Comparing the Observable Seasonal Trends in Aerosol Measurements in Kingsburg, CA Over 2018-2020

Kingsburg High School

Students: Saneh Kahlon, Ajmeet Pama-Ghuman, Judith Reyes, and Jillian Sasaki

Advisor: Leigh-Ann Olsen

Abstract

Aerosols are particulates, both naturally and anthropogenically produced, capable of affecting the passage of sunlight (Lara). This is measured in the form of Aerosol Optical Thickness readings, or AOT. Typically, an increased presence of particles results in a higher reading. The burning of organic materials, pollen, dust, pesticides, and vehicular emissions can result in the collection of particulates in the air. They can then be transported by the wind over large distances, as was observed in the AOT readings at Kingsburg. Aerosol Optical Thickness (AOT) reading collections were taken and analyzed in order to detect average aerosol trends. The rainy season in the Central Valley tends to be between December and March. Precipitation attracts aerosol particulates, removing them from the atmosphere which contributed to the observations in this study where average AOT readings decreased in the rainy season (Chu).

Research Question

This study was set in motion after trends were observed in weather data collected from the weather station in Kingsburg, CA located at the Latitude 36.519, Longitude -119.546, and Elevation 129.5. Based on these patterns, a question was proposed: What are the similarities and differences observed in annual aerosol measurement trends between Oct. 2018-Mar. 2019 and Oct. 2019-Mar. 2020 in Kingsburg, CA? Kingsburg typically has compromised air quality due to its geographical location within the Central Valley as a result of agricultural activity.

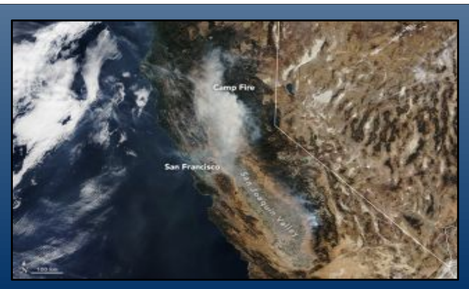
Hypothesis

An expected visible trend of average aerosol readings throughout the course of the year would be higher in the fall and lower in the spring due to the typical annual rainy season lasting from December to March. An inversion layer of warm air characteristic of valleys tends to trap pollutants/particulates for prolonged periods of time. Since rain droplets attract particulates in the air and carry them out of the atmosphere it can be presumed in the following days after a rain event that average aerosol readings would be lower (Chu). It's anticipated that there would be a higher average aerosol reading in the 2018-2019 season than 2019-2020 due to a major fire occurring in Nov. 2018. This trend is expected to be supported by the use of standard error as a means of rejecting an occurrence of an anomaly in data collection.

Investigation Plan

In order to determine a correlation, data was collected based on weather clearings on school days in Kingsburg, CA.

1. Throughout the months of October to March of 2018-2019 and 2019-2020, data was collected at the Kingsburg High School Science Building Weather Station.
   a. This data consisted of current air and soil temps, barometric pressure, humidity, cloud coverage, precipitation amounts and pH, along with aerosols.
2. Collected data was submitted to the GLOBE website and through the GLOBE app along with aerosol data collection using a spreadsheet. The aerosol values were collected in groups of 5 per day and the average of each day that was collected was then placed onto the spreadsheet.
3. Using the averages per day, we graphed each year's average aerosol values into individual graphs. This is then compared to analyze the values throughout the year, following the progression of Fall to Spring, to the other year.
   a. This was then compared to known rain events.



Research Methods

Observations were made using data from the KHS Science Building weather station that collected daily air temp, including current, min, and max alongside relative humidity, cloud data, and precipitation. Typically, data collection occurred within an hour (at max) of solar noon, as per GLOBE atmosphere protocols. These observations were collected through a series of processes beginning with placing a hygrometer in the station 30 min before collection, then collecting the time/temperature from the station and barometric pressure from a barometer and Weather Underground. Aerosols were collected on clear days suitable for AOT measurements that were also school days, typically taken around solar noon. Five readings were taken on each collection day in order to formulate accurate data. After all of these observations were written down--as automatic input does not exist yet at our station-- the GLOBE observer app and online Data Entry Forms were utilized to send in both cloud and aerosol observations. Precautions were established to avoid any obstructions in order to take the best possible images and make the most accurate observations.

GLOBE Data

Figure 1: Average Aerosol Values Over Oct. 2018 - Mar. 2019

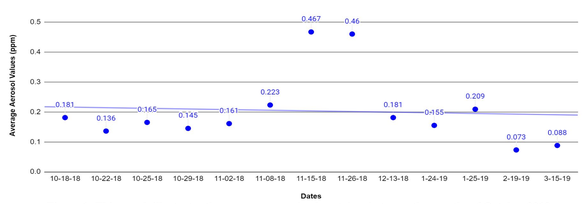


Figure 1: This graph illustrates the average aerosol values taken between the months of October 2018 and March 2019. It also shows a trendline of the values given.

Figure 2: Average Aerosol Values Over Oct. 2019 - Mar. 2020

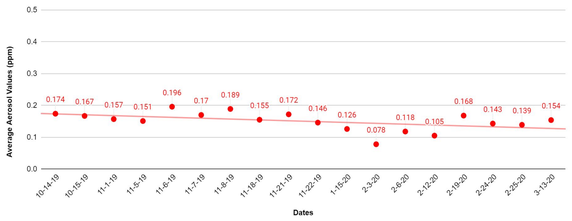


Figure 2: This graph displays the average aerosol values collected between Oct. 2019 and Mar. 2019 with a general trendline for the period.

Figure 3: Average AOT Values Over 2018-2020

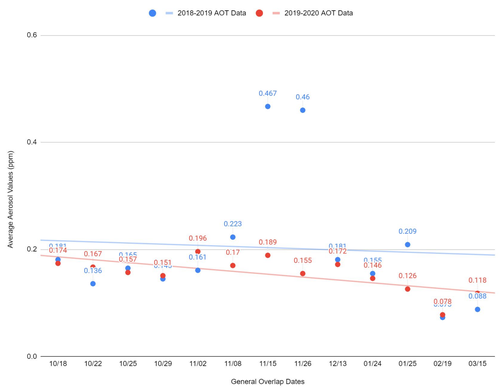


Figure 3: This graph shows the trends of the two years aerosol data was collected using dates that nearly overlap.

Data Summary

Figure #1 displays the average AOT readings from October 18th, 2018 through March 15th, 2019 data collection period. The trend line suggests the year-long decline in average AOT readings. The two obvious outliers of 0.467 and 0.46 dated 11-15-2018 and 11-26-2018 support the impact of the Camp Fire on particulate matter readings within the region.

Figure #2 shows the average AOT readings from October 14th, 2019 through March 13th, 2020 data collection period. The trend line suggests the year-long decline in average AOT readings.

Figure #3 illustrates the graph of the average AOT readings from 2018-2019 and 2019-2020. It also includes the trend lines from both lines, comparing the obvious decline but the contrasting difference in slope. There is a much more rapid decline from 2019-2020 than in 2018-2019.

Data Analysis

Within this data collection set, the data points used in the graph all have a minimal standard error that shows they are precise and accurate, ensuring that they are not a result of improper data collection. The decreasing trend lines shown in both Figure 1 and Figure 2 are compared in Figure 3, which indicates that a general drop in average AOT readings is an annual occurrence.

The 2018-2019 season had greater average AOT readings than 2019-2020, likely due to the outliers formed as a result of the Camp Fire in Nov. 2018 influencing the trendline to be more stagnant. Fires on such a magnitude of the Camp Fire release mass amounts of aerosols into the air, therefore impacting the readings during the following weeks. However, the rainy season normalized the readings in Dec. 2018. The 2019-2020 trendline would be more representative of an annual average AOT decline as the occurrence of outliers is not present.

A gradual decline in values through December to March in both years coincides with the rainy season, characteristic of CA. A typical characteristic of this region is to have collections of particulates within the inversion layers present, gathering during the summer and fall when precipitation is rare, which are largely removed by rain events. Precipitation typically coagulates to aerosols that are present in the sky (Chu). Due to its polarity, the rain droplets attract the particles and descend together, removing them from the atmosphere (Chu). This removal of particles would contribute to lower average AOT readings during the rainy seasons where such a phenomenon is occurring, further explaining the trends observed in the figures.

Conclusions

Based on the data collected and research done, it is apparent that Kingsburg's geographical location has a significant impact on particulate matter within the inversion layers of the Central Valley. Natural occurrences of precipitation and the presiding inversion layer, which traps the particulate matter in the basin, allows for aerosols to create an optimal environment for a general decline in aerosol readings as this reservoir of aerosols can be significantly depleted by a singular rain event. The rain season and the observed decreasing trends in AOT readings occur simultaneously, as apparent in the figures provided. The rainy season, typically falling between December and March for the CA location, contributes to lower concentrations of particulate matter within the air. In the months leading up to the rainy season, AOT readings are relatively high in comparison to those taken in early spring. The trends observed in our data figures display a downward trend around this window of time, there is a strong conclusive lean towards the claim that the rain season and observed decreasing trends within our figures coincide with one another on a cause-effect basis. If this study was to be furthered, it would be ideal to have collections of agricultural burn days, pollen counts, and air quality measurements as these factors have a significant impact on the readings of this region. Despite natural cycles such as precipitation that tend to lower the levels of particulate matter in the air, average AOT readings could be speculated to be increasing as a result of inversion layers, fog, fires, and wind patterns, as well as anthropogenic impacts such as agriculture over long periods of time. This progressional change in readings would be ideal to pursue in further studies or projects using other forms of data including this study as a baseline for trends of this region.

Limitations/ Sources of Error

In 2018-2019 limited data collection resulted in only thirteen aerosol measurements being taken, with five measurements being removed due to inaccurate readings from improper handling of the calitoo. In 2019-2020 eight measurements were removed due to the same issue. A limitation occurred in October of 2019 as the on-site barometer ceased to operate, therefore we relied upon Weather Underground, a website with daily barometric data, for readings. Additionally, on Jan. 9th, 2020 at 11:56 AM the battery was changed in the weather station, and once again on Jan. 15th at 11:56 AM. Another limitation was that we did not have the resources to obtain pollen measurements or agricultural burn days. Finally, the interference of COVID-19 interrupted our data collection, reducing days to analyze, as well as communicate, therefore the project was not as comprehensive as it could have been. Computerized collection of data will likely stabilize the inconsistency of collection of days along with providing more substantial evidence. Taking into consideration the fluctuations in surrounding regions can also help solidify the proposed hypothesis.

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