Observations of Ozone and PM 2.5 concentrations During NYC's (June 28-30th 2021) heat wave.

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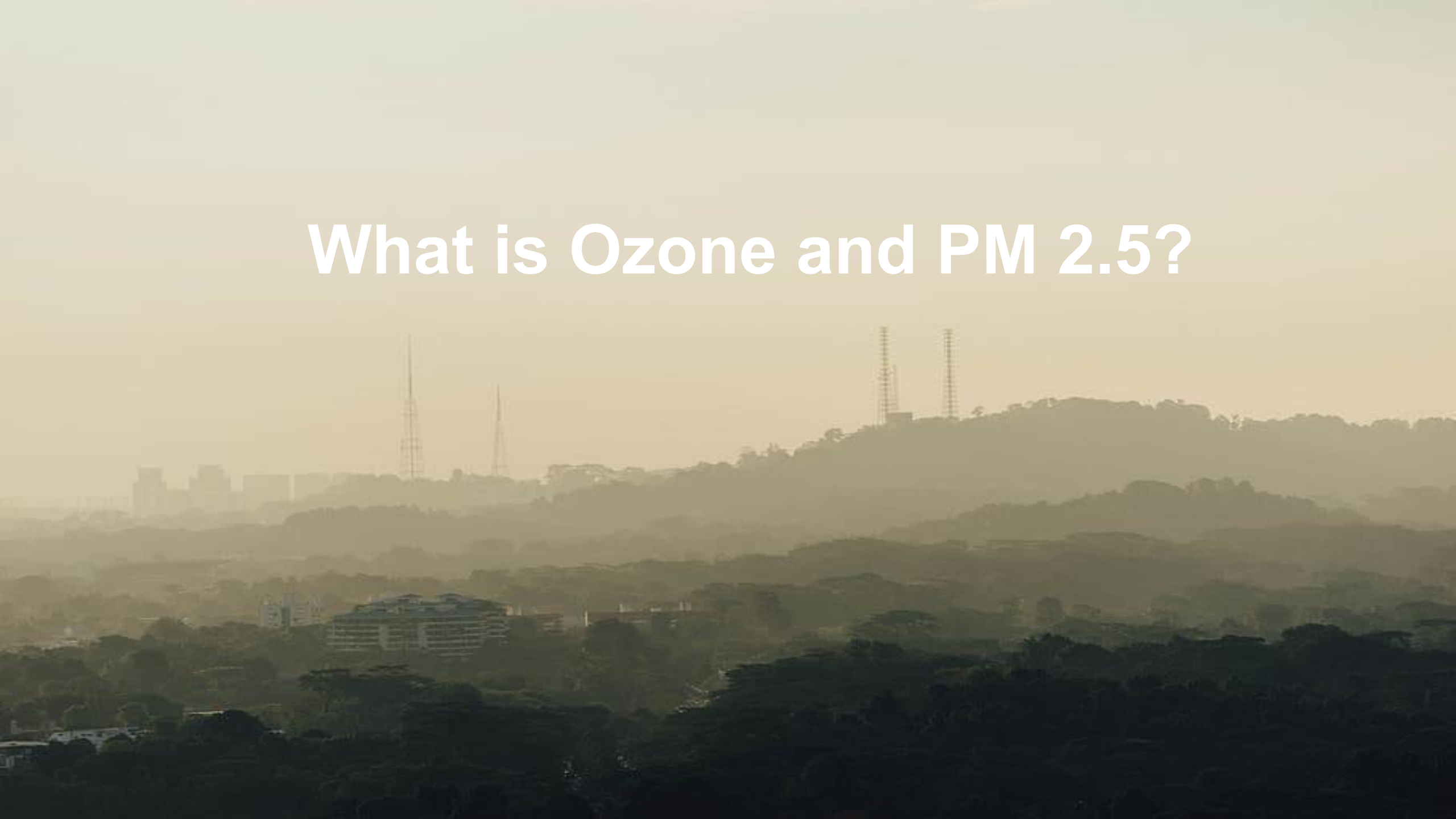
What is Ozone and PM 2.5?



Ozone/ Surface Ozone

- Ozone is a gas composed of three atoms of oxygen. Ozone occurs both in the Earth's upper atmosphere and at ground level.
- Ozone at ground-level, also known as surface ozone, is a harmful air pollutant. Breathing ground-level ozone can have several consequences to our health, from chest pain to worsening bronchitis.[1]
- Surface ozone is the product of near surface chemical reactions between Nitrogen Oxides and Volatile Organic Compounds (VOC).[1]
- Ozone levels start to notably rise on hotter days.[1]

Particulate Matter 2.5 (microns)

- Particulate Matter consist of particles with a diameter of 2.5 microns (micrometers) or less
- These particles can be inhaled and can accumulate causing damage to the respiratory system.[2]
- PM 2.5 is emitted to the air by combustion processes, volcanic emissions and can be the product of chemical reactions in the air.[2]


What are Heat Waves?

Heat Waves

- In the NY Metro area, the NOAA National Weather Service defines Heat Waves as “At least 3 consecutive days with high temperatures of at least 90 degrees”.[3]

- Cities are arguably more vulnerable to HWs than rural areas because of the Urban Heat Island (UHI) effect.[4]

Mixing-Layer Height

- The Mixing-Layer Height is part of the Planetary Boundary Layer (PBL). The PBL is the lowest part of the atmosphere.

- The MLH is the height at which pollutants, and other atmospheric substances from Earth’s surface, are uniformly distributed by vertical turbulent mixing process.

Why Analyze MLH and Pollutant Levels During Heat Waves?

- It allow us to understand the interactions between the MLH and pollutants, thus improving the forecast of surface air pollutants.[12]
- It helps us understand whether high temperatures, such as heat waves, have an effect on the rate in which pollutants are formed, evolved or dissipated.

- The NY State Department of Environmental Conservation (DEC) and the NYC Department of Health (DOH) could device **policy** strategies for human health protection concerning these air pollutants.

Instruments Used at CCNY Buildings

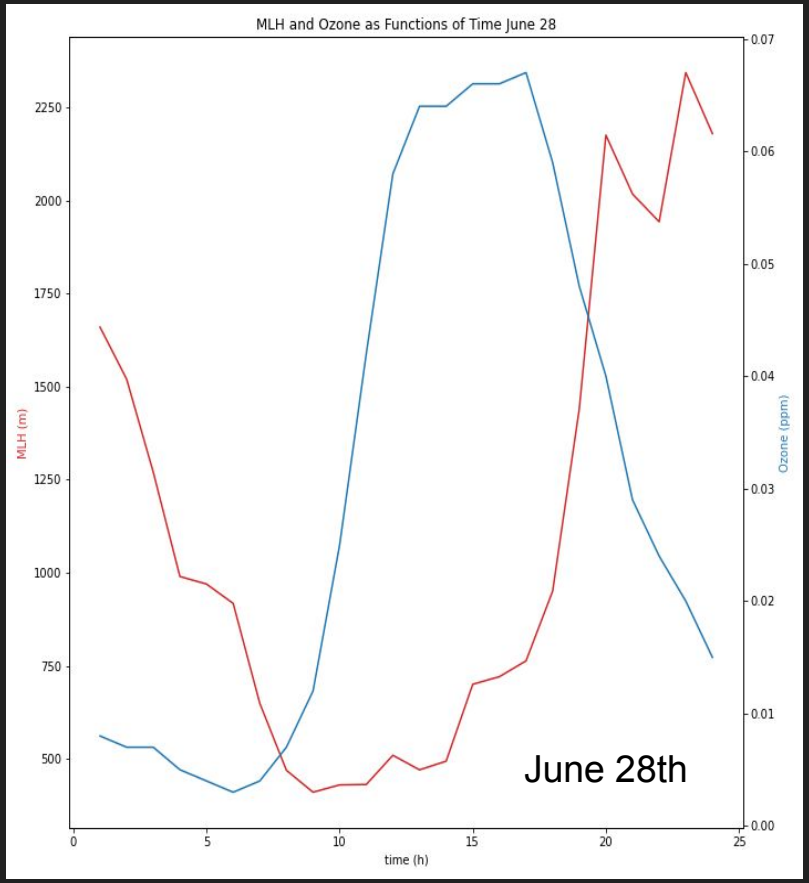
Doppler Lidar

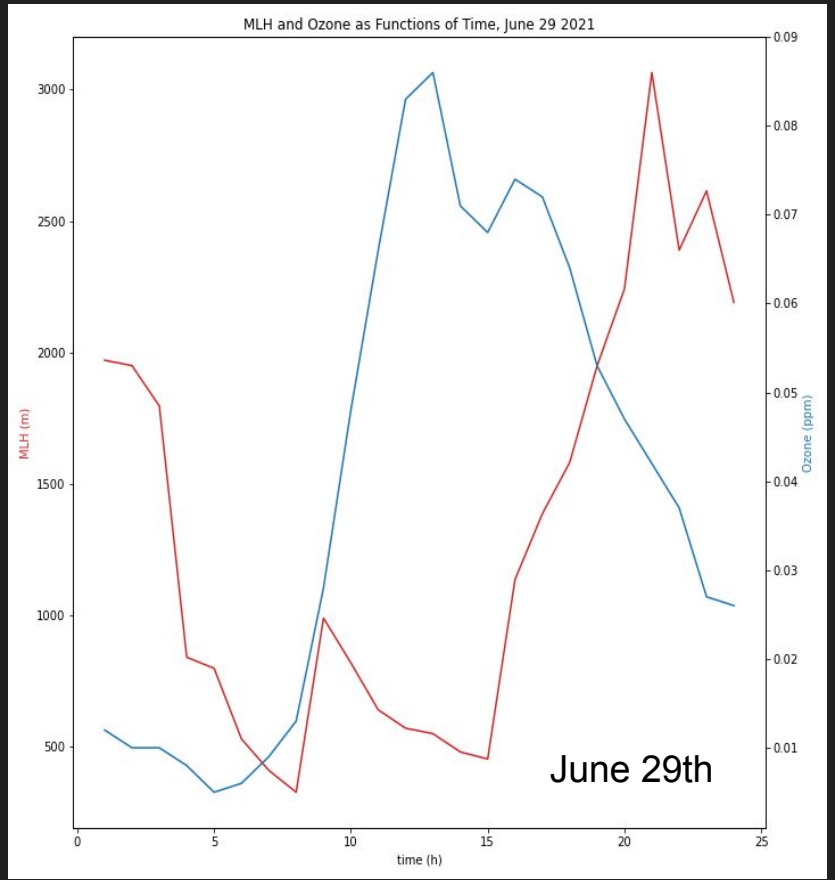
Vaisala CL31 Ceilometer

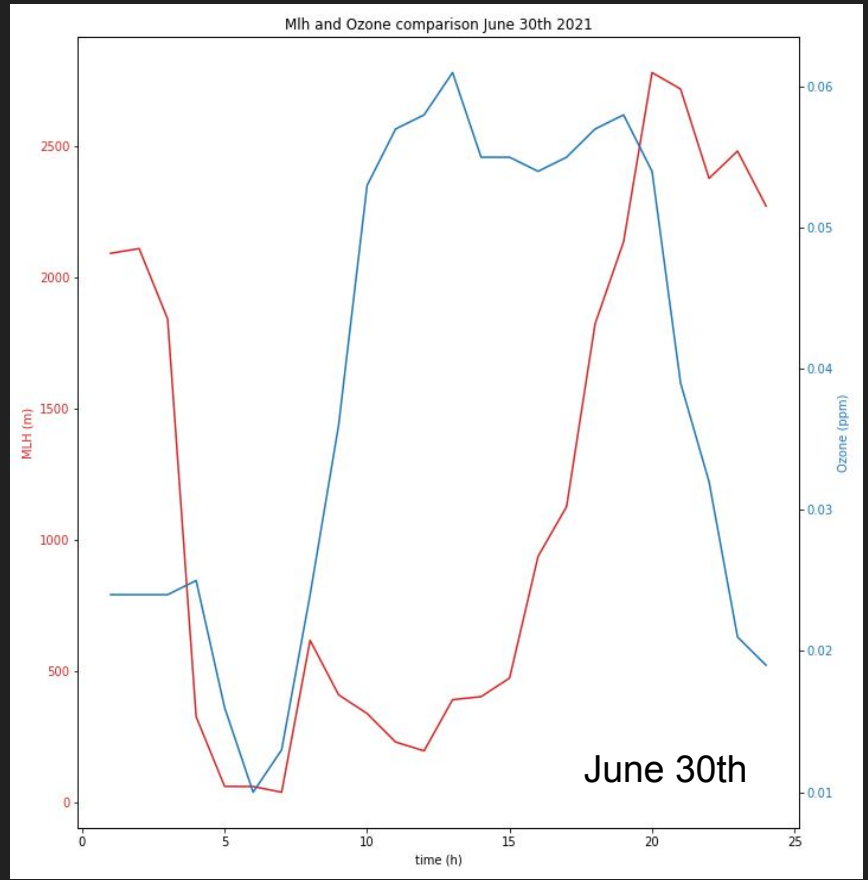
New York State Department of Environmental Conservation shed on top of CCNY Administration building. Ozone sensors and particle counters are in this shed.

3 Day Plots of MLH and Ozone as Functions of Time

Ozone
MLH

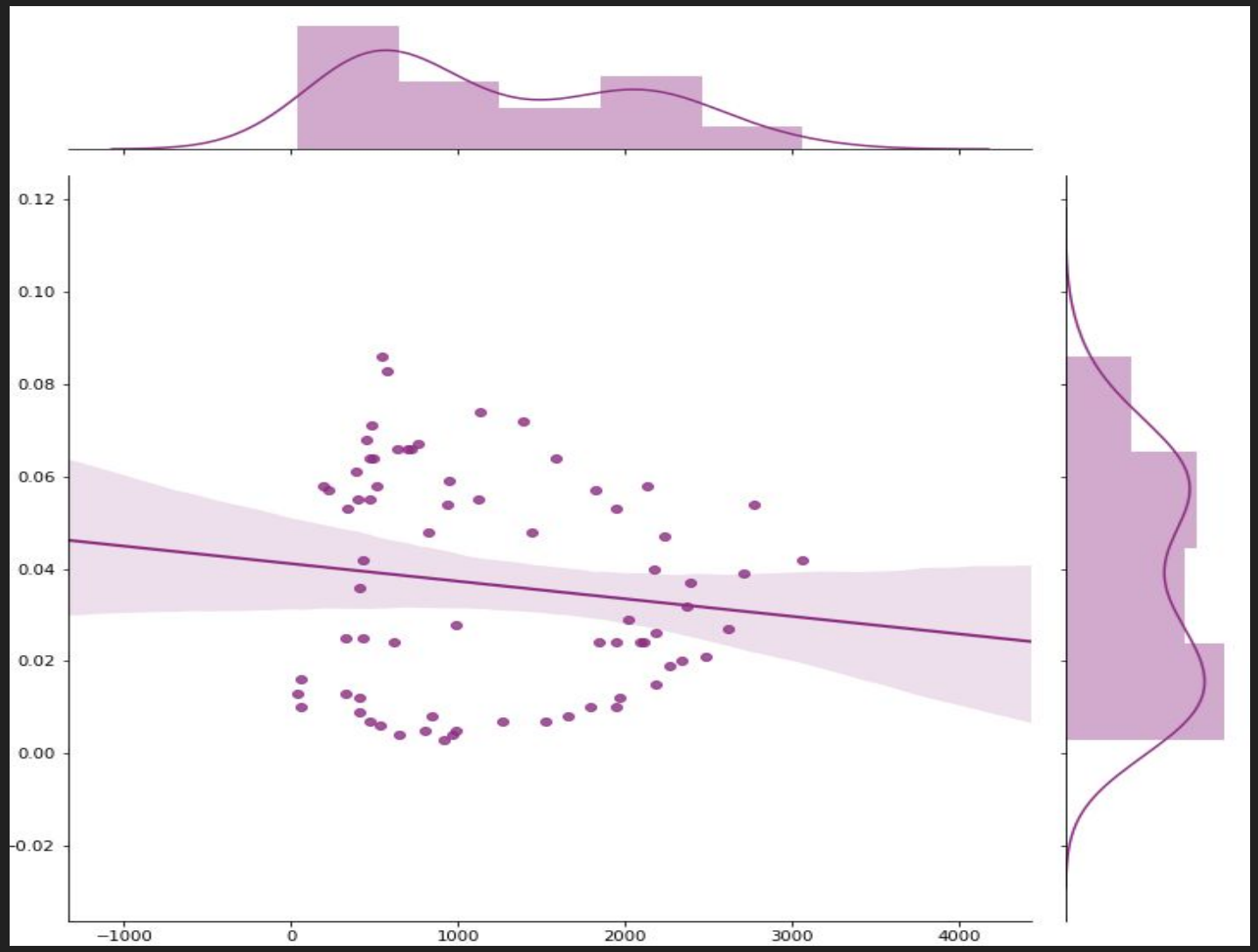






- Geib et al. (2017) found a strong positive correlation between Ozone levels and MLH, specially for the outskirts of the city of Berlin Germany.
- Geib et. al. assumed that the strong correlation was because “both MLH and O_3 concentrations increase after sunrise” as well as other physical processes.

Mixing Layer Height and Ozone

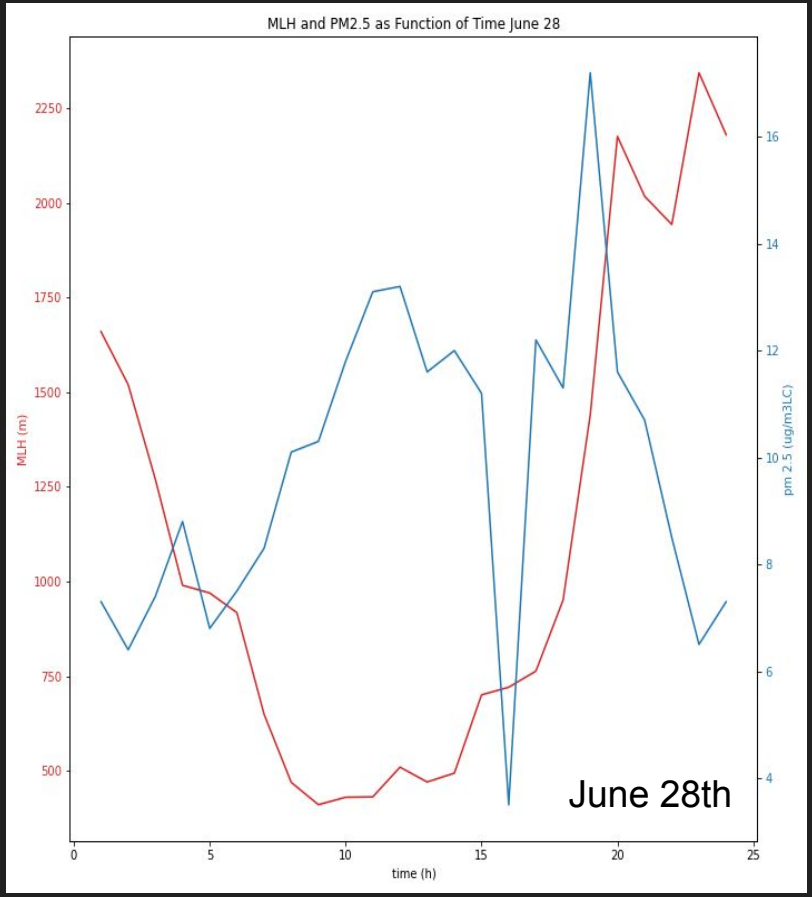


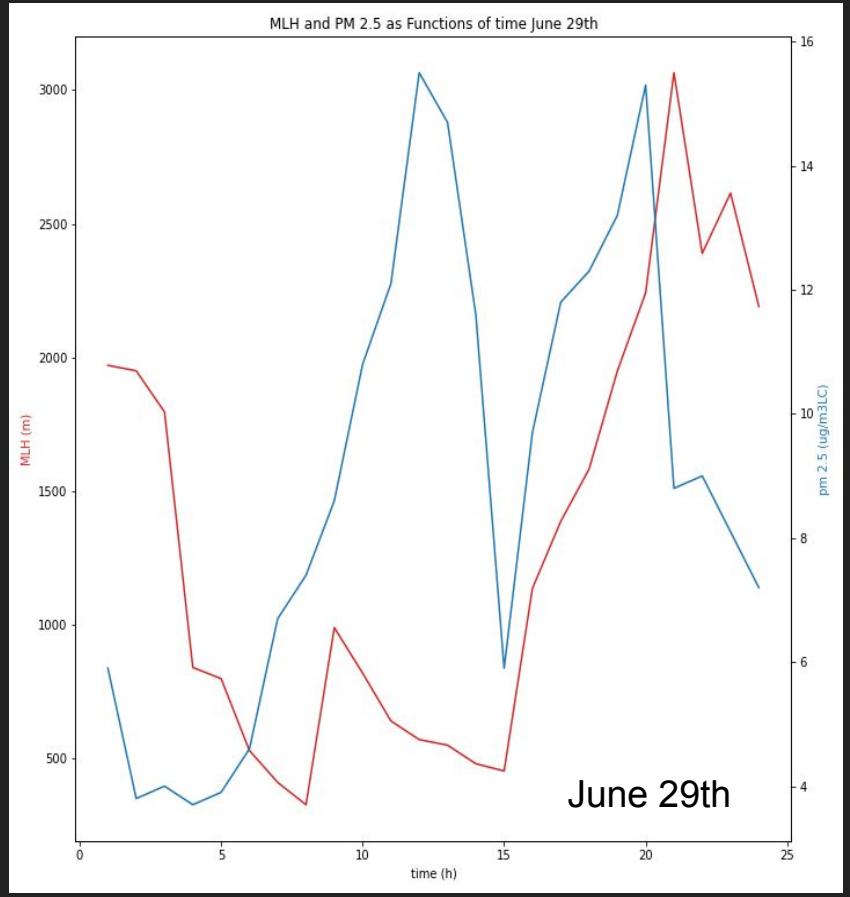
Pearson C. = -0.13214570882690455
P-value = 0.26849708392747557

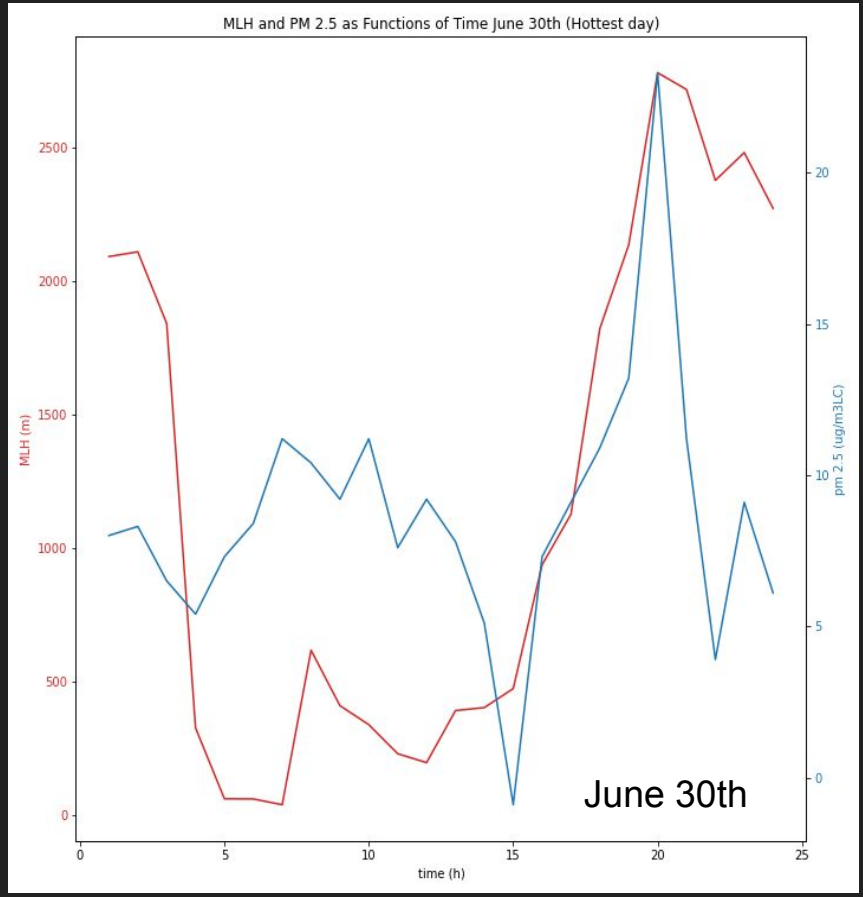
The person value indicates a weak negative correlation. However the probability that this is the case is not good as the P >> 0.05. This might be due to the high temperatures observed and the amount of data analyzed.

MLH and $PM_{2.5}$ as Function of Time

pm2.5
MLH

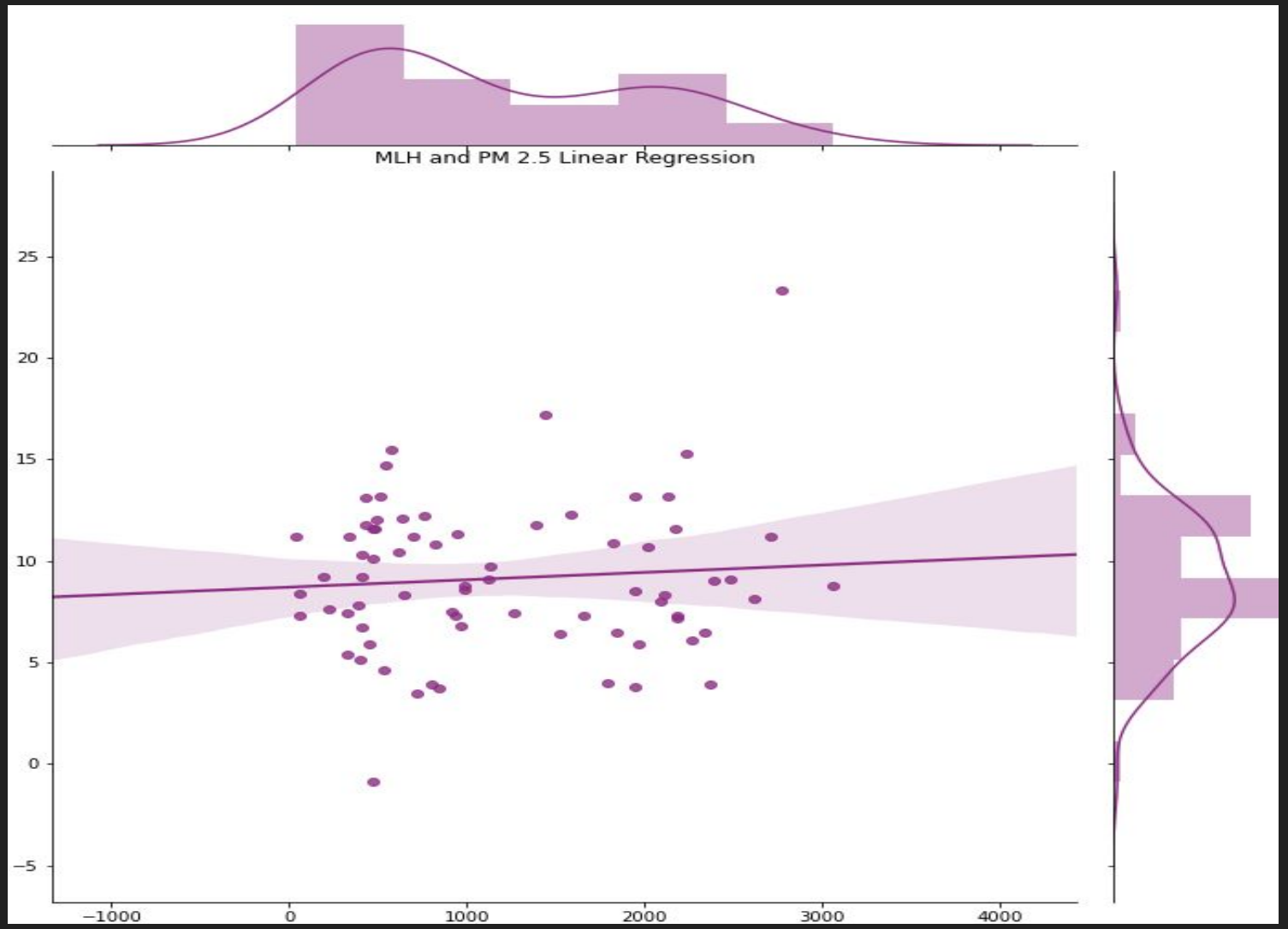






- Tang et al.(2015) noted a strong correlation between daily pollutant variation and MLH but only when the relative humidity increase by 80%
- The team concluded that "the dissipation of atmospheric particles mainly depends on the MLH"

Mixing Layer Height and PM2.5



Pearson C. = -0.13214570882690455

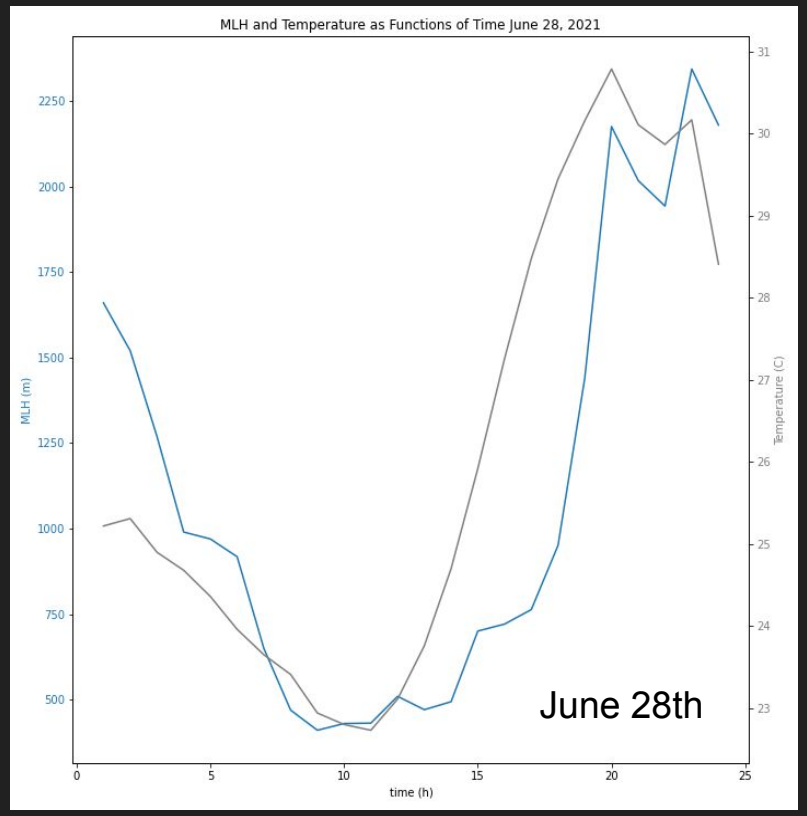
P-value = 0.26849708392747557

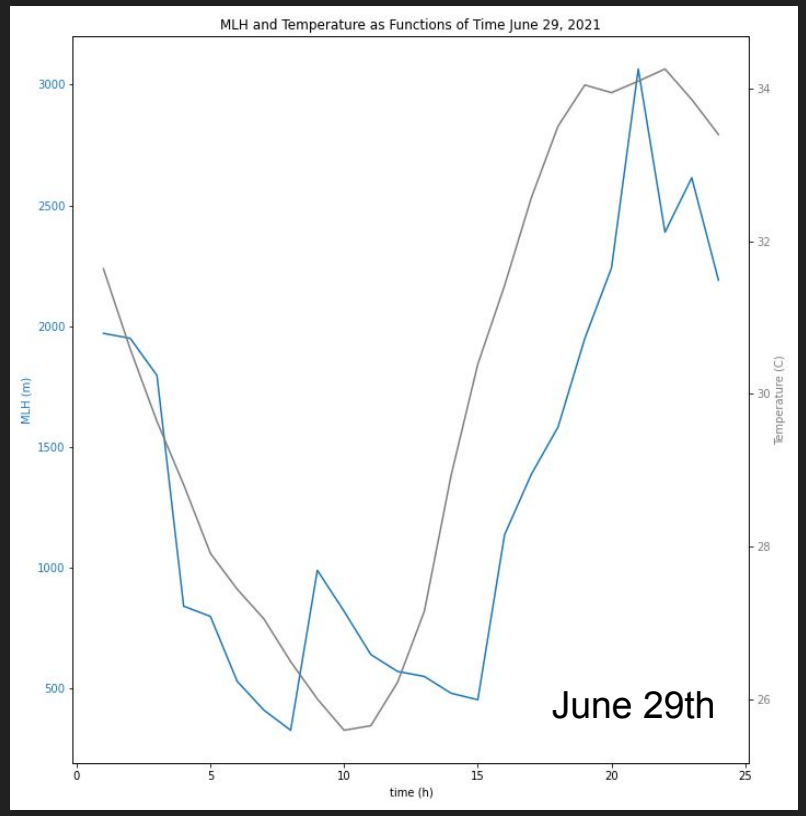
Observations on Other Parameters

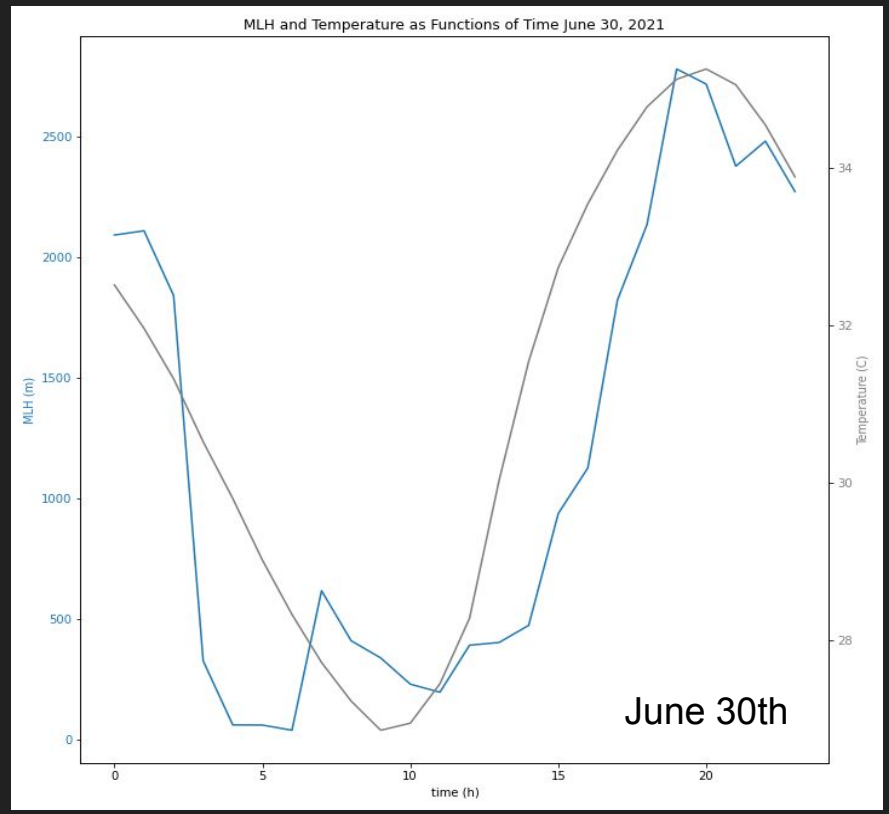
MLH and Temperature as Function of Time

Temperature

MLH

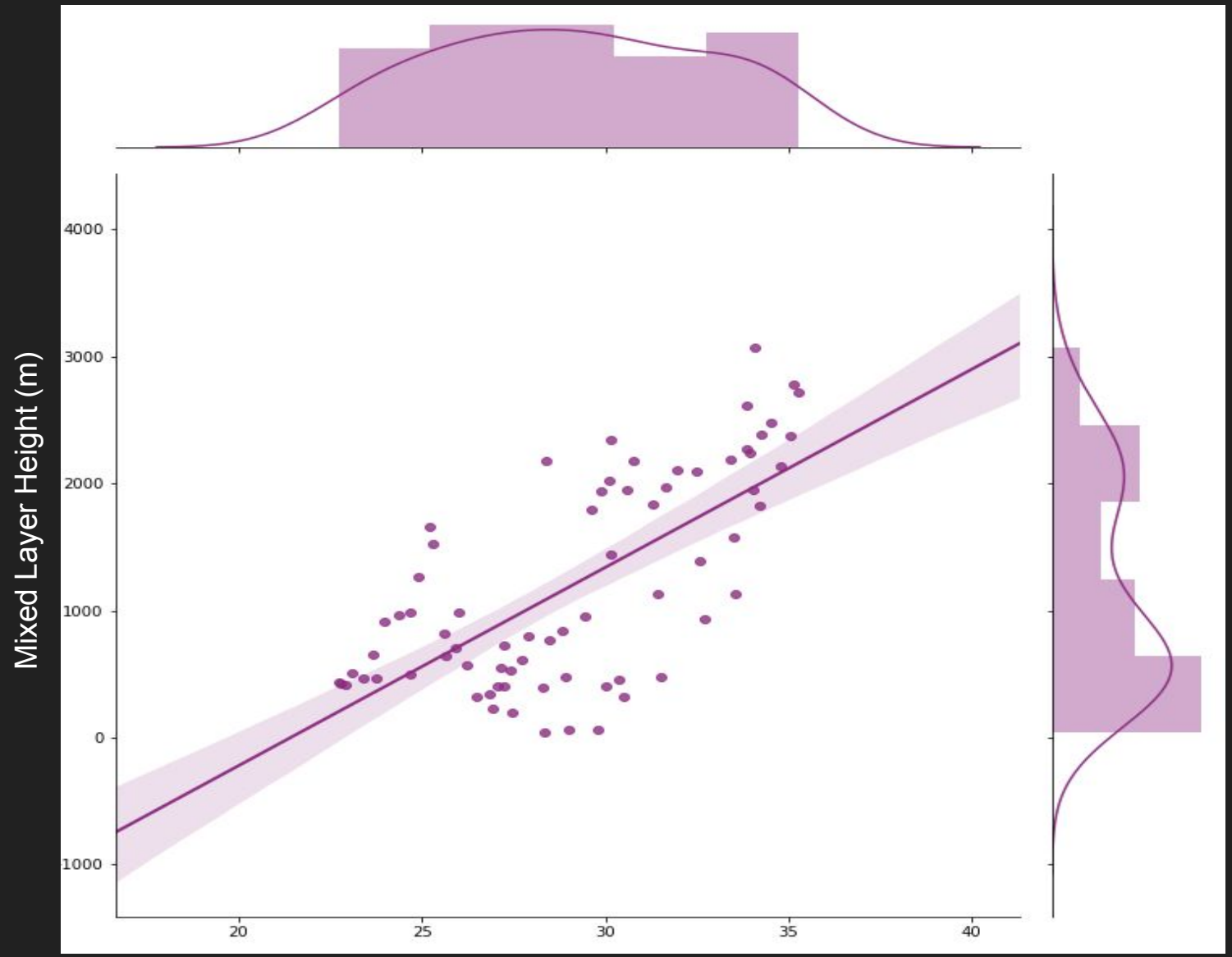






- Kalisa et al. (2018) conducted an experiment in the UK to understand the correlation between pollutants and heat waves. The researchers found that all pollutants increase with the peak of the highest temperatures recorded.[8]
- Since some studies[11] suggest that MLH might be key to the dissipation of pollutants we wanted to see if the two, temperature and MLH, are correlated.

Mixed Layer Height and Temperature

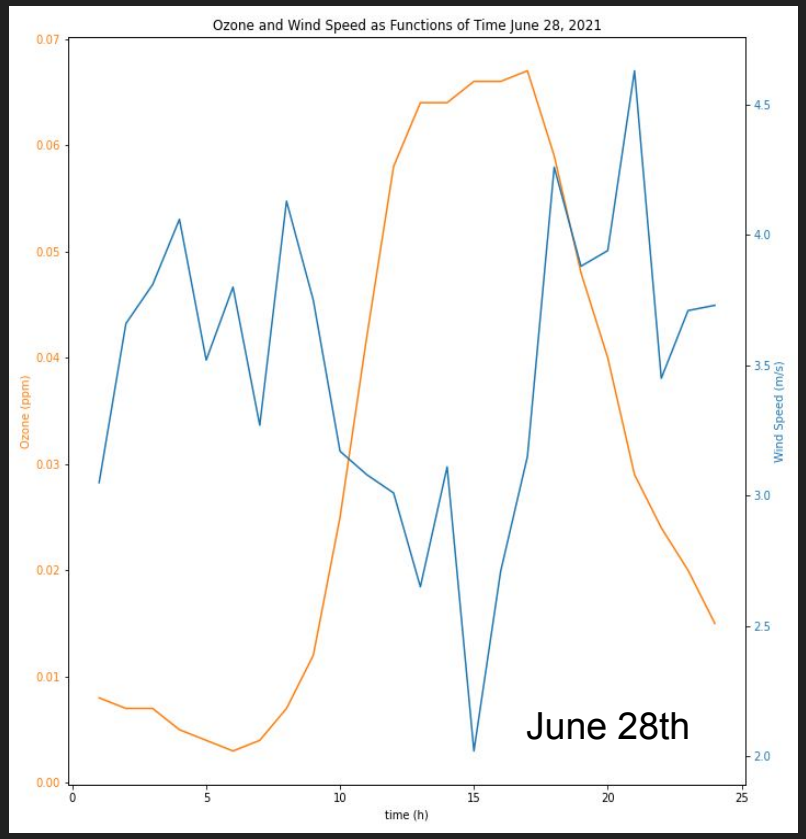


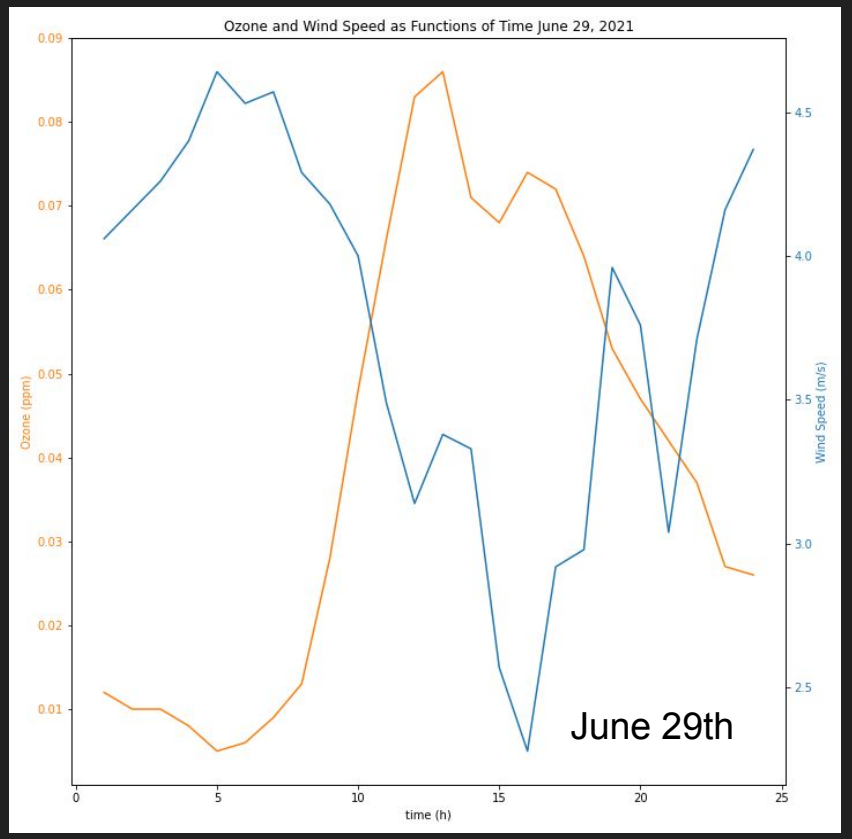
Pearson C. =
0.6959616520363912

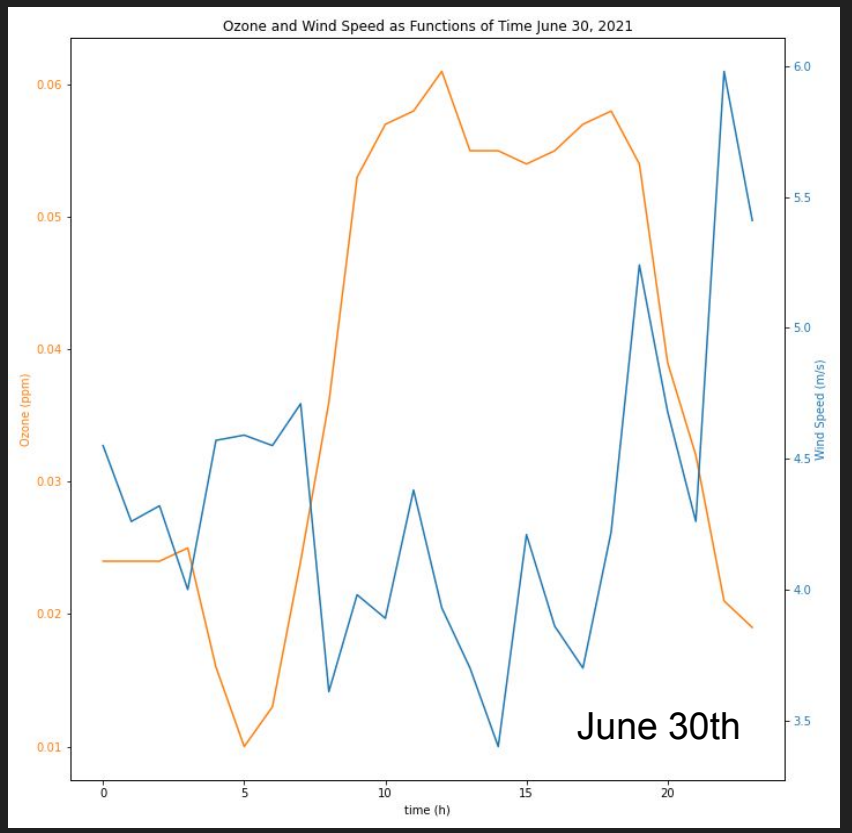
P-Value =
1.1510716786742871e-11

Ozone Concentration vs Weather Station Surface Wind Speed

Ozone
Wind Speed

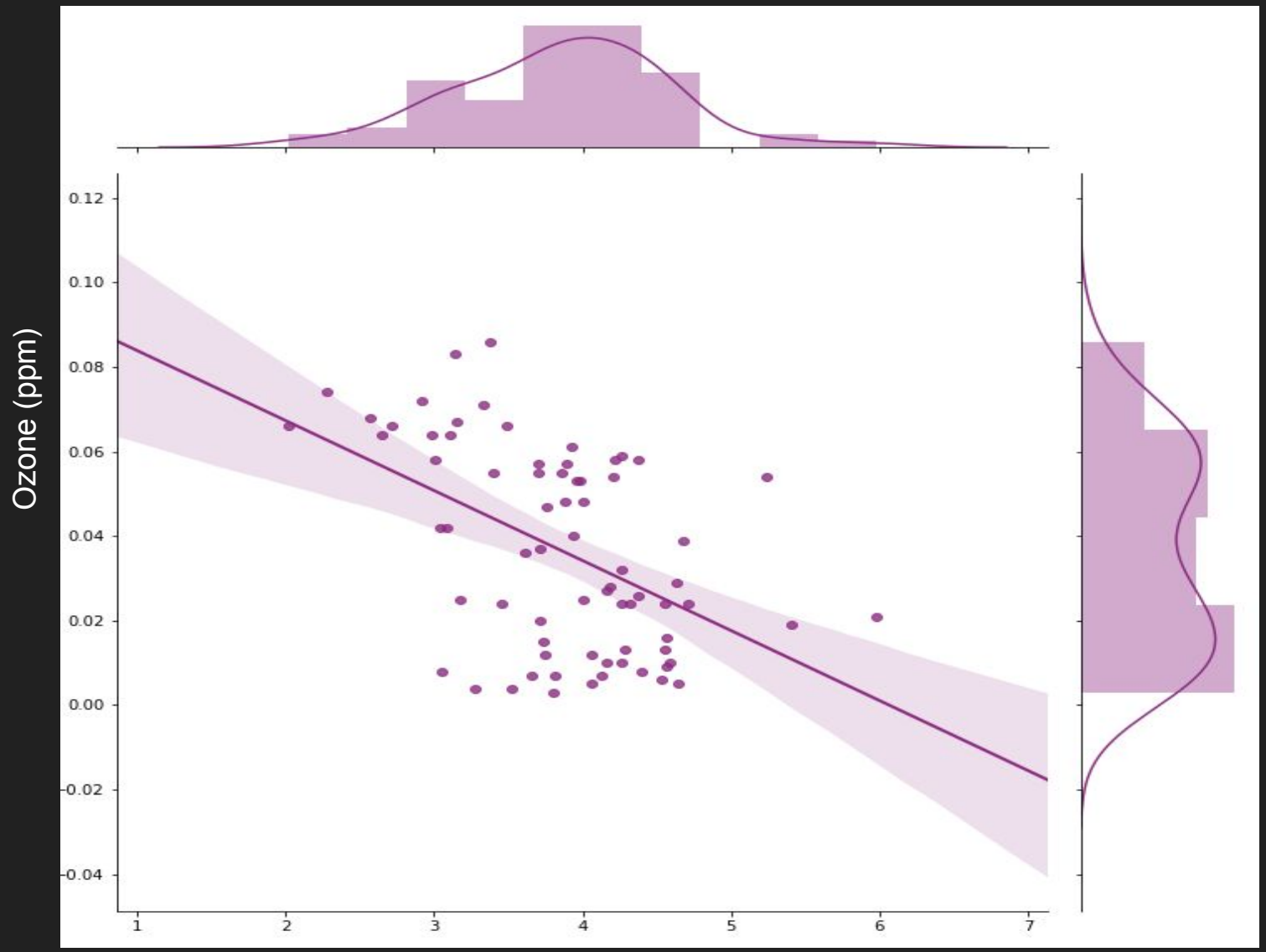






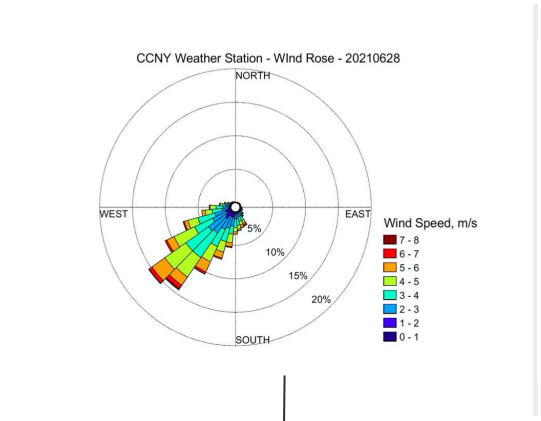
Afonso and Pires (2017) created a numerical model and found that wind speed is one of the parameters that affects O_3 behaviour.

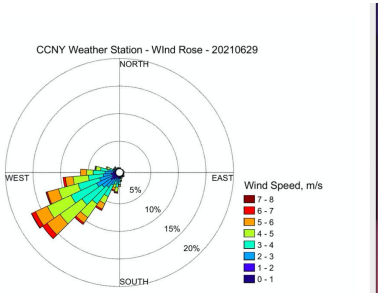
Ozone vs Wind Speed

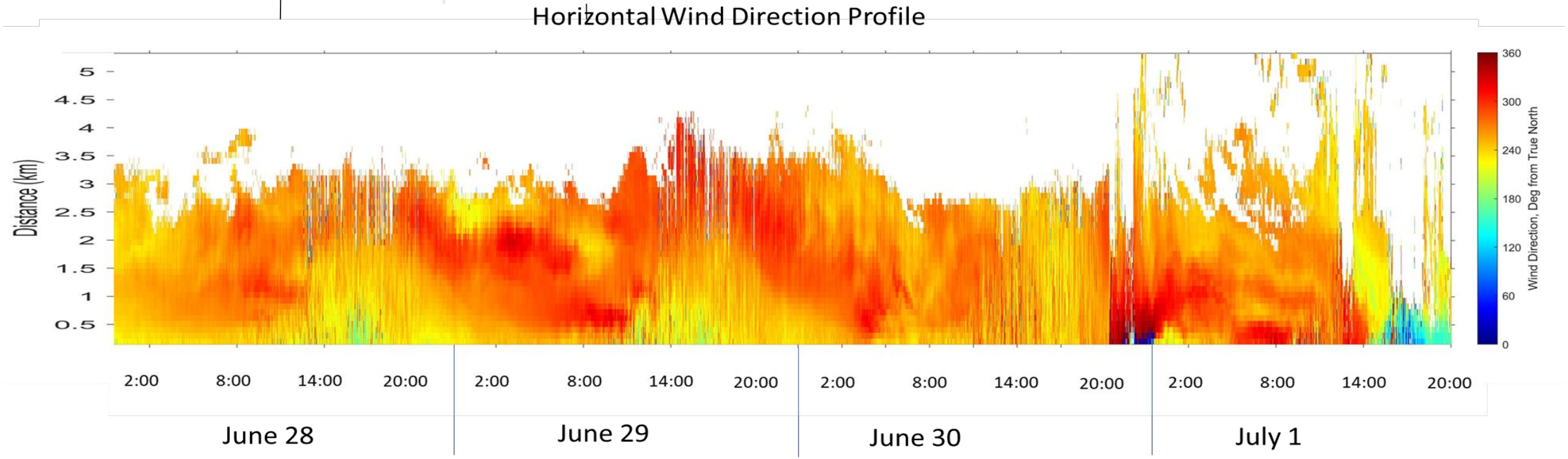


Pearson Coefficient =
-0.49337981195589564
P-Value = 1.0651385769474192e-05

Doppler Lidar Observations (and surface wind rose)
During the End of June Heat Event







Conclusions

- The correlation between pollutants (O_3 and $PM_{2.5}$) and MLH was weak and did not agree with the findings found by other researchers. This might be due to our small data set of because some researchers focused on year long data and not only a heat wave event.
- A positive correlation was found between temperature and MLH. We would like to know if this is due to the high temperatures for those days or if this is true for any temperature.
- A negative correlation was also observed between ozone levels and wind speed.

- The Vertical Profile of the Horizontal Wind Direction and Wind Speed observations will enable better understanding of the Pollutant Sources

Future Work

- Further data collection and observations to better understand MLH dynamics and air pollutant transport.
- Compare MLH vs Temperature graphs for days with lower temperature values to see if the correlation found holds
- Pollutants crossing State Boundaries is a Very Important Subject to Explore Further

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