DRAFT

Modeling of Near-Road Concentration of Primary PM2.5 based on TRAN-LA's Model Outputs

By

Ji Luo
Kanok Boriboonsomsin

April 2014

1. INTRODUCTION

The TRAN-LA model, being developed as part of the University of California's Multi-campus Research Program and Initiatives (MRPI), provides transportation network equilibrium results for the six-county region of the Southern California Association of Governments (SCAG). The model has been calibrated to the traffic conditions in calendar year 2000. Primary outputs of the TRAN-LA model include traffic flow and average traffic speed on each link of the aggregate roadway network for the region. There are 696 links in the model. This report describes the use of these model outputs to estimate near-road concentration of primary PM2.5 (particulate matter smaller than 2.5 micron) along the aggregate roadway network for the region.

1.1. Modeling Framework

Modeling air pollutant concentration nearby roadways is a complex process, involving multiple modeling components. Figure 1 shows the multi-step modeling framework of this study. Traffic activity, in terms of traffic flow and speed, on each roadway link of the aggregate roadway network were obtained from TRAN-LA's network equilibrium results[1]. Traffic emission factors were previously modeled using the EMFAC2011 emission model and the results documented in a separate report[2]. Thus, the main focus of this report is on the modeling of air pollutant concentration using the state-of-the-practice CALINE4 dispersion model.

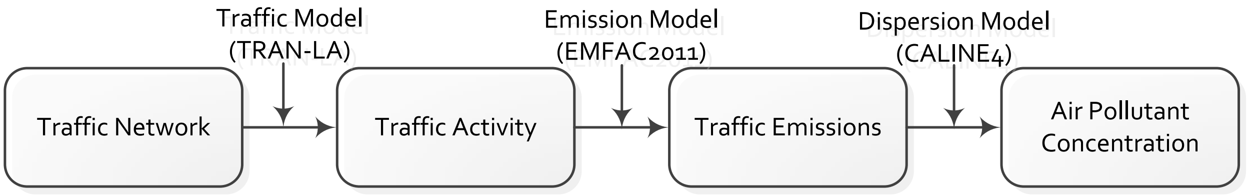

Figure 1. Modeling framework used in this study

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[1] Anas, A. and Hiramatsu, T. Report on the Network Aggregation for TRAN-LA and the Calibration and Testing of the TRAN-LA Road Network Equilibrium Model. Revised August 10, 2011.

[2] Scora, G. and Boriboonsomsin, K. Vehicle Fuel Use and Emission Factors. October 19, 2012.

1.2. Scope of Study

Particulate matter or particles can be formed in different ways. Primary particles are emitted directly from a source, such as construction sites, unpaved roads, smokestacks, fires, and combustion engines. In contrast, secondary particles are formed in complicated reactions in the atmosphere of chemicals such as sulfur dioxides and nitrogen oxides that are emitted from power plants, industries, and automobiles. This study only deals with primary particles that are dispersed from vehicular traffic into the air nearby the roadways.

Particles from vehicular traffic are emitted from multiple sources, including the combustion of fuel (especially diesel) and the wear and tear of tires and brake pads. This study only models particle emissions from the combustion of fuel (i.e., running exhaust particle emissions), which account for the majority of traffic-related particle emissions.

2. TRAFFIC AND EMISSION MODELING

TRAN-LA's aggregate roadway network consists of 696 links connecting 104 model zones. Primary results of the TRAN-LA model include traffic flow and average traffic speed on each of the 696 links[3]. The traffic flow and average traffic speed results are plotted in geographic information system (GIS) and shown in Figure 2 and Figure 3, respectively. As expected, heavy traffic flow and low average traffic speed are found mostly on the links in the Los Angeles and Orange counties.

Traffic emission factors were previously modeled using the EMFAC2011 emission model developed by the California Air Resources Board. Figure 4 shows running exhaust emission factors of PM2.5 as a function of average speed for light-duty vehicles (LDV), heavy-duty diesel trucks (HDDT), urban bus (UBUS), and the weighted average of the three (aggregated).

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[3] Anas, A. and Hiramatsu, T. Report on the Network Aggregation for TRAN-LA and the Calibration and Testing of the TRAN-LA Road Network Equilibrium Model. Revised August 10, 2011.

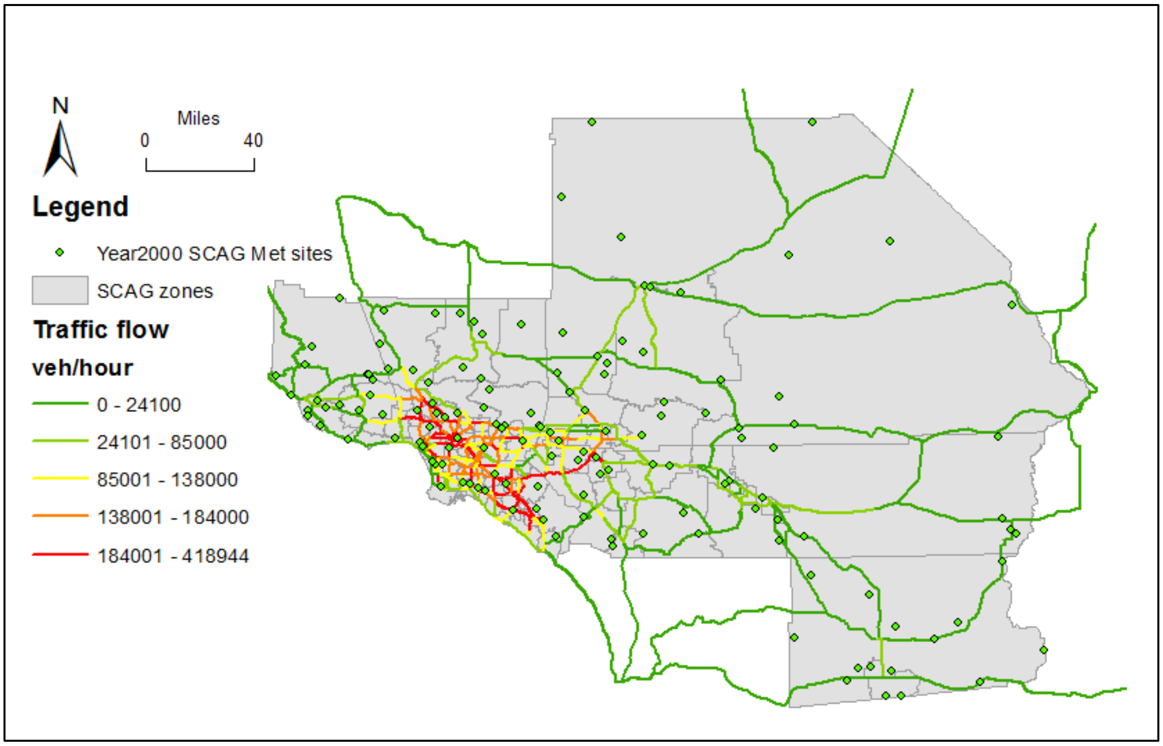

Figure 2. Traffic flow on TRAN-LA's aggregate roadway network

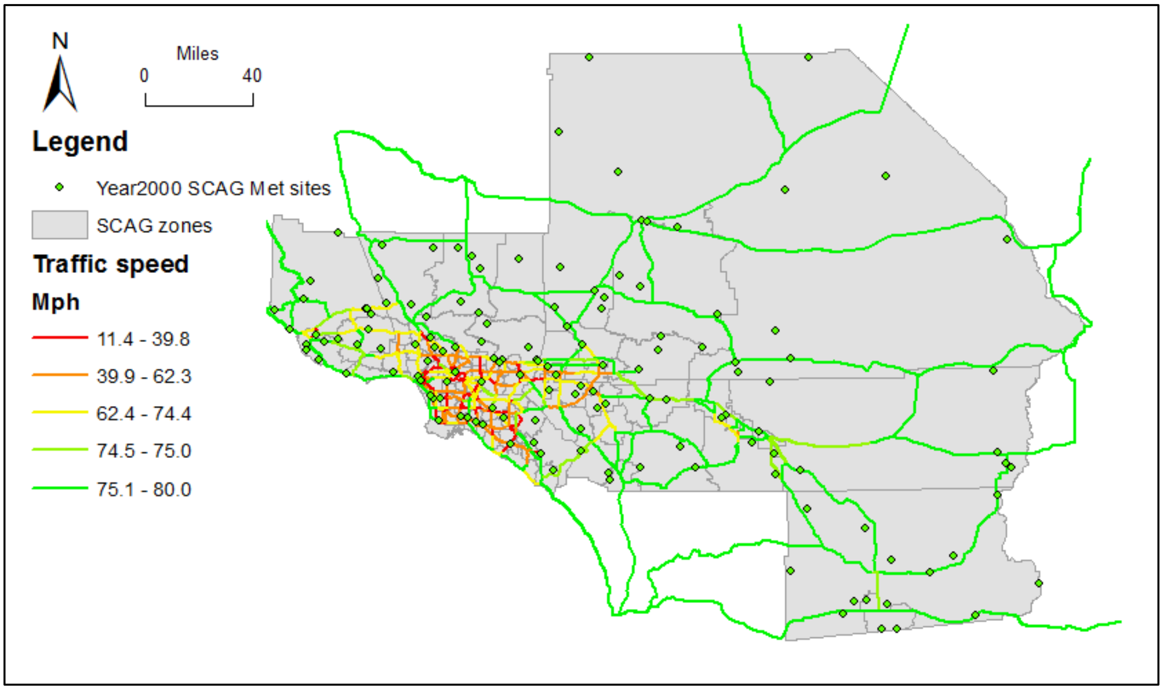

Figure 3. Traffic speed on TRAN-LA's aggregate roadway network

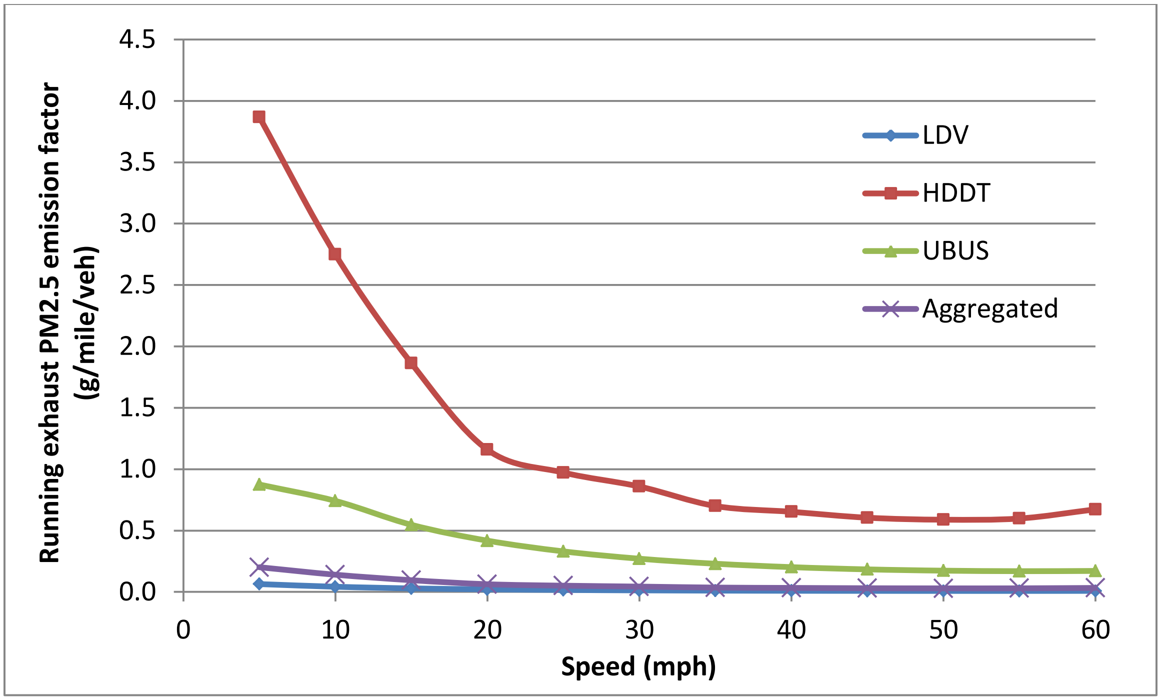

Figure 4. PM2.5 emission factors from EMFAC2011

Particle emissions are more dominant in diesel vehicles than gasoline counterparts. And since heavy-duty diesel trucks consume more fuel per mile than light-duty vehicles, the PM2.5 emission factors for heavy-duty diesel trucks are significantly higher throughout the entire speed range. These emission factors are expressed in the unit of grams per mile per vehicle. Thus, to calculate the emission mass on each link of the aggregate roadway network, the emission factors were multiplied with link distance and traffic flow on the link according to Equation 1.

$$E_k = EF(v_k) \cdot d_k \cdot q_k \tag{1}$$

where E_k = Emission mass on link k (grams)

$EF(v_k)$ = Emission factor for average speed on link k (grams per mile per vehicle)

d_k = Distance of link k (miles)

q_k = Traffic flow on link k (vehicles)

k = 1, 2, 3, …, 696

The current TRAN-LA model does not differentiate traffic flow by vehicle type. Therefore, in this study the aggregated emission factors were used. They were calculated as an average of emission factors for the three vehicle types weighted by vehicle miles traveled (VMT) for each vehicle type obtained from the EMFAC2011 model. Once TRAN-LA differentiates traffic flow (and average speed) by vehicle type in the future, the calculation of emission mass can be done separately for each vehicle type. Then, emission mass for the individual vehicle types can be aggregated to result in total emission mass for the link.

3. AIR DISPERSION MODELING

The air pollutant dispersion modeling in this study was conducted using the CALINE4 model, developed by the California Department of Transportation[4]. The model can be used for line-source dispersion analysis of carbon monoxide (CO), nitrogen dioxide (NO_2), particulate matter (PM), and general inert gases. CALINE4 is based on assumptions that pollutants emitted from motor vehicles traveling along a segment of roadway can be represented as a line source of emissions, and that pollutants disperse in a Gaussian distribution fashion from a defined mixing zone (area of uniform emissions and turbulence) over the roadway being modeled. The model calculates pollutant concentrations at the locations of receptors specified in the input file. In most applications, receptors are placed at a typical breathing height of 1.8 m (6 ft)[5].

The CALINE4 model is in a public domain, and can be downloaded from the California Department of Transportation's website[6]. The model requires a number of inputs as listed in Table 2. Part 1 specifies the title of the scenario run while part 2 specifies the pollutant to be modeled. The scenario parameters in part 3 were obtained from various sources or based on

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[4] Benson, P. E. *CALINE4 – A Dispersion Model for Predicting Air Pollutant Concentrations near Roadways*. Report No. FHWA/CA/TL-84/15, California Department of Transportation, Sacramento, California, November 1984.

[5] U.S. Environmental Protection Agency. *Guideline for Modeling Carbon Monoxide from Roadway Intersections*. EPA Publication No. EPA-454/R-92-005, Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina, November 1992

[6] http://www.dot.ca.gov/hq/env/air/software/caline4/calinesw.htm.

some assumptions. For instance, the surface roughness length was set as the lower limit for urban areas, which is 1.0 meter[7]. Both the setting velocity and deposition velocity of PM2.5 were set to zero since PM2.5 setting velocity is insignificant and the modeling output is not sensitive to both parameters. An example CALINE4 input file created in this study is given in Appendix A. The traffic flows and traffic emission factors in parts 7 and 8 were obtained from the traffic and emission modeling results presented in Section 2 of this report. Other key input components are described in the following subsections.

Table 1. CALINE4 input file components

Part	Description
1	Title
2	Name of pollutant
3	Scenario parameters: Surface roughness length, molecular weight, setting velocity, deposition velocity, number of receptors, number of links, distance unit, altitude above sea level
4	Receptor index and their Cartesian coordinates
5	Link index and link parameters: Link type, coordinates, link height, mixing zone width, canyon/bluff mix left, canyon/bluff mix right
6	Averaging time interval specification
7	Traffic flow for each input link
8	Traffic emission factor for each input link
9	Meteorology inputs: Wind direction, wind speed, stability class, mixing height, wind standard deviation, background concentration, air temperature

3.1. Receptor Setup

Receptors were initially setup as a 200 x 200 sq m grid that covers the SCAG region. This grid size is chosen to provide enough resolution to capture meaningful PM2.5 concentration gradients while not resulting in an excessive number of receptors. The entire grid consists of 4,354,889 receptors, with 1,771 rows and 2,459 columns. Then, the receptors within a 5,000-meter buffer on both sides of the roadway links were selected as the effective receptors. The number of effective receptors is 927,429, which were entered in part 4 of CALINE4 input files. The underlying assumption is that PM2.5 emissions from traffic will not reach the receptors that are

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[7] Schnelle and Dey, Atmospheric Dispersion Modeling Compliance Guide, McGraw-Hill Professional, 1999.

more than 5,000 meters away from the road centerline. An example of effective receptors is shown in Figure 5.

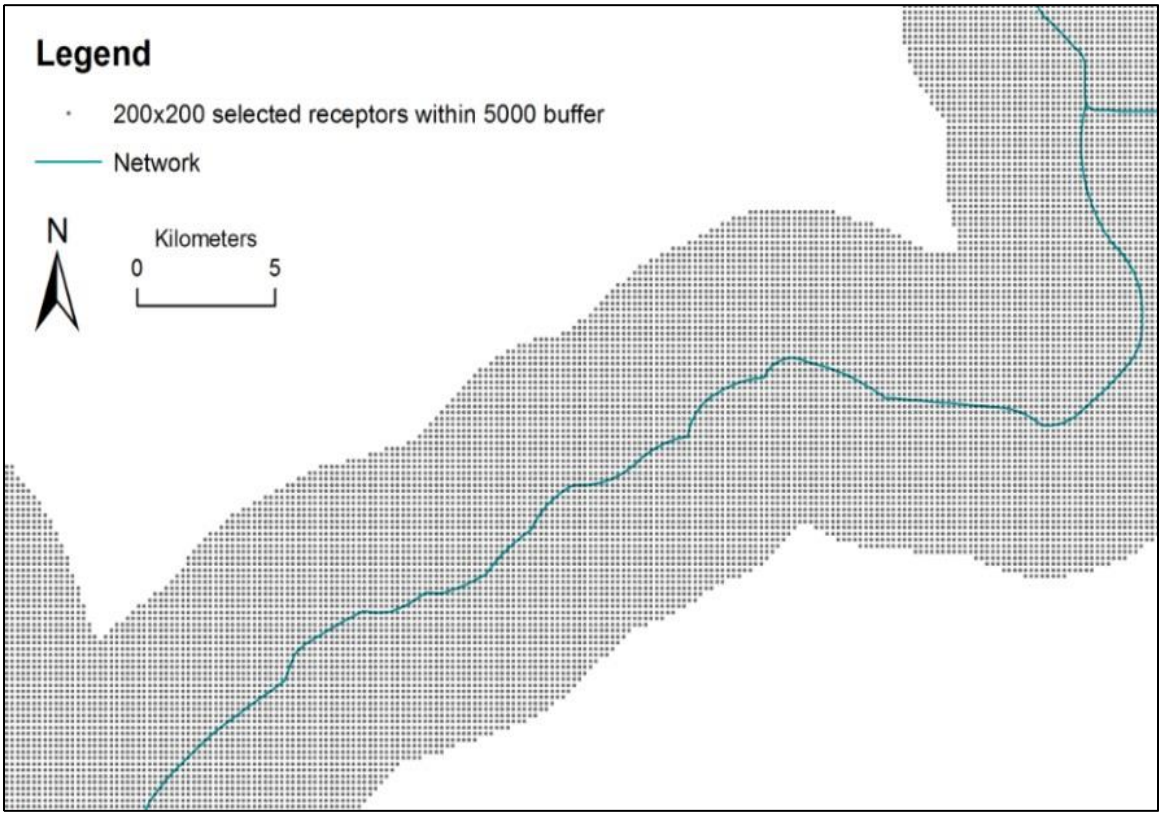
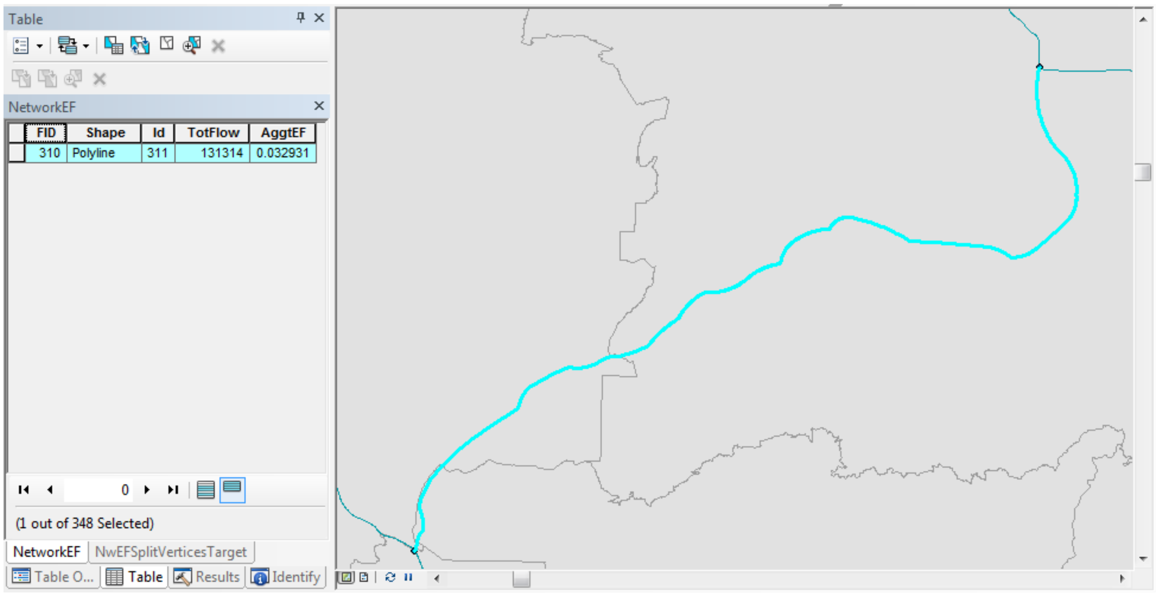


Figure 5. Effective receptors within 5,000 meters of road centerline

3.2. Roadway Link Characterization

The SCAG region has a vast roadway network, which was aggregated to 696 links in the TRAN-LA model. Each aggregate link consists of many links in the original roadway network and, as a result, may include several curves between the start node and end node, as shown in Figure 6. However, curvy links cannot be represented in CALINE4 as the model takes start node and end node coordinates as an input and then virtually creates a straight line between the two nodes to represent a link. Therefore, the aggregate links in the TRAN-LA model needed to be split into a series of linear road segments. The splitting of aggregate links was performed in ArcGIS using the ‘Split line at vertices’ tool, which resulted in 77,844 road segments. An example of road segments after the splitting is given in Figure 7.

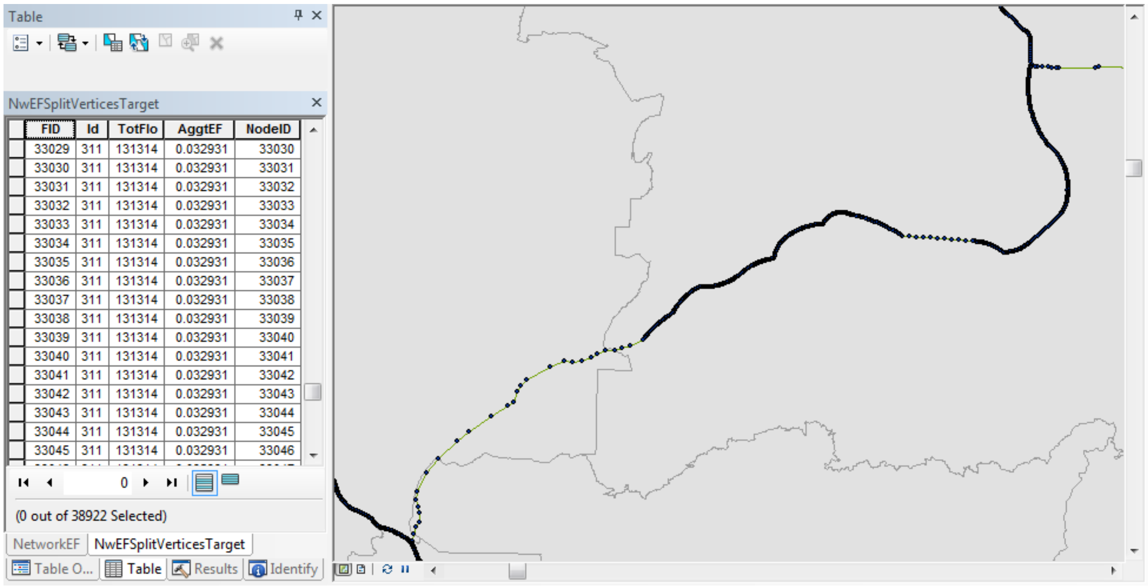


NetworkEF

FID	Shape	Id	TotFlow	AggtEF
310	Polyline	311	131314	0.032931

(1 out of 348 Selected)

Figure 6. Aggregate link in TRAN-LA containing multiple curves



NwEFSplitVerticesTarget

FID	Id	TotFlo	AggtEF	NodeID
33029	311	131314	0.032931	33030
33030	311	131314	0.032931	33031
33031	311	131314	0.032931	33032
33032	311	131314	0.032931	33033
33033	311	131314	0.032931	33034
33034	311	131314	0.032931	33035
33035	311	131314	0.032931	33036
33036	311	131314	0.032931	33037
33037	311	131314	0.032931	33038
33038	311	131314	0.032931	33039
33039	311	131314	0.032931	33040
33040	311	131314	0.032931	33041
33041	311	131314	0.032931	33042
33042	311	131314	0.032931	33043
33043	311	131314	0.032931	33044
33044	311	131314	0.032931	33045
33045	311	131314	0.032931	33046

(0 out of 38922 Selected)

Figure 7. A series of linear segments in after splitting the aggregate link

After splitting an aggregate link into small road segments, the aggregate link ID, traffic flow, and traffic emission factor were passed along to each road segment. To obtain the node coordinates of the linear segments, the ArcGIS tool ‘Feature to points’ was applied to find the two ends of a line feature. Then, the ArcGIS tool ‘Add XY’ was used to assign the coordinates of the node pair for each road segment. These coordinates were entered in part 5 of CALINE4 input files.

In addition to link coordinates, part 5 of CALINE4 input files also require other link parameters including link type, link height, mixing zone width, canyon/bluff mix left, and canyon/bluff mix right. Table 2 lists the settings of these links parameters. In this study, 'at-grade' link type was selected for all segments. In CALINE4, at-grade links mean no plume mixing below ground level, which is assumed to be at the height of zero[8]. Mixing zone width was set as two times an average road width. Assuming that roads are composed of 3 lanes and each lane is 10 feet wide[9], the average road width of 10 meters was used. Note that CALINE4 only models links whose length is larger than the mixing zone width, so it was necessary to reduce the mixing zone width for some of the links according to their length.

Table 2. Link parameter settings

Parameter	**Settings**
Link type	1 (at-grade)
Link height	0 meter (matching at-grade requirement)
Mixing zone width	20 meters (for link length > 21 meters) 10 meters (for 10 meters < link length ≤ 21 meters) 1 meter (for link length ≤10 meters)
Canyon/bluff mix left	0 meter
Canyon/bluff mix right	0 meter

3.3. Meteorology Data Processing

Meteorology data inputs are critical to the air dispersion modeling. In this study, all valid meteorology measurement sites in the SCAG region were included for a better representation of the weather patterns of Southern California. The locations of these measurement sites are shown as one of the GIS layers in Figure 2 and Figure 3.

The mandatory inputs including wind speed, wind direction, wind direction standard deviation, and air temperature for calendar year 2000 were obtained from the routine hourly measurements

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[8] Caltrans - UC Davis Air Quality Project, User's guide for CL4: a user-friendly Interface for the CALINE 4 model for transportation project impact assessments, June, 1998.

[9] Caltrans. FAQ. http://www.dot.ca.gov/hq/paffairs/faq/faq92.htm.

made by the South Coast Air Quality Management District[10]. All the observed data from each site were downloaded and processed using Python scripts. For air temperature, a simple average of all the hourly observed values was calculated and used as the annual average value. For wind speed and wind direction, the calculation followed the guidance provided by the U.S. Environmental Protection Agency[11]. A table containing meteorology measurement site information and the processed weather parameters is provided in Appendix B.

Once the meteorology data at each site had been processed, the association between the meteorology measurement sites and the roadway links had to be created so that each roadway link could be assigned representative meteorology data values. To create such association, the ‘Spatial join’ function in ArcGIS was applied to assign each roadway link a closest meteorology site. Then, the processed meteorology data from that site were used as CALINE4 data inputs for that roadway link.

Another two meteorology inputs are atmospheric stability and boundary layer mixing height. Stability Class 2 (moderate to strong turbulence, mostly occurring during daytime) was selected as a representative class for the SCAG region. It is possible to compute the mixing height for a specific modeling time span (such as morning or afternoon) if detailed meteorology measurements (solar radiation, upper air wind profile, etc.) are available. In this study, the mixing height of 1,300 meters was selected to represent a typical day.

3.4. Model Execution

The user interface of the CALINE4 software provides a convenient way to enter and visualize input data, but is limited to only 20 links and 20 receptors at a time. It is thus suitable for small-scale modeling projects. In order to deal with 77,844 roadway links and 927,429 receptors to be modeled in this study, an execution of the model in batch mode is necessary.

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[10] CARB, Meteorology Data Query Tool, http://www.arb.ca.gov/aqmis2/metselect.php

[11] U.S EPA, Meteorological Monitoring Guidance for Regulatory Modeling Applications, Feb, 2000, http://www.epa.gov/scram001/guidance/met/mmgrma.pdf.

In addition to the software with user interface, an executable file 'CALINE4.exe' is also available. This file can read formatted input files and execute them in batch mode. To make use of the batch mode, a MATLAB script was created to perform the following tasks:

1. Select 20 neighboring roadway links and identify receptors within a 2,000-meter buffer.
2. Divide the identified receptors into groups of 20 and assign a unique index to each link-receptor group.
3. Create input text files containing the links, receptors, meteorology data, traffic flow, traffic emission factor, and other required inputs (as listed in Table 1) as well as a corresponding batch run command file. An example of batch run command file is given in Appendix C.
4. Run the batch command to execute the input files for all the link-receptor groups.
5. Read the output files according to the link-receptor group index and extract the estimated PM2.5 concentration value at each receptor.
6. Update the PM2.5 concentration values for the effective receptors (within a 5,000-meter buffer) by adding the newly estimated concentration values to the existing values.
7. Repeat steps 1-6 for all the roadway links in the network.

4. RESULTS AND DISCUSSION

Once the batch execution of the CALINE4 model was completed, the final PM2.5 concentration values for the effective receptors were joined with the receptor layer in ArcGIS. Then, a spatial interpolation was performed to create a contour map of PM2.5 concentration along the aggregate roadway network. Note that the estimated PM2.5 concentration results should be viewed in relative term. They can be used to compare the impact along one roadway segment versus another. However, the values of the PM2.5 concentration are in most cases overestimated. This is because the traffic flows on the aggregate roadway network are much higher than what they would be if the original roadway network was used in the traffic equilibrium process. Therefore, having extremely high PM2.5 concentrations in these results does not mean that the level of air pollution exceeds the air quality standards.

Figure 8 shows the contour map of PM2.5 concentration for the South Bay area in Los Angeles County. High concentrations of PM2.5 are evident at many interchanges and along some freeways. As expected, the PM2.5 concentration fades out as the distance from roadway increases.

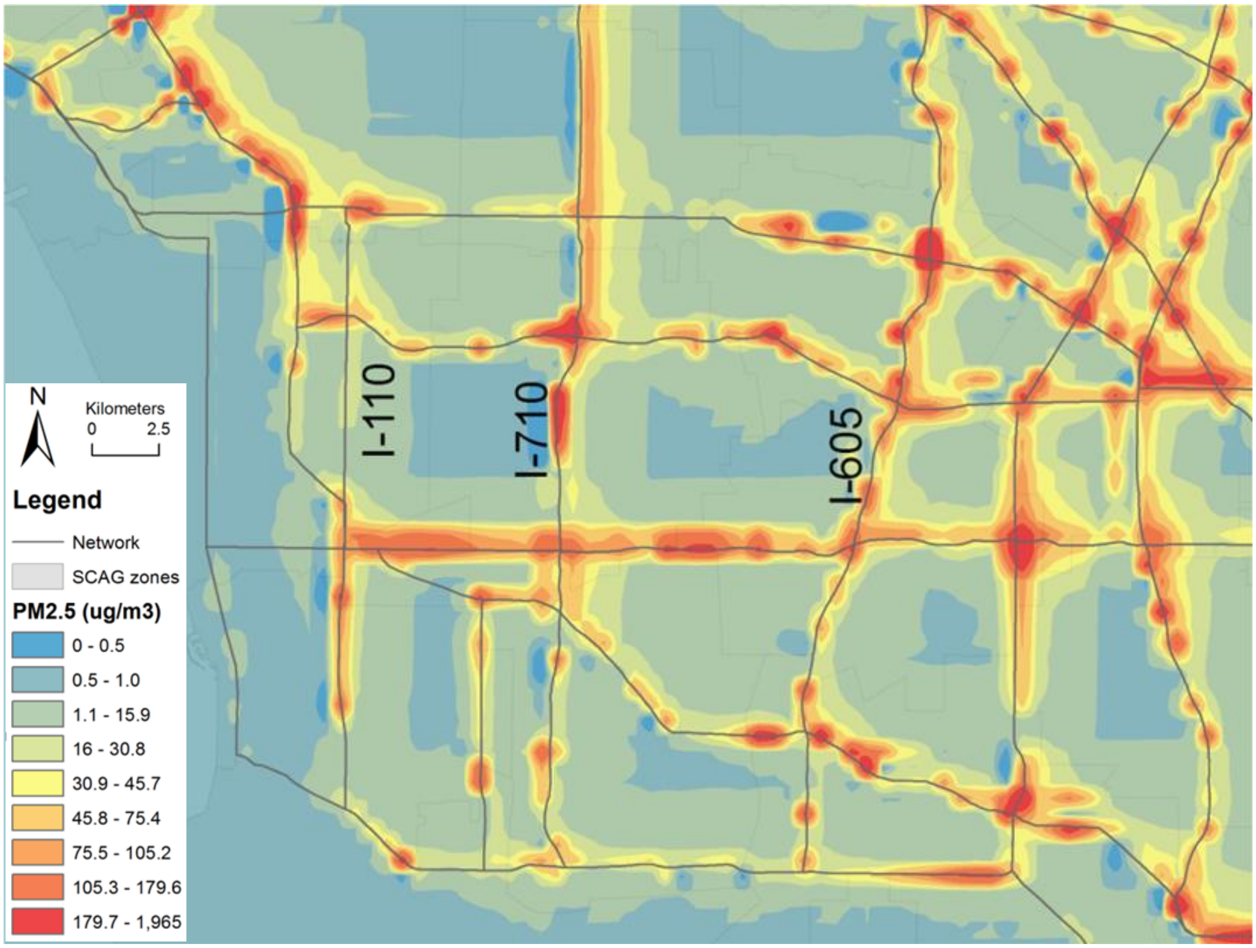

Figure 8. Estimated PM2.5 concentration along aggregate roadway network in South Bay area

Figure 9 show the contour map of PM2.5 concentration for the entire SCAG region. In general, higher concentrations of PM2.5 are found along roadways in Los Angeles and Orange Counties, especially I-5 between SR-55 and SR-133, I-405 between I-10 and I-105, SR-2 in West Hollywood, Los Angeles. These roadway segments have common characteristics, which are high traffic flow and low traffic speed.

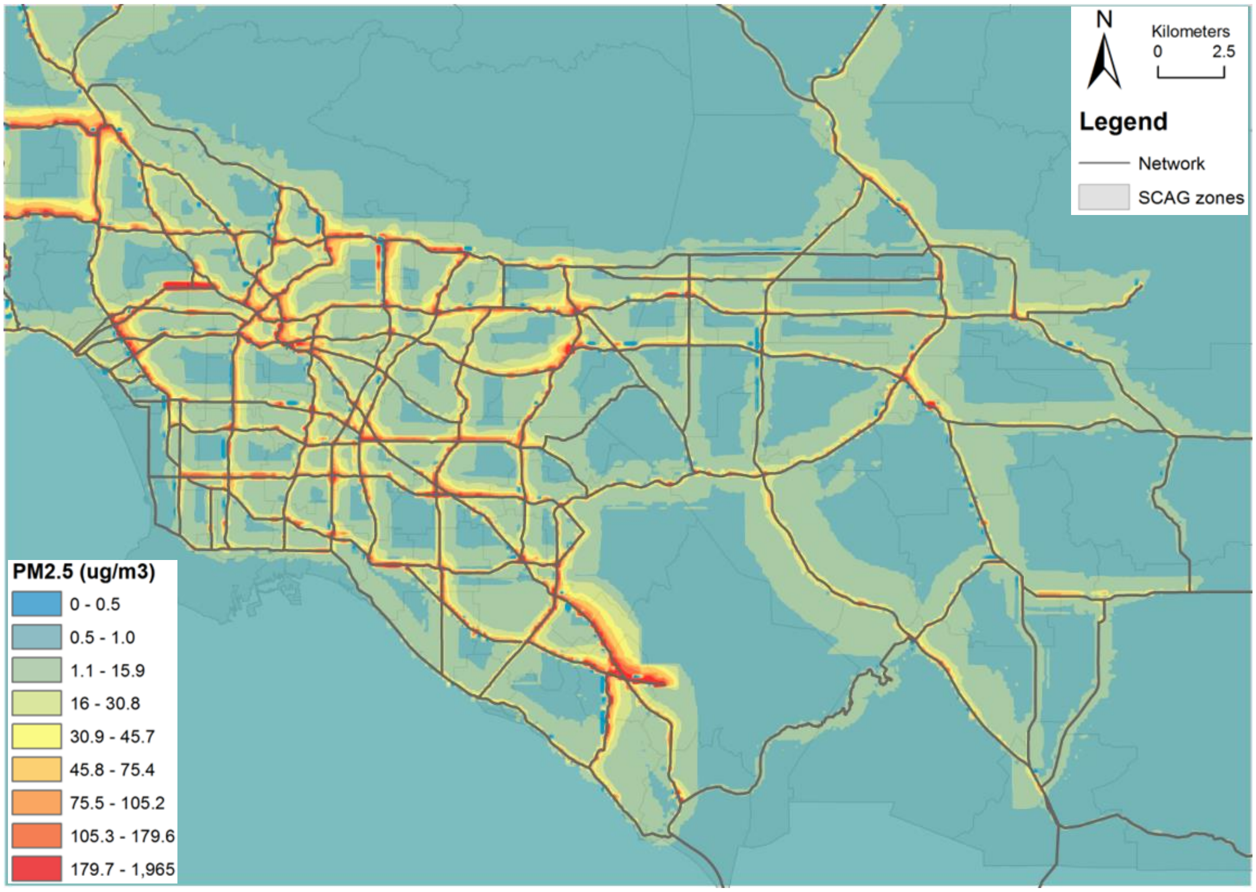

Figure 9. Estimated PM2.5 concentration along aggregate roadway network for entire SCAG region

It should be noted that the goal of this phase of the study is to set up the framework for modeling air pollution impact of traffic in the SCAG region. It is envisioned that the framework can then be used for future modeling needs such as modeling other types of air pollutant, modeling air pollution using traffic equilibrium results from a more disaggregate network, etc. The goal of this phase of the study has been achieved. The following considerations should be given when using the modeling framework in the future:

1. The use of average meteorology data did not reveal the variation of the air pollution impact. For instance, the annual average wind speed was quite low because after sunset the wind speed in general was mostly below 1 m/s. Therefore, the PM2.5 did not seem to disperse a long distance as most of the PM2.5 hotspots were within 1 km of road centerline. Future modeling efforts may consider the variation of meteorology data by time of day, seasonally, etc.

2. The buffer of 2,000 meters for identifying receptors was sufficient for this phase of study because of the weak average wind speed. If the wind speed increases significantly, the buffer distance may also need to increase accordingly.
3. Some of the important parameters, such as mixing zone width and atmospheric mixing height, can be estimated more accurately based on a set of routinely measured meteorology data (such as wind speed, air temperature, solar radiation, etc.).
4. The use of traffic equilibrium results from a more disaggregate network will improve PM2.5 concentration estimates in two ways. First, the traffic flows on roadway links will be more realistic, resulting in more accurate levels of concentration. Second, the spatial distribution of PM2.5 concentration estimates will be better represented.

APPENDIX A: EXAMPLE OF CALINE4 INPUT FILE

```
2000LA-PlanPM2.5
4Particulates
100 0 0 0 20 20 1 1 1 0
R1
R2
R3
R4
R5
R6
R7
R8
R9
R10
R11
R12
R13
R14
R15
R16
R17
R18
R19
R20
380455.15349      3763457.8862               1.6
380655.15349      3763457.8862               1.6
380855.15349      3763457.8862               1.6
381055.15349      3763457.8862               1.6
381255.15349      3763457.8862               1.6
381455.15349      3763457.8862               1.6
381655.15349      3763457.8862               1.6
381855.15349      3763457.8862               1.6
382055.15349      3763457.8862               1.6
382255.15349      3763457.8862               1.6
382455.15349      3763457.8862               1.6
382655.15349      3763457.8862               1.6
382855.15349      3763457.8862               1.6
383055.15349      3763457.8862               1.6
383255.15349      3763457.8862               1.6
383455.15349      3763457.8862               1.6
383655.15349      3763457.8862               1.6
383855.15349      3763457.8862               1.6
384055.15349      3763457.8862               1.6
384255.15349      3763457.8862               1.6
Link1
Link2
Link3
Link4
Link5
Link6
Link7
Link8
Link9
Link10
Link11
Link12
Link13
Link14
Link15
```

```
Link16
Link17
Link18
Link19
Link20
1   387899  3766046   387870  3766046        0       20        0        0        0
1   387870  3766046   387842  3766047        0       20        0        0        0
1   387842  3766047   387813  3766047        0       20        0        0        0
1   387813  3766047   387785  3766048        0       20        0        0        0
1   387785  3766048   387757  3766050        0       20        0        0        0
1   387757  3766050   387728  3766051        0       20        0        0        0
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1   387699  3766053   387670  3766056        0       20        0        0        0
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1   387645  3766058   387620  3766060        0       20        0        0        0
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1   387567  3766066   387517  3766072        0       20        0        0        0
1   387517  3766072   387410  3766086        0       20        0        0        0
1   387410  3766086   387361  3766091        0       20        0        0        0
1   387361  3766091   387338  3766094        0       20        0        0        0
1   387338  3766094   387317  3766096        0       20        0        0        0
1   387317  3766096   387296  3766098        0       10        0        0        0
1   387296  3766098   387276  3766099        0       10        0        0        0
1   387276  3766099   387255  3766101        0       10        0        0        0
1   387255  3766101   387235  3766102        0       10        0        0        0
11101Hour 1
66384  66384  66384  66384  66384  66384  66384  66384  66384  66384
66384  66384  66384  66384  66384  66384  66384  66384  66384  66384
0.039178     0.039178     0.039178     0.039178     0.039178     0.039178     0.039178
0.039178    0.039178    0.039178
0.039178     0.039178     0.039178     0.039178     0.039178     0.039178     0.039178
0.039178    0.039178    0.039178
241.3188 0.82624 2 1300 104.0613 0 18.1039
```

APPENDIX B: METEOROLOGY SITES USED IN THIS STUDY

Basin	Air basin
Cnty abbr	County abbreviation
Name	Site name
Site	Site number
Lat	Latitude
Lon	Longitude
District	Air quality management district
Met_id	Meteorology site ID
Elev	Elevation (meters above sea level)
WD	Wind direction (degrees)
WS	Wind speed (meters per second)
WD_stdev	Wind direction standard deviation (degrees)
Temp	Air temperature (degrees Celcius)

Basin	Cnty abbr	Name	Site	Lat	Lon	District	Met_id	Elev	WD	WS	WD_stdev	Temp
SS	IMP	Buttercup	3541	32.7397	-114.884	IMP	BTC01	66	105.3	1.0	143.4	14.9
SS	IMP	Cahuilla	3516	32.9736	-115.174	IMP	CHL01	85	84.1	1.1	127.5	15.7
SS	IMP	Calexico-East	3173	32.67418	-115.391	IMP	CLX01		152.7	1.1	102.3	15.9
SS	IMP	Calexico-Ethel Street	3135	32.67609	-115.483	IMP	CLX02	0	123.4	0.6	119.7	23.1
SS	IMP	Calipatria - Mulberry	5724	33.044	-115.415	IMP		-34	246.3	0.4	90.7	21.1
SS	IMP	Fish Creek Mountains	3434	32.9903	-116.067	IMP	RFCM	232	237.4	1.0	104.5	25.5
SS	IMP	Meloland	5747	32.807	-115.446	IMP		-15	206.1	0.6	95.7	22.4
SS	IMP	Palo Verde	6552	33.3875	-114.723	IMP	CI072	70	255.6	0.6	111.4	21.6
SS	IMP	Salton Sea East	5774	33.22	-115.58	IMP		-69	209.7	0.9	91.6	22.6
SS	IMP	Salton Sea West	5773	33.327	-115.95	IMP		-69	115.1	0.4	107.0	23.6
SS	IMP	Seeley	5735	32.759	-115.732	IMP		12	188.5	0.9	109.8	22.4
SS	IMP	Squaw Lake	3468	32.9078	-114.474	IMP	RSQL	91	113.9	0.2	124.2	24.6
MD	LA	Mill Creek (ANF)	3480	34.3903	-118.083	AV	RMCA	1530	235.1	1.2	107.5	13.8
MD	LA	Mill Creek (BDF)	3315	34.0836	-117.035	AV	RMLC	899	155.9	0.7	116.7	17.4
MD	LA	Poppy Park	3316	34.7325	-118.383	AV	RPOP	841	221.4	1.8	103.1	17.0
MD	LA	Saddleback Butte	3645	34.6847	-117.821	AV	RSDL	789	179.0	1.4	118.5	17.3
SC	LA	Acton	3326	34.4458	-118.2	SC	RACN	1174	84.5	0.9	113.8	16.2
SC	LA	Azusa	2484	34.1364	-117.924	SC	AZU01	187	186.0	0.8	110.2	18.7
SC	LA	Beverly Hills	3362	34.125	-118.412	SC	RBHL	59	239.8	0.7	94.8	17.6

Basin	Cnty abbr	Name	Site	Lat	Lon	Dis-trict	Met_id	Elev	WD	WS	WD_ stdev	Temp
SC	LA	Burbank-W Palm Avenue	2492	34.1758	-118.317	SC	BUR03	171	292.3	0.9	88.5	18.1
SC	LA	Camp 9	3359	34.3617	-118.422	SC	RCP9	1219	340.1	0.8	104.5	15.2
SC	LA	Chilao	3329	34.3317	-118.03	SC	RCIO	1661	329.0	1.1	100.1	14.2
SC	LA	Claremont	3466	34.1369	-117.707	SC	RCLR	501	197.1	0.8	118.1	16.7
SC	LA	Claremont #2	5742	34.13	-117.696	SC		494	214.0	0.6	112.9	17.4
SC	LA	Del Valle	3544	34.4311	-118.683	SC	DLV01	390	160.8	0.5	113.7	17.7
SC	LA	Glendale #2	5778	34.2	-118.232	SC		270	261.0	0.4	123.8	16.0
SC	LA	Glendora-Laurel	2849	34.14438	-117.85	SC	GLD03	84	216.8	0.4	108.0	17.0
SC	LA	Hawthorne	2045	33.9208	-118.37	SC	HAW01	6	214.6	1.3	112.1	17.4
SC	LA	Leo Carrillo	3621	34.0456	-118.936	SC	RLEO	15	154.2	1.0	122.6	16.5
SC	LA	Long Beach #2	5816	33.797	-118.094	SC		9	230.8	0.7	109.2	14.5
SC	LA	Los Angeles-North Main Street	2899	34.06639	-118.227	SC	LAX06	27	241.3	0.8	104.1	18.1
SC	LA	Lynwood	2583	33.92899	-118.211	SC	LYN01	8	244.2	0.7	110.5	17.0
SC	LA	Malibu Hills	3364	34.0583	-118.633	SC	RMLB	480	100.3	0.4	106.9	18.1
SC	LA	Monrovia	5803	34.14528	-117.985	SC		181.4	225.5	0.4	123.6	17.4
SC	LA	North Long Beach	2429	33.82417	-118.189	SC	NLB01	30	237.3	0.6	101.6	17.6
SC	LA	Pasadena-S Wilson Avenue	2160	34.13278	-118.127	SC	PAS04	76	265.7	0.2	91.9	17.0
SC	LA	Pico Rivera	2166	34.01407	-118.061	SC	PIC01	21	232.1	1.1	89.9	18.0
SC	LA	Pomona	2898	34.06697	-117.751	SC	POM01	82	198.7	0.8	126.6	17.0
SC	LA	Pomona #2	5740	34.058	-117.812	SC		222	162.2	0.4	130.8	16.4
SC	LA	Reseda	2420	34.19917	-118.533	SC	RES01	224	173.5	0.2	105.8	17.0
SC	LA	Santa Clarita-County Fire Station	2855	34.38805	-118.534	SC	SLI02	114	276.1	0.4	104.0	17.0
SC	LA	Santa Fe Dam	3363	34.1208	-117.946	SC	RSAF	152	60.4	0.3	95.3	15.0
SC	LA	Santa Monica	5754	34.044	-118.476	SC		104	195.3	0.6	121.7	16.3
SC	LA	Saugus	3358	34.425	-118.525	SC	RSAU	442	229.4	0.4	109.3	17.8
SC	LA	Tanbark	3361	34.2069	-117.761	SC	RTAN	792	23.7	0.1	130.7	16.8
SC	LA	West Los Angeles-VA Hospital	2494	34.05056	-118.457	SC	WSL03	90	242.5	0.8	107.0	17.0
SC	LA	Whitaker Peak	3545	34.5686	-118.74	SC	WPK01	1256	131.9	1.8	102.4	15.1
SC	ORA	Anaheim-Harbor Blvd	2623	33.82028	-117.914	SC	ANA02	11	228.0	1.0	90.5	18.3
SC	ORA	Bell Canyon	3370	33.5417	-117.592	SC	RBEC	20	255.1	2.2	99.3	17.4
SC	ORA	Costa Mesa-Mesa Verde Drive	2937	33.67456	-117.926	SC	COS03		222.9	0.7	115.5	17.0
SC	ORA	El Toro	2603	33.62722	-117.691	SC	ETR01	42	252.6	0.2	109.4	17.0
SC	ORA	Fremont Canyon	3367	33.8081	-117.711	SC	RFMC	543	262.6	1.4	81.0	17.7

Basin	Cnty abbr	Name	Site	Lat	Lon	Dis-trict	Met_id	Elev	WD	WS	WD_ stdev	Temp
SC	ORA	Irvine	5738	33.689	-117.721	SC		125	221.3	0.2	100.2	16.6
SC	ORA	La Habra	2249	33.92504	-117.953	SC	LAH01	25	198.0	0.3	129.2	17.0
SC	ORA	Mission Viejo-26081 Via Pera	3265	33.63028	-117.675	SC	MVJ01	49	212.1	0.3	110.4	16.7
MD	RIV	Blythe #3	5780	33.557	-114.666	MD		84	223.2	0.2	109.2	21.1
MD	RIV	Lost Horse	3325	34.0178	-116.188	SC	RLTH	1280	87.0	0.4	130.7	16.4
MD	RIV	Rice Valley	3443	34.0608	-114.732	MD	RRVL	250	233.4	0.4	100.7	23.4
MD	RIV	Ripley	5796	33.532	-114.634	MD		76	284.1	0.4	119.0	20.4
SC	RIV	Anza	3369	33.555	-116.673	SC	RANZ	279	218.1	0.1	117.7	14.6
SC	RIV	Banning Airport	3168	33.9208	-116.858	SC	BAN01	220	191.1	3.2	64.2	18.3
SC	RIV	Clark	3595	33.8767	-117.309	SC	RCLK	524	169.4	1.3	125.5	18.8
SC	RIV	El Cariso	3436	33.6472	-117.411	SC	RELC	832	321.0	0.2	111.2	17.3
SC	RIV	Keenwild	3323	33.6667	-116.767	SC	RKNW	1500	173.5	0.5	123.1	14.1
SC	RIV	Lake Elsinore-W Flint Street	2943	33.67649	-117.331	SC	LEL01	439	237.8	0.2	117.1	17.0
SC	RIV	Perris	2525	33.78932	-117.228	SC	PER01	134	130.5	0.4	131.9	17.0
SC	RIV	Riverside-Rubidoux	2596	33.99951	-117.416	SC	RIV08	76	160.2	1.1	130.4	18.7
SC	RIV	Santa Rosa Plateau	3371	33.5286	-117.231	SC	RSAR	604	224.5	0.8	109.3	16.9
SC	RIV	Temecula #4	5733	33.49	-117.222	SC		433	89.2	0.3	105.1	16.9
SC	RIV	Temecula East II	5782	33.557	-117.03	SC		468	239.0	0.5	104.6	16.0
SC	RIV	Temescal #1 (CNF)	3655	33.7625	-117.411	SC	RTEM1	343	119.5	0.1	112.3	18.8
SC	RIV	UC Riverside	5726	33.965	-117.336	SC		311	224.6	0.6	93.3	17.9
SS	RIV	Cathedral City	5766	33.843	-116.479	SC		120	113.1	1.5	123.3	22.3
SS	RIV	Indio #2	5806	33.746	-116.258	SC		12	165.8	1.5	95.1	23.2
SS	RIV	Indio-Jackson Street	2878	33.70857	-116.215	SC	IDO03		150.4	1.1	117.9	17.0
SS	RIV	La Quinta	5818	33.686	-116.306	SC		13	52.1	0.2	95.3	12.8
SS	RIV	Mecca	5786	33.538	-115.992	SC		-55	152.9	0.5	119.1	22.3
SS	RIV	Oasis	5781	33.516	-116.154	SC		4	159.7	0.5	104.0	23.0
MD	SBD	Barstow NE	5779	34.884	-116.983	MD		179	184.6	1.7	96.0	19.0
MD	SBD	Burns Canyon	3327	34.2083	-116.621	MD	RBCN	1829	226.2	0.4	117.1	14.0
MD	SBD	Cypress	5959	34.5925	-117.168			964	173.2	3.2	91.3	12.5
MD	SBD	El Mirage	3435	34.6344	-117.549	MD	RELM	878	161.0	1.2	134.7	16.9
MD	SBD	Granite Mountain	3321	34.53556	-117.026	MD	RGAM	1439	172.8	2.8	94.8	15.4
MD	SBD	Horse Thief Springs	3441	35.7706	-115.909	MD	RHTS	1524	249.4	0.4	112.8	16.2
MD	SBD	Joshua Tree-National Monument	3152	34.06948	-116.389	MD	JOS01	378	242.7	2.3	78.7	16.5
MD	SBD	Means Lake	3448	34.3844	-116.524	MD	RMLK	884	213.9	0.6	112.7	19.0
MD	SBD	MID Hills	3438	35.1231	-115.411	MD	RMDH	1650	187.9	1.2	103.1	13.8

Basin	Cnty abbr	Name	Site	Lat	Lon	District	Met_id	Elev	WD	WS	WD_stdev	Temp
MD	SBD	Mojave River Sink	3354	35.0531	-116.079	MD	RMJ2	290	206.2	1.1	107.3	21.6
MD	SBD	Mormon Rock	3520	34.3175	-117.502	MD	MMN01	1006	323.2	0.5	103.4	15.1
MD	SBD	Opal Mountain	3440	35.1542	-117.176	MD	ROPL	988	199.4	2.1	104.0	18.1
MD	SBD	Squaw Springs	3469	35.3683	-117.57	MD	RSQS	1103	201.8	2.1	92.5	18.3
MD	SBD	Victorville #5	5765	34.478	-117.261	MD		881	233.7	1.5	99.0	16.2
MD	SBD	Yucca Valley	3311	34.1233	-116.408	MD	RYUC	994	203.9	0.6	114.4	17.4
SC	SBD	Converse	3542	34.1942	-116.913	SC	CNV01	1712	200.8	0.8	108.0	12.9
SC	SBD	Crestline	2499	34.24139	-117.276	SC	LKG01	1389	274.9	0.9	93.3	17.0
SC	SBD	Devore	3319	34.2211	-117.403	SC	RDEV	634	196.5	0.4	122.2	18.0
SC	SBD	Fawnskin	3320	34.2661	-116.899	SC	RFWS	2103	223.5	0.3	106.5	8.5
SC	SBD	Fontana-Arrow Highway	2266	34.10011	-117.492	SC	FON02	116	224.8	0.8	109.8	17.0
SC	SBD	Redlands-Dearborn	2077	34.05975	-117.147	SC	RDL02		173.9	0.4	128.6	17.0
SC	SBD	San Bernardino-4th Street	2221	34.10666	-117.274	SC	SNB02		224.0	1.0	111.8	18.5
SC	SBD	Upland	2485	34.10333	-117.629	SC	UPL01	384	187.2	1.0	108.5	17.8
SCC	VEN	Camarillo	5797	34.232	-118.994	VEN		40	237.6	0.3	101.5	16.0
SCC	VEN	Cheeseboro	3360	34.1847	-118.717	VEN	RCHE	503	93.0	0.4	105.7	17.8
SCC	VEN	Chuchupate	3572	34.8064	-119.013	VEN	CHC01	1494	85.0	0.3	114.8	10.3
SCC	VEN	El Rio-Rio Mesa School #2	2991	34.25236	-119.143	VEN	ERI02	10	177.3	0.8	111.5	15.4
SCC	VEN	Ojai	3532	34.4483	-119.23	VEN	OJA05	233	199.4	0.8	121.3	16.6
SCC	VEN	Ojai-Ojai Avenue	3172	34.44806	-119.231	VEN	OJA03	80	204.0	0.7	113.1	15.5
SCC	VEN	Piru #2	6553	34.375	-118.789	VEN	CI101	195	159.4	0.1	97.2	16.5
SCC	VEN	Piru-2 miles SW	2702	34.40259	-118.825	VEN	PRU01	55	204.1	1.0	99.3	17.9
SCC	VEN	Piru-3301 Pacific Avenue	3505	34.40431	-118.81	VEN	PRU02		19.7	2.2	73.8	13.5
SCC	VEN	Port Hueneme	6554	34.1733	-119.2	VEN	CI097	5	203.3	0.6	116.0	15.3
SCC	VEN	Rose Valley	3355	34.5433	-119.184	VEN	RROV	1015	213.6	0.8	112.7	12.4
SCC	VEN	Santa Barbara Island	4770	33.4833	-119.033	VEN		110	8.8	2.9	94.4	13.7
SCC	VEN	Simi Valley-Cochran Street	2880	34.27622	-118.684	VEN	SIM04	94	191.8	0.7	113.5	17.0
SCC	VEN	Simi Valley-Upper Air	3171	34.2913	-118.798	VEN	SIM05	85	157.3	0.5	119.2	16.8
SCC	VEN	Thousand Oaks-Moorpark Road	2984	34.21028	-118.871	VEN	THO02	71	155.0	0.5	109.9	16.4
SCC	VEN	Ventura County-W Casitas Pass Road	2756	34.38667	-119.417	VEN	VEN02	98	173.7	0.5	92.9	15.8
SCC	VEN	Ventura-Emma Wood State Beach	2088	34.28074	-119.315	VEN	VEN05	1	154.7	1.5	111.5	14.9

APPENDIX C: EXAMPLE OF BATCH RUN COMMAND FILE

(Change Disk if needed)

```
Caline4_w32.exe <L828R1.txt>oAM-L828R1.txt
Caline4_w32.exe <L828R2.txt>oAM-L828R2.txt
Caline4_w32.exe <L828R3.txt>oAM-L828R3.txt
Caline4_w32.exe <L828R4.txt>oAM-L828R4.txt
Caline4_w32.exe <L828R5.txt>oAM-L828R5.txt
Caline4_w32.exe <L828R6.txt>oAM-L828R6.txt
Caline4_w32.exe <L828R7.txt>oAM-L828R7.txt
Caline4_w32.exe <L828R8.txt>oAM-L828R8.txt
Caline4_w32.exe <L828R9.txt>oAM-L828R9.txt
Caline4_w32.exe <L828R10.txt>oAM-L828R10.txt
Caline4_w32.exe <L828R11.txt>oAM-L828R11.txt
Caline4_w32.exe <L828R12.txt>oAM-L828R12.txt
Caline4_w32.exe <L828R13.txt>oAM-L828R13.txt
Caline4_w32.exe <L828R14.txt>oAM-L828R14.txt
Caline4_w32.exe <L828R15.txt>oAM-L828R15.txt
Caline4_w32.exe <L828R16.txt>oAM-L828R16.txt
Caline4_w32.exe <L828R17.txt>oAM-L828R17.txt
Caline4_w32.exe <L828R18.txt>oAM-L828R18.txt
Caline4_w32.exe <L828R19.txt>oAM-L828R19.txt
Caline4_w32.exe <L828R20.txt>oAM-L828R20.txt
Caline4_w32.exe <L828R21.txt>oAM-L828R21.txt
Caline4_w32.exe <L828R22.txt>oAM-L828R22.txt
```

Note: This file will process the receptor groups R1 to R22 for Link 828 with CALINE4_w32.exe in one batch run.