropospheric ozone is produced from the reactions of nitrogen oxides and hydrocarbons in the presence of sunlight. Urban areas commonly exhibit high value ozone days on very sunny and warm days with little atmospheric motion. Ozone can be transported by moving air masses.

Particulate Matter 2.5

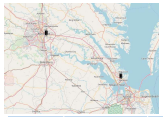
Particulate matter (PM) is the sum of solid and liquid particles in the air. Particulate matter can be classified by size. $PM_{2.5}$ is small inhalable particles that are 2.5µm or smaller, presenting as either solids or liquid droplets. These particles are made up of many different chemicals. They may come from point sources or chemical reactions involving sulfur dioxides and nitrogen oxides, which are emitted from automobiles, industry and power plants. Some sources of PM include smokestacks, fires, engine combustion, construction, and other chemical processes that occur naturally. Particulate matter can be transported by moving air masses.

PurpleAir

The PurpleAir sensor is used world wide in citizen science efforts to measure PM. It is a small sensor featuring two plant-tower laser light scattering particle counters, developed to detect $PM_{2.5}$ and PM_{10} and can be used to determine the air quality index of a given area and display it on a public website. It transmits data via Wi-Fi connection to the PurpleAir website. The frequency of measurement is approximately 90 seconds.

Aeroqual AQY1

Aeroqual AQY1 is a small sensor that measures ozone, PM2.5, nitrogen dioxide, temperature, dew point, and relative humidity. It transmits data wirelessly through a Wi-Fi connection to a password protected account on the Aeroqual cloud. It measures PM2.5 using a laser light scattering particle counter. Ozone is measured with a metal oxide sensor, while nitrogen dioxide is measured with an electrochemical sensor. The frequency of measurement for all parameters is every 1 minute.

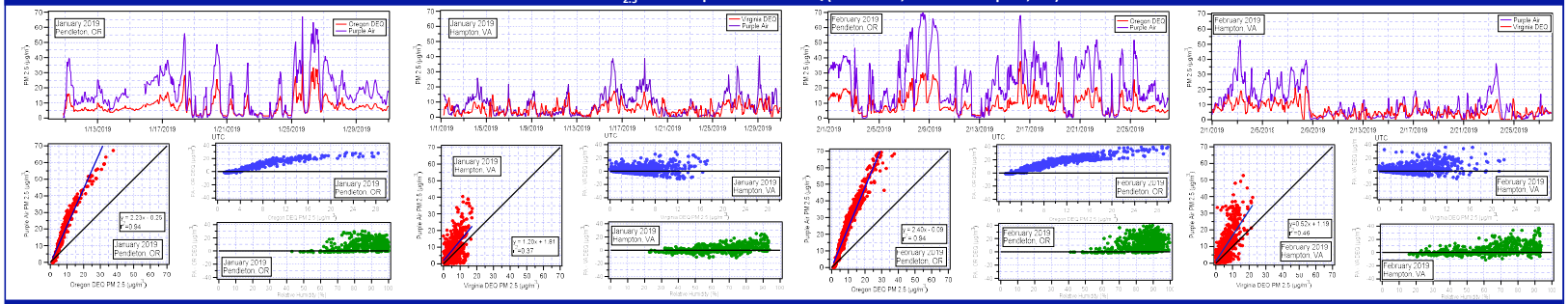


	PurpleAir $PM_{2.5}$	Aeroqual $PM_{2.5}$	Aeroqual O_3
Range	0-500 µg/m³	0-1000 µg/m³	0-200 ppb
Accuracy/ Precision	±10 µg/m³	±10 µg/m³	<4 ppb, 4%

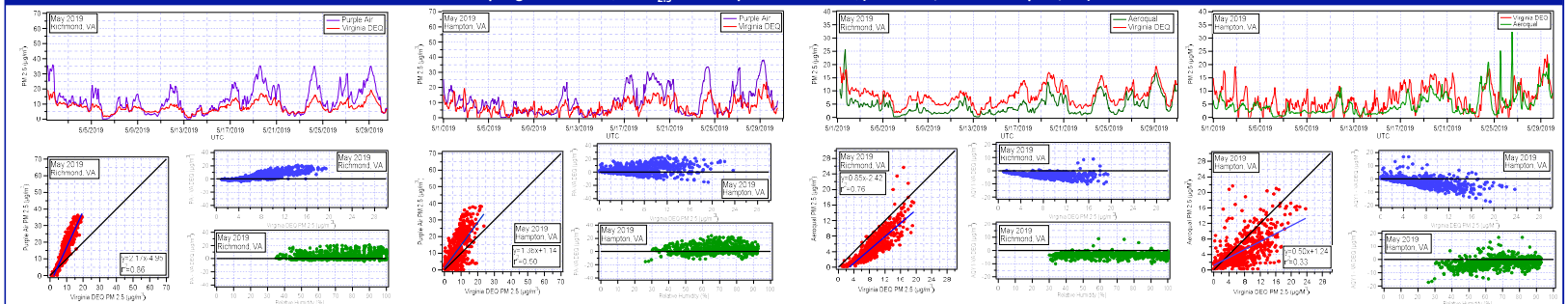
Summary

For the purpose of this study the PurpleAir sensor and the Aeroqual AQY1 were used in three different geographical regions and were intercompared with preliminary Department of Environmental Quality (DEQ) data from Pendleton OR, Richmond VA, and Hampton VA. Pendleton experiences colder temperatures and lower humidities, with higher $PM_{2.5}$ levels in the summer due to forest fires, and use of woodburning stoves in the winter. Richmond is an urban city located along the Eastern Corridor. Hampton, located near the Chesapeake Bay, has a coastal influence. An evaluation of the PurpleAir sensor was made in all three locations, while the Aeroqual AQY1 was evaluated for Richmond and Hampton. PurpleAir $PM_{2.5}$ levels are typically a factor of two higher when compared to DEQ $PM_{2.5}$. Aeroqual $PM_{2.5}$ is typically lower than DEQ $PM_{2.5}$. Both Aeroqual and PurpleAir exhibit a dependence on relative humidity. Aeroqual ozone captures the diurnal trend when compared with DEQ ozone; however, the correlation varies with season.

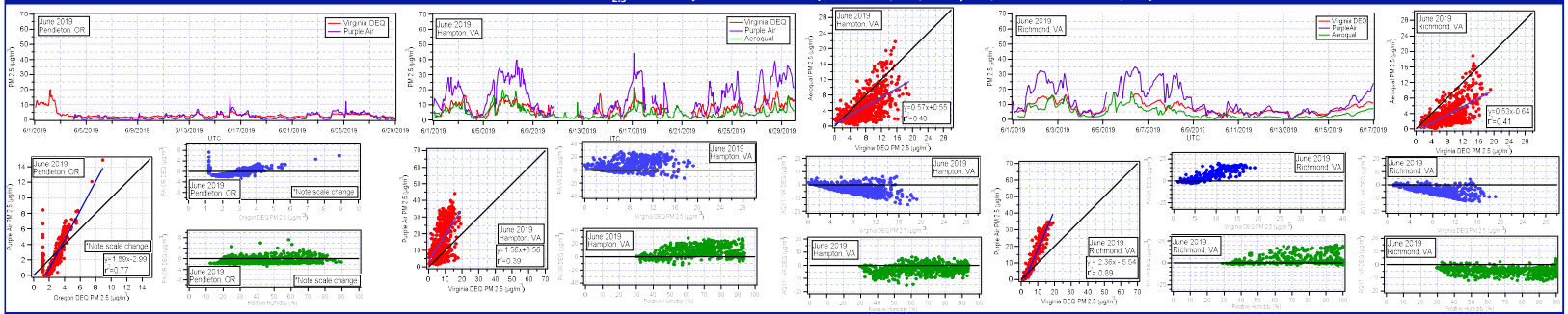
Winter PA-II $PM_{2.5}$ Intercomparison with DEQ (Pendleton, OR and Hampton, VA)



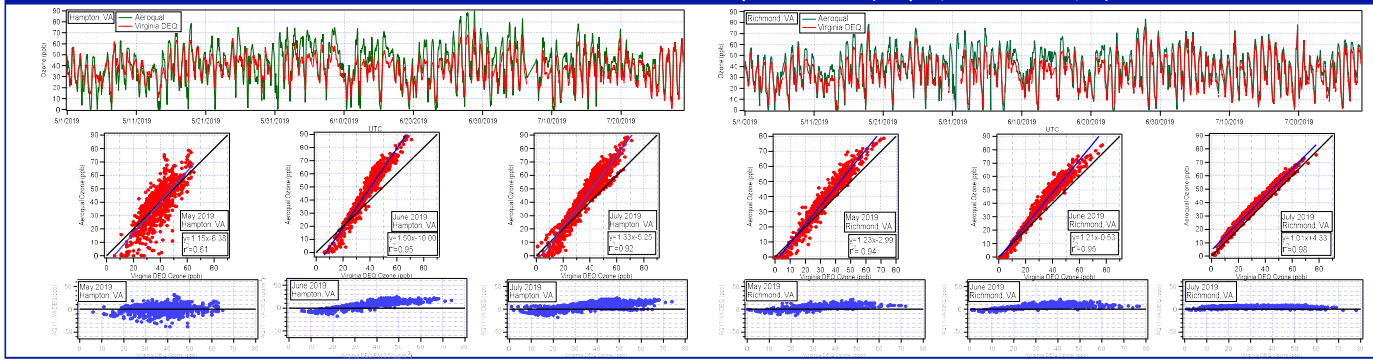
Spring PA-II and AQY1 $PM_{2.5}$ Intercomparison with DEQ (Richmond, VA and Hampton, VA)



Summer PA-II and AQY1 $PM_{2.5}$ Intercomparison with DEQ (Pendleton, OR, Hampton, VA and Richmond, VA)



Summer AQY1 Ozone Intercomparison with DEQ (Hampton, VA and Richmond, VA)



Acknowledgements

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References

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