APPENDIX B

Meteorological and Air Dispersion Modeling Methodology

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Appendix B: Meteorological and Air Dispersion Modeling Methodology

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In this appendix, we describe the model selection for application in this study. We also describe the methodologies and key inputs for meteorological and air dispersion modeling.

B.1 Model Selection

The selection of an air dispersion model depends on many factors, such as, the nature of the pollutant (e.g., gaseous, particulate, reactive, inert), the characteristics of emission sources (point, area, volume, or line), emission source and receptor relationship, the meteorological and topographic complexities of the area, the complexity of the source distribution, the spatial scale and resolution required for the analysis, the level of detail and accuracy required for the analysis, and averaging times to be modeled. Several models approved by the United States Environmental Protection Agency (U.S. EPA) and other groups are available to quantify pollutant impacts from the diesel particulate matter (diesel PM) sources near and in the West Oakland community. These models include: ISCST3, AERMOD, ASPEN, CALPUFF, UTM-TOX, and CAMx. For this study we have selected the CALPUFF model. Below, we describe each model and discuss its application to the West Oakland community evaluation and provide the basis for selection of the CALPUFF model for this study.

<u>ISCST3 and AERMOD</u>

In the past two decades, the most commonly used model for air toxics modeling was the U.S. EPA's Industrial Source Complex model (ISCST3). The ISCST3 model is a steady-state Gaussian plume model, which can be used to assess primary pollutant concentration and deposition from a wide variety of sources. It can be applied in urban or rural areas, and has optional features to account for settling and dry deposition of particles, reactive decay, and limited terrain elevations. However, ISCST3 has been phased out by U.S. EPA and will no longer be considered as an U.S. EPA-approved model for regulatory applications. AERMOD has been developed as a replacement for ISCST3. Because AERMOD is designed for near-field and steady-state conditions, AERMOD has some inherent limitations for applications in complex terrain and for source – receptor distances exceeding roughly 50 km in all terrain situations. For example, there is no consideration in AERMOD of causal effects (i.e. the time it takes pollutants to travel from point A to point B), the trajectory of the airflow is treated as straight-line, and it relies on spatially uniform meteorological conditions. AERMOD also has very limited capability for treating chemical transformation, and it is unsuitable for estimating secondary formation of the pollutants such as nitrate and sulfate PM. Furthermore, because of the Gaussian plume model formulation, AERMOD can only consider wind data from a single location and it cannot directly simulate near stagnation conditions (i.e., very low wind speeds). These important limitations make AERMOD unsuitable for the San Francisco Bay area with its complex wind and terrain patterns.

ASPEN

The Assessment System for Population Exposure Nationwide (ASPEN) was developed for the inhalation component of U.S. EPA's Cumulative Exposure Project (Rosenbaum et al. 1999). ASPEN includes an air dispersion module similar to the long-term average version of ISC, i.e., ISCLT2. It includes treatment of wet and dry deposition for particles, and simple treatment of chemical transformation. The concentrations estimated from ASPEN are designed to represent population-weighted averages over a size scale of census tracts or several square kilometers (i.e., middle-scale to neighborhood-scale). ASPEN can utilize meteorological information from several locations, and includes a simplified treatment of secondary formation of gaseous air toxics. Although ASPEN has been used in an U.S. EPA's air toxic modeling study (Rosenbaum et al. 1999) and the ARB's community risk study (http://www.arb.ca.gov/toxics/cti/hlthrisk/hlthrisk.htm), it lacks the capability to fully incorporate 3-dimensional wind fields. As such, wind fetches from the points of emission release are assumed to be straight lines, regardless of the patterns at downwind locations; and wind patterns in upper layers are derived from surface patterns based on atmospheric stability and land use (i.e., urban or rural), rather than being independently estimated. In addition, ASPEN is a micro-scale model and it only can be used when there are distances of less than 50 km between the emission source and receptors. Given the significant terrain features in the San Francisco Bay area, the complex wind patterns within the modeling domain, and greater than 50 km distance between the emission sources and receptors, ASPEN's assumptions of straight wind fetches and other characteristics would be inadequate for use in this study.

UAM-TOX

The Urban Airshed Model for Toxics (UAM-TOX) is an enhanced version of U.S. EPA's UAM model. It is a three-dimensional grid model designed to simulate all-important physical and chemical processes that occur in the atmosphere. The model incorporates mathematical representations of the processes of transport, diffusion, chemical reaction and deposition. UAM-TOX has been used in several air toxic studies, such as the Southern California MATES-II study. However, because UAM-TOX is a grid based model, all emissions are characterized as being spread uniformly over a 3-dimensional grid cell. This characterization may result in a significant loss of spatial resolution information for the emission sources included in the West Oakland community study. In addition, UAM-TOX treats emission sources as ground level releases for area emission sources. This is not suitable for this study since most sources have a release height of at lease 3 meters as well as hot exhaust resulting in an effective release height of at least 5 meters.

CAMx

CAMx is a multi-scale photochemical model designed to simulate primary and secondary pollutants over a large range of spatial scales from hundreds to thousands of kilometers using a flexible, nested grid structure. It is a 3-dimensional Eularian (grid based) dispersion and photochemical model. It is capable of treating the transport, dispersion, and chemical reaction and removal of a wide variety of gaseous and particulate pollutants. CAMx includes plume-in-grid algorithms for treating near-source, sub-grid scale dispersion. Nevertheless, CAMx requires a gridded emission input (except for point sources). This means that area sources can be no smaller in size than a single grid cell. This is not suitable for the West Oakland community study where many emission sources are much smaller in size than a single grid cell. In addition, for area source emissions, CAMx treats the emission source as a ground level release. Again, this is not suitable for our study since most sources have a release height of at least 3 meters as well as hot exhaust resulting in an effective release height of at least 5 meters. Some sources are even higher. For example, for transiting ships, the effective release height could reach 50 meters.

CALPUFF

As one of the U.S. EPA's preferred air dispersion models, CALPUFF is a multi-layer, multi-species non-steady-state puff dispersion model that can simulate the effects of time- and space-varying meteorological conditions on pollutant transport, transformation, and removal. CALPUFF is designed to be applied on scales of tens of meters to tens of kilometers (near-field) and from tens of kilometers to hundreds of kilometers (far-field). It includes algorithms for sub-grid scale effects, such as terrain impingement, as well as, longer range effects, such as pollutant removal due to wet scavenging, dry deposition, and reactive decay. CALPUFF can handle various types of emission source characterization, such as point, volume, line, and area sources. The non-steady-state nature allows CALPUFF to account for causal effects and non-straight-line trajectories. More importantly, CALPUFF can account for spatially varying meteorological conditions with a three-dimensional wind field. As such, in many situations CALPUFF is capable of producing more accurate results than other models, such as AERMOD. The technical decision on choosing a puff model or a plume model is based on considerations of pollutant transport distance and the potential for temporally and/or spatially varying flow fields due to influences of complex terrain, non-uniform land use patterns, coastal effects, and stagnation conditions characterized by calm or very low wind speeds with variable wind directions.

Selection of CALPUFF for the West Oakland Community Study

Due to their inability to treat complex wind patterns, ISCST3, AERMOD, and ASPEN are judged to be unsuitable for application to the San Francisco Bay area. UAM-TOX and CAMx are able to simulate complex wind patterns with 3-dimensional wind fields, but both lack the ability to provide fine spatial resolution of emission allocation and are unable to handle elevated emission sources. Conversely, CALPUFF has the ability to simulate complex 3-D wind fields and to treat emission sources in fine spatial resolution and to handle elevated emission sources. As summarized below, CALPUFF can be used in many situations:

- Near-field impacts in complex flow or dispersion
  - Complex terrain (terrain channeling, slop flows)
  - Inhomogeneity in surface conditions/dispersion rates, urban/rural, land/water
  - Land use variations
  - Pollutant build-up in valleys, stagnation, inversion, recirculation, and fumigation conditions
  - Over water transport and coastal conditions
  - Light wind speed and calm wind conditions

- Mesoscale and/or long range transport
  - Spatial variability in meteorological fields
  - Causality effects (i.e. the time it takes pollutants to travel to the terrain features)
  - Chemical transformation, wet deposition, dry deposition
  - Mesoscale circulations (land/lake breeze circulations, up/down valley flows)

- Multiple source impacts within a spatially-varying field
  - Cumulative impact assessments
  - Source contributions
  - Non-steady state release

These model features are relevant to this study that needs to simulate the transport and dispersion of diesel PM emissions from a wide variety of sources impacting the West Oakland community including operations at the Port of Oakland, trucks traveling on nearby freeways, and ships transiting in the San Francisco Bay area which has complex flows and terrain.

B.2 Meteorological Modeling Approach (CALMET)

The CALMET meteorological processor is a key component of the CALPUFF modeling system. Its primary purpose is to prepare meteorological inputs for running CALPUFF, consisting of 3-D wind fields, 2-D gridded derived boundary layer parameter fields (e.g. mixing height, friction velocity, Monin Obukhov length, etc.), and 2-D gridded fields of surface measurements and precipitation rates (for use in calculating wet deposition fluxes). Execution of the CALMET meteorological model requires establishment of the modeling domain (meteorological grid), preprocessing and quality assuring meteorological and geophysical input data, and determination of appropriate control file settings. Meteorological input data include surface, upper-air, and overwater data. MM5 data can be used as an initial wind field estimate. Geophysical input data include terrain and land-use data.

B.2.1 Modeling Domain

The CALMET/CALPUFF modeling system uses a grid system consisting of an array of horizontal grid cells and multiple vertical layers. Three gridded domains need to be defined in the CALMET/CALPUFF model – meteorological, computational, and sampling. The meteorological gridded domain defines the extent over which land use, winds, and other meteorological variables are defined. The computational gridded domain defines the extent of the concentration calculations, and is required to be identical to or a subset of the meteorological domain. The sampling or receptor domain defines the extent over which receptors are arranged with a nesting factor. (A nesting factor of one means the sampling grid cell size equal to the cell size of the computational grid.) The sampling grid must be identical to or a subset of the computational grid. It may also be nested inside the computational grid, i.e., several sampling grid cells per computational grid cell.

In this study, the modeling domain includes the Port of Oakland Maritime facility (Port), the ocean to the west of the Golden Gate Bridge out to the outer buoys, the inner bay waterway between Golden Gate Bridge and the Port, and the nearby communities. The size of the modeling domain has been determined by considering that the domain should cover all ship travel routes in the nearby ocean and the inner waterways to and from the Port, the Port property, and other land-based areas capturing an area with expected risks level of 10 per million or greater based on a screening analysis using CALPUFF. The modeling domain is shown in Figure B-1. The size of the domain is 100 km by 100 km, which is sufficiently small that the flat earth approximation is valid and the UTM coordinate system was used in the assessment. The southwest corner of the domain is located at UTM coordinate 505 km Easting and 4135 km Northing and the northeast corner at 605 Easting and 4235 Northing (Zone 10), as indicated in Figure B-1. Selection of grid cell size reflects a compromise between the desire to define meteorological and geophysical variations on a very small scale, and the computer time and resources necessary to do so. Given the complex terrain (sea-land, rolling mountains), non-uniform land-use characteristics, and water surfaces large enough to cause strong local-scale flows, we selected a grid cell size of 0.5 km x 0.5 km for the meteorological modeling. To provide a more detailed estimate of localized impacts of the emissions on the nearby community of the Port (West Oakland community), we used a grid cell size of 250 m x 250 m for the areas bordering the Port.

The meteorological grid was defined by 10 vertical layers. Cell heights were set at 20, 60, 80, 100, 300, 600, 1000, 1500, 2200, and 3000 meters above-ground level (AGL)

CALMET/CALPUFF was set to run for the period of January 1 through December 31, 2000. A one-year period is necessary to enable estimation of the annual average concentrations which are required in a health impact assessment.

Figure B-1: Modeling Domain (100 km x 100 km)

B.2.2 Geophysical Data

CALMET requires geophysical data in order to prepare the wind fields and other meteorological parameters. The geophysical data include:

- Land use categories
- Terrain elevations
- Surface roughness length
- Albedo
- Bowen ratio
- Soil heat flux parameter
- Vegetation leaf area index
- Anthropogenic heat flux

As described below, these data were derived from terrain and land use data and processed into gridded fields within the modeling domain.

B.2.2.1 Terrain Data

Gridded terrain elevations for the modeling domain were derived from 3 arc-second Digital Elevation Models (DEM) produced by the United States Geological Survey (USGS). Elevations are in meters relative to mean sea level. The spacing of the elevations along each profile is 3 arc-seconds, which corresponds to a spacing of approximately 90 meters.

As defined above, the CALMET computational domain encompasses an area of 100 km x 100 km. A horizontal grid spacing of 0.5 km in the horizontal was selected to adequately represent the important terrain features. The raw terrain data were processed into each gridded cell (0.5 km x 0.5 km) within the domain. The gridded terrain elevations for the whole domain of CALMET (100 km x 100 km) are presented in Figure B-2. This terrain field effectively resolves major land features in the model domain.

B.2.2.2 Land Use Data

Land use and land cover (LULC) data were downloaded from the USGS at the 1:250,000-scale with file names corresponding to the 1:250,000-scale map names. CALMET defined 14 default land use categories (Table B-1). Land use data were processed to produce a 0.5-km resolution gridded field of fractional land use categories and land use weighted values of surface and vegetation properties for each CALMET grid cell. Surface properties, such as albedo, Bowen ratio, roughness length, soil heat flux, and leaf area index are computed proportionally to the fractional land use within each grid cell. The default values for these land use related parameters are listed in Table B-1. The distribution of land use types within each grid cell was used to establish composite values for these parameters. For example, if 50% of the LULC land use data values allocated to a grid cell were type 10 (Bowen ratio = 1.5) and the other 50% type 20 (Bowen ratio = 1.0), the composite Bowen ratio for the cell was set to 1.25. The generated land use categories for each CALMET grid cell are shown in Figure B-3.

Figure B-2: Terrain Elevations within the Modeling Domain

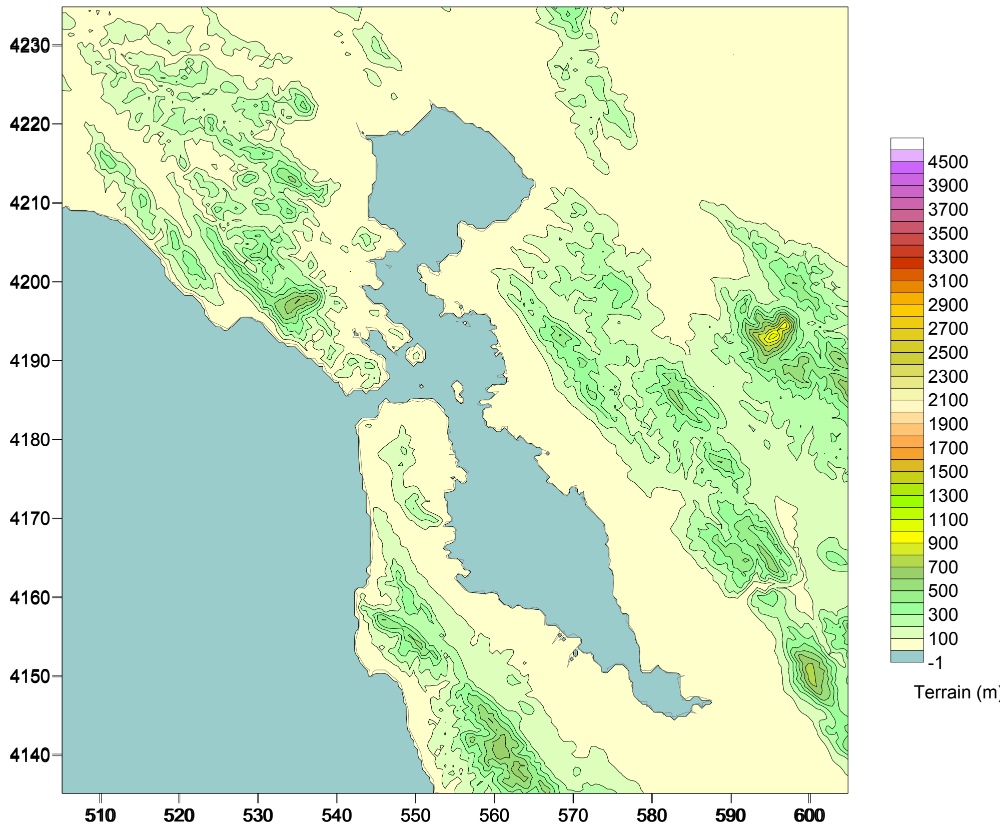


Table B-1: Default CALMET Land Use Categories and Associated Geophysical Parameters based on the U.S. Geological Survey Land Use Classification System (14-Category System)
(Adopted from Scire, et al., 2000a)

Land Use Type	Description	Surface Roughness (m)	Albedo	Bowen Ratio	Soil Heat Flux Parameter	Anthropogenic Heat Flux (W/m ^{2})	Leaf Area Index
10	Urban or Built-up Land	1.0	0.18	1.5	.25	0.0	0.2
20	Agricultural Land – Unirrigated	0.25	0.15	1.0	.15	0.0	3.0
-20*	Agricultural Land – Irrigated	0.25	0.15	0.5	.15	0.0	3.0
30	Rangeland	0.05	0.25	1.0	.15	0.0	0.5
40	Forest Land	1.0	0.10	1.0	.15	0.0	7.0
50	Water	0.001	0.10	0.0	1.0	0.0	0.0
54	Small Water Body	0.001	0.10	0.0	1.0	0.0	0.0
55	Large Water Body	0.001	0.10	0.0	1.0	0.0	0.0
60	Wetland	1.0	0.10	0.5	.25	0.0	2.0
61	Forested Wetland	1.0	0.1	0.5	0.25	0.0	2.0
62	Nonforested Wetland	0.2	0.1	0.1	0.25	0.0	1.0
70	Barren Land	0.05	0.3	1.0	.15	0.0	0.05
80	Tundra	.20	0.3	0.5	.15	0.0	0.0
90	Perennial Snow or Ice	0.05	0.7	0.5	.15	0.0	0.0

*Negative Values indicate “irrigated” land use.

Figure B-3: Spatial Land Use Index within the Modeling Domain
(See Table B-2 for details)

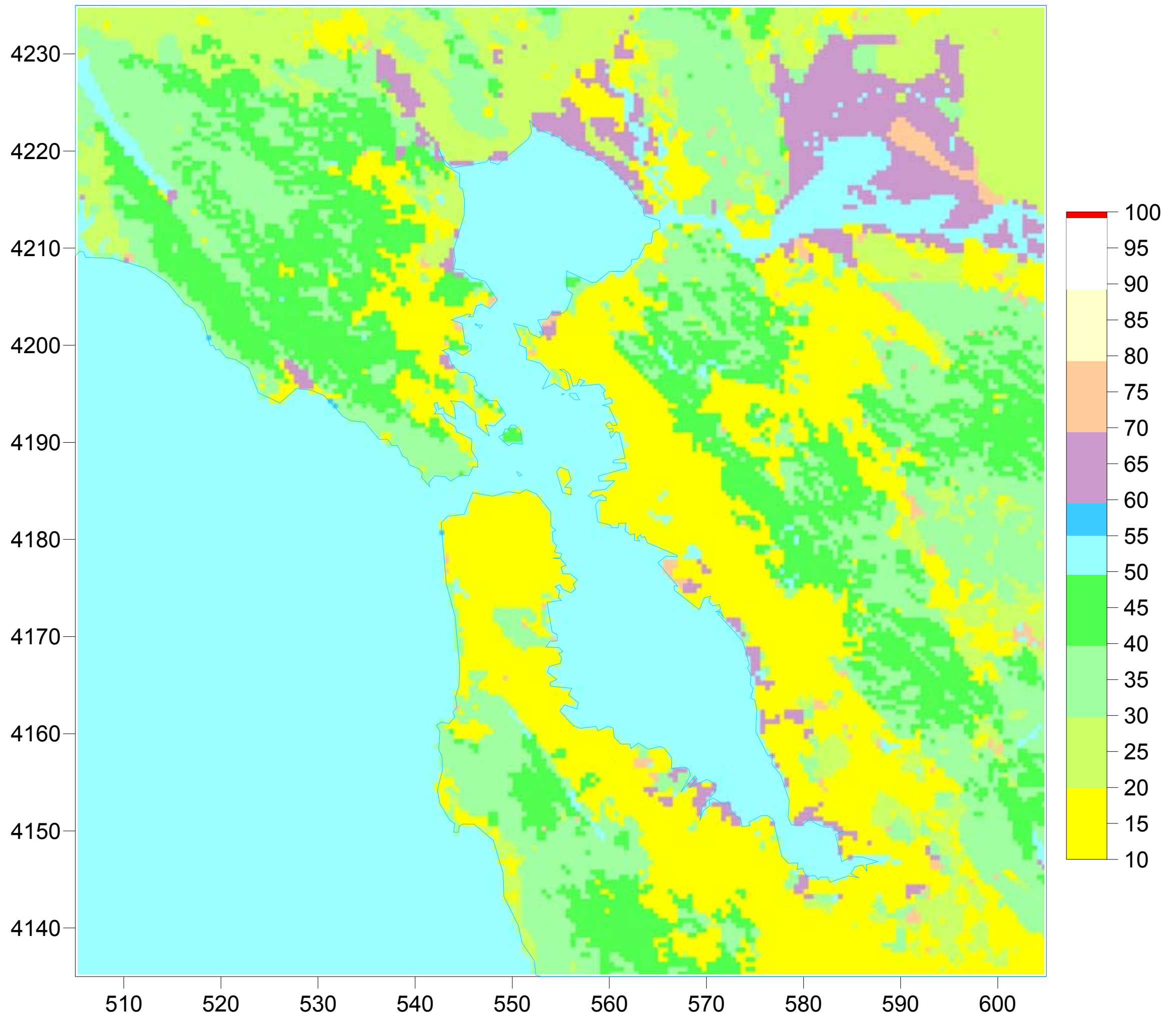


Table B-2: U.S. Geological Land Use and Land Cover Classification System
(Adopted from Scire et al., 2000a)

Level I		Level II	
10	Urban or Built-up Land	11	Residential
		12	Commercial and Services
		13	Industrial
		14	Transportation, Communications and Utilities
		15	Industrial and Commercial Complexes
		16	Mixed Urban or Built-up Land
		17	Other Urban or Built-up Land
20	Agricultural Land	21	Cropland
		22	Orchards, Groves, Vineyards, Nurseries, and Ornamental Horticultural Areas
		23	Confined Feeding Operations
		24	Other Agricultural Land
30	Rangeland	31	Herbaceous Rangeland
		32	Shrub and Brush Rangeland
		33	Mixed Rangeland
40	Forest Land	41	Deciduous Forest Land
		42	Evergreen Forest Land
		43	Mixed Forest Land
50	Water	51	Streams and Canals
		52	Lakes
		53	Reservoirs
		54	Bays and Estuaries
		55	Oceans and Seas
60	Wetland	61	Forested Wetland
		62	Nonforested Wetland
70	Barren Land	71	Dry Salt Flats
		72	Beaches
		73	Sandy Areas Other then Beaches
		74	Bare Exposed Rock
		75	Strip Mines, Quarries, and Gravel Pits
		76	Transitional Areas
		77	Mixed Barren Land
80	Tundra	81	Shrub and Brush Tundra
		82	Herbaceous Tundra
		83	Bare Ground
		84	Wet Tundra
		85	Mixed Tundra
90	Perennial Snow/Ice	91	Perennial Snowfields
		92	Glaciers

B.2.3 Meteorological Data

The recommended meteorological inputs to CALPUFF are the time-dependent outputs of CALMET, a meteorological model that contains a diagnostic wind field module and over-water and over-land boundary layer modules (Scire et al., 2000b). The outputs of CALMET are hourly gridded fields of micro-meteorological parameters and three-dimensional wind and temperature fields. The wind field module in CALMET combines an objective analysis procedure using wind observations with parameterized treatments of slope flows, valley flows, terrain kinematic effects, terrain blocking effects, and sea/lake breeze circulations. The boundary layer modules of CALMET produce gridded fields of micrometeorological parameters, such as friction velocity, convective velocity scale, and Monin-Obukhov lengths, as well as mixing heights and PGT stability classes...

Three options were considered for initializing the wind field in CALMET:

1. Observations (surface, upper air, and buoy) and MM5

2. Observations only

3. MM5 only

For the first option, MM5 data are used as the initial wind field and then local topography and weather observations (surface, upper-air, and buoy) are used to refine the wind field predetermined by MM5 data. The use of MM5 data as the initial wind field has been found to improve the overall wind field characterization in most applications. If MM5 data are not available, then the second option, the use of local observations including surface, upper air, and buoy, must be selected. It has been reported that the first option has provided better results than use of local observations alone. The third option, the use of MM5 data alone to drive the CALMET analysis has not provided consistent results, and is considered the least desirable approach.

At the time work on this study was initiated, MM5 data for the San Francisco Bay area was not available. Because of this, observations from land-based surface stations, over-water buoys, upper air measurements, terrain elevations, and land use categories were used to create the CALPUFF meteorological fields. Descriptions of the local observations used as inputs to CALMET are described in sections B.2.3.1 through B.2.3.3.

As the study was well underway, MM5 data for the San Francisco Bay area became available. This was used to generate second CALMET data set which incorporated the MM5 data and observations from land-based surface stations, over-water buoys, and upper air measurements. This data set was then used to conduct sensitivity studies for wet and dry deposition (Appendix H).

B.2.3.1 Surface Data

CALMET requires hourly surface observations for

- Wind speed
- Wind direction
- Temperature
- Cloud cover
- Ceiling height
- Surface pressure
- Relative humidity
- Precipitation type (e.g., snow, rain, etc.)

Hourly surface meteorological data used in this study were obtained from two sources: the National Climatic Data Center (NCDC) and the Bay Area Air Quality Management District (BAAQMD). The original NCDC surface meteorological data were in DATSAV3 format and were converted into the CD-144 format. The parameters include: wind speed, wind direction, dry bulk temperature, opaque cloud cover, and ceiling height. There are thirteen available hourly surface meteorological data sets within or near the modeling domain. These stations are graphically presented in Figure B-4 and the corresponding information is presented in Table B-3.

In addition, seventeen hourly surface measurements collected by the BAAQMD were also used in this study. These data include: wind speed, wind direction, temperature, relative humidity, stability, sigma theta, and solar insolation. The first four parameters were processed and merged with the 13 NCDC data sets into the final file. The 17 monitoring stations are graphically presented in Figure B-4 and the corresponding information is presented in Table B-3.

Figure B-4: Meteorological Stations Within or Near the Modeling Domain

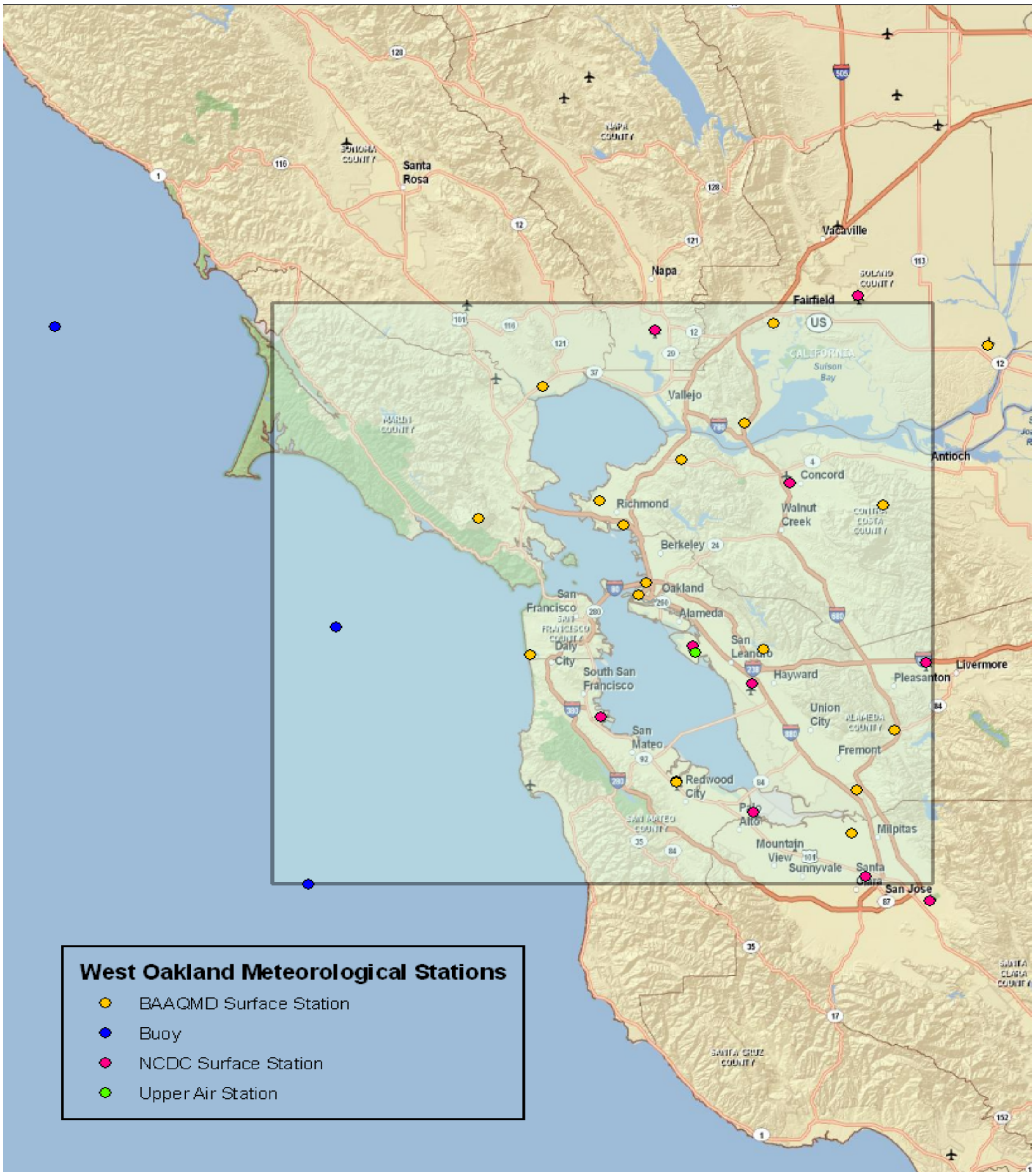


Table B-3: Selected Meteorological Stations for Surface, Buoy, and Upper Air Measurements in the San Francisco Bay Area

Category	ID	Station Name	UTM X(km)	UTM Y(km)	Sources
Surface Stations	24955	Napa Co. Airport	563.031	4230.289	NCDC
	24936	Concord/Buchanan	583.439	4203.839	NCDC
	24935	Hayward Air Terminal	577.615	4169.383	NCDC
	24927	Livemore Municipal	604.033	4173.001	NCDC
	24930	Oakland Airport	568.740	4175.962	NCDC
	24937	Palo Alto Airport	577.823	4147.193	NCDC
	24946	San Jose/Reid/Hillv	604.548	4131.950	NCDC
	24940	San Francisco Intl	554.720	4163.652	NCDC
	24945	San Jose Intl	594.752	4136.271	NCDC
	24938	San Carlos Airport	566.282	4152.641	NCDC
	45160	Travis AFB/Farefield	593.607	4236.132	NCDC
	1803	NUMMI	593.387	4151.102	BAAQMD
	1804	Oakalnd STP	561.708	4186.701	BAAQMD
	1805	Port of Oakalnd	560.408	4184.718	BAAQMD
	1903	Chabot	579.392	4175.220	BAAQMD
	1904	Sunol	599.208	4161.329	BAAQMD
	2703	Chevron Refinery	554.539	4200.849	BAAQMD
	2760	Phillips Carbon	567.005	4207.926	BAAQMD
	2905	Kregor Peak	597.429	4200.082	BAAQMD
	2950	UC Richmond	558.194	4196.566	BAAQMD
	3901	Mt. Tamalpais	536.169	4197.835	BAAQMD
	5905	Fort Funston	544.026	4174.290	BAAQMD
	6901	San Carlos	566.118	4152.496	BAAQMD
	7905	Alviso	592.645	4143.610	BAAQMD
	8702	Valero Warehouse	576.588	4214.271	BAAQMD
	8901	Rio Vista	613.352	4227.509	BAAQMD
	8902	Suisun STP	580.903	4231.417	BAAQMD
	9903	Sonoma Baylds	546.040	4220.548	BAAQMD
Buoys	46026	18 NM West OF SF	514.680	4179.077	NDBC
	46012	Half Moon Bay, SW of SF	510.503	4134.909	NDBC
	46013	Bodega Bay, NW of SF	472.283	4230.827	NDBC
Upper Air Station	23230	Oakland Airport	569.039	4174.668	NCDC

Note: NDBC - National Data Buoy Center; NCDC - National Climate Data Center.
BAAQMD - Bay Area Air Quality Management District

B.2.3.2 Over-Water (Buoy) Data

Because the modeling domain and the emission sources extend over the ocean, over-water meteorological data are also required. Buoy data can enhance the simulation of meteorological conditions in marine environments since turbulent dispersion over-water is different from over-land. The required over-water measurements required by CALMET are available for the Pacific Ocean near the U.S. coastline from the National Data Buoy Center (NDBC). The measurements are taken from buoys that are at varying distances from the coast. While most of the buoys are owned and operated by NDBC, there are also several other agencies that submit their data to the NDBC database. Over-water measurements available include:

- Air-sea temperature difference
- Air temperature
- Relative humidity
- Over-water mixing height
- Wind speed
- Wind direction
- Over-water temperature gradients above and below mixing height

Data from three NDBC moored buoys near the San Francisco Bay Area were used in this study: San Francisco (Station 46026), Bodega Bay (Station 46013), and Half Moon Bay (Station 46012). Data for the year 2000 were used. The locations and station coordinates of the three buoys are provided in Figure B-4 and Table B-3.

B.2.3.3 Upper Air Data

CALMET also requires upper air sounding data which are typically available from NCDC or the National Weather Service (NWS) stations. Upper air data required by CALMET are standard NCDC format TD6201 radiosonde data including wind speed, wind direction, temperature, pressure, and elevation. These observations are collected twice a day at multiple levels in the atmosphere and serve as vertical profiles. There are two upper air stations available in the San Francisco Bay area: The Oakland International Airport and Pillar Point. The Oakland International Airport was selected as the source for upper air data for this study. NCDC staff has indicated that this station has reliable, complete, and representative upper air station in the Northern California. In addition, the Oakland International Airport station is very close to the Port of Oakland (about 3-4 miles). Pillar Point was not selected as it is not a full-time station and has many incomplete data sets.

B.2.4 CALMET Modeling

B.2.4.1 Data Processing

Four types of data need to be processed prior to input into the CALMET model: geophysical, upper air, surface, and overwater data. Figure B-5 depicts the flow chart for the data processing.

The DEM data was extracted for the modeling domain grid using the utility program TERREL. Land-use data were extracted from the USGS files and processed using utility programs CTGCOMP and CTGPROC. Terrain elevations and the corresponding land use parameters were assigned to each CALMET grid cell for a GEO.DAT file for input to CALMET using the MAKEGEO processor by interpolating the DEM and LULC data.

Since the modeling domain spans both over-water and over-land regions, the global self-consistent hierarchical high-resolution shoreline (GSHHS) was used to define the coastal lines. For the meteorological data, the missing data were filled before processing. Note that CALMET requires at least one valid record among all stations at any given hour for a given parameter such as wind speeds. Therefore, when all records simultaneously missed relevant records, surrogate data were generated by interpolating values from the previous and/or subsequent record. If data were missing for a longer period such as a day, the missing data were filled by repeating the previous or subsequent day. Table B-4 lists the completeness of the raw surface meteorological data for major parameters, including wind speed, wind direction, temperature, relative humility, and cloud cover.

The surface data were processed with the CALMET preprocessor utility program, SMERGE, to create the SURF.DAT file for input to CALMET. The upper air data were processed by the CALMET preprocessor utility program, READ62, to create an upper air file for each station (UPn.DAT). The over water meteorological data were processed into an over-water surface station format (i.e., SEA.DAT) for input to CALMET.

B.2.4.2 CALMET Parameter Settings

There are numerous operating parameters that must be established for CALMET to help define how the meteorological data will be treated in the model. While CALMET provides default values for most parameters, there are several key parameters that require selection by the user. Below, we provide a brief description of each parameter and the value selected by ARB staff that was used in this study.

Figure B-5: Meteorological Data Processing Flow Chart

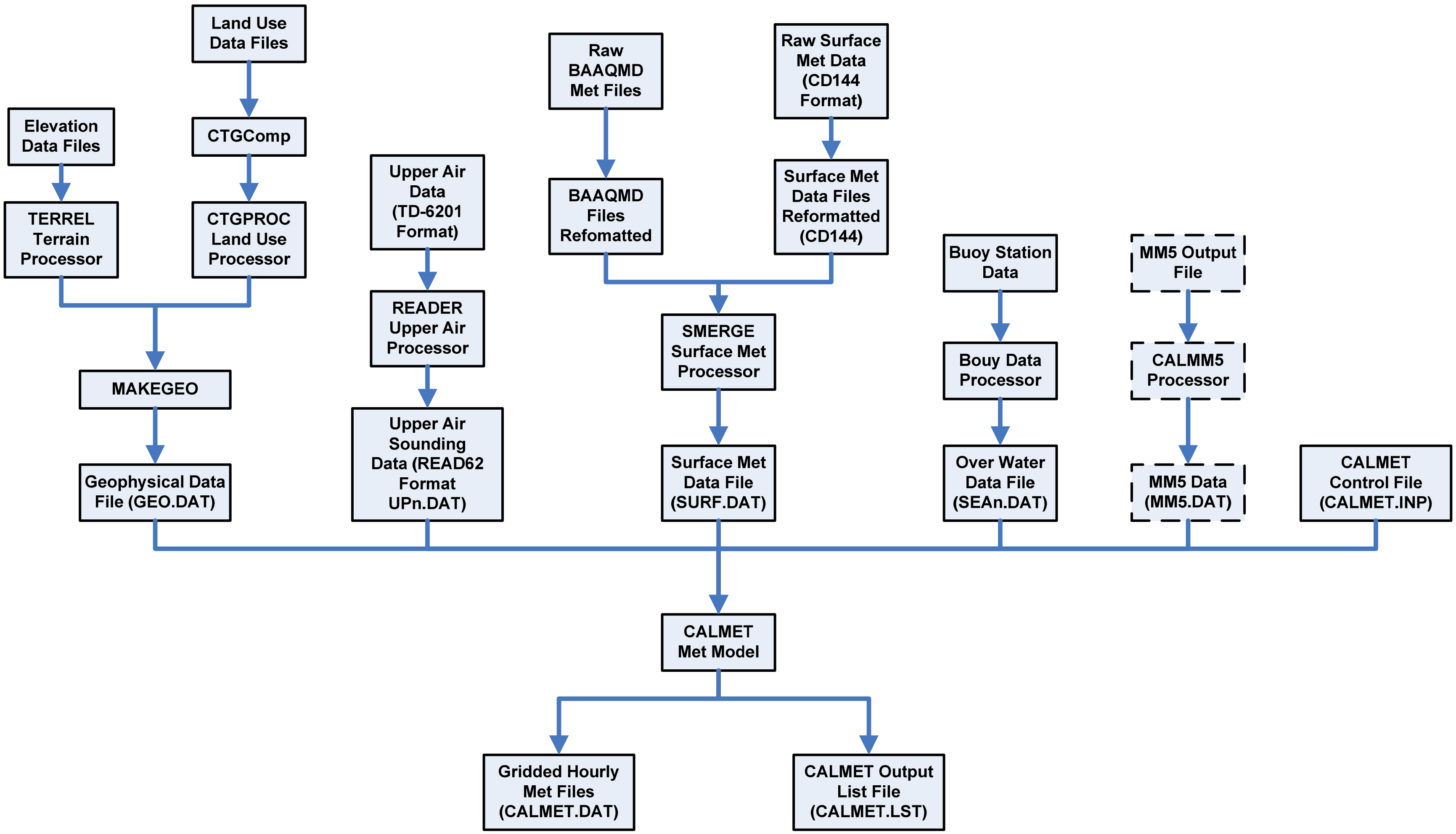


Table B-4: Completeness of the Raw Surface Meteorological Data

Station ID	Location	WS	WD	T	RH	Cloud Cover
24955	Napa County Airport	95.57%	95.14%	97.52%	N/A	96.41%
24936	Concord/Buchanan	90.29%	89.98%	94.21%	N/A	94.17%
24935	Hayward Air Terminal	95.46%	95.26%	97.61%	N/A	97.52%
24927	Livermore Municipal	92.17%	91.77%	96.03%	N/A	96.27%
24930	Oakland Airport	95.72%	95.72%	97.79%	N/A	97.84%
24937	Palo Alto Airport	51.05%	51.05%	58.69%	N/A	58.95%
24946	San Jose/Reid/Hillv	59.68%	59.68%	61.37%	N/A	63.10%
24830	Sacramento Executive	91.89%	91.79%	97.31%	N/A	97.58%
24940	San Francisco Intl.	96.20%	95.54%	97.48%	N/A	97.47%
24945	San Jose Intl.	92.63%	92.55%	97.71%	N/A	97.72%
24938	San Carlos Airport	52.14%	52.14%	58.67%	N/A	59.45%
24957	Santa Rosa	91.99%	91.58%	96.88%	N/A	97.22%
45160	Travis AFB/Fairfield	84.37%	83.90%	97.34%	N/A	97.42%
1803	Nummi	96.84%	96.84%	96.73%	60.42%	N/A
1804	Oakland STP	99.97%	99.97%	99.97%	99.97%	N/A
1805	Port of Oakland	99.84%	99.84%	0.00%	0.00%	N/A
1903	Chabot	99.98%	99.98%	99.98%	0.00%	N/A
1904	Sunol	99.34%	99.34%	99.43%	0.00%	N/A
2703	Chevron Refinery	99.29%	99.29%	99.91%	0.00%	N/A
2760	Phillips Carbon	97.94%	96.73%	96.73%	0.00%	N/A
2905	Kregor Peak	99.54%	99.54%	99.90%	0.00%	N/A
2950	UC Richmond	99.97%	99.97%	99.97%	0.00%	N/A
3901	Mt. Tamalpais	99.76%	98.08%	99.67%	0.00%	N/A
5905	Fort Funston	97.91%	97.91%	97.91%	97.91%	N/A
6901	San Carlos	99.98%	99.98%	99.98%	99.98%	N/A
7905	Alviso	99.95%	99.95%	99.95%	0.00%	N/A
8702	Valero Warehouse	98.58%	98.58%	98.58%	0.00%	N/A
8901	Rio Vista	99.93%	99.93%	99.93%	98.75%	N/A
8902	Suisun STP	99.93%	99.93%	99.93%	0.00%	N/A
9903	Sonoma Baylds	66.11%	66.11%	66.11%	0.00%	N/A

R1 and R2 – R1 and R2 affect how the surface and upper air observations are blended into the initial winds. They define a radial distance to which the winds are equal in weight to the observed surface and upper air winds. The effect of R1 and R2 is to reintroduce the observations where they exist, but not have them erase the terrain effects created during the initial processing. In this study, both R1 and R2 were set to 1 km. This selection was based on the terrain features near the observation sites. Having the relatively small value of 1 km can limit the influence of observations to a smaller area. This is important in a region such as the San Francisco Bay area with complex terrain. In complex terrain it is not appropriate to interpolate local observations to a large area as channeling (blocking effects) and slope flows contribute significantly to the wind field, and can substantially limit the spatial representativeness of a particular observation.

RMAX1, RMAX2 and RMAX3- The maximum radii of influence of observations for surface layer over land (RMAX1), for upper air layers over land (RMAX2), and for data over water (RMAX3) were set to 5 km. This setting can prevent the influence of observations in west Oakland on the wind predictions in east Oakland since the terrain features in west Oakland are very different than that on the eastern side of the city of Oakland.

RMIN - The minimum radius of influence used in the wind interpolation (RMIN) was set to 0.1 km. Observations were used for a CALMET grid if the distance of the grid to the observation site is within this limit.

IEXTRP - Vertical extrapolation was set to -4, which uses similarity theory to extrapolate surface wind observations aloft. This allows the observations made at the 10 m level have influence above the layer 1.

BIAS - The bias parameters (weighting factors) for surface and upper air observations were selected and applied to the 10 layers in this study. Bias values can range from -1.0 to 1.0. Positive bias reduces the weight of surface observation in the initialization of wind at the layer, while the negative bias reduces the weight of upper air observations. For the first layer (ground layer) and the last layer (top layer), the weighting factors were set to -1 and +1, respectively, that is, upper air observations did not have any influence on the surface observations, and the surface observations also did not have any influence on upper air observations. For the other eight layers, the weighting factors were set to 1, 0.9, 0.8, 0.5, 0, -0.5, -0.8, and -0.9.

TERRAD – This option controls the distance out from a hill or valley wall that the terrain-flows can have an effect on local winds. For this study, the option was set to 10 km which is about the distance from east Oakland to the observation site in the west Oakland.

A summary of the key CLMET parameters are provided in Table B-5.

Table B-5: CALMET Model Parameter Values or Options

Parameter	Parameter description	Values
IWFCOD	Use diagnostic wind module to develop the 3-D wind fields	Applied
IFRADJ	Froude number adjustment effects	Calculated
IKINE	Kinematic effects to adjust winds	Not applied
IOBR	O'Brien procedure for adjustment of vertical velocity	Not applied
ISLOPE	Slope flow effects	Calculated
IEXTRP	Extrapolating surface wind observations to upper layers	Similarity theory
BIAS	Layer dependent biases modifying the weights of surface and upper air stations	-1, -0.9, -0.8, -0.5, 0, 0.5, 0.8, 0.9, 1, 1.
RMAX1	Max. radius of influence over land in the surface layer	5 km
RMAX2	Max. radius of influence over land aloft	5 km
RMAX3	Max. radius of influence over water	5 km
RMIN	Min. radius of influence used in wind field interpolation	0.1 km
R1	Relative weight at surface of Step 1 field and observations	1 km
R2	Relative weight aloft of Step 1 field and observations	1 km
TERRAD	Radius of influence of terrain features	10 km
ISURFT	Surface met stations to use for the surface temperature	30
IUPT	Upper air station to use for the domain-scale lapse rate and winds	Oakland
IUPWND	Mixing height constants and variables	Default values
IRAD	Interpolation type for temperature	1/R
TRADKM	Radius of influence for temperature interpolation	50 km
IAVET	Spatial averaging of temperature	Calculated
TGDEFB and TGDEFA	Temperature gradient below and above the mixing height over water	Default values
IAVEZI	Spatial averaging for mixing heights	Calculated
MNMDAV	Max. search radius in averaging process	Default values
HAFANG	Half-angle of upwind looking cone for averaging	Default values
ILEVZI	Layer of winds used in upwind averaging	Default values
DPTMIN	Minimum potential temperature lapse rate in the stable layer above the current convective mixing ht	0.001 K/m
DZZI	Depth of layer above current conv. mixing height through which lapse rate is computed	Default values
ZIMIN	Minimum overland mixing height	20 m
ZIMAX	Maximum overland mixing height	3000 m

B.2.4.3 CALMET Model Performance

To confirm the reasonableness of the wind fields developed by CALMET, hourly wind field vectors for the first day of each season of the year for the ten vertical layers were plotted and visually evaluated. The wind roses from the surface meteorological station sites were also plotted and compared with the observations. These evaluations are discussed below.

<u>Wind Field Vectors</u>

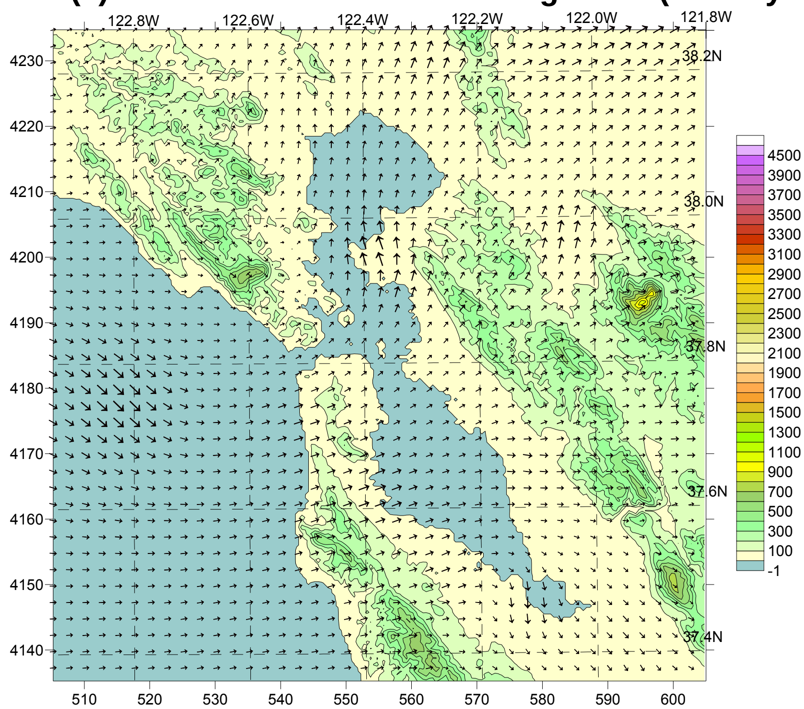
An example of the wind vector plots on July 1, 2000 at 1300 PST is provided in Figure B-6a through Figure B-6c for the surface (10 m), 600 m and 3000 m winds, respectively. Note that the length of the vector is proportional to wind speed.

In this example, surface winds were highly variable with terrain features and exhibited almost all phenomena of complex terrain, such as circulation, mountain/hill blocking, channeling, and valley flows. In the northern coastal ranges of the San Francisco Bay area, the winds were lighter and showed the damping or blocking effects (slowing of the windspeeds) of the mountains. In the inner bay, San Francisco Bay area winds flow through the Golden Bridge and then turn toward the northeast and/or north. These winds then flow into the inland valley areas of Napa, Fairfield, and Sacramento. In addition, the plot shows how the wind field converges in valley locations and diverges as it meets mountains and hills. In Figure B-6c, it can be seen that the winds at 2600 m above the surface were uniform (easterly winds) over all terrain features, which indicates that winds at 2600 m above the surface were not affected by the surface terrain. These plots demonstrate the complexity of the winds within the modeling domain and verify the reasonableness of the selection of CALMET/CALPUFF model.

All other wind vector plots are provided in Appendix G. In addition, the BAAQMD has developed the GOOGLE-based animations of the wind wield vectors for 2:00 PM of each day for the entire year of 2000 based on the CALMET outputs (http://ftp.baaqmd.gov/met).

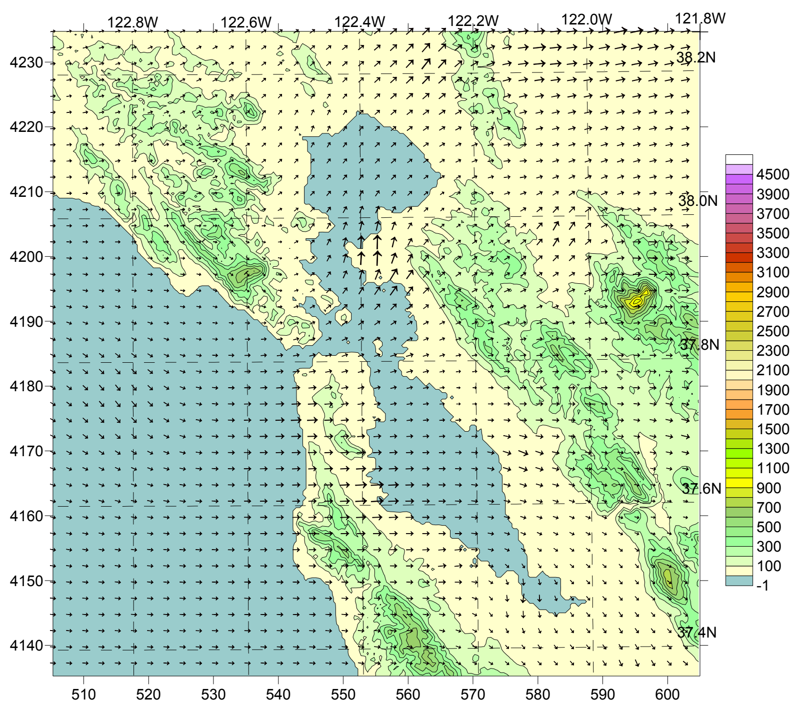
Figure B-6: Illustrations of the Wind Vectors on July 1, 2000 at 1300 PST

(a) Wind vector at 10 m above ground (first layer)



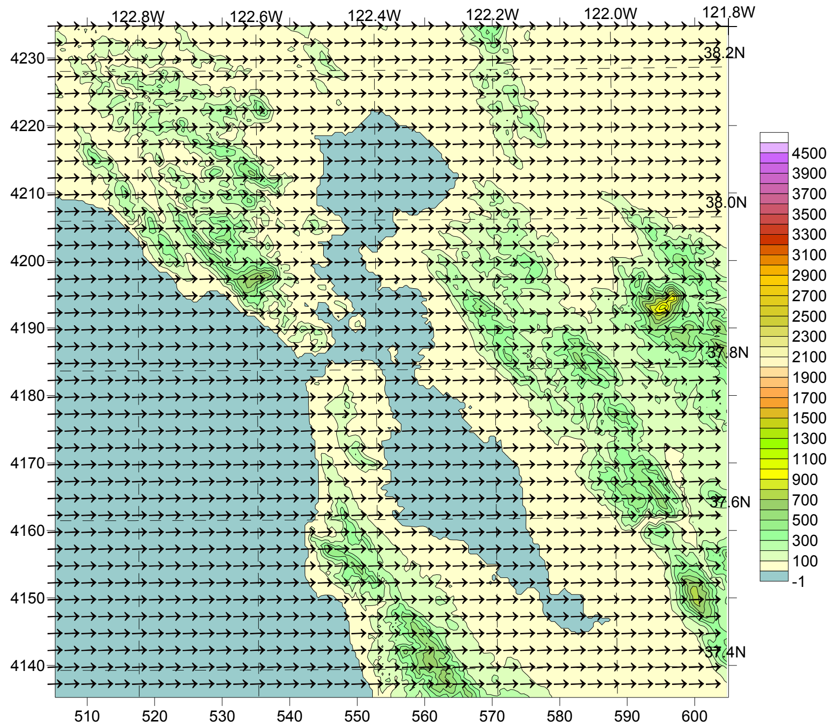
July 1, 2000, 12 to 13 pm, layer 1

(b) Wind vector at 450 m above ground (6th layer)



July 1, 2000, 12 to 13 pm, layer 6

(c) Wind vector at 2600 m above ground (top layer)



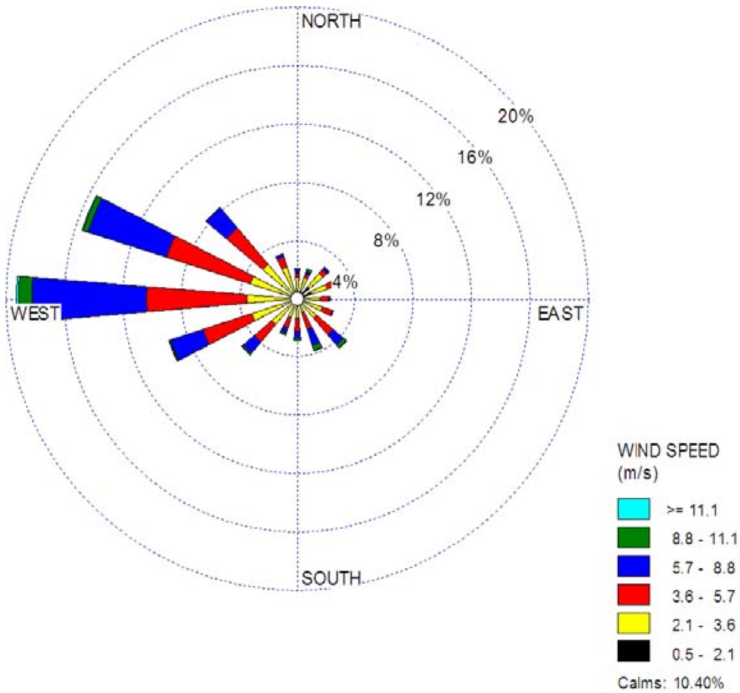
July 1, 2000, 12 to 13 pm, layer 10

<u>Wind Rose Plots</u>

A further evaluation of the reasonableness of the CALMET meteorological output was conducted by comparing the model predicted wind parameters with the observed surface wind measurements. The annual and seasonal wind roses are extracted from the CALMET outputs and plotted for all surface observation sites within the domain. These predictions are then compared against the observations for each site. Note that the extracted wind roses from the CALMET outputs are set up at the surface level, i.e., 10 m above the ground for each site. All wind roses for the observed and predicted are presented in Appendix F. Table B-6 summarizes the annual averaged results and the comparisons for major wind parameters, including wind speed, wind direction, and temperature. As can be seen in Table B-6, for most sites, the predicted wind parameter values are very close to those of the observed, especially for wind direction and temperature. For two NDCD sites (Palo Alto Airport and San Carlos Airport), the predicted wind speeds are lower than those of the observed. This may be due to the fact that since the observation data was only about 52% complete, the missing data were extrapolated from other nearby observation stations which tended to have lower wind speeds, resulting in overall lower annual average predictions. For the other five sites (Oakland STP, Port of Oakland, Phillips Carbon, Kregor Peak, and Valero Warehouse), the predicted wind speeds are

Figure B-7: Wind Roses –Measured vs. Predicted for Oakland Airport (2000)

(a) Measurement (annual avg. wind speed = 3.87 m/s)



(b) CALMET prediction (annual avg. wind speed = 3.78 m/s)

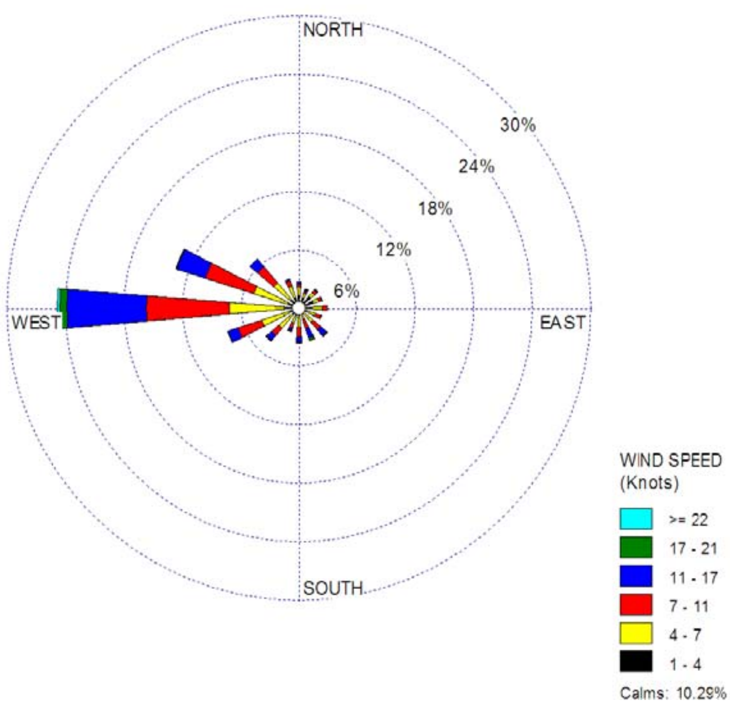


Table B-6: Comparisons of CALMET Predictions vs. Measurement for Annual Wind Speed/Directions and Temperature

The predicted winds are set up at the height of 10 meters from the ground)

(Station-ID	Location	Measurement			CALMET Simulation			Comparison		
		WS (m/s)	WD (degree)	T (K)	WS (m/s)	WD (degree)	T (K)	WS (%)	WD (%)	T (%)
24955	Napa County Airport	3.56	170.60	286.60	3.50	204.6	286.7	-1.69%	19.93%	0.03%
24936	Concord/Buchanan	3.41	177.20	288.90	3.33	194.6	288.3	-2.35%	9.82%	-0.21%
24935	Hayward Air Terminal	3.28	189.60	287.60	3.21	209.7	287.4	-2.13%	10.62%	-0.07%
24927	Livermore Municipal	3.09	166.97	287.80	2.99	185.9	287.5	-3.24%	11.34%	-0.10%
24930	Oakland Airport	3.87	205.50	286.90	3.78	221.9	286.8	-2.33%	7.98%	-0.03%
24937	Palo Alto Airport	4.21	218.00	289.30	2.98	239.6	287.8	-29.22%	9.89%	-0.52%
24940	San Francisco Intl.	4.63	201.60	286.97	4.67	225.0	286.9	0.86%	11.61%	-0.02%
24945	San Jose Intl.	3.13	204.60	288.30	3.04	240.9	288.2	-3.04%	17.73%	-0.02%
24938	San Carlos Airport	4.60	244.90	289.70	2.92	231.9	287.8	-36.61%	-5.32%	-0.66%
1803	Nummi	2.44	201.10	285.40	2.45	212.0	288.0	0.41%	5.42%	0.91%
1804	Oakland STP	3.45	230.30	286.90	2.52	230.2	286.7	-27.10%	-0.04%	-0.08%
1805	Port of Oakland	3.05	229.76	286.40	2.63	230.5	286.6	-13.77%	0.30%	0.06%
1903	Chabot	2.84	197.20	286.50	2.80	197.2	286.7	-1.41%	0.00%	0.07%
1904	Sunol	3.09	193.70	287.50	2.97	194.1	287.4	-3.77%	0.21%	-0.03%
2703	Chevron Refinery	3.72	179.20	286.70	3.72	182.7	286.6	0.00%	1.95%	-0.03%
2760	Phillips Carbon	2.70	197.90	284.40	2.37	206.9	287.1	-12.22%	4.55%	0.95%
2905	Kregor Peak	5.92	205.40	287.10	4.77	207.7	287.3	-19.43%	1.12%	0.07%
2950	UC Richmond	3.38	199.40	286.60	3.27	198.8	286.5	-3.25%	-0.30%	-0.03%
3901	Mt. Tamalpais	3.97	240.80	285.99	4.31	240.4	286.0	8.56%	-0.17%	0.01%
5905	Fort Funston	4.19	205.95	283.60	4.20	211.1	285.5	0.24%	2.50%	0.67%
6901	San Carlos	2.91	230.10	287.90	2.89	232.9	287.8	-0.69%	1.22%	-0.05%
7905	Alviso	2.96	232.80	287.97	2.94	231.4	287.9	-0.68%	-0.60%	-0.02%
8702	Valero Warehouse	4.68	232.60	287.96	3.64	232.2	287.7	-22.31%	-0.17%	-0.09%
8902	Suisun STP	4.37	225.50	287.86	4.36	225.6	287.6	-0.31%	0.05%	-0.09%
9903	Sonoma Baylds	3.26	244.10	287.40	3.07	231.9	286.3	-5.74%	-5.01%	-0.40%
2742	Shell East	2.86	195.10	288.29	2.92	216.0	287.8	2.10%	10.71%	-0.17%
2774	Phillips Hillcrest	2.63	208.80	287.42	2.40	201.0	287.1	-8.75%	-3.74%	-0.11%

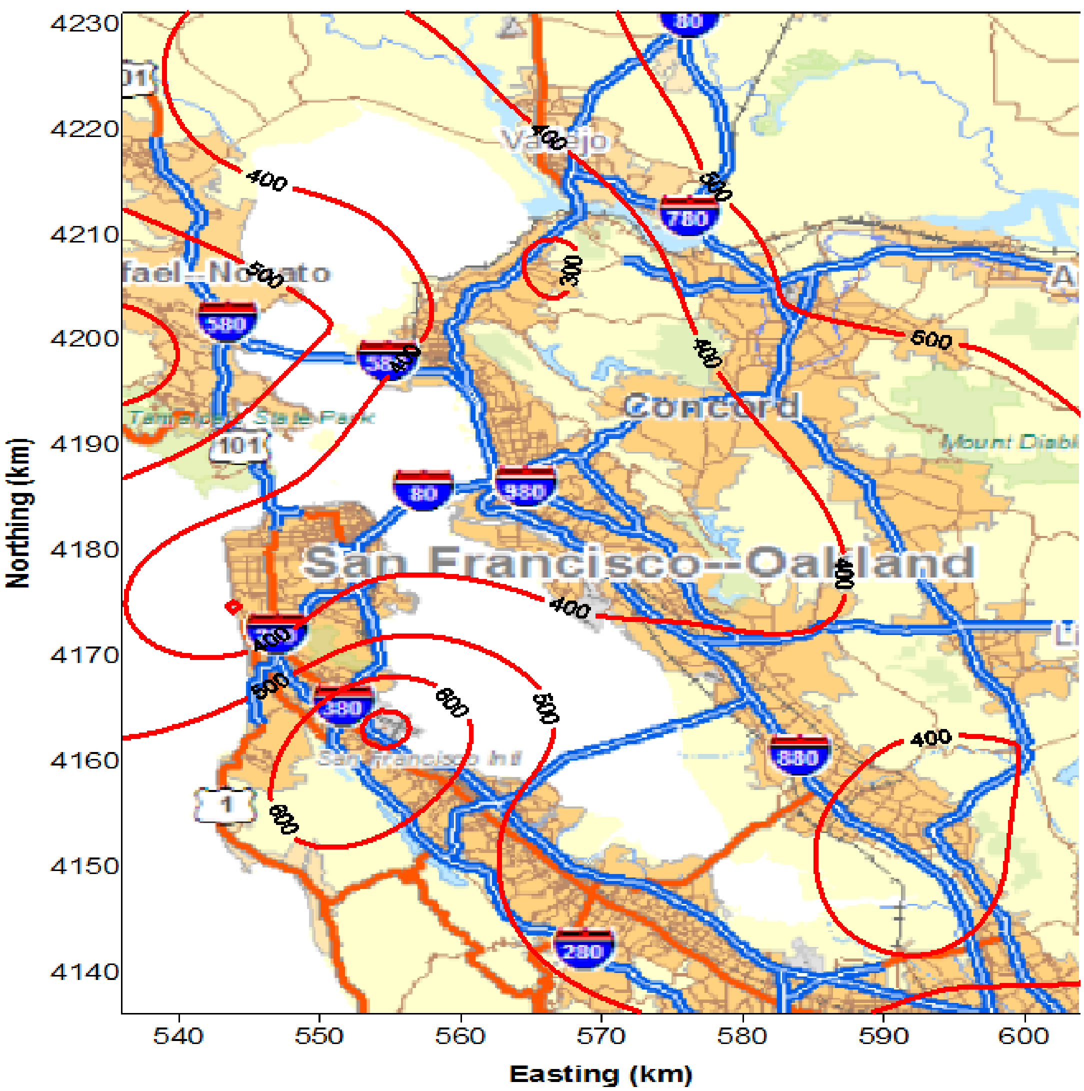
also lower than those of the observed. This is attributed to the fact that the wind measurement sensor heights for these sites were set up at levels higher than 10 m above the ground. Although the wind roses for the five sites at their sensor heights were not extrapolated, the results are reasonable and consistent with the general observation that as the wind sensor height increases, the higher wind speeds would be expected. Figure B-7a and Figure B-7b present the observed and predicted wind roses, respectively, for the Oakland Airport site, which is about 3-4 miles from the Port. Comparing with the observations in Figure B-7b, it is shown that the predicted wind rose is very close to the observed. The annual average wind speeds for the observed and predicted were about 3.87 m/s and 3.78 m/s, respectively. The predicted dominant wind directions (annual average) were about 24.5 %, 13.5 %, and 8.0 % from west to east, northwest to southeast, and southwest to northeast, respectively, which are a little different than those of the observed (19.5 %, 15.4 %, and 9.2 %). The seasonal wind roses for the Oakland Airport site, provided in Appendix F, reveal that the dominant west to east flow occurred in all seasons with the peak flows primarily in spring and summer (April to September). The frequency of these directions reached over 30% in the spring and summer. There was more variability in the wind directions seen during autumn and winter (October to March). Note that each station may have different wind flow pattern. The wind roses for all other stations are provided in Appendix F.

To validate CALMET predictions for winds, two BAAQMD surface measurement sites which were not included in the CALMET modeling were chosen to determine how well CALMET predicts wind speeds and wind directions. The two sites are located at Shell East (UTMx = 578.598 km, UTMy = 4207.749 km in Zone 10) and Phillips Hillcrest (UTMx = 565.062 km, UTMy = 4209.801 km in Zone 10). At both of these sites, the wind sensors were set up at 10 m above ground level. The predicted wind speeds and wind directions at 10 m above the ground for the two sites were extracted from the CALMET output. The results are also presented in Table B-6 (last two rows). It can be seen that the agreement between the measurements and predictions for the two sites are satisfactory.

Mixing Heights

Extracting mixing heights from the CALMET outputs for the observation sites is another means to evaluate the reasonableness of the wind fields generated by CALMET. For this comparison, the predicted mixing heights within the domain are plotted as the contours as shown in Figure B-8. The CALMET predicted mixing heights range from about 300 m to 700 m above the ground. These estimates match the general assumptions used in the BAAQMD meteorological data sets which generally fall between 300 m and 600 m. The mixing heights exhibit a small seasonal pattern. For example, at the Oakland Airport site, the average mixing heights are 420, 430, 360, and 300 meters for 1^{st}, 2^{nd}, 3^{rd}, and 4^{st} quarter of 2000, respectively (the annual average of 380 m). This is probably due to the higher wind speeds in the San Francisco Bay area as the seasons change, which results in a larger contribution of mechanical mixing.

Figure B-8: Annual Average Mixing Heights (m) in the Modeling Domain



B.3 CALPUFF Modeling Approach

B.3.1 Modeling Domain and Receptor Network

In this study, the CALPUFF modeling domain was identical to the meteorological modeling domain. Gridded receptors with the resolution of 0.5 km x 0.5 km were placed within the whole domain. To estimate localized impacts of the emissions on the West Oakland community, a nested receptor network with a medium resolution of 250 m x 250 m was also considered in this study. All receptors were identified by UTM coordinates in the zone 10. The elevation of each receptor within the modeling domain was determined from the USGS topographic data. The receptor networks for the whole domain and the West Oakland community are presented in Figure B-9.

B.3.2 CALPUFF Modeling Options

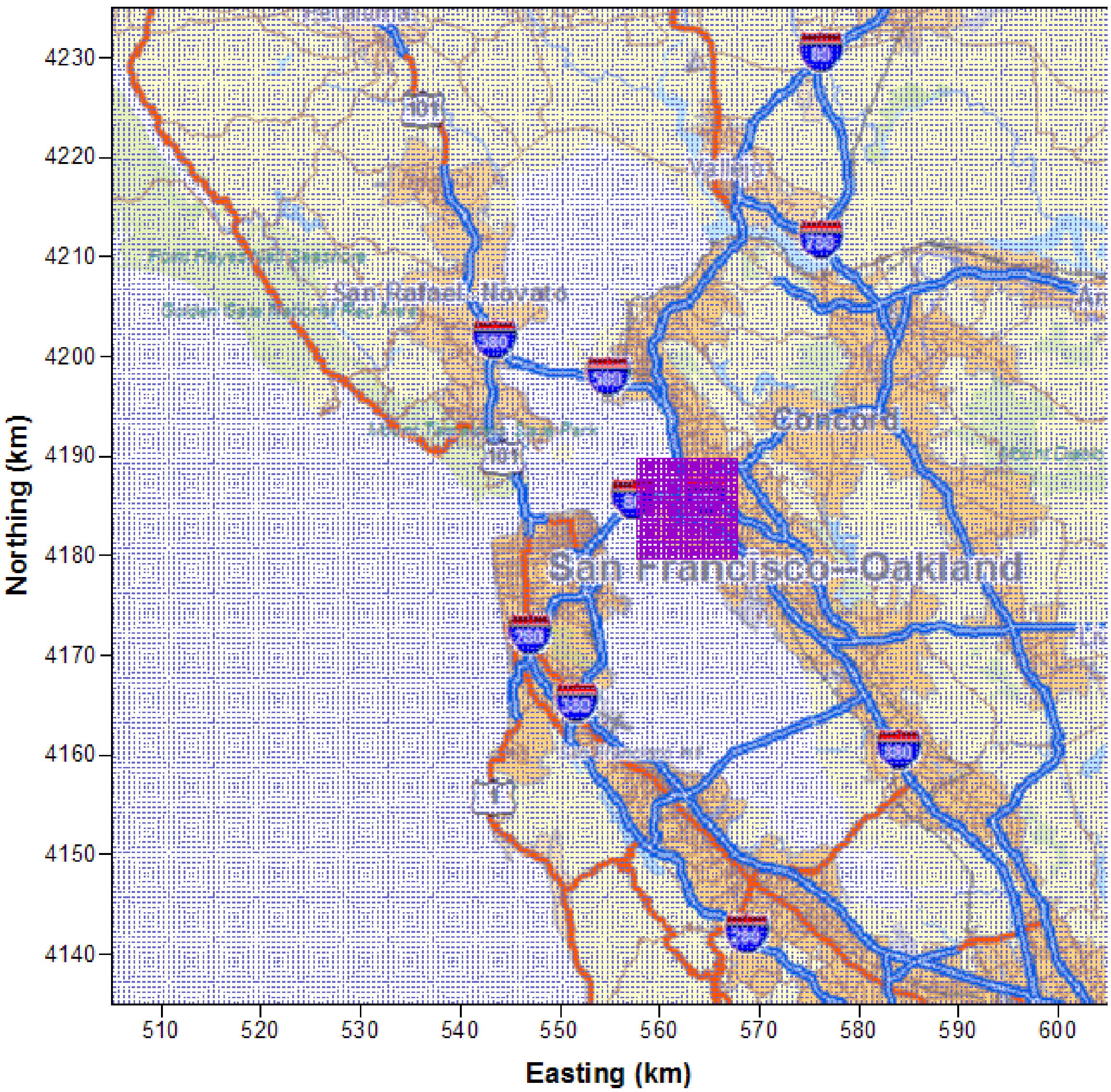
CALPUFF modeling options specify variables and algorithms for representing physical processes that are important for accurate predictions of air concentrations. The options for this study were selected to maximize performance in predicting long term average concentrations in the domain.

The key modeling options used in this study were:

- Gaussian vertical distribution in the near-field;
- Partial plume path adjustment for terrain;
- Transitional plume rise;
- Stack tip downwash;
- Vertical wind shear not modeled above stack top;
- PG dispersion coefficients (rural areas), MP coefficients (urban areas);
- Partial plume penetration;
- No subgrid-scale terrain adjustment;
- No wet and dry removal processes, no chemical transformation, pollutants characterized as inert;
- Horizontal puff size beyond which Heffter equations are used for sigma-y and sigma-z of 550 m;
- Not use Heffter equation for sigma-z;
- PG stability class above mixed layer of 5;
- Minimum wind speed (m/s) for non-calm conditions of 0.5 m/s; and
- Maximum mixing height of 3000 m.

Because speciation profiles and scavenging coefficients for diesel PM were not available, wet and dry deposition processes were not included in this

Figure B-9: Receptor Networks for Regional and West Oakland Domains



modeling exercise. In addition, because most diesel PM emission sources in this study are near the West Oakland community, the effects of dry and wet deposition are minimized. Nevertheless, we conducted a sensitivity modeling study to evaluate the impacts of not addressing wet and dry deposition and determined that the impacts of the dry and wet depositions on the population-weighted diesel PM concentrations within the modeling domain were less than 5 **%** (details provided in Appendix H).

B.3.3 Source Treatment

The diesel PM emission sources defined in this study were modeled as an area source, a point source, a line source, or a volume source depending on the emission source characteristics. Model parameters for area sources include emission rate/strength, release height, lengths of X and Y sides of rectangular areas or vertices for polygons, and initial vertical (σ_{zo}) dimensions of the area source plume. Model parameters for point sources include emission rate, stack height, stack diameter, stack exhaust temperature, and stack exhaust exit velocity. Volume sources need such parameters as emission rate, source release height, sigma-y, and sigma-z.

OGV transiting emissions were modeled as a series of area sources along the travel routes within the San Francisco Bay and out to the outer buoys. Coordinates for the links were created by Port and ARB staff and the link widths ranged from 280 m to 550 m and from 550 m to about 2 km for traveling within the inner San Francisco Bay and over the ocean water surface, respectively. Ships maneuvering from the Bay Bridge to the individual terminals were modeled as individual polygon area sources with slightly different release heights. The ship hotelling emissions at berths were modeled as individual point sources.

Commercial harbor craft emissions were simulated similar to the OGVs but with different links. Cargo handling equipment and port truck emissions were simulated as area sources with the polygon features of the dispersion model. The on-road heavy-duty trucks were simulated as line sources, or a series of small area sources. The link widths range from 10 m (street roads) to 35 m (freeways, three lanes in each direction + 3 meters wake width on each side).

Emission sources for locomotives within the Port and the community were characterized as either a point source or a volume source depending on whether the locomotive was stationary or moving. For stationary locomotives, including idling and load testing, the emissions were simulated as a series of point sources. For moving locomotives, the emissions were simulated as a series of volume sources to mimic the effects of initial dispersion due to plume downwash. Port-related locomotives were simulated as polygon area sources.

The modeling parameters for major emission source categories are summarized in Table B-7.

Table B-7: Major Emission Source Model Parameters

Model Parameter	OGV	CHC	CHE	RAIL	TRUCK	HOTEL
Release Height (m)	50	6	5 – 6.0	5-10	5	H =43 m T = 618 K V = 16 m/s D = 0.5 m
Link Width (m)	-	-	-	20-30	10-35	
Link Width in the Bay (m)	280-550	100-400	-	-	-	
Link Width in the Ocean (m)	550 - 2000	2-10 km	-	-	-	
σ_{zo} (m)	23.26	4.79	2.33–2.79	2.33-4.65	2.33	

Note: OGV = Ocean-going vessels, CHC = commercial harbor craft, CHE = cargo handling equipment, H = release height, T = exhaust temperature, V = exhaust exit velocity, and D = stack diameter.

B.3.4 Spatial and Temporal Allocation of Emissions

The Port, through its contractor Envrion, provided spatial emission allocations for all source categories associated with Port operations (Part I). UP worked with its contractor, Sierra Research, to spatially allocate the emissions within the UP-Oakland Rail Yard. For Part III sources, ARB and BAAQMD staff estimated the emissions and spatially allocated the emissions. If any emission source was not allocated or had been misallocated, ARB staff used GIS mapping to allocate the emissions. Figure B-10 provides an example of the spatially allocated commercial harbor craft emissions. As shown, the harbor craft emissions were allocated in an area outside the Bolden Gate Bridge and within the inner San Francisco Bay area. Each polygon represents a portion of the harbor craft inventory and the darker the shading in the polygon, the more emissions that were released within that area. The detailed spatial allocations of emissions for each category of all three parts are presented in Appendix E.

In order to determine the temporal allocation of emission sources, the Port/Environ used activity surrogates to estimate the relative activity throughout the year by day and by time of day. They chose activity surrogates thought to best represent the overall activity levels of the emission source categories; including vessel calls for marine vessels and TEU movements for cargo handling and truck activity. ARB and BAAQMD staff temporally allocated all the emission sources for Part III based on discussions with operators and from input to a survey of businesses in the area. The assumptions for the temporal distribution of the emissions are listed Table B-8.

Figure B-10: Spatial Allocations of Part III Commercial Harbor Craft Emissions

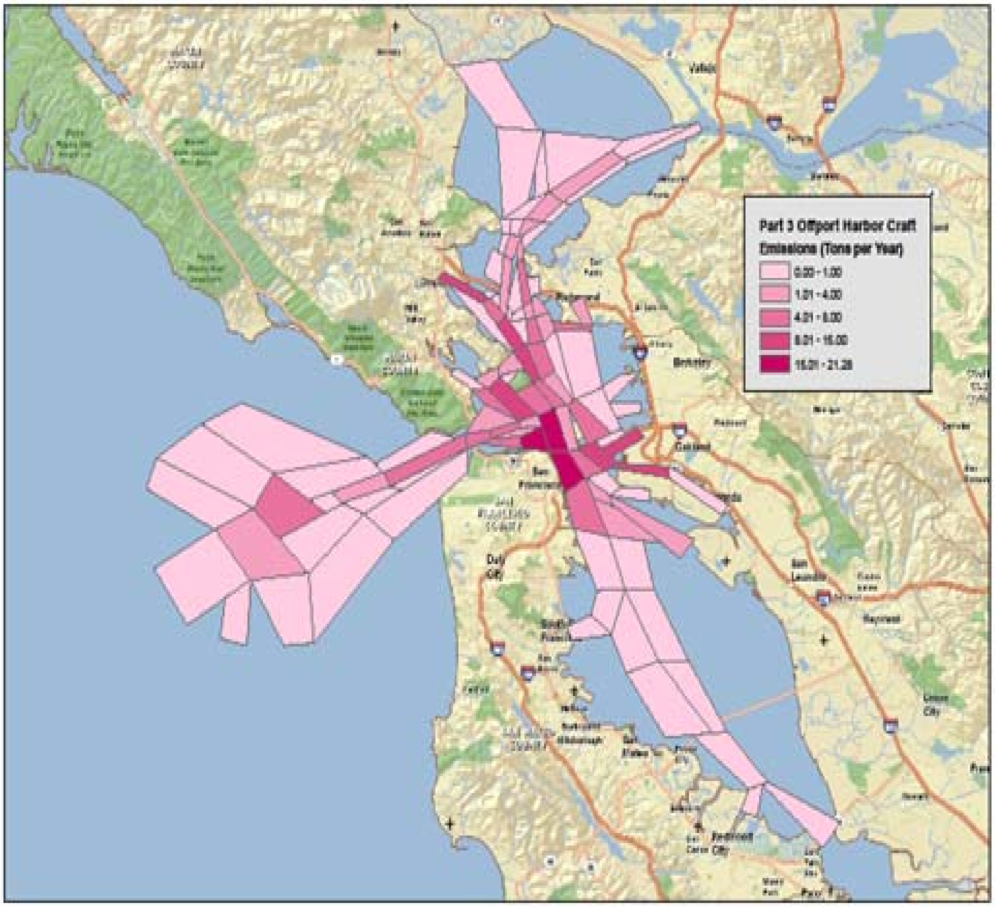


Table B-8: The Diurnal Temporal Profiles for Different Emission Source Categories

Hour	OGV			HARBOR CRAFT			TRUCKS*			CHE		LOCOMOTIVE		OTHERS*	
	Transiting	Maneuvering	Hotelling	Dredging	Tug Ass	Others	Port	On-Road	Off-Road	Port	Off-Port	Port/Off-Port	Amtrak	Construction	Stationary
1	1.90%	3.00%	4.17%	0.00%	3.00%	1.67%	0.02%	1.34%	1.40%	0.02%	0.00%	4.17%	6.93%	0.00%	0.00%
2	2.11%	2.30%	4.17%	0.00%	2.30%	1.67%	0.05%	1.06%	1.12%	0.05%	0.00%	4.17%	5.94%	0.00%	0.00%
3	2.21%	2.20%	4.17%	0.00%	2.20%	1.67%	0.02%	1.38%	1.12%	0.02%	0.00%	4.17%	6.93%	0.00%	0.00%
4	4.71%	2.80%	4.17%	0.00%	2.80%	1.67%	0.05%	2.01%	1.12%	0.05%	0.00%	4.17%	6.93%	0.00%	0.00%
5	5.52%	5.11%	4.17%	0.00%	5.11%	1.67%	0.02%	3.02%	1.96%	0.02%	0.00%	4.17%	6.93%	0.00%	0.00%
6	5.72%	9.02%	4.17%	0.00%	9.02%	1.67%	0.26%	5.78%	2.24%	0.26%	0.00%	4.17%	5.94%	0.00%	0.00%
7	5.82%	10.62%	4.17%	0.00%	10.62%	6.67%	1.40%	6.60%	2.52%	1.40%	10.00%	4.17%	5.94%	0.00%	0.00%
8	8.23%	3.81%	4.17%	0.00%	3.81%	6.67%	4.58%	6.22%	8.40%	4.58%	10.00%	4.17%	1.98%	12.50%	11.11%
9	2.00%	3.61%	4.17%	12.50%	3.61%	6.67%	10.76%	6.02%	8.68%	10.76%	10.00%	4.17%	2.97%	12.50%	11.11%
10	3.51%	1.50%	4.17%	12.50%	1.50%	6.67%	11.33%	7.15%	8.68%	11.33%	10.00%	4.17%	1.98%	12.50%	11.11%
11	1.70%	1.00%	4.17%	12.50%	1.00%	6.67%	10.61%	7.18%	8.68%	10.61%	10.00%	4.17%	1.98%	12.50%	11.11%
12	1.70%	1.30%	4.17%	12.50%	1.30%	6.67%	12.25%	7.35%	8.68%	12.25%	10.00%	4.17%	5.94%	12.50%	11.11%
13	2.81%	1.50%	4.17%	12.50%	1.50%	6.67%	8.38%	6.98%	8.68%	8.38%	10.00%	4.17%	3.96%	12.50%	11.11%
14	4.21%	2.60%	4.17%	12.50%	2.60%	6.67%	10.12%	6.84%	8.40%	10.12%	10.00%	4.17%	2.97%	12.50%	11.11%
15	5.12%	3.91%	4.17%	12.50%	3.91%	6.67%	10.90%	6.20%	8.40%	10.90%	10.00%	4.17%	2.97%	12.50%	11.11%
16	4.31%	6.31%	4.17%	12.50%	6.31%	6.67%	8.32%	5.22%	8.12%	8.32%	10.00%	4.17%	1.98%	0.00%	11.11%
17	5.02%	8.42%	4.17%	0.00%	8.42%	6.67%	7.49%	4.26%	1.68%	7.49%	0.00%	4.17%	1.98%	0.00%	0.00%
18	6.72%	9.42%	4.17%	0.00%	9.42%	6.67%	2.63%	3.56%	1.68%	2.63%	0.00%	4.17%	0.99%	0.00%	0.00%
19	6.62%	7.42%	4.17%	0.00%	7.42%	1.67%	0.44%	3.20%	1.40%	0.44%	0.00%	4.17%	1.98%	0.00%	0.00%
20	6.02%	7.11%	4.17%	0.00%	7.11%	1.67%	0.10%	2.36%	1.40%	0.10%	0.00%	4.17%	1.98%	0.00%	0.00%
21	6.62%	2.10%	4.17%	0.00%	2.10%	1.67%	0.11%	1.93%	1.40%	0.11%	0.00%	4.17%	2.97%	0.00%	0.00%
22	2.00%	1.00%	4.17%	0.00%	1.00%	1.67%	0.08%	1.57%	1.40%	0.08%	0.00%	4.17%	4.95%	0.00%	0.00%
23	3.31%	1.10%	4.17%	0.00%	1.10%	1.67%	0.04%	1.43%	1.40%	0.04%	0.00%	4.17%	5.94%	0.00%	0.00%
24	2.11%	2.80%	4.17%	0.00%	2.80%	1.67%	0.04%	1.34%	1.40%	0.04%	0.00%	4.17%	6.93%	0.00%	0.00%

Note: The profiles vary by individual sources and the averages of the sources are listed here.