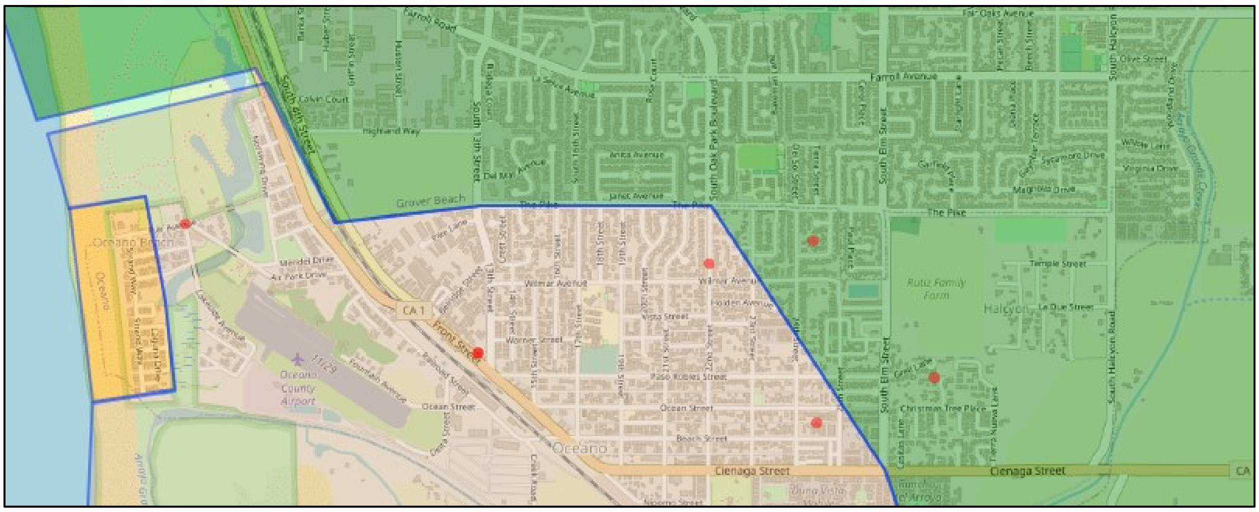
REVISIONS TO THE AIR QUALITY FORECAST MAP IN SOUTHERN SAN LUIS OBISPO COUNTY



SLO COUNTY apcd | Air Pollution Control District
San Luis Obispo County

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SOUTHERN SAN LUIS OBISPO COUNTY
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Executive Summary

The San Luis Obispo Air Pollution Control District (District) divides San Luis Obispo County into zones for the purposes of forecasting and reporting air quality. For each forecast zone, the District provides a daily air quality forecast based on anticipated levels of ozone, PM_{10}, and $PM_{2.5}$. In Southern San Luis Obispo County—Pismo Beach, Grover Beach, Oceano, Arroyo Grande, and Nipomo—levels of PM_{10} and $PM_{2.5}$ can vary greatly, especially during wind-event days when onshore winds entrain dust from the Oceano Dunes State Vehicular Recreation Area (ODSVRA). As shown in Figure 2, the forecast zones in this region are quite small relative to the rest of the county.

The current zone boundaries in South County were informed by the results of the District's South County Community Monitoring Study, in which PM_{10} data was collected by a dense but temporary network of non-regulatory PM_{10} monitors on the Nipomo Mesa in 2012. Since that study, the Oso Flaco station was established downwind of the southern extent of the ODSVRA, and short-term monitoring has also been conducted near Dorothea Lang Elementary School in Nipomo, on the northern Nipomo Mesa behind Lopez High School and off North View Ave., and along Highway 1 in Oceano at the Oceano Community Services District (CSD). In addition, a small network of low-cost PM_{10} sensors was established in Oceano. At that same time, dust mitigation projects within the ODSVRA have impacted dust generation and likely changed the PM_{10} concentration gradient downwind. Considering this, it was decided to examine all the new data and consider whether revisions to the forecast zone boundaries are warranted.

To determine which permanent site best represents each temporary monitoring location, this report compares wind-event day PM_{10} levels measured at each temporary site to each of the permanent monitor stations. This analysis largely supports the current forecast zone map. For example, it confirms the large PM_{10} gradient on wind-event days documented in the South County Community Monitoring Study. It also shows that the Oso Flaco, Lopez High School, and Northview Ave. locations are correctly assigned to the NRP, Mesa2, and NRP zones, respectively, and it supports the assignment of eastern Oceano to the San Luis Obispo zone.

It also suggests some revisions to forecast zone boundaries. The current forecast zone map puts the area around Dorothea Lange Elementary School in the Mesa2 zone, but the monitoring at the Calle Cielo and Via Alta Mesa sites suggests that this location is better represented by NRP. The Oceano CSD data suggest that western Oceano should be in the NRP zone, rather than the San Luis Obispo zone as it currently is. Finally, the sensor data confirms the east-west PM_{10} gradient in Oceano but suggest that the Pier Ave. location should be in the NRP or San Luis Obispo zone, rather than the Mesa2 zone as it currently is.

Based on this analysis, it is recommended that forecast zone boundaries be redrawn as shown in Figures 11 and 12. (The cover page of this report shows the changes in Oceano, with the revised map on top.) These revisions essentially enlarge the NRP forecast zone, while shrinking the Mesa2 and San Luis Obispo zones. With these recommended changes, all of the cities of Arroyo Grande, Pismo Beach, and Grover Beach remain in the San Luis Obispo zone. The portion of Oceano in the Mesa2 zone would shrink to the area within about 1,000 ft. of the mean high tide line. Most of

Oceano east and north of Highway 1 (Cabrillo Hwy./Cienaga St.) would be reclassified from the San Luis Obispo zone to the NRP zone. The eastern boundary of the Mesa2 zone would move seaward, changing the area around Dorothea Lange Elementary School from the Mesa2 zone to the NRP zone.

This analysis confirms that the Lopez High School area, the Northview Ave. area, and the Oso Flaco area are appropriately in the Mesa2, NRP, and NRP zones, respectively. Finally, this analysis provides additional evidence that wind-event day PM_{10} levels at CDF have been attenuated in recent years relative to Mesa2; the likely cause of this is the dust mitigation measures installed upwind of the site.

Introduction

Forecast Zones

The District divides San Luis Obispo County into zones for the purposes of forecasting and reporting air quality. For each zone, the District provides a daily air quality forecast, based on anticipated levels of ozone and particulate matter—both PM_{10} and $PM_{2.5}$. Each forecast zone is associated with a permanent air quality monitoring station; for example, in the Atascadero forecast zone, the concentrations of ozone and particulate matter are assumed to be most similar to the levels measured at the District's Atascadero monitoring station. See the map in Figure 1, below, for the current forecast zone boundaries, and the District's Ambient Air Monitoring Network Plan for a comprehensive description of the monitoring stations within the County.[1]

For each forecast zone, the forecast represents the highest forecasted Air Quality Index in the zone. For example, if ozone is predicted to be in the good range, PM_{10} is predicted to be moderate, and $PM_{2.5}$ is predicted to be unhealthy for sensitive groups, then the overall forecast reported for the zone would be unhealthy for sensitive groups.

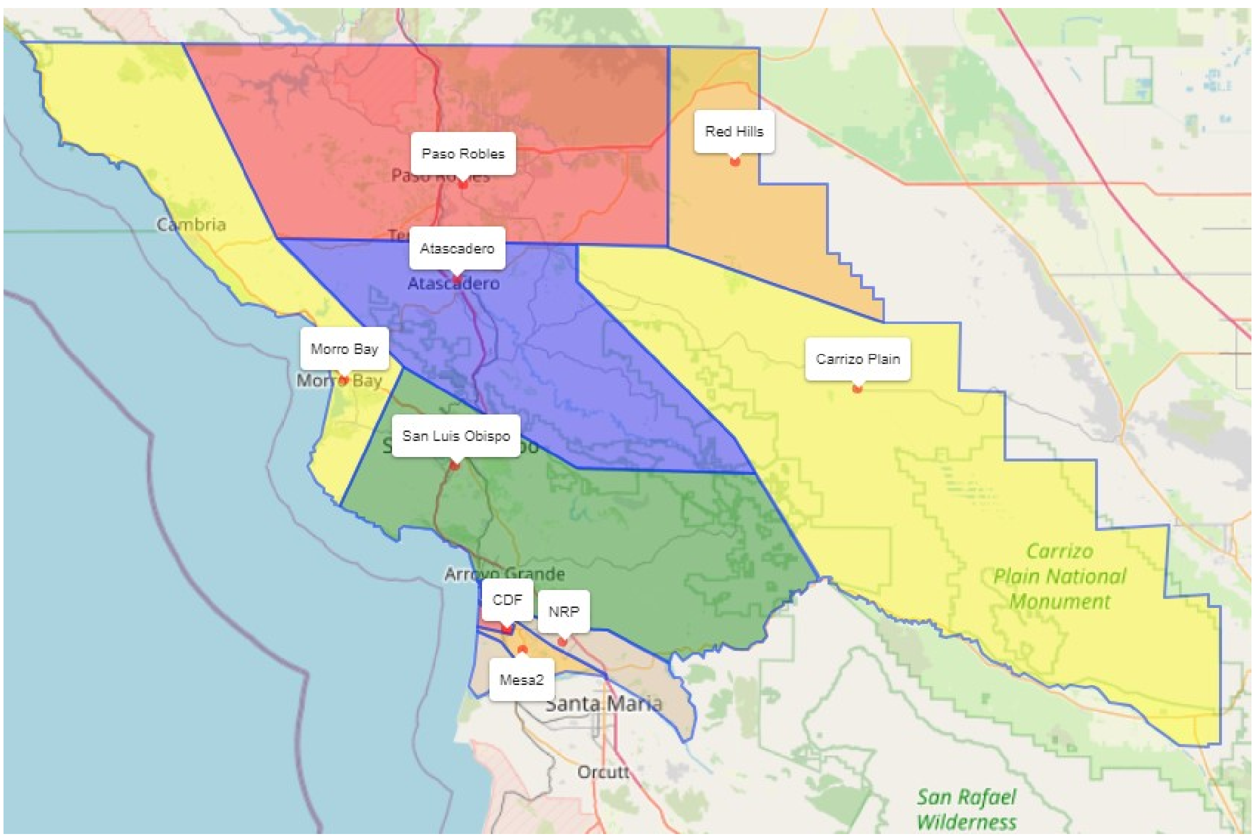

Figure 1: Current Forecast Zones and Monitoring Stations.

[1] San Luis Obispo County Air Pollution Control District, "2020 District's Ambient Air Monitoring Network Plan," June 2020. Available online at https://www.slocleanair.org/air-quality/monitoring-stations.php.

Not all forecast zones have monitors for ozone, PM_{10}, and/or $PM_{2.5}$, so levels measured at nearby stations inform the forecasting for unmeasured pollutants. For example, only ozone is measured at the Morro Bay station, so trends in particulate matter concentrations at the nearby San Luis Obispo, Atascadero, and Paso Robles zones stations inform the particulate matter forecast for the Morro Bay zone.

It is important to recognize that within each zone, air quality can vary significantly and is impacted by local topography, emission sources, and meteorology. Furthermore, locations that are closer to the zone's monitoring station will have pollutant levels that more closely align with the levels measured at the station. Further away from the monitoring station, larger differences are expected. For a location along or near zone boundaries, actual levels are probably closer to the average of what is reported for the zones.

In Southern San Luis Obispo County—Pismo Beach, Grover Beach, Oceano, Arroyo Grande, and Nipomo—ozone levels are typically relatively uniform and are well represented by the monitor at the Nipomo Regional Park (NRP) station. Levels of PM_{10} and $PM_{2.5}$ are more heterogeneous, especially during wind-event days when onshore winds entrain dust from the Oceano Dunes State Vehicular Recreation Area (ODSVRA). As shown in Figure 2, below, there are several permanent monitoring stations in this area; relative to the rest of the County, here the zones are quite small.

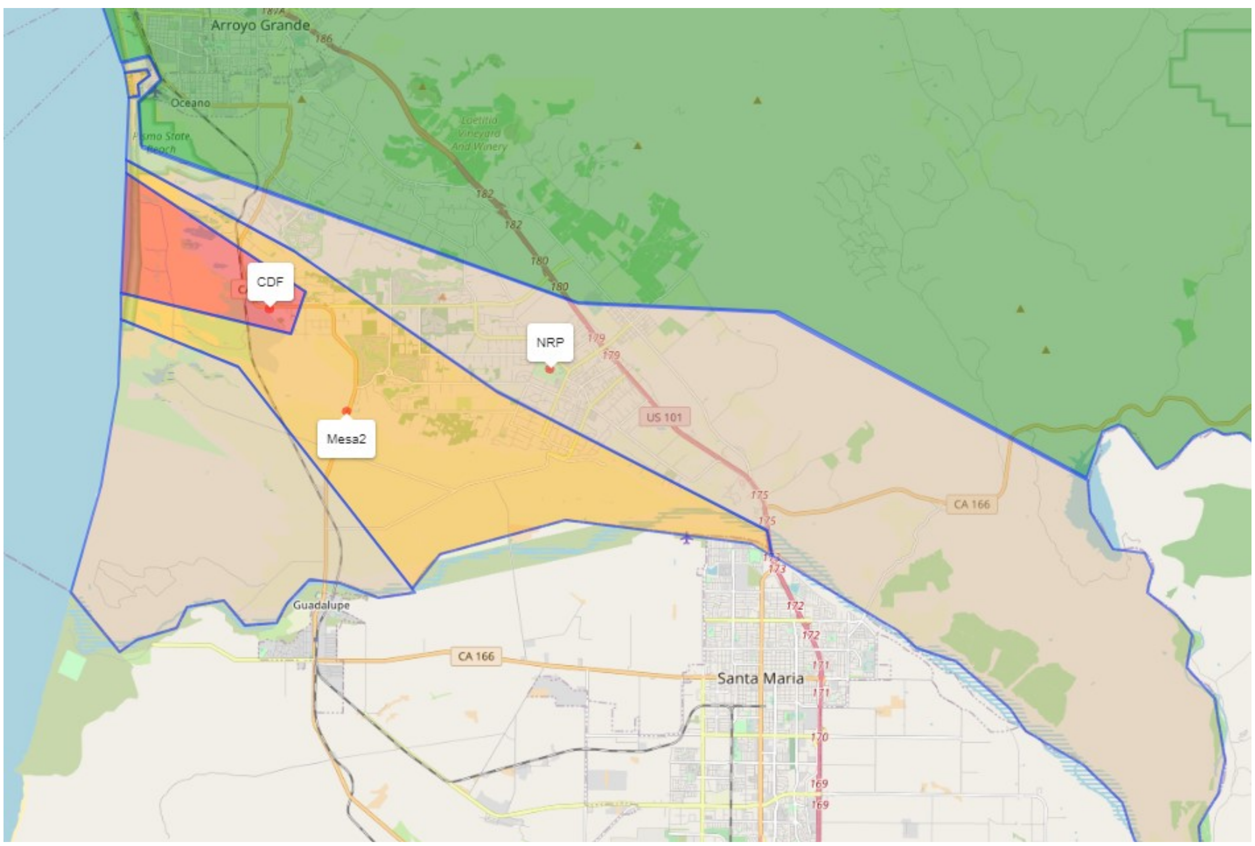

Figure 2: South County Forecast Zones. The green area is part of the San Luis Obispo forecast; the NRP zone is split into two parts.

In the current map, all of the cities of Arroyo Grande, Pismo Beach, and Grover Beach are in the San Luis Obispo zone, despite these cities being closer to the CDF, Mesa2, and NRP monitoring stations. In Oceano, the situation is more complex. The area closest to the shore around Strand Way and Pier Ave. is in the Mesa2 zone, while the portion of the city east of Highway 1 is in the San Luis Obispo zone, with a small area in between assigned to the Mesa2 zone. Much of Nipomo is within the NRP forecast zone except for the southwest portion, which is in the Mesa2 zone. The rest of unincorporated southern San Luis Obispo County is divided between the NRP, Mesa2, and CDF zones.

Development of Current Forecast Zone Boundaries

The current zone boundaries were informed by the results of the District's South County Community Monitoring Study, in which PM_{10} data were collected by a dense but temporary network of non-regulatory PM_{10} monitors on the Nipomo Mesa in 2012.[2] The goal of the study was to "map the spatial extent and concentration gradient of the dust plume [from the ODSVRA] to better understand its impacts on Nipomo Mesa and Oceano neighborhoods. The data collected was ultimately intended to facilitate the preparation of more detailed air quality forecasts for those areas and enhance the ability of local residents to individually determine if or when protective actions might be needed on high [particulate matter] days."

To achieve this goal, "[a] saturation monitoring approach was utilized for this project with 23 semi-portable, real time beta attenuation (EBAM) PM_{10} monitors … deployed across the Nipomo Mesa, as well as near the beach and adjacent to Pier Avenue and in Oceano. These monitors gathered data during the months of March through May 2012 to capture the period known to have the highest winds and prevalence of dust episodes." Maps of the monitoring locations, taken from Reference 2 are shown in Figures 3 and 4, below.

Figure 3: Oceano Monitoring Locations in the South County Community Monitoring Project. Reproduced from Figure 7 Reference 2.

[2] San Luis Obispo County Air Pollution Control District, "South County Community Monitoring Project," January 2013. Available online at https://www.slocleanair.org/library/air-quality-reports.php.

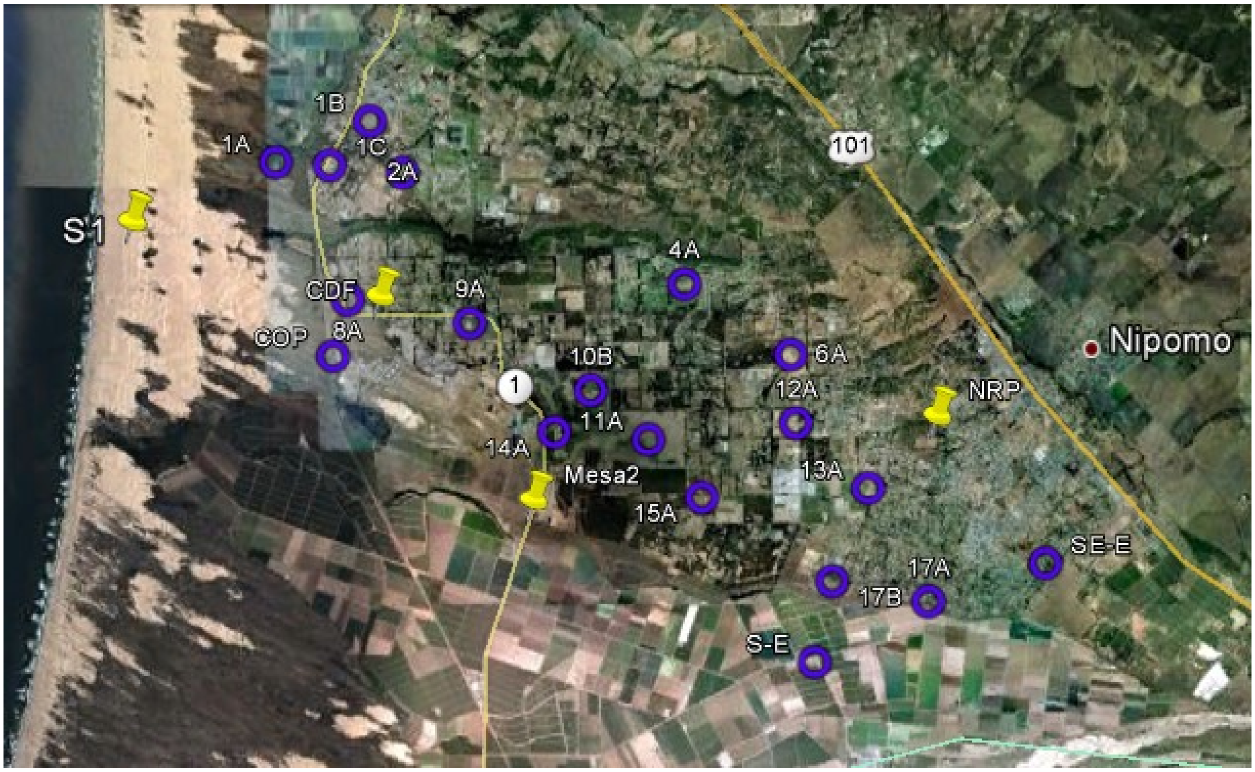

Figure 4: Nipomo Mesa Monitoring Locations in the South County Community Monitoring Project. Reproduced from Figure 6 in Reference 2

For each of the 23 temporary monitoring locations, PM_{10} concentrations on wind-event days were compared to the levels measured simultaneously at the District's permanent monitoring stations. Based on these comparisons, the permanent station which best represents each temporary location was determined. The District's staff meteorologist used his professional judgement to synthesize this information with the results of previous Phase 1 and Phase 2 studies[3,4] and draw the forecast zone boundaries depicted in Figure 2, above.

Reexamining the Forecast Zones Boundaries

Since the 2012 study, PM_{10} monitoring at the District's CDF, Mesa2, NRP, and San Luis Obispo permanent sites has continued, and in 2015 a new permanent site called Oso Flaco was established downwind of the southern extent of the ODSVRA. Short-term monitoring with both regulatory monitors (BAMs) and non-regulatory monitors (EBAMs) has been conducted near Dorothea Lang Elementary School in Nipomo, on the northern Nipomo Mesa behind Lopez High School and off North View Ave., and along Highway 1 in Oceano at the Oceano Community Services District (CSD). Finally, as described in the District's Community Air Monitoring in Oceano report,[5] a small network of

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[3] San Luis Obispo County Air Pollution Control District, "Nipomo Particulate Matter Study," 2007. Available online at https://www.slocleanair.org/library/air-quality-reports.php.

[4] San Luis Obispo County Air Pollution Control District, "South County Phase 2 Particulate Study," February 2010. Available online at https://www.slocleanair.org/library/air-quality-reports.php.

[5] San Luis Obispo County Air Pollution Control District, "Community Air Monitoring in Oceano, California," January 2020. Available online at https://www.slocleanair.org/library/air-quality-reports.php.

low-cost PM_{10} sensor was established in Oceano in 2019. Most these new and/or temporary sites are in locations that were unsampled in the 2012 study.

At that same time, dust mitigation projects within the ODSVRA have impacted dust generation and likely changed the PM_{10} concentration gradient downwind.[6,7] In light of this, it was decided to examine all the new data and consider whether revisions to the forecast zone boundaries are warranted.

Methods

Monitoring Sites

This report analyzes data collected from 2017 through early 2021. Other than short interruptions for maintenance, repairs, and QA/QC, the permanent regulatory sites (CDF, Mesa2, NRP, SLO, and Oso Flaco) have run continuously during this period, except for Oso Flaco, which was offline in early 2017. Also included for comparison purposes is data from the permanent PM_{10} monitor in Santa Maria, which is operated by the Santa Barbara APCD.

The temporary sites in Southern San Luis Obispo County have operated more sporadically. In Oceano, data from the network of low-cost AirVisual sensors (described in Reference 5) was used; Figure 6, below, shows these monitoring locations. Most of the temporary PM_{10} data from the Nipomo Mesa was collected using regulatory BAM monitors, but an EBAM and a non-regulatory BAM were used at some sites; Figure 5, below, shows the locations of these monitors. Table 1 summarizes the sampling periods and instruments for the sites included the analysis.

Data Handling

At the time of this analysis, pre-2021 data from permanent sites run by the District (CDF, Mesa2, NRP, Oso Flaco) was fully validated. Data collected in 2021 were not fully validated and were still preliminary. Data for the San Luis Obispo and Santa Maria permanent sites were collected by third parties and extracted from California Air Resources Board archives; the data are believed to be high quality but may not have been fully validated. Data from temporary monitors and sensors were not subjected to the same validation procedures applied to District's permanent sites. These data were screened to remove suspicious values and data collected during periods of malfunction, but otherwise used as-is.

[6] San Luis Obispo County Air Pollution Control District, "Frequently Asked Questions: Air Quality and the Temporary Closure of Oceano Dunes," June 30, 2020. Available online at https://storage.googleapis.com/slocleanair-org/images/cms/upload/files/June2020FAQ-42.pdf

[7] San Luis Obispo County Air Pollution Control District, "2019: Annual Air Quality Report," November 2020. Available online at https://www.slocleanair.org/library/air-quality-reports.php.

Table 1: Sampling Periods and Instruments

Site Name	First Period		Second Period	
	Dates	Instrument	Dates	Instrument
CDF	1/1/2017 - 2/5/2021 [a]	BAM		
Mesa2	1/1/2017 - 2/5/2021 [a]	BAM		
NRP	1/1/2017 - 2/5/2021 [a]	BAM		
Oso Flaco	3/25/2017 - 2/5/2021	BAM		
San Luis Obispo	1/1/2017 - 2/5/2021 [a]	BAM		
Santa Maria	1/1/2017 - 2/5/2021	BAM		
Calle Cielo	11/16/2018 - 4/11/2019	BAM	4/22/2020 - 12/1/2020	Non-regulatory BAM
Via Alta Mesa	4/21/2020 - 7/6/2020	EBAM		
Lopez HS	7/19/2017 - 7/22/2019	BAM	11/21/2019 - 2/5/2021	BAM
North View	3/7/2018 - 9/24/2018	BAM	4/12/2019 - 11/30/2020	BAM
Oceano CSD (BAM)	4/4/2019 - 10/10/2019	BAM		
Oceano CSD (AirVisual)	5/18/2019 - 4/30/2021	AirVisual		
Pier Ave.	2/20/2020 – 4/30/2021	AirVisual		
22nd St.	3/8/2019 – 2/7/2020	AirVisual		
Scott Lee Dr.	9/4/2020 – 4/30/2021	AirVisual		
24th St.	3/1/2020 – 4/30/2021	AirVisual		
Oceano East	3/27/20219 – 6/22/2020	AirVisual		

[a] When comparing these sites with Nipomo Mesa temporary sites, data from 1/1/2017 through 2/5/2021 were used. When comparing to Oceano sites, data from 3/1/2019 through 4/30/21 were used.

Data collected using via EBAM and non-regulatory BAM monitors were adjusted using correction factors derived from prior collocation at CDF.[8] No corrections were applied to data from the AirVisual sensor in Oceano, as data from a single sensor collocated with a BAM suggested that at least that particular sensor has low bias.[5]

The forecast map for southern San Luis Obispo County is meant primarily to capture the PM_{10} gradient caused by wind-blown dust from the ODSVRA. Other potential sources—like wildfire smoke and dust transport from the San Joaquin Valley—have much more homogeneous impacts on the area's air quality. The following days were influenced by these sources and were therefore removed from the dataset: 9/2/2017, 12/4/2017, 12/16/2017, 12/17/2017, 11/17/2018, 11/18/2018, 12/4/2018, 12/16/2018, 12/17/2018, 10/27/2019, 10/28/2019, 10/28/2019, 10/29/2019, 10/29/2019, 10/30/2019, 10/30/2019, 10/31/2019, 11/1/2019, 11/2/2019, 7/6/2020, 8/18/2020, 8/19/2020, 8/20/2020, 8/21/2020, 8/22/2020, 8/23/2020, 9/11/2020, 9/12/2020, 9/13/2020, 9/14/2020, 9/15/2020, 9/16/2020, 10/2/2020, 10/3/2020, 10/4/2020. Furthermore, since the impact of wind-blown dust is the main consideration for defining zone boundaries, **only data from wind-event days was used in the analysis.** Here, a wind-event day was defined as any day when the California PM_{10} standard (24-hour average of 50 $\mu g/m^3$) was exceeded at CDF or Mesa2.

[8] A discussion of this analysis is beyond the scope of this report, but a report is available from the District upon request.

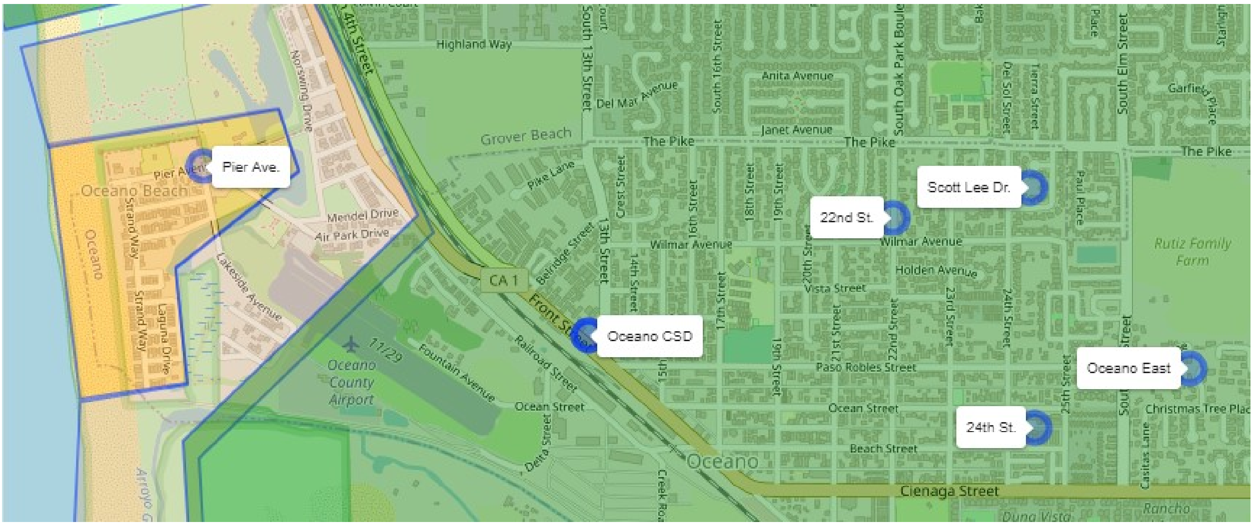

Figure 6: Map of Temporary and Permanent Monitoring Stations in Oceano Analyzed in this Report. Forecast Zones: Orange - Mesa2; Tan - NRP; Green – SLO

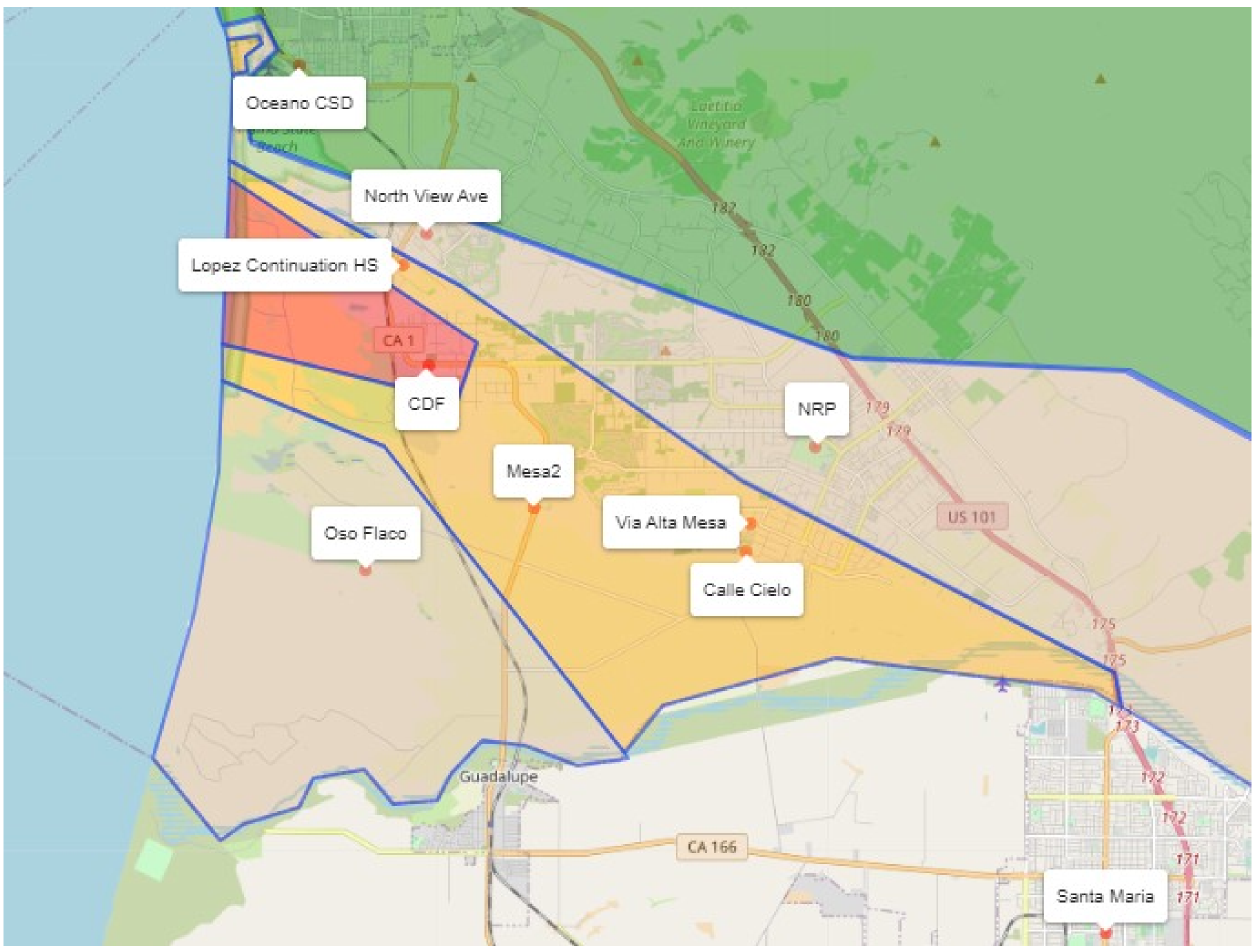

Figure 5: Map of Temporary and Permanent Monitoring Stations on/near the Nipomo Mesa Analyzed in this Report. Forecast Zones: Red - CDF; Orange - Mesa2; Tan - NRP; Green – SLO.

Analytical Methods

The fundamental question is: *Which permanent site is most similar to each of the temporary sites*? The 2012 study (Reference 2), answered this question by calculating the mean ratio of PM_{10} at each temporary site to each of the permanent sites (see Table 1 of that study). The permanent site resulting in the ratio closest to 1 was taken to be the most comparable. A similar approach was used here.

These ratios were calculated for every pair of sites in the study. In calculating the ratio of Site A to Site B, the following algorithm was applied:

1. Discard all hours when only one (or neither) of the sites has valid data.
2. Calculate 24-hour averages from the hourly data. Discard any daily averages comprising less than 16 valid hourly measurements. Call these daily averages A_i and B_i.
3. Calculate the ratio as:

$$\frac{\sum_{i=1}^{n} A_i}{\sum_{i=1}^{n} B_i}$$

If no data were missing, then using hourly data or daily averages would give identical results. In practice, however, at least a few hours are lost at each site due to QA/QC activities, maintenance and repairs, and power failures. As long as the day is at least 75% complete, the daily average calculated from the remaining valid hours is considered valid. Thus, a multi-day average of daily averages is not necessarily the same as a multi-day average of the underlying hourly values. In effect, hours from incomplete days receive slightly greater weight in the grand average than hours from complete days. In practice, it matters little whether the ratio is calculated with hourly or daily data. Initially, ratios were calculated both ways, and found to give similar results, leading to identical conclusions. Only the results using daily averages are presented here.[8]

The ratio calculation method also bears some explanation. Intuitively, calculating the "average ratio" of concentrations between two sites seems as simple as calculating the ratios for each hour (or each 24-hour average) and then averaging the ratios, i.e., calculating the average ratio of A_i and B_i as $\frac{1}{n}\sum_{i=1}^{n}\frac{A_i}{B_i}$. This procedure can be unstable, as a small number in the denominator can yield a very large ratio which can skew the average. Instead, it is better to calculate the "average ratio" as the average concentration at one site divided by the average concentration at the other, as in the algorithm presented above. Another approach to calculating "average" or "typical" ratio is to use linear regression, but with the regression line forced through the origin (i.e., with the *y*-intercept set to zero.) The ratio is the slope of the resulting fit. This method was also explored, but using Deming regression rather than ordinary least squares, since both variables are subject to measurement error. The results were similar to the simpler method used in the algorithm, above, and are not presented here.[8]

In addition to the ratio method, a simple differencing method was also explored. Called "concentration bias," this was calculated as the average difference between concentrations, i.e., $\frac{1}{n}\sum_{i=1}^{n}(A_i - B_i)$. A concentration bias of zero would indicate that on average the sites measure the same concentration.

Visualization of Results

Colored matrices are used to visualize the results. Each site is compared to every other site and the resulting concentration ratio or bias values are displayed as a color-code matrix. For concentration ratios, values close to 1 indicate similar concentration and are colored purple. Values far from 1 indicate the sites have very different concentrations and are colored yellow; intermediate values are shaded accordingly. The values on the diagonal are all 1, since these represent the site compared to itself. For example, in Figure 7, below, the CDF/Mesa2 ratio is 1.178, while the value for the Mesa/CDF ratio is 0.849; note that these values are reciprocal, as expected, and they are colored the same shade for clarity. For concentration biases (e.g., Figure 8), values close to zero indicate similar concentrations and are colored purple, and values with large absolute values are shaded yellow. The monitoring periods for Oceano CSD and Via Alta Mesa did not overlap, so these sites cannot be compared to each other and the matrix entries for this pair are blank.

Results

Temporary BAM and EBAM Sites on the Nipomo Mesa

Figure 7, below, summarizes the ratios for the temporary BAM and EBAM sites, i.e., all sites other than AirVisual sensor sites in Oceano. Every site is compared to every other site. See the Visualization of Results section, directly above, for further explanation of how to interpret this figure. CDF and San Luis Obispo are the most dissimilar, with typical wind-event day PM_{10} concentrations at CDF more than 3-fold higher than at San Luis Obispo. Comparing the temporary sites to the permanent sites, Calle Cielo is most similar to NRP, with a ratio of 0.969 indicating that typical wind-event day concentrations the site are about 97% of those at NRP. Via Alta Mesa is also most similar to NRP; however, PM_{10} levels are typically somewhat higher than NRP (ratio: 1.211), but still much lower than Mesa2 (ratio: 0.563). The Lopez High School site is very similar to Mesa2 (ratio: 0.978), and the North View Ave. site is very similar to NRP (ratio: 0.948). Finally, concentrations at the Oceano CSD site are very similar, but typically somewhat higher than, those at NRP and Santa Maria. In the current forecast zone map, this location is in the San Luis Obispo zone, but this analysis indicates that this assignment underestimates wind-event-day concentrations there by a factor of about 2.3.

Figure 8, below, summarizes the results using the concentration bias method. Overall, the pattern is very similar to that of Figure 7, with the largest difference again being between CDF and San Luis Obispo, where 24-hour average PM_{10} levels on wind-event days are nearly 50 $\mu g/m^3$ higher at CDF than San Luis Obispo. Comparing the temporary sites to the permanent sites, Calle Cielo appears most similar to NRP, with an average difference of only about 1 $\mu g/m^3$. The Via Alta Mesa site is also most similar to NRP, but typically about 7 $\mu g/m^3$ higher during wind-events. The Lopez High School site is most similar to Mesa2, with an average difference of only about 1 $\mu g/m^3$, and the North View Ave. site is closest to NRP, with an average difference of about 2 $\mu g/m^3$. Finally, the temporary BAM monitor in Oceano was much higher than the San Luis Obispo on wind-event days (by about 23 $\mu g/m^3$) but similar to NRP, averaging only about 3.5 $\mu g/m^3$ higher.

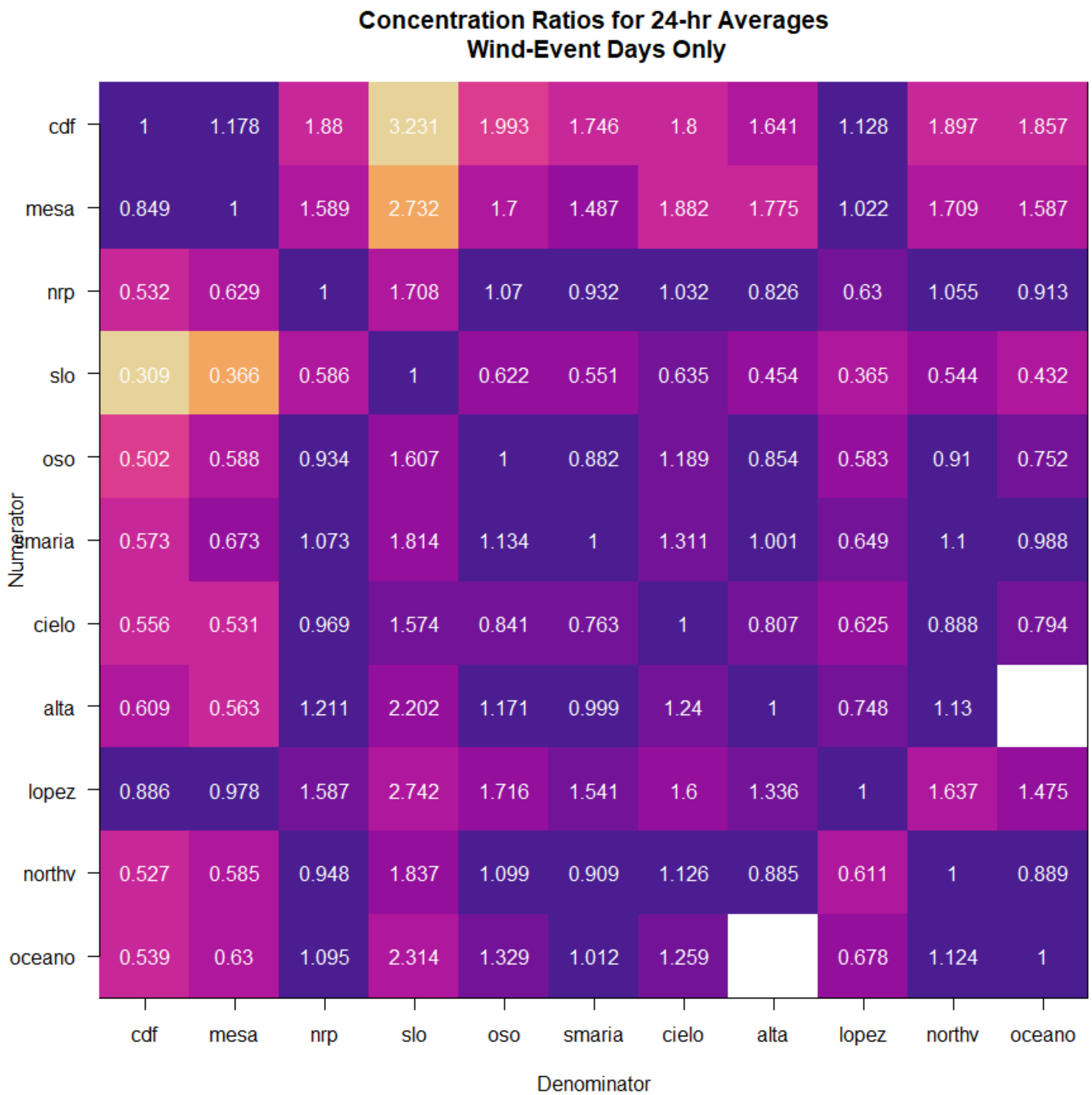

Figure 7: Concentration Ratios for 24-hr Averages. Only wind-event days are included in the calculation of ratios. The following site abbreviations are used: cdf: CDF; mesa: Mesa2; nrp: NRP; slo: San Luis Obispo; oso: Oso Flaco; smaria: Santa Maria; cielo: Calle Cielo; alta: Via Alta Mesa; lopez: Lopez High School; northv: North View Ave.; oceano: Oceano CSD.

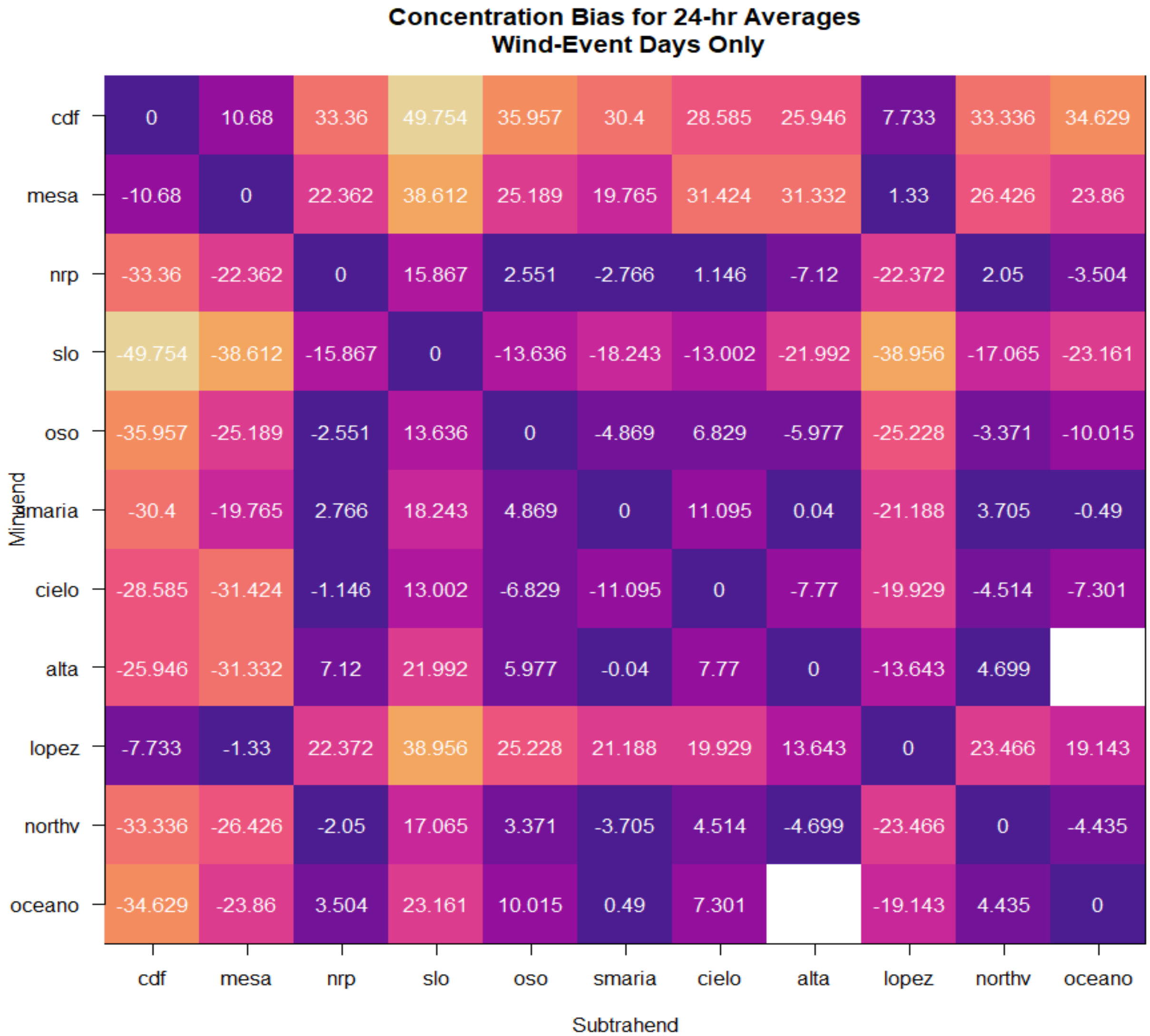

Figure 8: Concentration Biases for 24-hr Averages. Only wind-event days are included in the calculations. See the caption for site abbreviations.

AirVisual Sensor Sites in Oceano

The AirVisual sensors in Oceano were compared to one another, to the temporary BAM at the Oceano CSD, and to the nearby permanent sites. Figure 9, below, summarizes the ratios for these comparisons. The Pier Ave. sensor was established after the temporary BAM at the CSD had been removed, so these sites cannot be compared, and the matrix is empty for this pair. Similarly, there is no overlap between the BAM monitoring at the CSD and the Scott Lee Drive and 24th St. sites, or between the 22nd St. site and the Scott Lee Drive and 24th St. sites.

Comparing the AirVisual sensor at the Oceano CSD to the collocated BAM, is appears that on wind-event days, this sensor reads about 15% higher than the regulatory monitor (CSD sensor to CSD BAM ratio: 1.151). This underscores that the sensors are not as accurate as the much more expensive regulatory grade instruments. In theory, the CSD sensor data could be corrected to account for this bias, but it is not known whether this bias is a general bias shared by all AirVisual sensor, or whether each sensor would require its own correction factor. Therefore, all sensor data was used as-is, without applying correction factors. It is believed that while biased, the sensor data is nonetheless accurate enough for the purpose here, which is determining which permanent site best represents each sensor location. For the CSD location, whether the BAM or sensor data is used, NRP is the most representative permanent site. For the Oceano BAM, CDF is about 81% higher (ratio: 1.807), Mesa2 is about 55% higher (ratio: 1.552), NRP about 91% of its value (ratio: 0.908), and San Luis Obispo is only about 43% of the value (ratio: 0.432). (The ratios for this pair given in Figure 9 differ slightly from those in Figure 7 due to somewhat different date ranges of the data used.) For the Oceano AirVisual sensor, the ratios are 1.237, 1.187, 0.689, and 0.394, respectively. For both, NRP is the best match.

Turning to the other locations, this analysis shows that wind-event PM_{10} at the Pier Ave. location is in between NRP and San Luis Obispo levels, with San Luis Obispo being the best surrogate of the two. The 22nd St. location is also in between NRP and San Luis Obispo, but with NRP matching somewhat better. The Scott Lee Dr. and Oceano East locations are overestimated by all of the permanent sites, but San Luis Obispo is the best match these sites. Concentrations at the 24th St. site are slightly higher than those at NRP, with a 24th St. to NRP ratio of 1.039.

Figure 10, below, summarizes the results using the concentration bias method. Overall, the pattern is very similar to that of Figure 9. Pier Ave. concentrations are in between NRP and San Luis Obispo, but closer to San Luis Obispo; 22nd St. is also in between NRP and San Luis Obispo, but in contrast to the ratio method, this metric indicates that San Luis Obispo is a slightly better surrogate. By this metric, the Scott Lee Dr. and Oceano East locations are again overestimated by all of the permanent sites, but San Luis Obispo is the best match these sites. The 24th St. location is best represented by NRP.

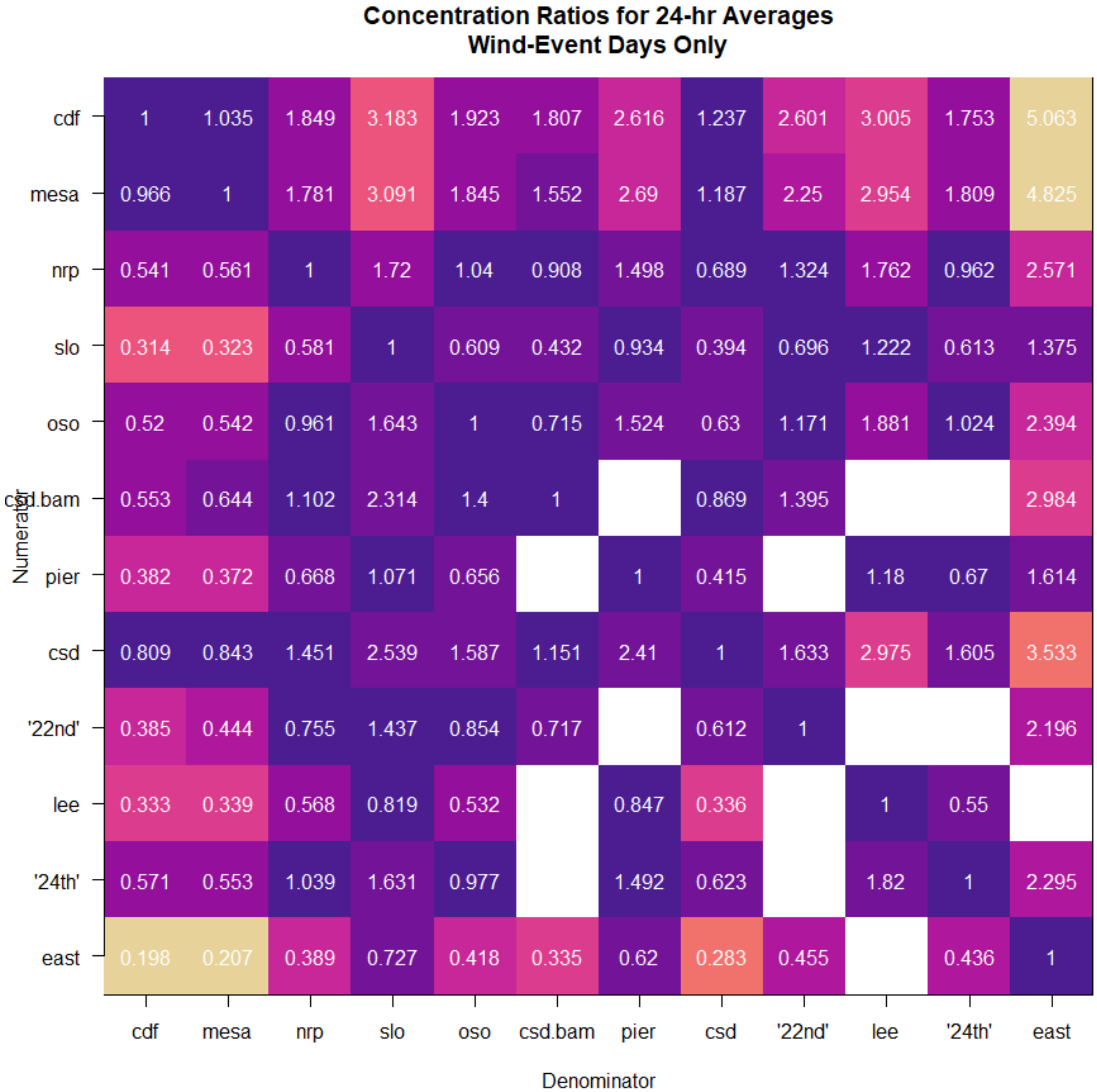

Figure 9: Concentration Ratios for 24-hr Averages: Oceano Sensor Sites. Only wind-event days are included in the calculation of ratios. The following site abbreviations are used: cdf: CDF; mesa: Mesa2; nrp: NRP; slo: San Luis Obispo; oso: Oso Flaco; csd.bam: BAM at Oceano Community Services District; pier: Pier Ave. sensor; csd: Oceano Community Services District sensor; 22nd: 22nd St., Oceano sensor; lee: Scott Lee Drive, Oceano sensor; 24th: 24th St., Oceano sensor; east: Oceano East sensor.

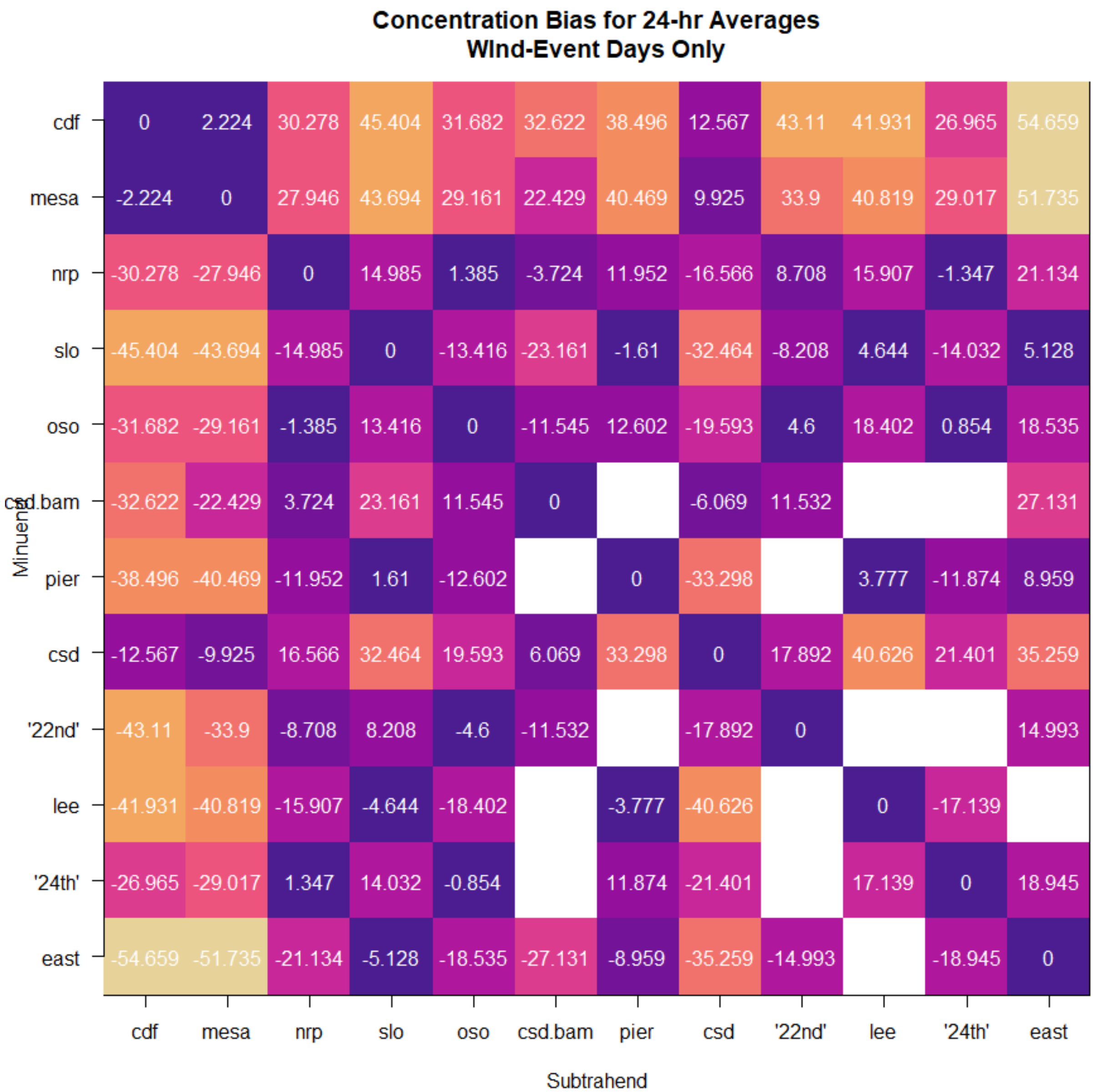

Figure 10: Concentration Biases for 24-hr Averages: Oceano Sensor Sites. Only wind-event days are included in the calculation. See the caption for Figure 9 for site abbreviations.

Discussion

The analysis supports the current forecast zone map in many ways. For example, it confirms the large PM_{10} gradient on wind-event days documented in the South County Community Monitoring Study,[2] with levels at CDF much greater than at Mesa2, which in turn is much greater than NRP, which is much greater than San Luis Obispo. The analysis also shows that the Oso Flaco, Lopez High School, and Northview Ave. locations are correctly assigned to the NRP, Mesa2, and NRP zones, respectively, even though they were not established until after the current forecast zones were drawn. It also supports the assignment of eastern Oceano (the Scott Lee Dr. and Oceano East sites) to the San Luis Obispo zone.

The analysis also suggests some that some areas are misclassified in the current map. The forecast zone map puts the area around Dorothea Lange Elementary School in the Mesa2 zone, but the monitoring at the Calle Cielo and Via Alta Mesa sites suggests that this location is better represented by NRP. The Oceano CSD BAM data suggest that western Oceano should be in the NRP zone, rather than the San Luis Obispo zone as it currently is. The Oceano sensor data confirm the east-west PM_{10} gradient noted in the Community Air Monitoring in Oceano report,[5] but suggest that the Pier Ave. location should be in the NRP or San Luis Obispo zone, rather than the Mesa2 zone as it currently is. These observations are summarized in Table 2, below.

Based on these results, some minor revisions to the current forecast zones shown in Figure 2 are warranted. The revised zones are shown in Figures 11 and 12, below. In adjusting the boundaries, changes were kept to a minimum, preserving as much of the original boundaries as possible. This is because the new and temporary sites included in this analysis tended to be in locations that were not sampled in the South County Community Monitoring Study. In most places, there was no new data, so these areas were kept in their current zones.

Table 2: Summary of Results

New/Temporary Site	Current Forecast Zone	Most Representative Permanent Site
Oso Flaco	NRP	NRP
Calle Cielo	Mesa2	NRP
Via Alta Mesa	Mesa2	NRP
Lopez HS	Mesa2	Mesa2
North View	NRP	NRP
Oceano CSD (BAM)	San Luis Obispo	NRP
Oceano CSD (AirVisual)	San Luis Obispo	NRP
Pier Ave.	Mesa2	NRP or San Luis Obispo
22nd St.	San Luis Obispo	NRP or San Luis Obispo
Scott Lee Dr.	San Luis Obispo	San Luis Obispo
24th St.	San Luis Obispo	NRP
Oceano East	San Luis Obispo	San Luis Obispo

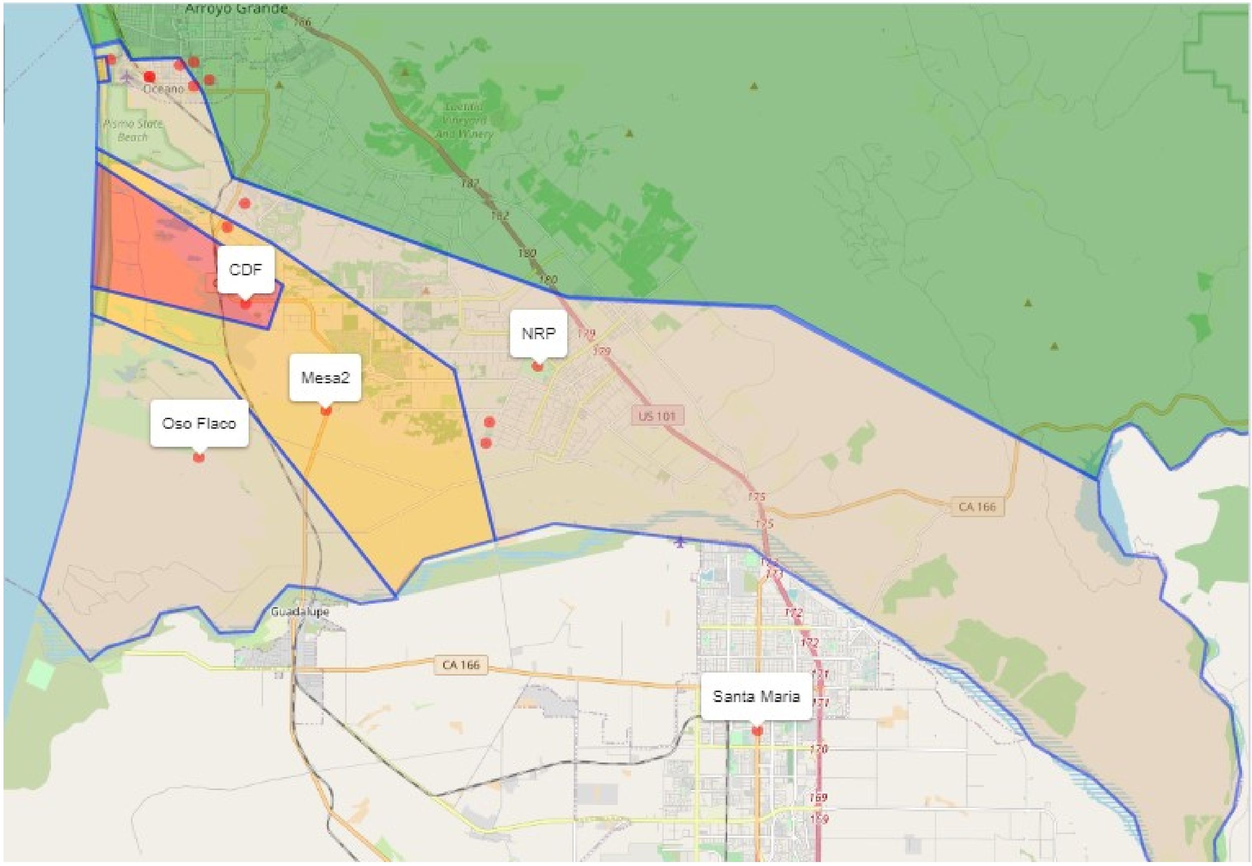

Figure 11: Revised Forecast Map. Permanent monitoring stations are labeled, and temporary sites are shown with red dots. Labels were omitted from these sites to reduce clutter. Forecast Zones: Orange - Mesa2; Tan - NRP; Green – San Luis Obispo.

Where new and old data conflict, more weight was given to newer data than older data, and to BAM or EBAM data than to sensor data. For example, based the South County Community Monitoring Study—particularly data from sites 17B and S-E (see Figure 4, above)—the boundary between the NRP and Mesa2 zone was drawn to put Dorothea Lange Elementary School and surrounding neighborhoods in the Mesa2 zone. Based on data collected since then and analyzed here, this area appears to be better represented by NRP, and the revised forecast map puts it in this zone. Similarly, the current map puts the location of the Pier Ave. sensor in the Mesa2 zone; however, the analysis presented here suggests this location should be in the San Luis Obispo or NRP zone. Balancing the larger uncertainty of the sensor data (versus EBAM data) against the freshness of the sensor data, the boundaries in this area were revised to put this location in the NRP zone.

Finally, and unrelated to the forecast zone boundaries, this analysis provides further evidence for reductions in PM_{10} levels at CDF caused by ODSVRA mitigation measures installed upwind of site starting 2018. As shown in Figure 7, the average wind-event day CDF/Mesa2 PM_{10} ratio is 1.178; as shown in Figure 8, the average difference in concentrations was 10.7 μg/m^3. These values were calculated using data from 1/1/2017 through 2/5/2021. In Figures 9 and 10, these values are recalculated, but using only more recent data, collected from 3/1/2019 through 4/30/2021. Considering only this more recent data, the values indicate that CDF and Mesa2 concentrations are more similar—1.035 and 2.2 μg/m^3, respectively—demonstrating the attenuation of wind-event PM_{10} at CDF.

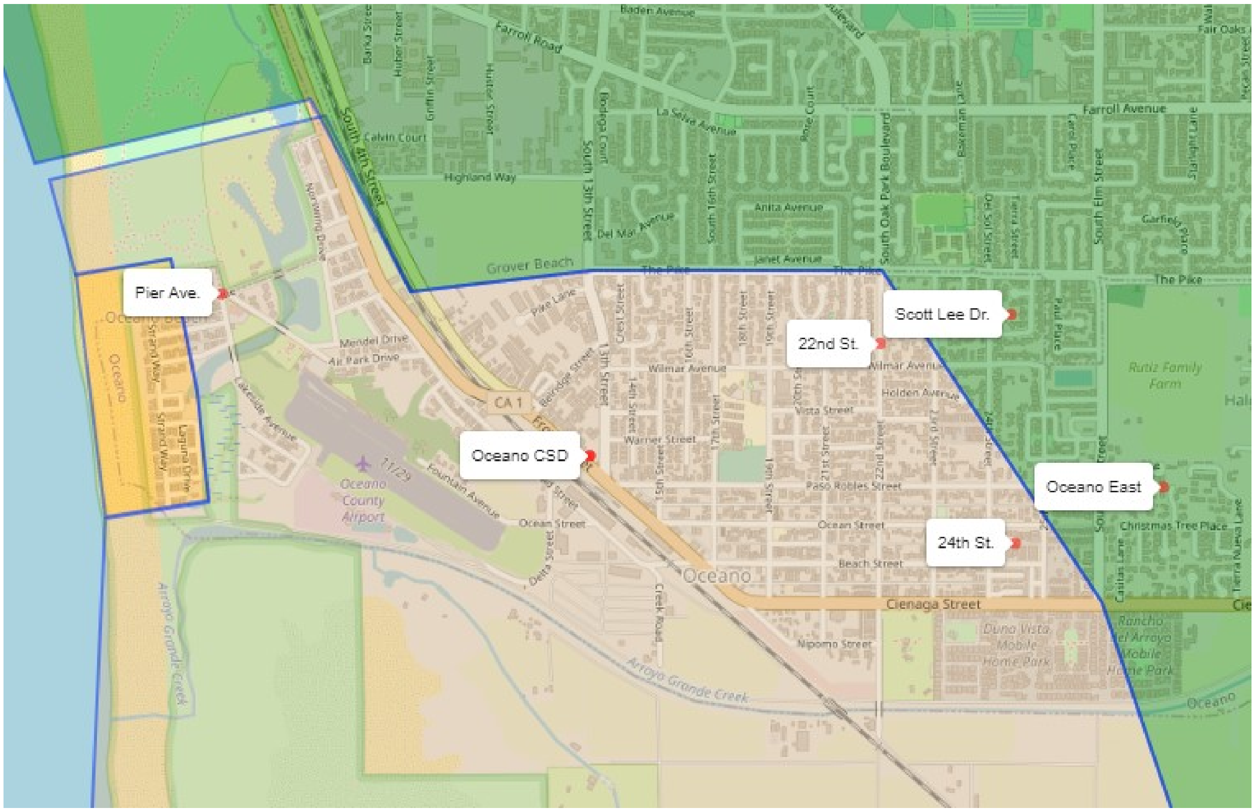

Figure 12 Revised Forecast Map in Oceano. Forecast Zones: Orange - Mesa2; Tan - NRP; Green – San Luis Obispo.

Conclusions and Recommendation

Based on more recent data from new locations, it is recommended that forecast zone boundaries be redrawn as shown in Figures 11 and 12. This revision essentially enlarges the NRP forecast zone, while shrinking the Mesa2 and San Luis Obispo zones. With these recommended changes, all of Arroyo Grande, Pismo Beach, and Grover Beach remain in the San Luis Obispo zone. The portion of Oceano in the Mesa2 zone would shrink to the area within about 1,000 ft. of the mean high tide line. Most of Oceano east and north of Highway 1 (Cabrillo Hwy./Cienaga St.) would be reclassified from the San Luis Obispo zone to the NRP zone. The eastern boundary of the Mesa2 zone would move seaward, changing the area around Dorothea Lange Elementary School from the Mesa2 zone to the NRP zone.

This analysis confirms that the Lopez High School area, the Northview Ave. area, and the Oso Flaco area are appropriately in the Mesa2, NRP, and NRP zones, respectively. Finally, this analysis provides additional evidence that wind-event day PM_{10} levels at CDF have been attenuated in recent years relative to Mesa2; the likely cause of this is the dust mitigation measures installed upwind of the site.