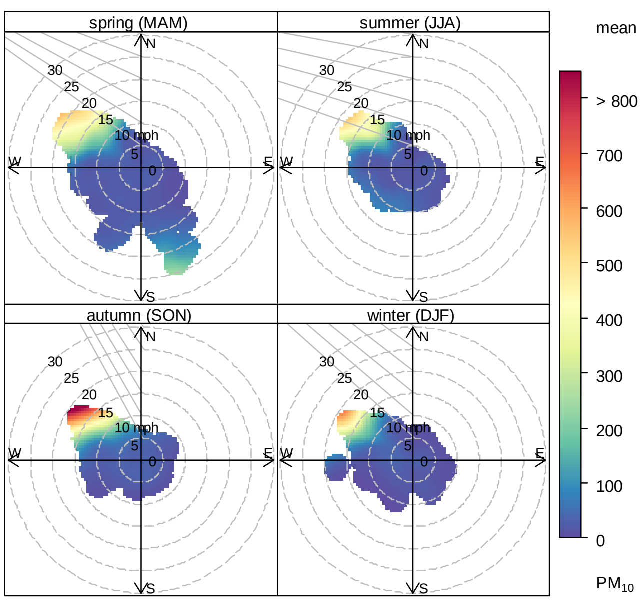
The Influence of the ODSVRA on PM_{10} Levels on the Nipomo Mesa

The Annual Air Quality Reports for 2012 and 2013 contained appendices analyzing the influence of the ODSVRA on PM_{10} measured at the CDF, Mesa2, and NRP monitoring stations in those years.[1] These appendices are presented below.

These analyses employ polar plots to depict the relationship between PM_{10} levels and wind speed and direction. In these plots, wind direction is shown as on a compass, and wind speed is plotted radially outward from the center. (The center thus represents calm conditions.) PM_{10} is displayed with the color scale, which can represent either the average PM_{10} concentration under the wind speed/wind direction combination at that point, or the maximum PM_{10} concentration.[2] As an example, the figure below presents polar plots of average hourly PM_{10} at CDF during 2013. The upper left panel of the figure is the plot for springtime levels.[3] This panel shows that in the spring when winds blew from the northwest at 20 mph, the *average* PM_{10} concentration at the site was about 400 to 500 µg/m^3.

CDF, Average Hourly PM_{10} Levels By Season



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[1] These reports—as well as reports for other years—are available in full on the district website at: http://www.slocleanair.org/library/air-quality-reports.php.

[2] These plots were produced using openair (Carslaw, D.C. and K. Ropkins, (2012) openair — an R package for air quality data analysis. Environmental Modelling & Software. Volume 27-28, 52-61,) which employs an algorithm that first populates wind speed/wind direction bins with pollutant concentrations, then finds the average or maximum concentration in each bin, and finally fits a smooth surface to these values. This surface is what is plotted in the color scale shown in the figure. There tend to be few observations along the edge of surface (i.e., at the highest wind speeds), so uncertainty is highest along the edge.

[3] In all figures with separate panels for each season, spring is taken to be March, April, and May; summer to be June, July, and August; fall to be September, October, and November; and winter to be December (2013), January, and February.

Appendix B of the 2012 Annual Air Quality Report for San Luis Obispo County

Appendix B: Coastal Dune Influence on South County PM_{10}

In contrast to the rest of the county, where PM_{10} and $PM_{2.5}$ levels have trended downward over the last 20 years, the Nipomo Mesa continues to see high levels of particulate matter pollution; there is no evidence of improvement at CDF or Mesa2, and only slight improvement has been observed at Nipomo Regional Park.[4] Studies by the SLOAPCD have determined that the dune complex along the coast of the Five Cities area is the source of the high particulate matter levels measured at these stations.[5,6]

The most recent SLOAPCD study used saturation monitoring on the Nipomo Mesa to better characterize the shape and extent of the dust plume that is generated when high winds blow across the dunes.[1] The result of this effort is shown below in Figure B-1. Of the three permanent monitoring stations in the area, CDF consistently records the highest PM_{10} levels. The area of the Nipomo Mesa where PM_{10} levels were found to most closely resemble those observed at this station is relatively small and is confined to the area immediately around and to the west the station, as depicted in purple in Figure B-1. This area

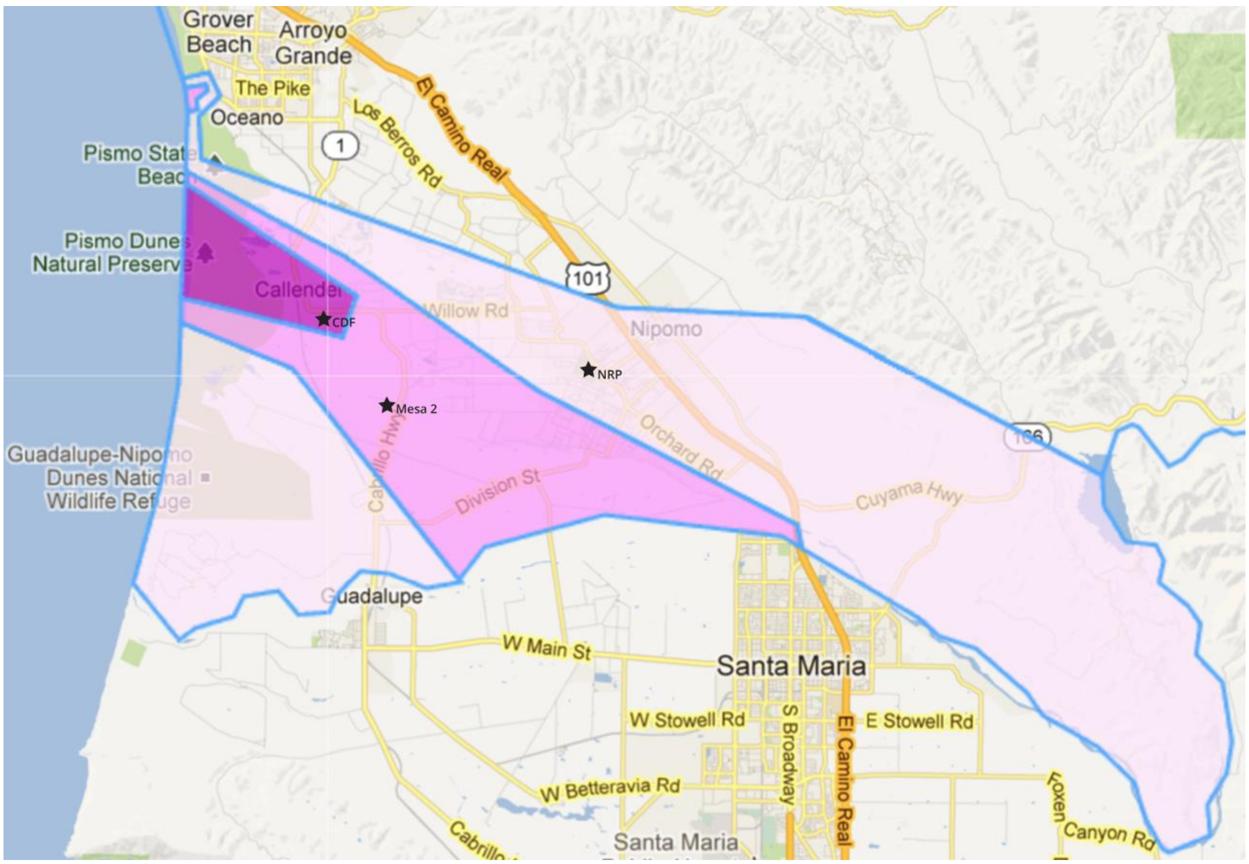

Figure B-1. Nipomo Mesa forecast map, from Reference 1.

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[4] Tupper, K.A., March 2013. Air Quality Trends, 1991-2011. San Luis Obispo County Air Pollution Control District, San Luis Obispo, Calif. http://www.slocleanair.org/images/cms/upload/files/Final%20AQ%20Trends%282%29.pdf

[5] San Luis Obispo County Air Pollution Control District, 2007. Nipomo Mesa Particulate Study. San Luis Obispo, Calif. http://www.slocleanair.org/images/cms/upload/files/air/pdf/pm_report2006_rev1.pdf

[6] Craig, J., Cahill, T., and Ono D., February 2010. South County Phase 2 Particulate Study. San Luis Obispo County Air Pollution Control District, San Luis Obispo, Calif. http://www.slocleanair.org/images/cms/upload/files/pdf/PM2-final_report.pdf

is referred to as the “CDF Forecast Zone” in SLOAPCD Air Quality forecasts and related materials. When winds are high and from the west or northwest, PM_{10} levels in this area are anticipated to be similar to those observed at CDF.

Mesa2 records the second highest PM_{10} levels on the Nipomo Mesa, and saturation monitoring determined that during high wind events, a large swath of the Mesa and a small part of Oceano experience PM_{10} levels similar to those seen at this site. This area is depicted in the middle shade of pink in Figure B-1, and is referred to as the “Mesa2 Forecast Zone” in SLOAPCD forecasts.

Of the three permanent monitoring stations on the Mesa, Nipomo Regional Park records the lowest PM_{10} levels. Saturation monitoring determined that the area depicted in light pink in Figure B-1 is most similar to this site in terms of PM_{10} levels during wind events. This area is referred to as the “NRP Forecast Zone” in SLOAPCD forecasts.

2012 PM_{10} on the Nipomo Mesa

Bivariate plots depicting 24-hr PM_{10} levels as a function of wind speed and direction—analogous to the ozone plots presented in Appendix A—show that coastal dunes continue to be the dominant influence on Nipomo Mesa PM_{10} levels in 2012. For CDF, average and maximum 24-hr PM_{10} levels by wind speed and direction bins are shown in Figure B-2, below. The highest levels are observed when winds are from the northwest, and increasing wind speeds correspond to higher peak and average PM_{10} levels. Though not apparent from these graphs, these conditions occur far more frequently in late spring and early summer than other times of the year. These observations corroborate SLOAPCD’s previous conclusions and point to the Oceano Dunes State Vehicular Recreation Area (ODSVRA) as the primary source of the high particulate levels measured at this station.

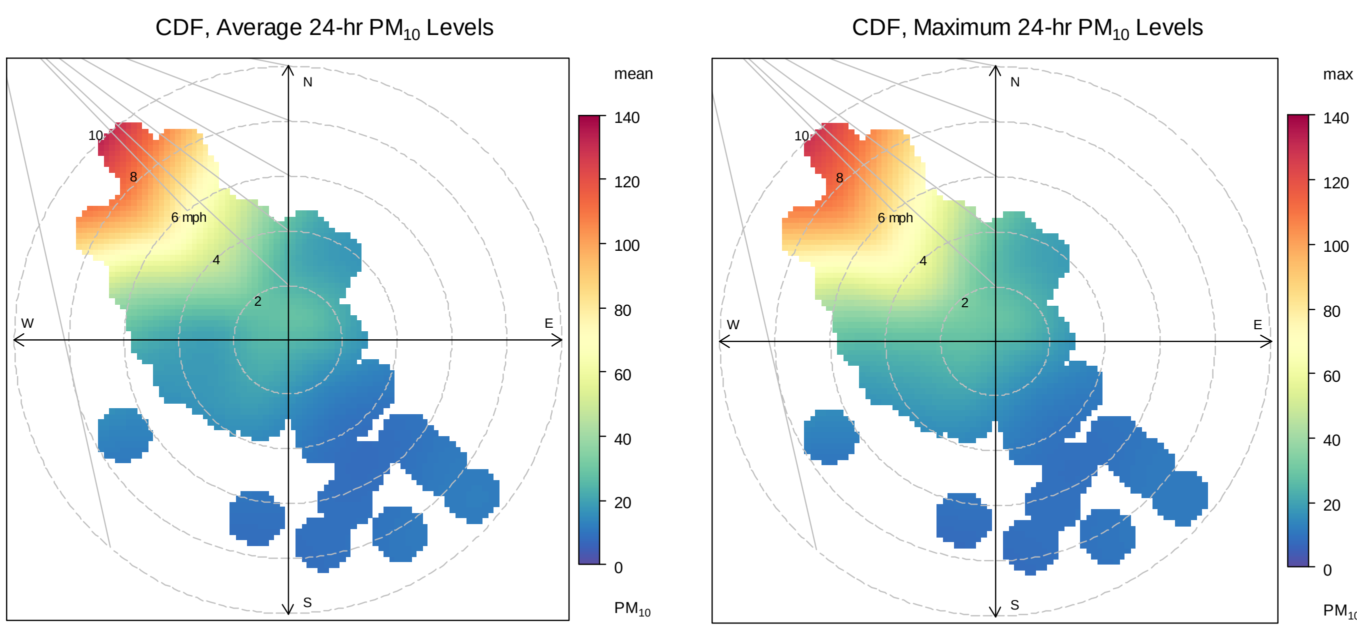

Figure B-2. Bivariate plots showing average (left panel) and maximum (right panel) 24-hour PM_{10} levels at CDF by wind speed, wind direction for 2012.

Figures B-3 and B-4 show the same plots for Mesa2 and Nipomo Regional Park. The plots for Mesa2 display the same pattern as for CDF: high northwesterly winds correspond to high PM_{10} levels, and point to the ODSVRA as the source of the high particulate levels measured at the station.

For Nipomo Regional Park, a somewhat different pattern is evident. High PM_{10} levels still correspond with high winds from the west, as would be expected with the ODSVRA as the dominant regional source. However, compared to CDF and Mesa2—which are close to the shore—PM_{10} levels are significantly lower at NRP, which is further from the coast and centrally located in the community. Some higher PM_{10} levels measured at NRP also occur under northeasterly and southeasterly winds, reflecting influence from sources other than the dunes under those conditions. Though not apparent from Figure B-4, these events typically occur during the late fall and winter months, which coincides with the period when residential and opening burning is allowed in that area.

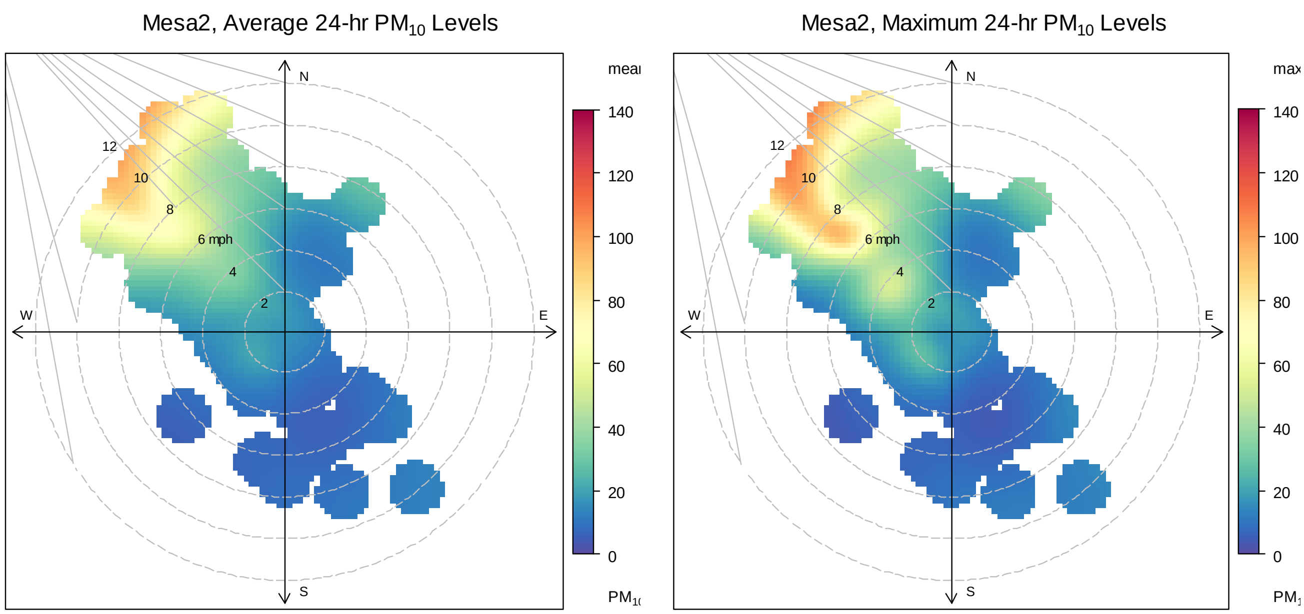

Figure B-3. Bivariate plots showing average (left panel) and maximum (right panel) 24-hour PM_{10} levels at Mesa2 by wind speed, wind direction for 2012.

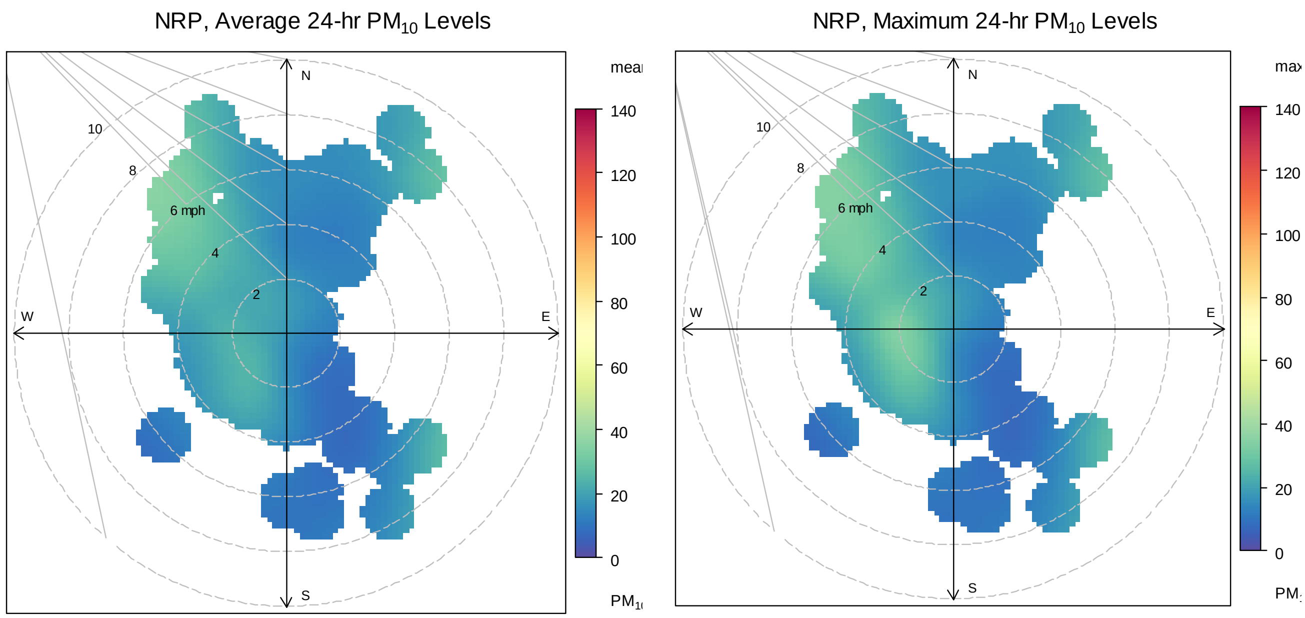

Figure B-4. Bivariate plots showing average (left panel) and maximum (right panel) 24-hour PM_{10} levels at Nipomo Regional Parks by wind speed, wind direction for 2012.

Appendix B of the 2013 Annual Air Quality Report for San Luis Obispo County

Appendix B: Particulate Matter Along the Southern Coast of San Luis Obispo County

In contrast to the rest of the county where PM_{10} and $PM_{2.5}$ levels have trended downward over the last 20 years, the Nipomo Mesa continues to see high levels of particulate matter pollution. A recent analysis of data from 1991 through 2011 found no evidence of improvement at CDF or Mesa2, and only slight improvement at Nipomo Regional Park.[7] Figure 10, above, suggests that whatever improvement Nipomo Regional Park saw through 2011 may have been erased in 2012 and 2013. Studies by the APCD have determined that the dune complex along the coast of the Five Cities area is the source of the high particulate matter levels measured at these stations.[8,9]

Exceedences of the 24-hour PM_{10} Standards on the Nipomo Mesa

Polar plots depicting hourly PM_{10} levels as a function of wind speed and direction—analogous to the ozone plots presented in Appendix A—show that coastal dunes continue to be the dominant influence on Nipomo Mesa PM_{10} levels in 2013. For CDF, hourly PM_{10} concentrations are shown by wind speed and direction in Figures B1 and B2. As in previous years, the highest levels are observed when winds are from the northwest, and increasing wind speeds correspond to higher PM_{10} levels. These conditions occurred most frequently in the spring and fall, as shown in the wind roses (Figure B3, middle panel). The same picture emerges for Mesa2 (Figures B5 through B7.) These observations of 2013 data corroborate APCD's previous conclusions and show the Oceano Dunes State Vehicular Recreation Area is the primary source of the high particulate levels measured at this station.

For Nipomo Regional Park (Figures B9 through B11), a somewhat different pattern is evident. High PM_{10} levels still correspond with high winds from the west, as would be expected with the ODSVRA as the dominant regional source. However, compared to CDF and Mesa2—which are close to the shore—PM_{10} levels are significantly lower at NRP, which is further from the coast and centrally located in the community. As was the case in 2012, in 2013 some higher PM_{10} levels also occur under other wind conditions, reflecting the influence of sources other than the dunes at this site.

Annual Average $PM_{2.5}$ Levels on the Nipomo Mesa

As noted earlier, there are two federal $PM_{2.5}$ standards: the 24-hour standard (35 $\mu g/m^3$) and the annual average standard (12 $\mu g/m^3$). In 2013, both were exceeded at CDF, but assuming current trends continue the station is only at risk violating the annual average standard. The station is not currently in danger of violating the 24-hour standard because it must be exceeded multiple times each year for a violation to occur, and the three exceedences observed there this year and last year are not enough. (Specifically, for standard to be violated, the 98^{th} percentile of the observed 24-hour values must exceed the standard. Since $PM_{2.5}$ is sampled daily, this means that the standard can be exceeded six or seven times each year without the standard being violated.)

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[7] Tupper, K.A., March 2013. Air Quality Trends, 1991-2011. San Luis Obispo County Air Pollution Control District, San Luis Obispo, Calif. http://www.slocleanair.org/images/cms/upload/files/Final%20AQ%20Trends%282%29.pdf

[8] San Luis Obispo County Air Pollution Control District, 2007. Nipomo Mesa Particulate Study. San Luis Obispo, Calif. http://www.slocleanair.org/images/cms/upload/files/air/pdf/pm_report2006_rev1.pdf

[9] Craig, J., Cahill, T., and Ono D., February 2010. South County Phase 2 Particulate Study. San Luis Obispo County Air Pollution Control District, San Luis Obispo, Calif. http://www.slocleanair.org/images/cms/upload/files/pdf/PM2-final_report.pdf

In contrast, the annual average standard is violated when the 3-year average exceeds the standard. As shown in Figure 11, annual average at CDF exceeded the standard in 2013 and approached it in 2011; 2012 was significantly lower. If subsequent years look like 2011 and 2013, then the station could violate the standard and the county could be designated as non-attainment for the annual average standard.

To investigate the sources that contribute to the $PM_{2.5}$ annual averages at CDF and Mesa2, polar plots of this pollutant vs wind speed and direction are shown in Figures B4 (CDF) and B8 (Mesa2). Instead of plotting maximum or average values (as was done for ozone and PM_{10}), frequency weighted means are plotted, since this statistic better shows which wind speed/direction regions contribute the most to the annual average. To understand why, it is helpful to compare the federal PM_{10} and $PM_{2.5}$ standards. The federal PM_{10} standard is based on a 24-hour averaging time; there is no annual average standard for this pollutant. For the federal PM_{10} standard to be violated, one or more exceedences per year are needed.[10] Polar plots of average and maximum PM_{10} levels are therefore insightful because they show the conditions under which the maximum values occur. It matters less how frequently those conditions occur because even if they occur only once per year this is still often enough to cause a violation if the maximum exceeds the standard. In contrast, when considering an annual average, the maximum values and their frequency of occurrence are both important. For example, a single day that is much greater than the 24-hour standard will not likely cause the annual average to exceed the standard, if the other 364 days are well below the standard. On the other hand, if many of the individual days frequently exceed the level of the annual average standard even by a small amount, this could result in an annual average that exceeds the standard.

The frequency weighted means plotted in Figures B4 and B8 capture this interplay and show which wind speed/direction combination contribute the most to the $PM_{2.5}$ annual average. At CDF in the summer, fall, and especially spring, 10 to 15 mph-winds from the northwest are the biggest contributor to average $PM_{2.5}$ levels. This indicates the dunes are the dominant source of fine particulates that impact the site during those months; in the fall and especially in the winter, stagnation also appears to contribute. At Mesa2 the pattern is similar. This site measures stronger northwesterly winds than CDF, especially in the spring (compare Figures B3 and B7). This explains why the area contributing most to the average $PM_{2.5}$ levels is shifted to higher wind speed values in the spring. In the summer and fall, this area splits into high and medium wind speed regions, and in the fall and winter, contributions from stagnation become apparent.

[10] Technically, for the federal 24-hr PM_{10} standard to be violated, the average number of expected exceedences over a 3-year period needs to be 1 or more exceedences per year.

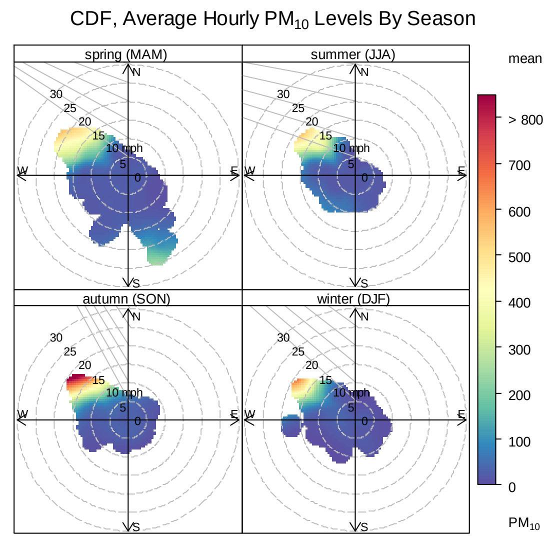

Figure B1. Polar plots showing average hourly PM_{10} levels at CDF by wind speed, wind direction, and season for 2013.

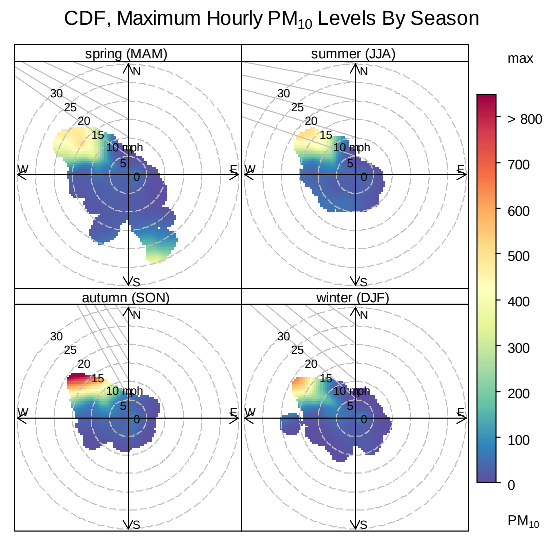

Figure B2. Polar plots showing maximum hourly PM_{10} levels at CDF by wind speed, wind direction, and season for 2013.

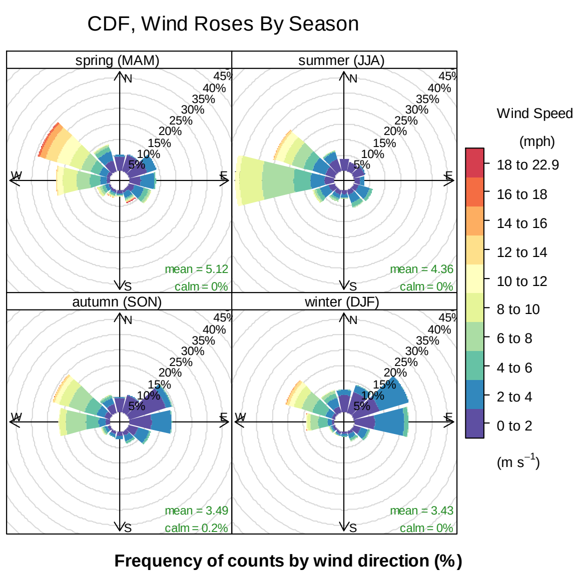

Figure B3. Wind roses showing the frequency distribution of wind speeds by direction and season at CDF in 2013.

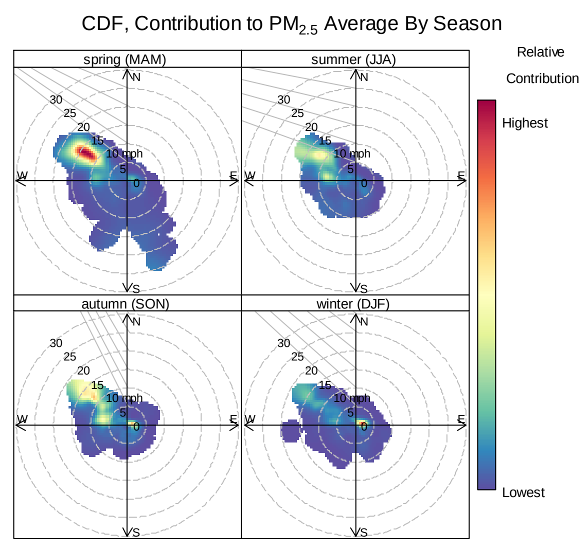

Figure B4. Polar plots showing contributions to the average $PM_{2.5}$ levels at CDF by wind speed, wind direction, and season for 2013.

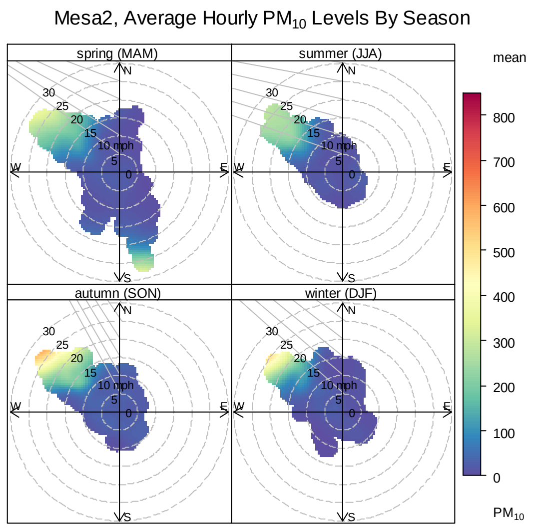

Figure B5. Polar plots showing average hourly PM_{10} levels at Mesa2 by wind speed, wind direction, and season for 2013.

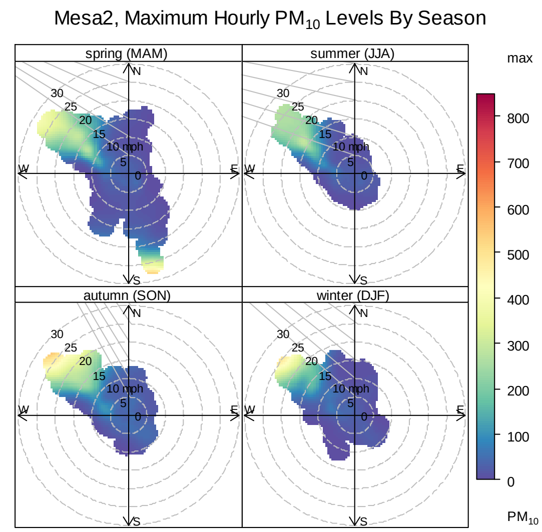

Figure B6. Polar plots showing maximum hourly PM_{10} levels at Mesa2 by wind speed, wind direction, and season for 2013.

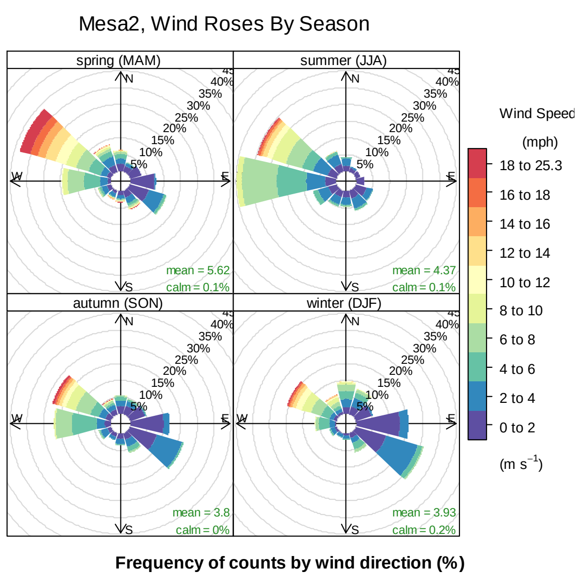

Figure B7. Wind roses showing the frequency distribution of wind speeds by direction and season at Mesa2 in 2013.

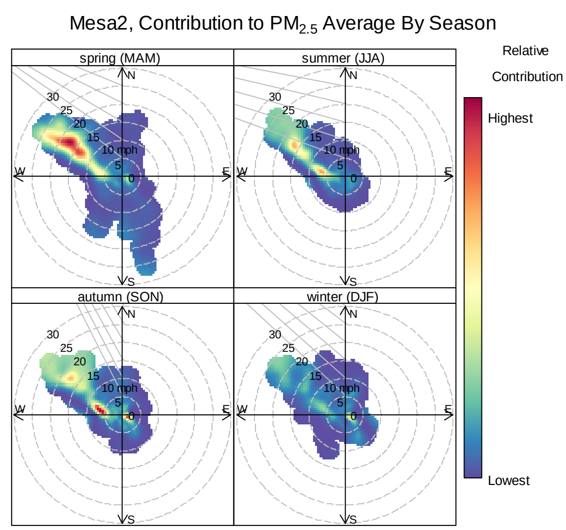

Figure B8. Polar plots showing contributions to the average $PM_{2.5}$ levels at Mesa2 by wind speed, wind direction, and season for 2013.

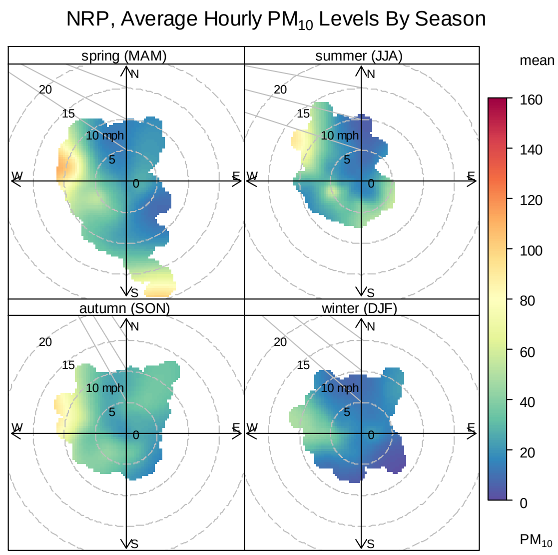

Figure B9. Polar plots showing average hourly PM_{10} levels at Nipomo Regional Park by wind speed, wind direction, and season for 2013. Note that the color scale has a different range than that in Figures B1, B2, B5, and B6.

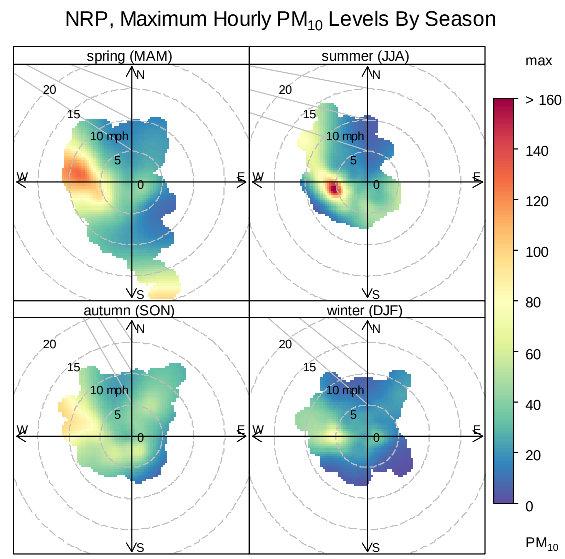

Figure B10. Polar plots showing maximum hourly PM_{10} levels at Nipomo Regional Park by wind speed, wind direction, and season for 2013. Note that the color scale has a different range than that in Figures B1, B2, B5, and B6.

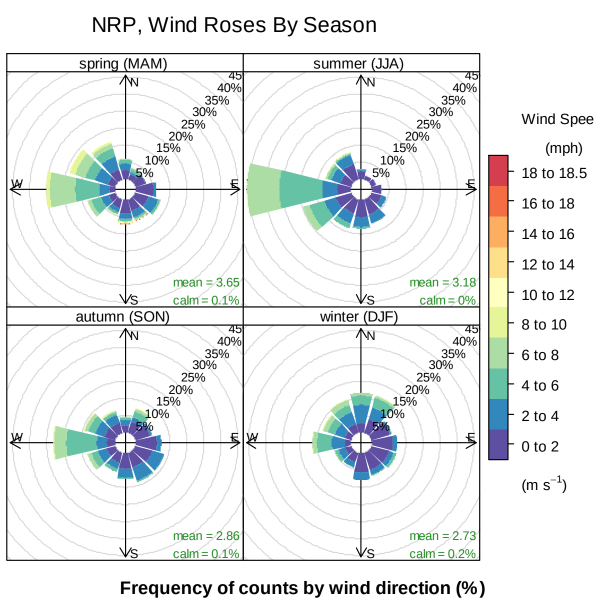

Figure B11. Wind roses showing the frequency distribution of wind speeds by direction and season at Nipomo Regional Park in 2013.