



Air Quality Monitoring 2016 Annual Report

Sequoia and Kings Canyon National Parks

Natural Resource Data Report NPS/SEKI/NRR—2017/1448



ON THE COVER

Photograph of the Ash Mountain air quality and meteorological station in Sequoia National Park.
Photograph courtesy of the National Park Service

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Summary of Air Quality Monitoring

Sequoia and Kings Canyon National Parks (SEKI) periodically experience the worst air quality in the National Park Service. Elevated ground-level ozone (O_3) may be the most damaging pollutant in SEKI, when in summer months, concentrations often exceed the federal ozone health standards of greater than 70 parts per billion (ppb) averaged over an 8 hour (h) period. Ozone is a secondary pollutant, formed when nitrogen oxides (NO_x) and volatile organic compounds (VOCs) combine with warming temperatures and sunlight. Above 70 ppb, ozone may have negative health effects particularly for sensitive groups, such as children, older people, and those with heart or lung disease (Table 1). As O_3 increases, others beyond sensitive groups may be affected (EPA 2016). Examples of ozone health effects include chest pain, coughing, throat irritation, congestion, and exasperation of bronchitis, emphysema, and asthma. The harmful effects of increased O_3 go beyond human health and into park ecosystems, including widespread damage to sensitive vegetation, which could alter how plants grow, produce and store food.

From early June to late October 2016, O_3 conditions were monitored and forecasted to employees and the public from two locations in SEKI: the Ash Mountain air quality station located in the foothills and the Lower Kaweah air quality station in the Giant Forest (Thermo TECO 49/49C Inst.; Figure 1). Daily ozone Air Quality Index (AQI) levels were forecasted through an internet-linked automated process that summarizes ozone and meteorology data from each station from the prior day, as well as expected conditions from weather forecasts. The forecasts are then made available through Twitter Inc. (@SequoiaKingsAir) and embedded for greater outreach through the SEKI Air Advisory website (NPS 2015b). At the end of each advisory season, validated data is downloaded from NPS Gaseous Pollutant and Meteorological Data Access Page, and graphics are generated using the OpenAir package in R Statistical Software (Carslaw and Ropkins 2012, R Software 2015).

From April to October 2016, the Ash Mountain site measured 87 days exceeding federal health standards (Figure 1). This was the most of any NPS unit, and was followed by the Lower Kaweah station in SEKI (64 days) and the Black Rock station in Joshua Tree N.P. (37 days). Most other NPS O_3 stations measured 10 days or less exceeding federal health standards (NPS 2016a). Air quality was poor in SEKI compared to most other NPS sites, and there was a marked increase in exceedance days from recent years. However, this rise can be largely attributed to the more stringent AQI breakpoints recently adopted, as opposed to an increase in O_3 concentration. During the SEKI advisory forecast season (June through October) in Ash Mountain, August had the highest number of days at the Unhealthy for Sensitive Groups level or higher (Figure 2, Figure 3), as well as the most hours exceeding health standards (Figure 4). During this period, 718 hours (h) over 80 days exceeded 70 ppb. At Lower Kaweah during the advisory season, August also had the highest number of days at the Unhealthy for Sensitive Groups level or higher (Figure 5, Figure 6), but the most hours exceeding health standards occurred in July (Figure 7). For the monitoring season, 552 h over 59 days exceeded 70 ppb. Particulate matter ($PM_{2.5}$) was also monitored for most of the year in Ash Mountain (BAM 1020, E-BAM Inst.). There were no monitoring days that reached Unhealthy AQI levels; 135 days reached Moderate and 158 days were within the Good range. For a more extensive look at air quality conditions in 2016, please refer to figures 8 through 14 at the end of this report.

Table 1. Air quality index developed by the EPA to protect public health. More stringent AQI breakpoints are were recently changed on Oct. 1, 2015. For SEKI and the region, this has resulted in several more days in AQI levels greater than “Unhealthy for Sensitive”.

Air Quality Index	PPB	Health Concern
Good (0-50)	(0-54)	None
Moderate (51-100)	(55-70)	Unusually sensitive people should consider reducing prolonged or heavy exertion
Unhealthy for Sensitive Groups (101-150)	(71-85)	People with heart or lung disease, older adults, and children should reduce prolonged or heavy exertion.
Unhealthy (151-200)	(86-105)	People with heart or lung disease, older adults, and children should avoid prolonged or heavy exertion. Everyone else should reduce prolonged or heavy exertion.
Very Unhealthy (201-300)	(106+)	People with heart or lung disease, older adults, and children should avoid all physical activity outdoors. Everyone else should avoid prolonged or heavy exertion.

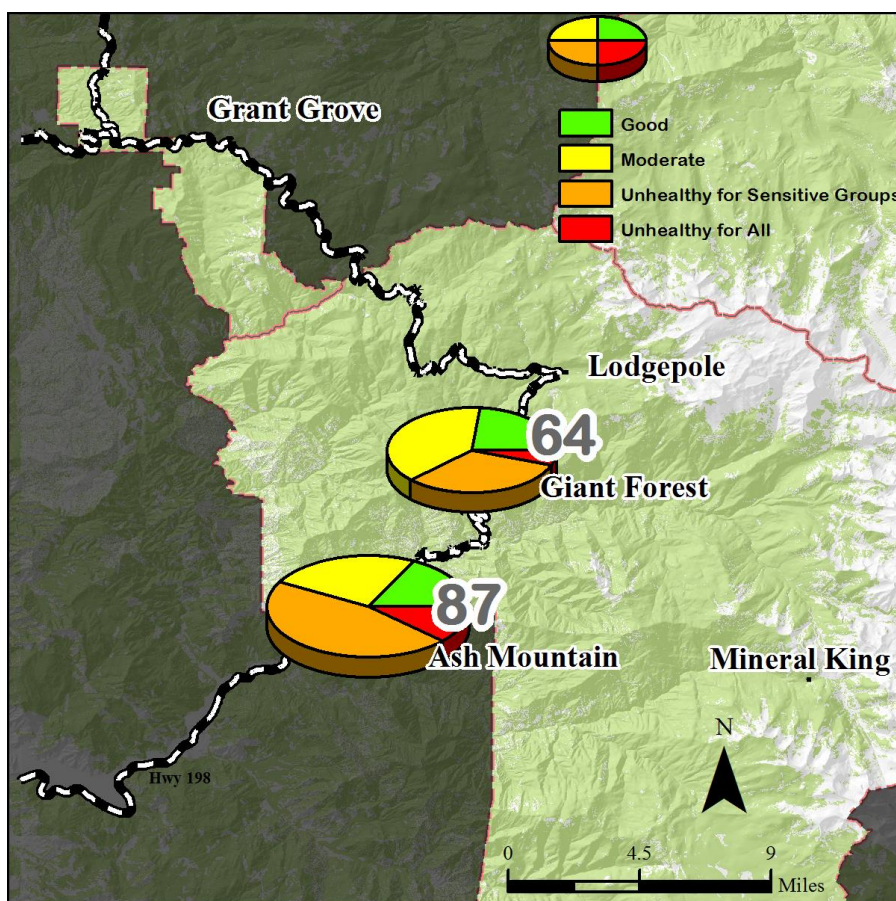


Figure 1. Location of monitoring sites depicting 2016 AQI level results (pie chart) during the SEKI ozone forecast season only (June-Oct.), and total number of exceedance days (dark grey) for all of 2016.

Ash Mountain Ozone Calendar: 2016

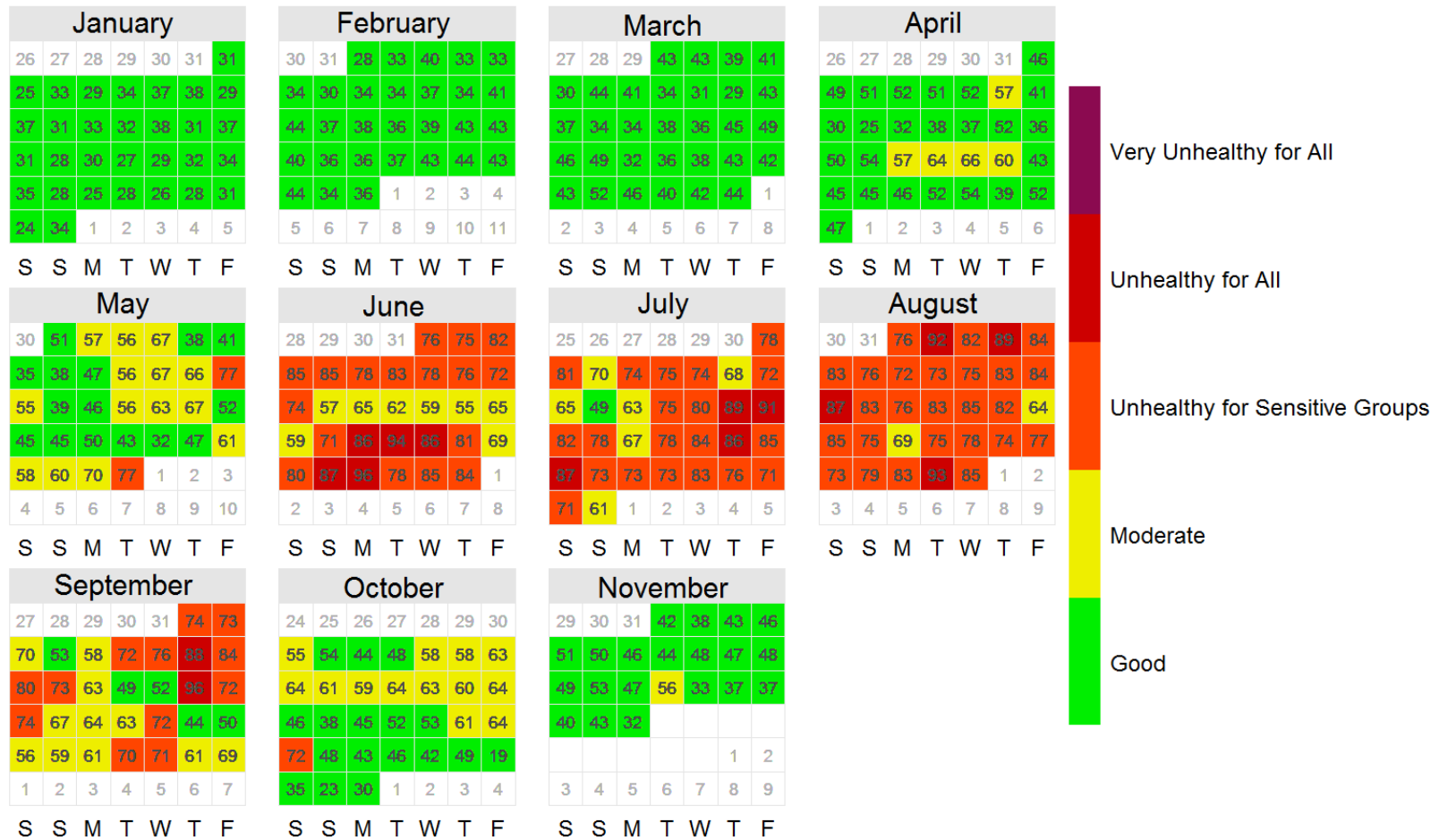


Figure 2. Calendar plot for O₃ concentrations at Ash Mountain. Each day of the month depicts the maximum O₃ 8-hr concentration and the corresponding AQI health level.

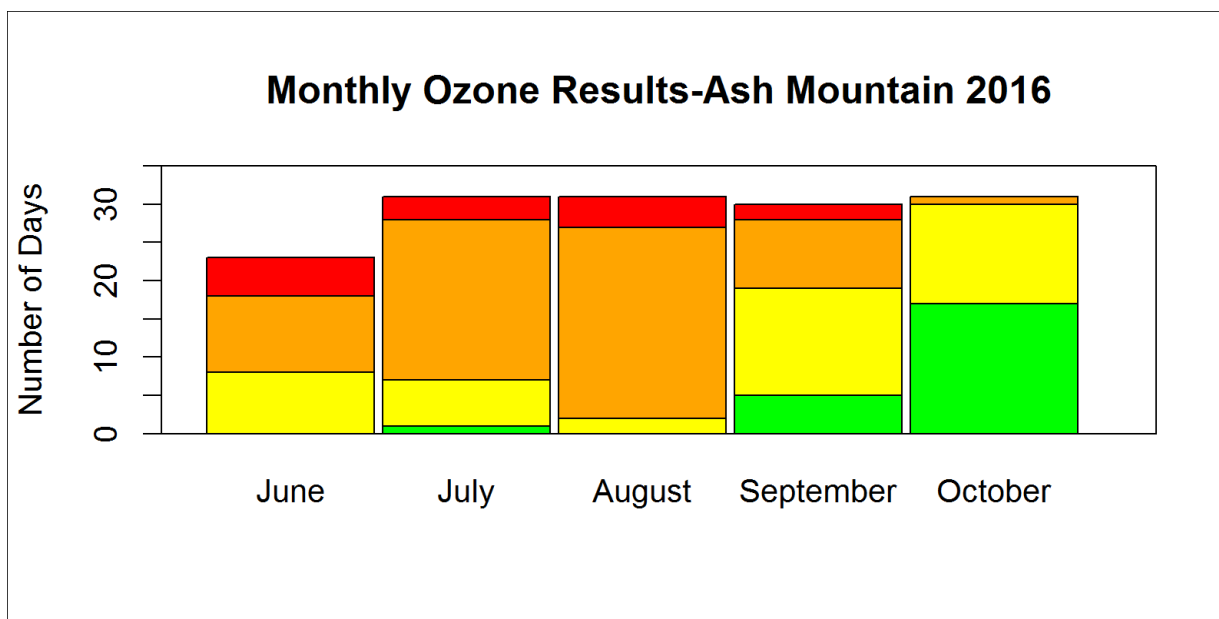


Figure 3 . Number of days each month spent within an AQI level at Ash Mountain during peak O₃ season. O₃ concentrations within the “Unhealthy for Sensitive” AQI level were the most common, followed by days within “Moderate”.

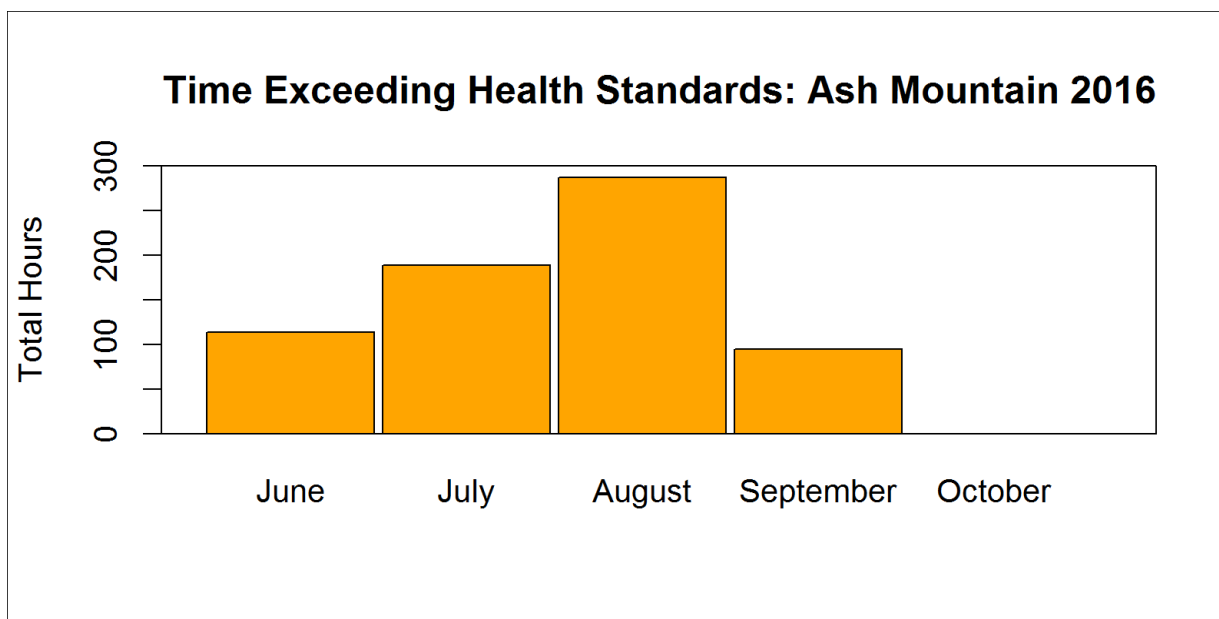


Figure 4. Total number of hours O_3 exceeded 70 ppb in each month at the Ash Mountain air quality monitoring station. Excluded are days where the O_3 monitors were disabled for maintenance.

Lower Kaweah Maximum O₃ 8hr: 2016

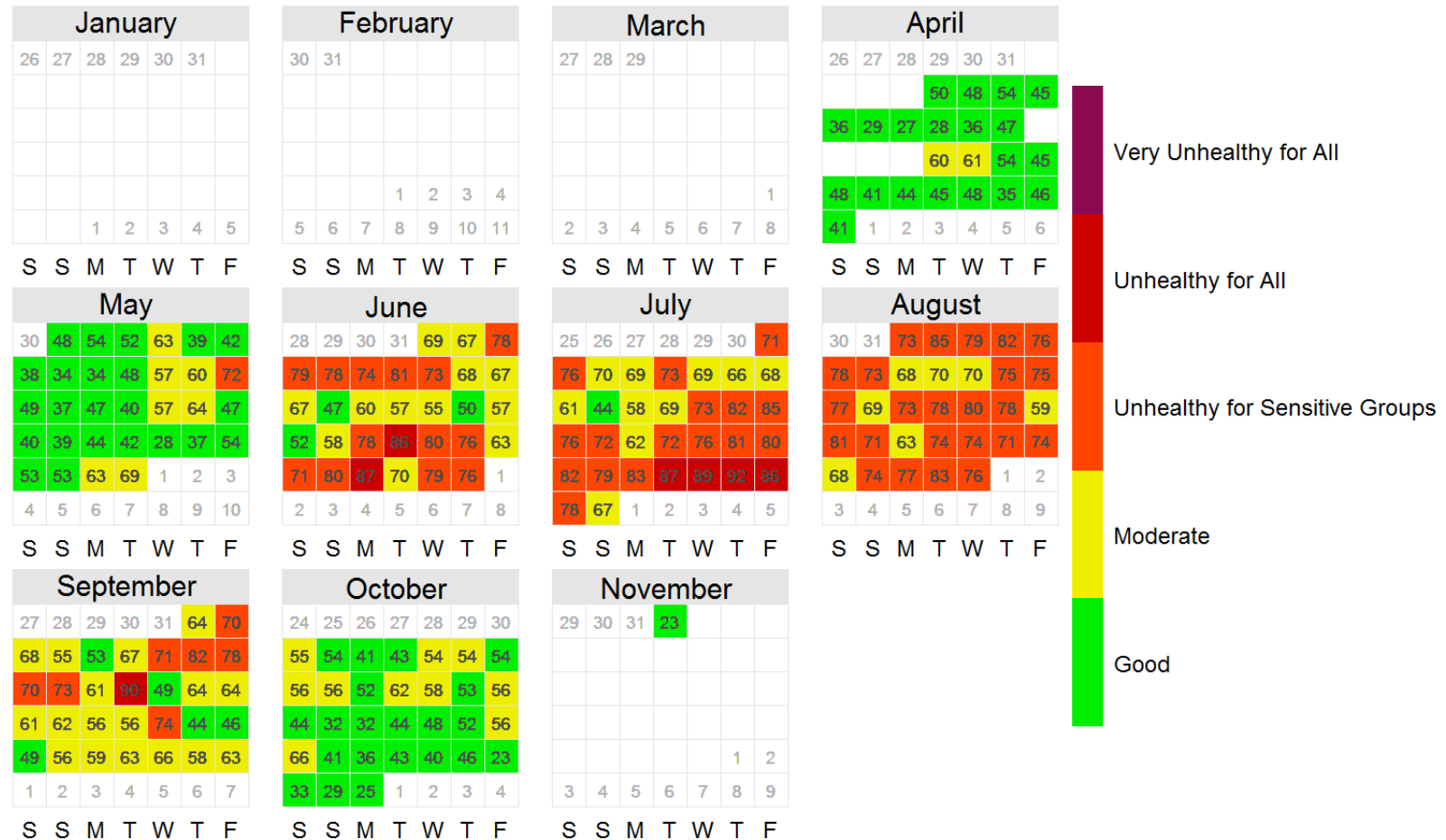


Figure 5. Calendar plot for O₃ concentrations at Lower Kaweah. Each day of the month depicts the maximum O₃ 8-hr concentration and the corresponding AQI health level. Blank days and months represent periods where validated Lower Kaweah data was unavailable.

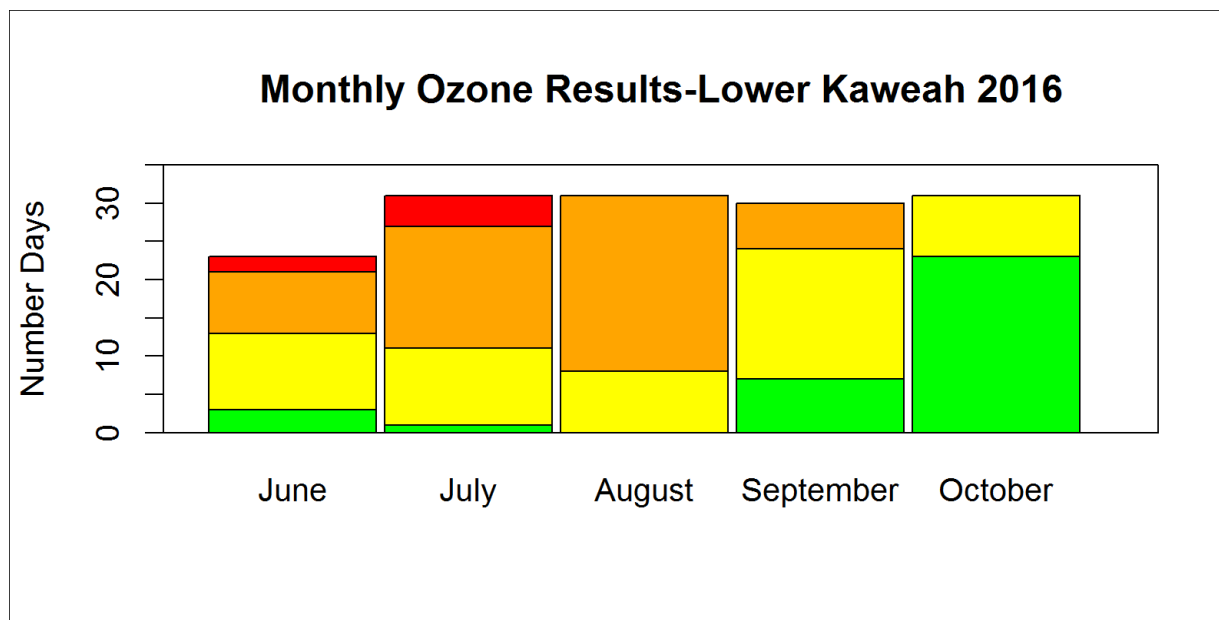


Figure 6. Number of days each month spent within an AQI level at Lower Kaweah during peak ozone season. O₃ concentrations within the “Unhealthy for Sensitive” and “Moderate” AQI level were the most common.

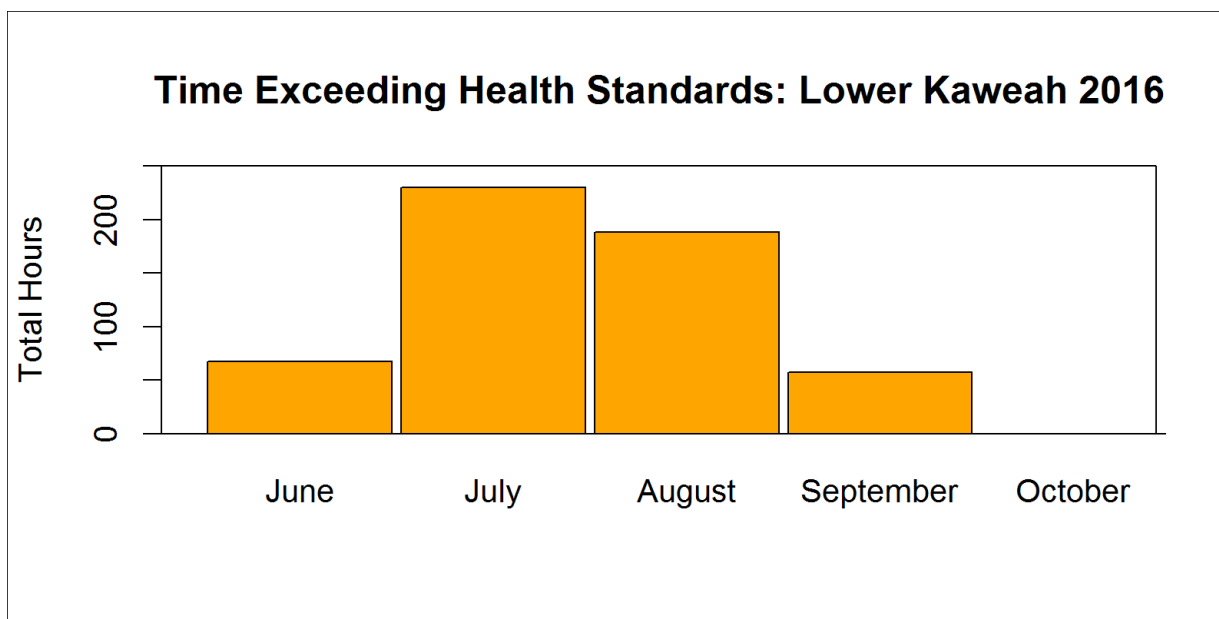


Figure 7.Total number of hours O₃ exceeded 70 ppb in each month at the Lower Kaweah air quality monitoring station. Excluded are days where the O₃ monitors were disabled for maintenance.

SEKI Air Advisory Program QA/QC

Each year, the effectiveness and accuracy of SEKI forecasts are evaluated. In 2016, we continued forecasting from our website. The short url (<http://go.nps.gov/sekiar>) resulted in 1,400 unique visits. There were also 2432 more website visitors at the long url. This marked the second year SEKI forecasts were made public, and based on website visitation; we consider this transition very successful.

To evaluate the accuracy of SEKI's daily AQI forecasts, we compared our predicted calls with the actual conditions (Table 2). In 2016, SEKI was correct 58% of the time when forecasting the foothills (via Ash Mountain data) and 64% of the time forecasting the middle elevations (via Lower Kaweah data) of the parks. SEKI's forecast accuracy dropped from 2015, which we attribute to needing to adjust to the new AQI breakpoints. This was especially apparent when we forecasted "Unhealthy for Sensitive" when the forecast should have been called higher. Prior to the newer breakpoints, we rarely forecasted in the "Unhealthy for All" AQI category, therefore we will be focusing on improving our forecasts between those AQI categories.

Table 2. Forecast accuracy for SEKI during the 2016 forecast season. Represented is the percentage of correct calls at each AQI level. Also included are the percentages of incorrect forecasts and the proportion of those that were forecasted higher or lower than the actual condition.

Forecaster	Actual AQI Condition	Ash Mountain			Lower Kaweah		
		Correct	Forecasted Higher	Forecasted Lower	Correct	Forecasted Higher	Forecasted Lower
SEKI	Across all AQI levels	58%	23%	19%	64%	16%	20%
	When Unhealthy for All	29%	0%	71%	50%	0%	50%
	When Unhealthy for Sensitive	56%	23%	20%	69%	4%	27%
	When Moderate	60%	28%	12%	49%	27%	24%
	When Good	74%	26%	0%	79%	21%	0%

SEKI Air Program: What else do we do?

In addition to monitoring for O₃, SEKI air quality sites operate within several nationwide air pollutant monitoring networks. This requires collection and maintenance of a variety of pollutants, which are used to determine status and trends of air quality conditions both locally and nationally (Table 3).

Table 3. Monitoring networks and pollutants measured in SEKI.

Air Monitoring Programs	Visibility	Ozone & Meteorology	Wet & Dry Deposition
Network Names	IMPROVE (Interagency Monitoring of Protected Visual Environments)	GPMN (Gaseous Pollutant Monitoring Network)	NADP (National Atmospheric Deposition Program)
	-	CASTNET (Clean Air Status and Trends Network)	CASTNET (Clean Air Status and Trends Network)
Parameters Measured	fine and coarse particle (PM2.5 & PM10) mass, elements, sulfate, nitrate, organic and elemental carbon	ozone, wind speed, wind direction, ambient temperature, relative humidity, solar radiation, precipitation	Wet: pH, sulfate, nitrate, ammonium, major anions and cations (NTN network), and mercury in precipitation (MDN network)
	scenic views, scattering, and absorption	-	Dry: sulfur dioxide, sulfate, nitric acid, nitrate, and ammonia (AMON network);
	24-hrs every 3 days	continuous, hourly averages	weekly
Frequency of Measurements	24-hrs every 3 days Visibility Data	continuous, hourly averages Ozone & Met Data	Wet Deposition Data
			Dry Deposition Data
Access to Data			

For a more extensive look at air quality conditions in 2016, please refer to figures 8 through 14 below.

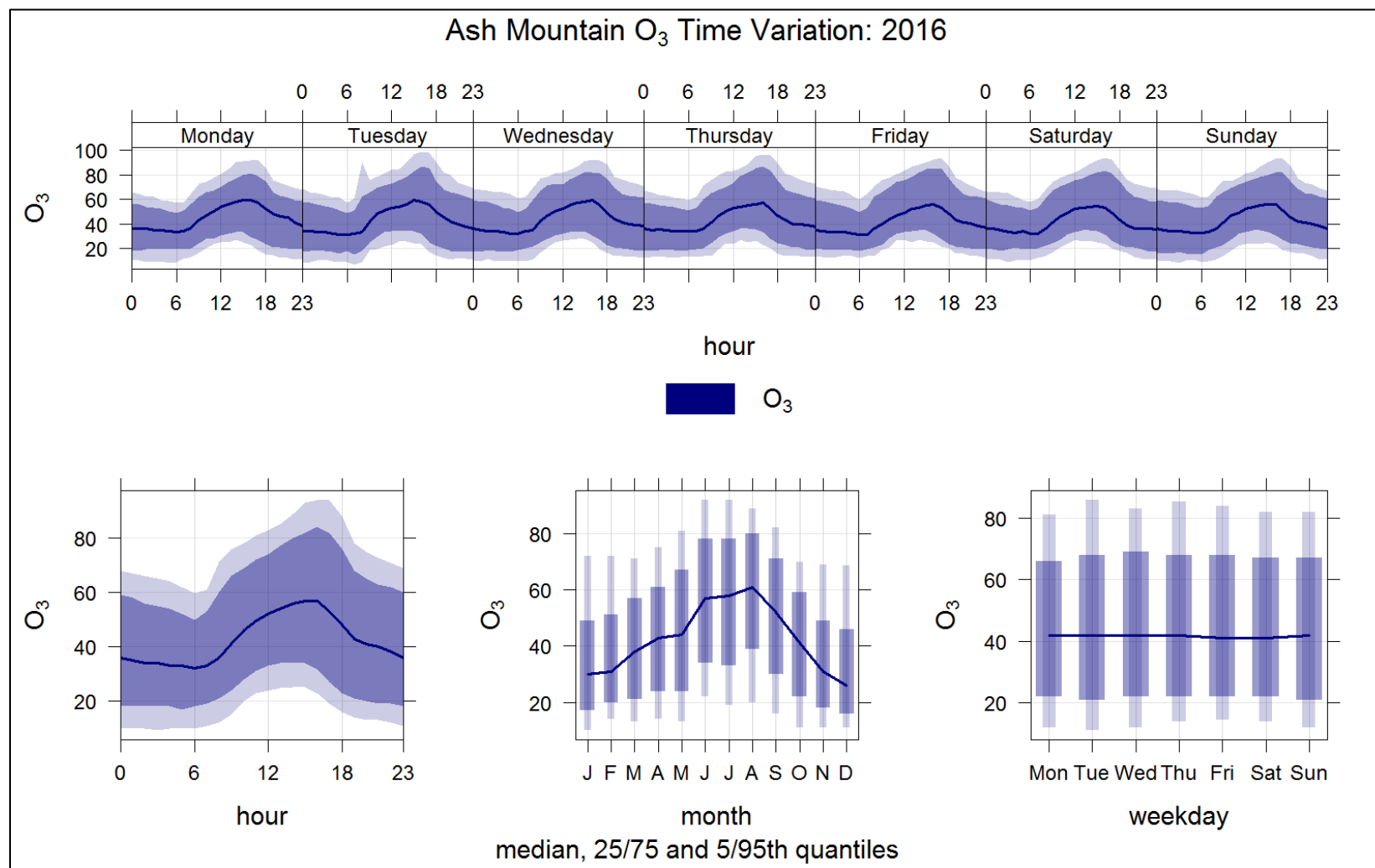


Figure 8. Time variation plot of median hourly O₃ concentrations at Ash Mountain. The purpose of a time variation plot of a pollutant can reveal prominent time of day, day of week, and monthly trends. In 2016 at Ash Mountain, median O₃ concentrations were the highest in the afternoons. The best months for O₃ were from November through April, and the highest concentrations were from May through October.

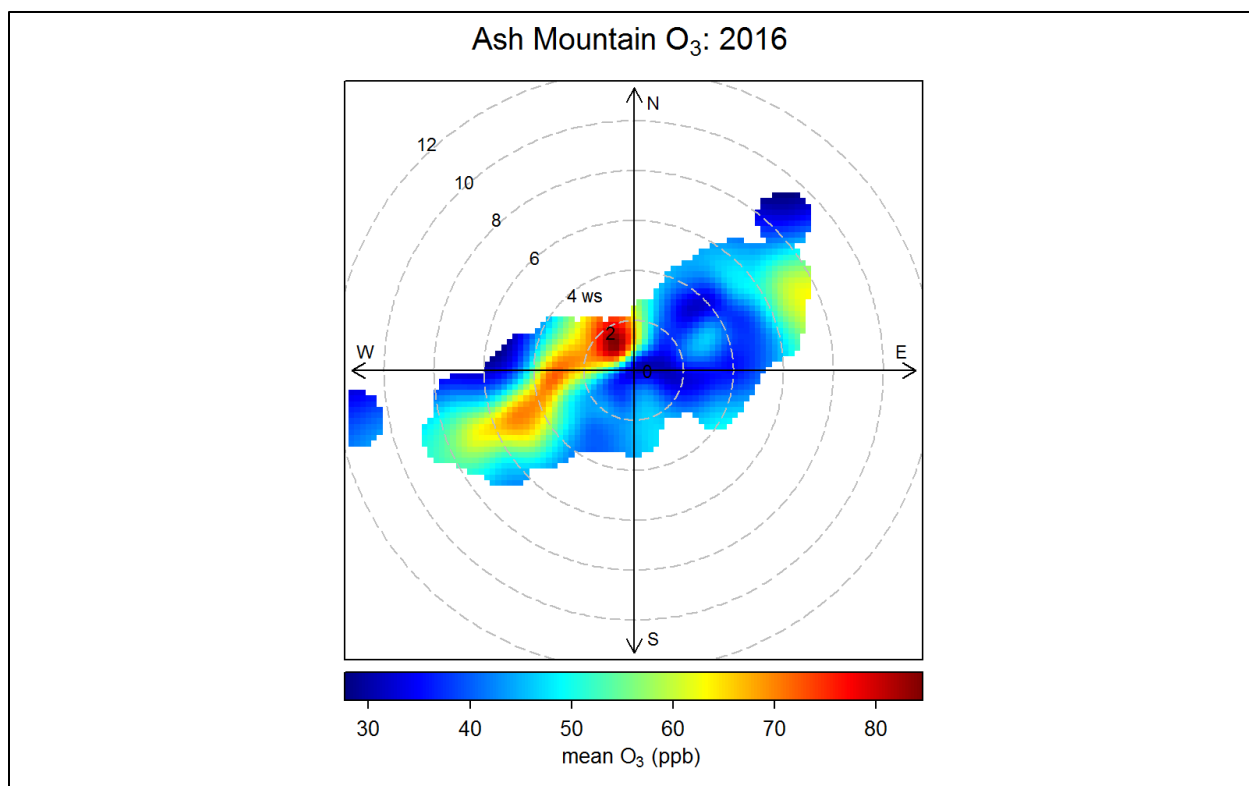


Figure 9. Polar plot of mean hourly O₃ concentrations at Ash Mountain. The polar plot function depicts how O₃ concentration varies by wind direction and wind speed. In 2016 at Ash Mountain, O₃ was higher at low wind speeds (< 2 m/s) coming from the north-west. O₃ decreased at higher wind speeds coming from the north-east.

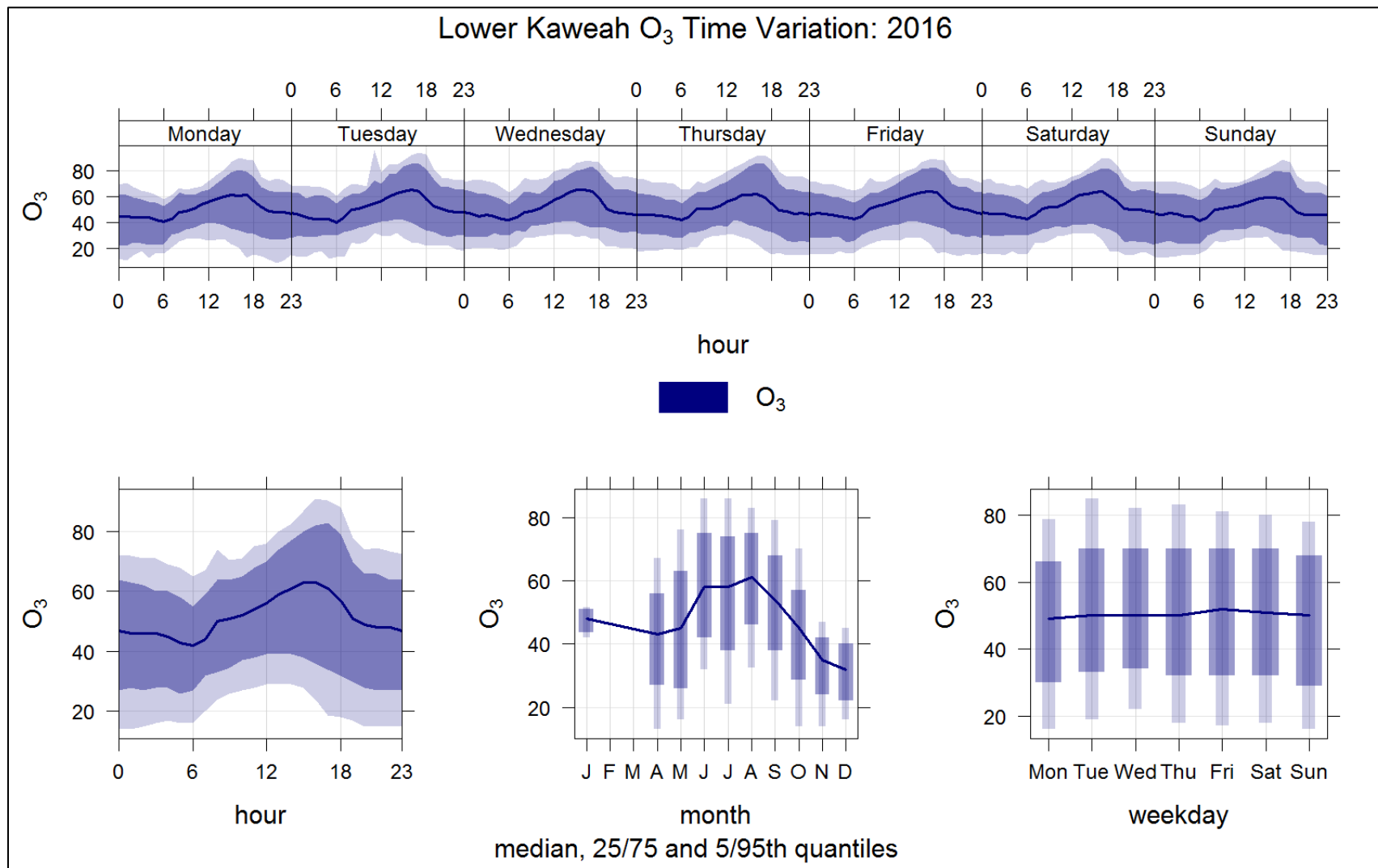


Figure 10. Time variation plot of median hourly O_3 concentrations at Lower Kaweah. The purpose of a time variation plot of a pollutant can reveal prominent time of day, day of week, and monthly trends. In 2016 at Lower Kaweah, median O_3 concentrations were the highest in the afternoon and early evening, and each weekday throughout the year. The best months for O_3 were from November through May, and the highest concentrations were from June through September. Note that this station only operates seasonally (April–November).

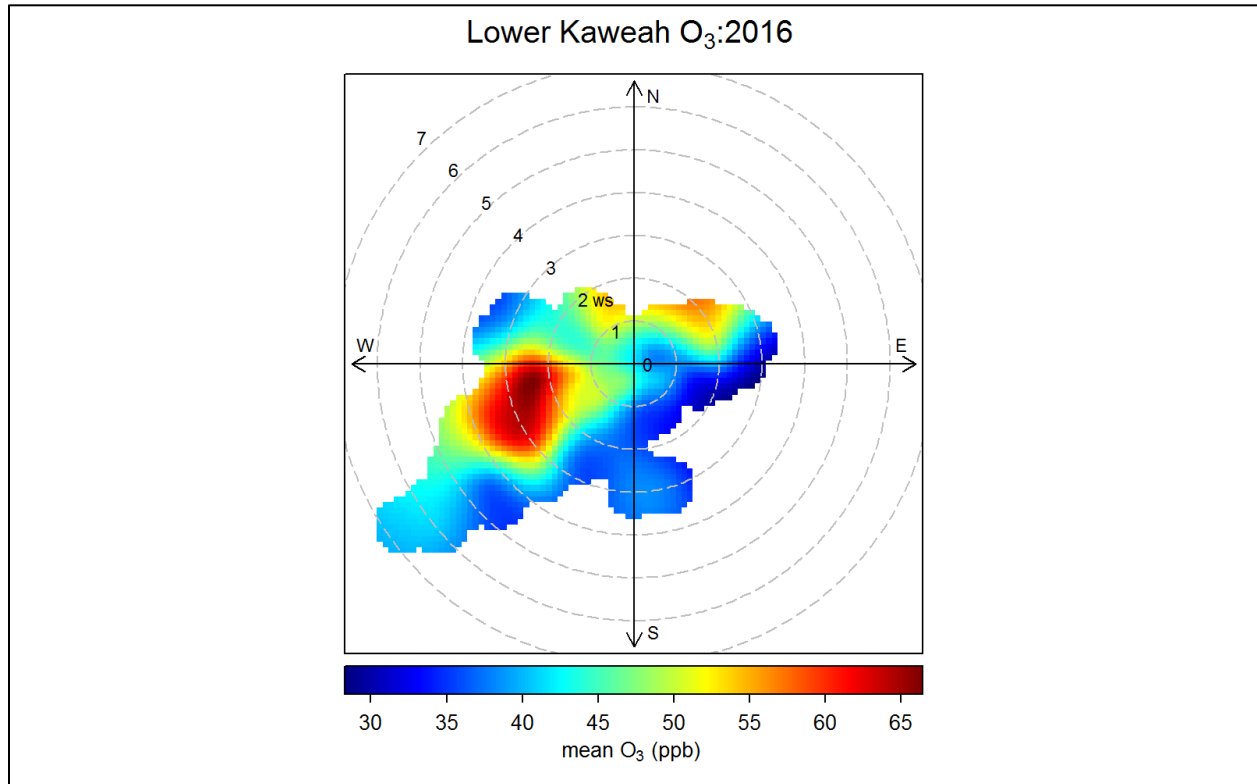


Figure 11. Polar plot of mean hourly O₃ concentrations at Lower Kaweah. The polar plot function depicts how O₃ concentrations vary by wind direction and wind speed. In 2016 at Lower Kaweah, O₃ increased at higher wind speeds (2-4 m/s) coming from the south-west. O₃ was decreased at lower wind speeds (0-3 m/s) coming from the east.

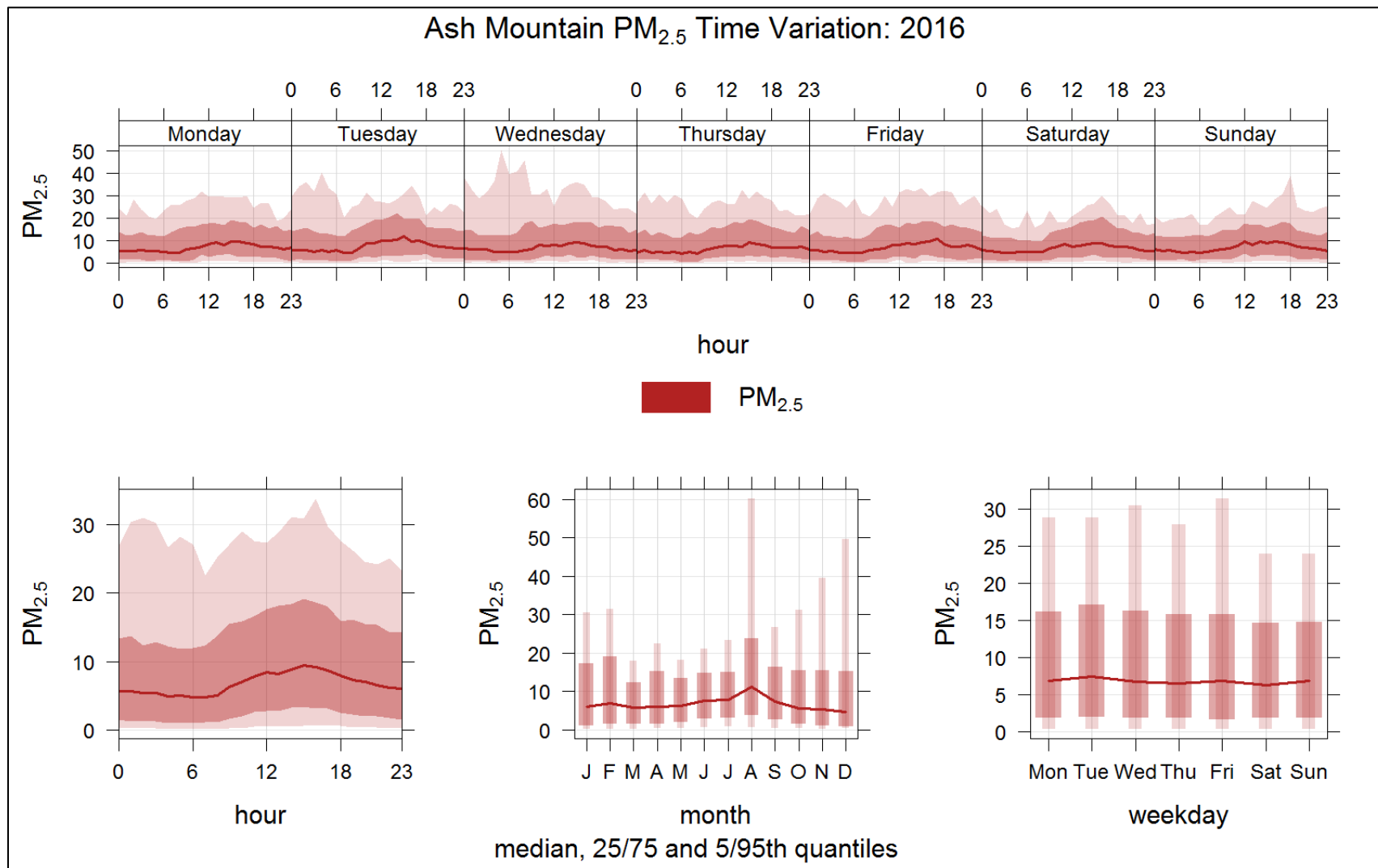


Figure 12. Time variation plot of median hourly PM_{2.5} concentrations at Ash Mountain. The purpose of a time variation plot of a pollutant can reveal prominent time of day, day of week, and monthly trends. In 2016 at Ash Mountain, median PM_{2.5} concentrations were highest in the afternoons throughout the year. The best months for PM_{2.5} were in the spring and early summer months, and the highest concentrations were in August.

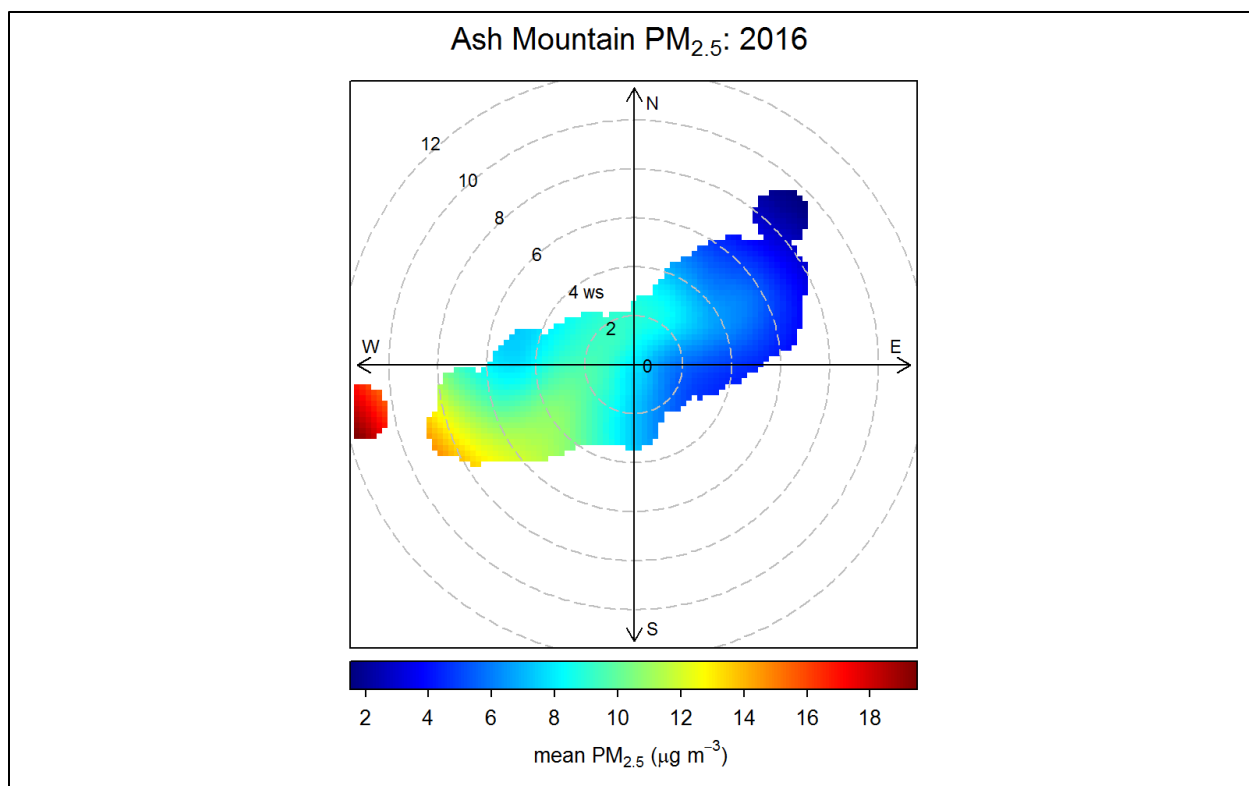


Figure 13. Polar plot of mean hourly PM_{2.5} concentrations at Ash Mountain. The polar plot function depicts how PM_{2.5} concentrations vary by wind direction and wind speed. In 2016 at Ash Mountain, PM_{2.5} was highest when wind was 10-12 m/s coming from the west and south-west. PM_{2.5} decreased at high north-easterly winds.

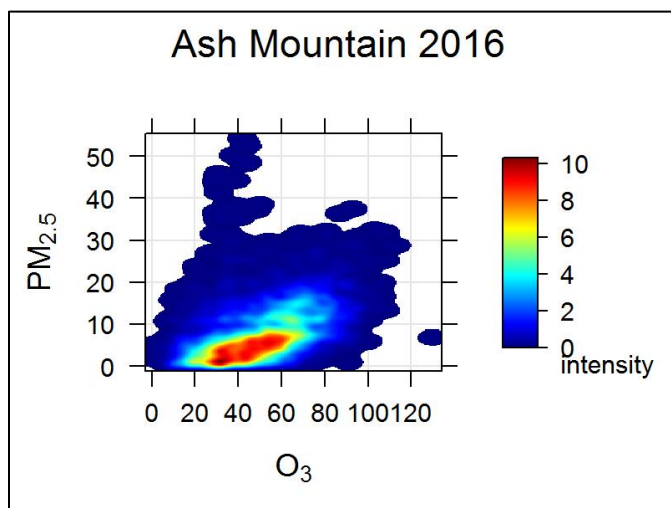


Figure 14. Scatter plot of hourly PM_{2.5} vs. O₃ at Ash Mountain using a kernel density estimate to show where most of the points lie. The darker red intensity indicates the most common relationship between the two pollutants. In 2016, PM_{2.5} and O₃ were commonly found together at low concentrations, well within the “Good” AQI level for each. At higher PM_{2.5} concentrations, O₃ was typically low, and at the highest O₃ concentrations, PM_{2.5} was also low.

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