APPENDIX D MODELING AND ATTAINMENT DEMONSTRATIONS

D.1 Overview

This document presents modeling documentation and results in support of a 1-hour ozone State Implementation Plan (SIP) update for the San Joaquin Valley Air Pollution Control District. The modeling results are for the July/August 2000 Central California Ozone Study (CCOS) episode, one of three ozone episodes intensively measured during the summer 2000 field study. Of the three CCOS episodes, the July/August episode was selected for use in this SIP. This determination was based on both the representativeness of the meteorology, ozone concentrations, and the performance of model for this period. Other ozone episodes are in development by the districts and their contractors, and may also be available for ozone SIP use by some or all of the districts in the region.

The process to develop and validate an air quality model is very complex and resource intensive. The development of the July/August CCOS episode was no exception. A great deal of time and effort was spent in the development and review of the modeling inputs, and in the application and validation of the air quality model. Many stakeholders have participated in this process, including local air districts and transportation planning agencies in the region, and members of the CCOS Technical Advisory Committee. The modeling for this episode is an ongoing effort, since it will eventually support many uses in addition to one-hour ozone SIP planning, and to reflect new information and improvements in the science. However, the modeling results presented in this document satisfy accepted model performance criteria and we believe they are acceptable and appropriate for use in SIP planning.

The remaining sections and appendices of this document provide a description of the model development and application process, the episode, the model inputs, the results of the model performance evaluation, and the results from application of the model to future years.

D.2 Episode Characterization

The characteristics and evolution of the July/August 2000 Central California Ozone Study (CCOS) episode are comprehensively documented by Technical and Business Systems (T&B, 2003). The reader is referred to that document for detailed information about the episode. In this section we briefly summarize the air quality and meteorology of the episode, and describe the CCOS database, which provides online access to all of the data collected during the field study.

D.2.1 Air Quality

Table D-1 summarizes the peak one-hour ozone concentrations measured during the July/August episode. The highest ozone concentration during this episode was 151 ppb on August 2 at Edison in the southern portion of the San Joaquin Valley. Peak ozone values on July 29 occurred in the San Joaquin Valley, where values near 130 ppb were recorded at Parlier and Edison; the Bay Area and Sacramento region experienced no federal 1-hour exceedances that day. On July 30, only the San Joaquin Valley exceeded the 1-hour NAAQS for ozone. Concentrations at Parlier and Edison were 129 and 128 respectively. The highest reading on July 31 occurred at Livermore in the Bay Area; the measured peak value was 126 ppb. This was the only exceedance of the federal standard on that day in the CCOS domain. The only federal 1-hour exceedances on August 1 occurred in the Sacramento region, which experienced its highest ozone readings of the episode. On that day the Sloughouse site recorded a peak value of 133 ppb. Similarly, the only exceedances on August 2 occurred in the San Joaquin Valley, which had peak readings of 131 ppb in the northern part of the valley (Turlock and Modesto) and the maximum concentration for the episode at Edison of 151 ppb.

Table D-1
Measured ozone concentrations during the July/August CCOS Episode

	Peak 1-Hour Ozone Concentrations							
Date	**Sacramento Nonattainment Area**		**Bay Area**		**San Joaquin Valley - North**		**San Joaquin Valley - South**	
	Basin Max (ppb)	**Station**	**Basin Max (ppb)**	**Station**	**Basin Max (ppb)**	**Station**	**Basin Max (ppb)**	**Station**
7/30/2000	121	Sloughhouse	82	Livermore (old)	129	Parlier	128	Edison
7/31/2000	103	Davis	126	Livermore (old)	118	Clovis	115	Edison
8/1/2000	133	Sloughhouse	94	Livermore (new)	118	Fresno-Sierra Skypark #2	116	Arvin
8/2/2000	116	Cool	98	Livermore (old)	131	Modesto & Turlock	151	Edison

There were several large wildfires during the July/August CCOS episode, and some of the peak ozone readings during the episode are suspected to have been influenced at least in part by wildfire emissions. Day-specific emissions from these wildfires have been included in the modeling inventories for the episode. Table D-2 summarizes the locations of, and total acres burned from, the largest fires which occurred during the episode.

Table D-2
Summary of wildfire activity and acreage burned during the July/August 2000 CCOS episode.

Day-Specific Point Sources?	Day-Specific Wildfires?	Characterization of Wildfires		
		Total Acres Burned July 29 - Aug 2, 2000	**Largest Fires in Domain, Acres**	**County**
Yes	**Yes**	99,000 acres burning in California (92,000 acres in CCOS domain). Fires burning in Oregon (9,100 acres) and in Nevada (112,000 acres).	67,300 2,500 700 300	Tulare Washoe, NV Kern Kern

D.3 Meteorological Conditions During the July/August 2000 CCOS Episode

The CCOS episode of July 27 through August 2, 2000, was typical of the weather types where exceedances of the one hour NAAQS have occurred. Historically exceedances of the NAAQS in the CCOS region occur during strong ridging. Lehrman, et. Al., (2003) typed weather patterns and determined that the episode began as a stagnant/flat type and ended with strong ridging. This was the same sequence of meteorology that occurred in the last episode used for the San Joaquin Valley ozone attainment plan in done in 1994. That August 3 to 6, 1990, also began with a stagnant/flat type and ended with strong ridging. Statistical analyses indicate that this episode is in the upper range of poor air pollution dispersion meteorology that results in exceedances of the NAAQS in the San Joaquin Valley. Lehrman (2003) reported that all days during the July-August 2000 ozone episode fall into meteorology categories within one standard deviation of the mean for days greater than the NAAQS.

A typical Great Basin high pressure system was observed during the course of this episode. The 500 mb analysis also showed the existence of a relatively large high pressure ridge with a maximum geopotential height of 5960 m that was centered over Utah and vicinity. A second high pressure center was also located off the coast of California around 35^{o}N latitude.

The high pressure ridge recorded by both surface and 500 mb analyses resulted in relatively calm winds with magnitude of less than 2 m/s near the surface. Dry bulb temperatures recorded by the surface observational network at 2 m height exceeded 100 ^{o}F, and dew point temperatures were around 40 ^{o}F within the SJV. 850 mb temperatures over the San Joaquin Valley (SJV) were larger in magnitude (80 ^oF/27 ^oC) than those recorded in a typical steady state atmosphere (less than 20^oC).

The pressure, temperature, and wind patterns observed near the surface persisted throughout the episode. The Great Basin high pressure system and 500 mb ridge remained nearly stationary, while the high pressure system located off the coast of California increased in strength and moved in a north-south direction during the episode.

Analysis of upper level winds at 300 mb did not indicate the existence of a well defined subtropical jet-stream, while the polar jet-stream was located at 55^{o}N latitude. The sub-tropical jet appears to have been reduced in magnitude over the continental United States, and was especially weak over California with a maximum value of only 20 m/s. Since upper level winds are the driving forces for near surface conditions, their absence typically implies weak near-surface winds.

An overall analyses of near-surface winds and temperature, 850 mb temperatures, 500 mb pressures, and 300 mb winds all suggest the existence of a blocking high pressure ridge located over the California-Nevada corridor. This pressure pattern can slow the progression of atmospheric motion from west to east, and its main effect can be seen as the creation of a relatively stagnant atmosphere within the SJV. While some inland penetration of the sea breeze was noted from surface and upper level weather maps, its effect on the circulation pattern within the SJV and its inland penetration distance does not appear to have been significant.

D.4 Field Study Data

The CCOS database is comprised of data collected under contract to CCOS as well as a variety of routine, supplemental sources. More specific information regarding the CCOS field study design and CCOS data collection efforts, including information on the supplemental data sources, can be found in the documents located under the following link:

http://www.arb.ca.gov/airways/CCOS/CCOS.htm

In addition, CCOS field data can be accessed in two ways:

- CCOS data and version-specific documentation are available under the following FTP link (Version 1A-06092003 of the CCOS database is used for model performance):

  ftp://eos.arb.ca.gov/pub/DATA/ccos/

- Interactive web queries (using the latest version of the database) are available at:

  http://www.arb.ca.gov/airways/Datamaintenance/default.asp

D.4.1 Field Data Quality Assurance (QA) and Quality Control (QC)

CCOS field study contractors were required to provide data to the database manager at QA Level 1B (a description of data QA/QC levels is provided at the end of this section). Sources of routinely collected, supplemental data (e.g. AIRS and CIMIS data) are also represented in the database and are assumed to be at QA Level 2. Further information on the CCOS database (e.g. data validity flags, system design, etc.) can be found at:

http://www.arb.ca.gov/airways/CRPAQS/lookups.htm

Prior to utilizing data in model validations, the data are plotted and screened for outliers by modeling staff. In general, few changes are made in elevating the status of a data record from Level 1B to Level 2 (i.e. in terms of the entire quantity of records in the database). Since some analyses are applied to episodes rather than to all samples, some data records in a file will achieve Level 2 designation while the remaining records will remain at Level 1B. Only a few data records will be designated as Level 3 to identify that they have undergone additional investigation. Data designated as Levels 2 or 3 validations are not necessarily "better" than data designated at Level 1B. The level only signifies that they have undergone additional scrutiny as a result of the tests described above.

D.4.2 Summary of QA/QC Levels

Level 1A (1A): These data have passed several validation tests applied by the field operator/investigator prior to data submission. The general features of Level 1A QA are:

1. Retain all data values and use the appropriate flags. Missing values should be 'null' and flagged as missing;
2. Flagging measurements when significant deviations from measurement assumptions have occurred;
3. Verifying computer file entries against data sheets;
4. Replacement of data from a backup data acquisition system in the event of failure of the primary system;
5. Adjustment of measurement values for quantifiable baseline and span or interference biases; and
6. Identification, investigation, and flagging of data that are beyond reasonable bounds or that are unrepresentative of the variable being measured (e.g. high light scattering associated with adverse weather).

Level 1B (1B): Level 1B consists of univariate checks such as maxima and minima, rates of change, and diurnal variations.

Level 2 (2): Level 2 validation is the first step in data analysis. Level 2 data validation takes place after data from various measurement methods have been assembled in the master database. Level 2 tests involve the testing of measurement assumptions (e.g. internal nephelometer temperatures do not significantly exceed ambient temperatures), comparisons of collocated measurements (e.g. filter and continuous sulfate and absorption), and internal consistency tests (e.g. the sum of measured aerosol species does not exceed measured mass concentrations).

Level 3 (3): Level 3 is applied when the results from different modeling and data analysis approaches are compared with each other and with measurements. The first assumption upon finding a measurement, which is inconsistent with physical expectations, is that the unusual value is due to a measurement error. If upon tracing the path of the measurement, nothing unusual is found, the value can be assumed to be a valid result of an environmental cause. The Level 3 designation is applied only to those variables that have undergone this re-examination after the completion of data analysis and modeling. Level 3 validation continues for as long as the database is maintained. A higher validation level assigned to a data record indicates that those data have gone through, and passed, a greater level of scrutiny than data at a lower level.

D.4.3 Database File Format and File Naming Convention

The data are organized in Parameter Group files as listed below in Table D-4. These files are in a standard, normalized file format and consist of data that span all CCOS monitoring periods and parameters. Documentation regarding these parameter group files is available at the following URL:

http://www.arb.ca.gov/airways/CRPAQS/lookups.htm

The file format standard is designed to facilitate incorporating user validation and QA back into the database. If users require to or intend to have data validation work integrated back into the database, a specific re-submittal process is required. Documentation of the file format, file naming convention, and data resubmittal standards is contained in the following two documents:

- Standard File Format and File Naming Convention: *FINAL – Parameter Groups – Record Layout – Rev. 2.0:* http://www.arb.ca.gov/airways/CRPAQS/lookups.htm
- Resubmittal Standards: *Data Review, Revision and Resubmits – release v2.0 (12/20/02)*: http://www.arb.ca.gov/airways/CRPAQS/lookups.htm

Table D-4
Parameter Groups*

Aircraft Air Quality and Meteorological – Parameter Group #14
Surface Continuous Gaseous Air Quality – Parameter Group #5
Surface Continuous Meteorological – Parameter Group #1
Surface VOC Canister – Parameter Group #13
Upper Level Air Quality – Parameter Group #6
Upper Level Virtual Temperature – Parameter Group #3
Upper Level Wind – Parameter Group #2
Upper Level Meteorological – Parameter Group #4
Surface DNPH Cartridge Carbonyl – Parameter Group #XX (still being created)

* Some of these

D.5 Meteorological Modeling

D.5.1 Introduction

Meteorological conditions leading to elevated ozone levels during summer 2000 Central California Ozone Study (CCOS) episodes were studied using the Pennsylvania State University/National Center for Atmospheric Research (PSU/NCAR) Mesoscale Model version 5 (MM5) (Grell et al, 1995) and the CALMET objective/diagnostic model (Earth Tech, 2000). The MM5 model best describes the physics that define the movement of the atmosphere. However, the meteorological regimes defined by such models do not always reproduce what is shown by meteorological measurements. As an alternative, the CALMET model generates meteorological fields by extrapolation of existing measurements. Therefore, the CALMET model may be better suited for use with the extensive measurements collected during the summer 2000 CCOS field study. However, meteorological measurements were not collected uniformly across the CCOS study domain. To best utilize the available CCOS meteorological measurements and to take advantage of the physics in MM5, a hybrid approach was utilized which matches measured meteorological parameters where measurements were made and relies on the physics within MM5 to estimate meteorological parameters where measurements were not available. This approach is described in more detail in sub-section D.5.3.

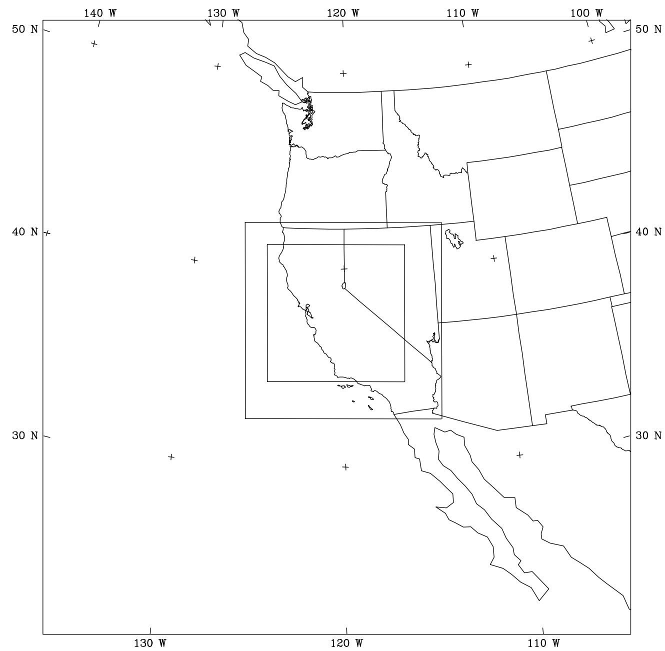
D.5.1.1 MM5

MM5 is a limited area, terrain-following sigma coordinate model based on a Lambert Conformal projection, and was developed by PSU and NCAR as a community mesoscale model. It is a non-hydrostatic numerical model that allows users to study the atmospheric motions at small scales by explicitly treating the effects of convective motions on atmospheric circulations. It has continuously been improved by contributions from a broad scientific community and improvements into the model are regularly incorporated. MM5 is maintained by and at NCAR, along with the necessary input meteorological and geographical data.

MM5 was set up with three nested grids of 36, 12 and 4 km (Figure D.1). The coarse grid nest with 36 km horizontal resolution provides the synoptic scale conditions to all three grids while the innermost grid with 4 km horizontal resolution resolves the fine details of atmospheric motions within the modeling domain. There are several options in MM5 to calculate the components of internal and external forces acting on a volume of air, such as radiation and microphysics, which may affect model results. Therefore, a number of alternative parameterizations were tested to develop the best possible meteorology for the CCOS episodes. Among the options tested were the Kain and Fritsch (1993) cumulus parameterization scheme for coarse grids, the MRF or Gayno Seaman planetary boundary layer (PBL) scheme for calculation of boundary layer fluxes, Dudhia's simple ice scheme for the treatment of excess moisture, the RRTM scheme for longwave radiation calculation (Mlawer, 1997) along with Dudhia's short wave radiation calculation, and the Blackadar multi-layer, force-restore method soil model.

Initial and boundary conditions were prepared using the analyses of observations prepared by the National Center for Environmental Prediction (NCEP) and archived at NCAR. Surface and upper air synoptic observations obtained by NCEP were also used to further refine the initial and boundary conditions. CCOS episodes were first simulated using initial and boundary conditions (IC/BCs) with no analysis or observational nudging on the two coarse grids. Then, IC/BCs were prepared from the 12 km grid output for the 4 km grid. Four-dimensional data assimilation, using surface and upper air observations collected during CCOS by surface stations, towers, rawinsondes, sodars, and radar wind profilers was used to improve IC/BCs for the 4 km grid. The model was used to simulate a 144 hour period during July 29-August 4, 2000, which included one of the CCOS episodes. The 3-D wind and temperature values simulated by the model were compared against surface and upper air observations to study the temporal and 3-D spatial structure of atmospheric motions as well as to evaluate the model performance.

Figure D.1
The location of the three nested grids adopted for the numerical modeling of CCOS episodes using MM5.



D.5.1.2 CALMET

The CALMET program is essentially a model that develops 2- and 3-dimensional fields of meteorological parameters using distance-weighted averaging (i.e., objective analysis). It is considered a 'diagnostic' model because it also includes features for averaging the results of the objective analysis with an input 'initial guess' wind field, for terrain adjustments, and algorithms for minimizing mass divergence. In addition to geographical inputs such as terrain heights and land use, CALMET requires meteorological observations over land and water, and upper-air meteorological profiles.

D.5.2 Domain and Vertical Structure

The CCOS study domain was defined in a Lambert Conical Projection with 2 Parallels (Table D-5). The domain extends from Los Angeles County in the south to the California/Oregon boundary in the north, and from the Pacific Ocean into Nevada in the east (Figure D.2). The horizontal study domain is comprised of 189 x 189, 4-km grid cells. Conventional wisdom indicates that cells on the boundary of a modeling domain can contain numerical anomalies, therefore a 2-cell offset was used to create an air quality modeling domain of 185 x 185, 4-km grid cells.

The vertical structure of the air quality modeling domain was defined based on the source of the meteorological inputs. For the July/August, 2000 CCOS episode, two meteorological models were used; each with a unique vertical structure: MM5 and CALMET. The MM5 prognostic meteorological model uses as vertical coordinates a normalized pressure index in a 'sigma' coordinate system. In this coordinate system, vertical heights are temperature- and pressure- dependent. Approximate vertical layer heights for sea level are shown in Table D-6. The CALMET meteorological model uses a fixed-height vertical structure and these levels are also shown in Table D-6. Both the MM5 model and the CALMET model use terrain-following coordinate systems and the heights are defined as height (meters) above ground level (magl).

The number and thickness of the vertical layers in the air quality modeling domain is also dependent on the height of the top of the domain. Ozonesonde measurements (data not shown) during the July/August, 2000 CCOS episode showed relatively high concentrations of ozone at heights above 5000 magl. Because these measurements suggested a natural vertical boundary, the top of the air quality modeling domain was set at 5000 magl (see Table D-6). For both meteorological models, 16 vertical layers were selected.

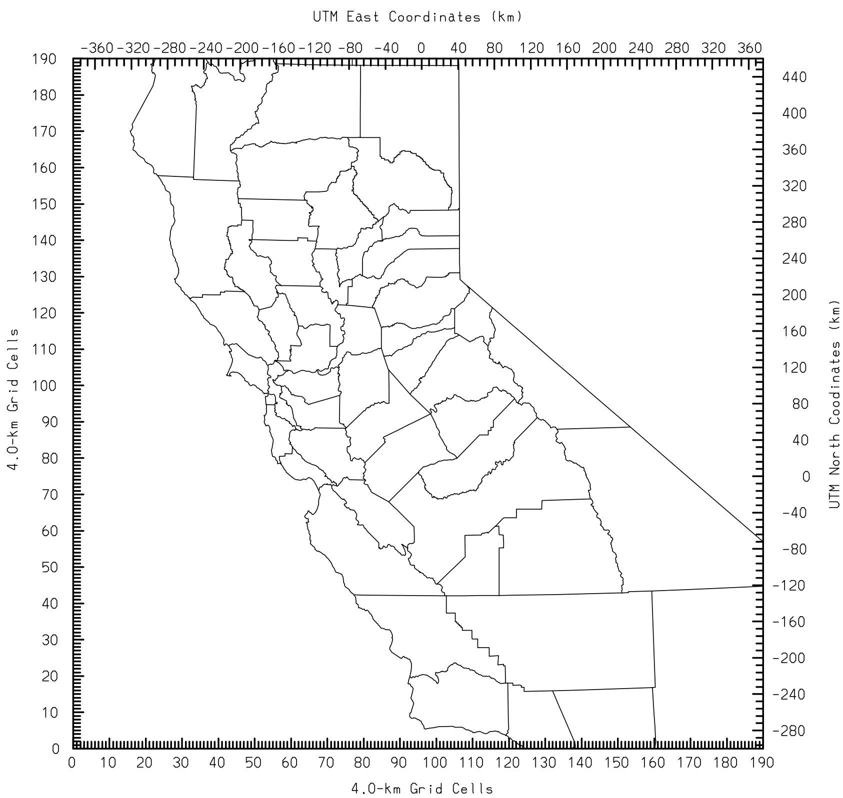
Table D-5
Lambert Conical Projection coordinate system used to define the CCOS modeling domain

Reference Latititudes	30 N 60 N
Central Meridian	120.5 W
Northing Offset	768.28 km
Easting Offset	0.0 km
Grid Cell Number	189 x 189
Grid Cell Size	4 km
Northing Origin	-300.0 km
Easting Origin	-384.0 km

Table D-6
The vertical structure of the air quality modeling domain for the July/August, 2000 CCOS episode based on the MM5 and CALMET meteorological models

Layer Number	MM5		CALMET	
	Thickness (m)	Height (m AGL)	Thickness (m)	Height (m AGL)
1	24	24	20	20
2	26	50	40	60
3	56	106	40	100
4	66	172	100	200
5	74	246	100	300
6	133	379	100	400
7	161	540	200	600
8	182	722	200	800
9	205	927	200	1000
10	232	1159	500	1500
11	265	1424	500	2000
12	356	1780	500	2500
13	488	2268	500	3000
14	666	2934	500	3500
15	926	3860	500	4000
16	1140	5000	1000	5000

Figure D.2
Air quality modeling domain for the CCOS July/August, 2000 episode.



D.5.3 Developing CALMET/MM5 Hybrid Meteorological Fields for CCOS Modeling

Prognostic meteorological models such as MM5 have shown promise for modeling areas which include complex meteorology. However, historically it has proven difficult to apply them successfully within California without modification. The 1994 San Joaquin Valley SIP was based on a version of MM5 that was altered from its original form (referred to as the "SARMAP Meteorological Model (MM5)" – Tesche and McNally, 1997). In their 2003 Air Quality Management Plan, the South Coast Air Quality Management District used MM5 for some ozone modeling; however, only after post-processing the MM5 outputs to make corrections (SCAQMD, 2003). Kumar and Russell (1996) concluded that prognostic meteorological models tend to overestimate wind velocities and underestimate air temperatures. They recommended that air quality models could get improved results with meteorological inputs from diagnostic models. The SCAQMD (2003) used CALMET for the greater part of their ozone modeling. Robe and Scire (1998) recommended a hybrid approach that combines MM5 and CALMET and this approach was successfully applied for ozone modeling by Barna et. al. (2000).

As described previously, a hybrid approach was utilized in this study which best utilizes the available CCOS meteorological measurements and takes advantage of the physics in MM5. This approach matches measured meteorological parameters where measurements were made and relies on the physics within MM5 to estimate meteorological parameters where measurements were not available. The CALMET/MM5 hybrid meteorological fields developed for the July/August 2000 CCOS episode include a weighted average of the wind fields generated by an objective analysis and the wind fields resulting from the prognostic meteorological model MM5. The CALMET meteorological model (EarthTech, 2000) has provisions for the incorporation of MM5 wind fields as CALMET 'initial guess' fields. However, because of the size of the CCOS modeling domain and the necessity of converting MM5 fields into text format for input into CALMET, this approach for developing hybrid meteorological fields is cumbersome. Also, the approach described by EarthTech presumes sufficient observational data for objective analysis throughout the modeling domain. The Central Valley of California is well represented with routine meteorological observational sites and the CCOS field study included a supplemental network of upper-air meteorological measurements. However, there are relatively few meteorological measurements for large portions of the CCOS domain, including over the Pacific Ocean and in Nevada. Therefore, an alternative approach to developing a hybrid meteorological field was developed that allows the use of 'virtual observations' from MM5-generated meteorological fields to fill in where other observations were not available.

To generate the CALMET/MM5 hybrid meteorological fields for the CCOS episodes, four pieces of software were used. The first piece of software was the CALMET model itself. For the CCOS modeling study, the CALMET v3.0 model code was used with modifications. Earth Tech (2000) describes CALMET v5.x and contains a number of improvements over version v3.0. However, these improvements were not sufficient to supercede CALMET v3.0 when considering the modifications to the code that had already been made (however, incorporating the modifications into CALMET v5.x would be straightforward). The most significant modification was to allow a CALMET output file to be used as an initial-guess field. This, and other modifications to CALMET v3.0, are described in following sections.

The second piece of software used is called 'mm5fmt'. This program reads the output file from the MM5 v3.x prognostic meteorological model and performs two functions. The first function is to extract meteorological parameters at selected spatial intervals and format them for input into CALMET as over-water observations, surface observations, and upper-air meteorological profiles. The second function is to reformat the MM5 model output into a CALMET output format.

The other two pieces of software required are utility programs to allow the list of virtual meteorological observations from MM5 and their respective site identifications to be merged with those actual observations and site locations.

D.5.3.1 Software

D.5.3.1.1 CALMET v3.0 and Code Modifications for CCOS

To use the CALMET output meteorological fields for CCOS air quality modeling, a number of modifications to the CALMET code were made. The air temperature fields are calculated within CALMET using objective analysis. However, the CCOS modeling domain includes complex topography with large changes in terrain elevations. Since most of the monitoring sites recording air temperatures within the domain were at lower elevations, the air temperatures at higher elevations would be over-estimated using objective analysis. To correct for this over estimation of temperatures, the CALMET code was modified so that air temperatures are adjusted for differences in terrain elevation prior to averaging. The vertical air temperature gradient was set to -0.0049 °C/m (note: the vertical temperature gradient was originally set to -0.0098 °C/m for the July/August, 2000 episode, but this was latter considered too extreme).

For some areas of the CCOS modeling domain, the network of monitoring sites for surface meteorology was fairly dense. However, in its default mode, CALMET uses these surface-based observations only in the vertical layer closest to the ground with a depth of 20 m. Above 20 m, meteorological parameters are averaged from the much less dense upper-air profile measurements. The CALMET model has a provision to extrapolate surface measurements vertically, but if this option is selected, the surface observations are extrapolated to the top of the modeling domain. For CCOS the domain top was set at 5000 magl and considered too high to be represented by surface-based observations. The CALMET code was modified to allow surface wind observations to be extrapolated for a set number of vertical layers. For the CCOS modeling study, an exponential increase in wind speed with height was assumed to a height of 200 magl.

The upper-air meteorological profiles input into CALMET must extend from the surface to the top of the modeling domain. For the CCOS model domain, the top was set to 5000 magl. However, the radar wind profilers used during the field study rarely recorded winds and temperatures above 2500 magl. To meet the CALMET input requirements, these profiles were extended to above 5000 magl, with the resulting potential for inaccuracies above the highest measurements. To partially compensate for these potential inaccuracies, a vertical profile of weighting factors was assigned and used to weight the objective analysis wind field with respect to the initial guess wind field (see Table D-7 – in CALMET, this weighting factor normally has a constant value for all levels). In the modified CALMET, the relative weight of the objective analysis field was gradually decreased with height until the 16th layer (above 4000 magl) where the objective analysis was weighted less than 10% relative to the initial guess field.

Table D-7
Vertical profile of weighting factors used to weight the objective analysis wind components relative to the initial guess field in CALMET

Layer	Layer Top (magl)	Weighting Factor
1	20	1.0
2	60	1.0
3	100	1.0
4	200	1.0
5	300	1.0
6	400	1.0
7	600	0.91
8	800	0.82
9	1000	0.73
10	1500	0.64
11	2000	0.55
12	2500	0.45
13	3000	0.36
14	3500	0.27
15	4000	0.18
16	5000	0.09

D.5.3.1.2 The Program ‘mm5fmt’

The program 'mm5fmt' was written to reformat MM5 v3.x model output as a CALMET model output. As a secondary function, the program outputs MM5-generated meteorological parameters at selected spatial intervals as 'virtual observations' for input into the CALMET model. The CALMET output file format contains 3-dimensional arrays of meteorological parameter fields, 2-dimensional arrays of dynamic variables, and 1-dimensional arrays of meteorological parameters specific to surface-based monitoring sites.

The 3-dimensional parameter fields within a CALMET output file are hourly horizontal wind speed components, vertical wind velocity, and air temperatures. These wind and temperature fields are mapped from the MM5 output file into the fixed-height vertical domain defined for CALMET (see Table D-10). The hydrostatic assumption was used to map the vertical layers in MM5, which is based on 'sigma' coordinates, to the fixed-height domain of CALMET.

The 2-dimensional parameter fields in the CALMET output file define the modeling domain, and hourly dynamic variables. Terrain heights and land use are taken directly from the MM5 output fields (the 24 MM5 land use categories are mapped into the 11 expected by CALMET). However, many of the hourly dynamic meteorology variables must be calculated. The PBL heights and aerodynamic roughness can be taken directly from MM5 output fields. However, the Monin-Obukov length, friction velocity, and scale convective velocity must be calculated. The energy fluxes necessary to calculate the Monin-Obukov length explicitly are available in the MM5 output fields; however, it was found that the sensible heat flux was not always consistent with the vertical temperature gradient near the surface. Therefore, the Monin-Obukov length is approximated from the gradient Richardson number, calculated using the 2 vertical layers closest to the surface.

The CALMET output file format also includes hourly air temperature, air density, solar radiation, and relative humidity at each of a number of surface monitoring sites. To satisfy the CALMET requirement for data at monitoring sites, arbitrary site locations were specified and extracted from MM5 (note: even though they are created in the same manner, this list of monitoring sites is distinctly different from the 'virtual sites' created in the following section). The parameter values for these arbitrary sites were taken from the appropriate grid cells in the MM5 output fields.

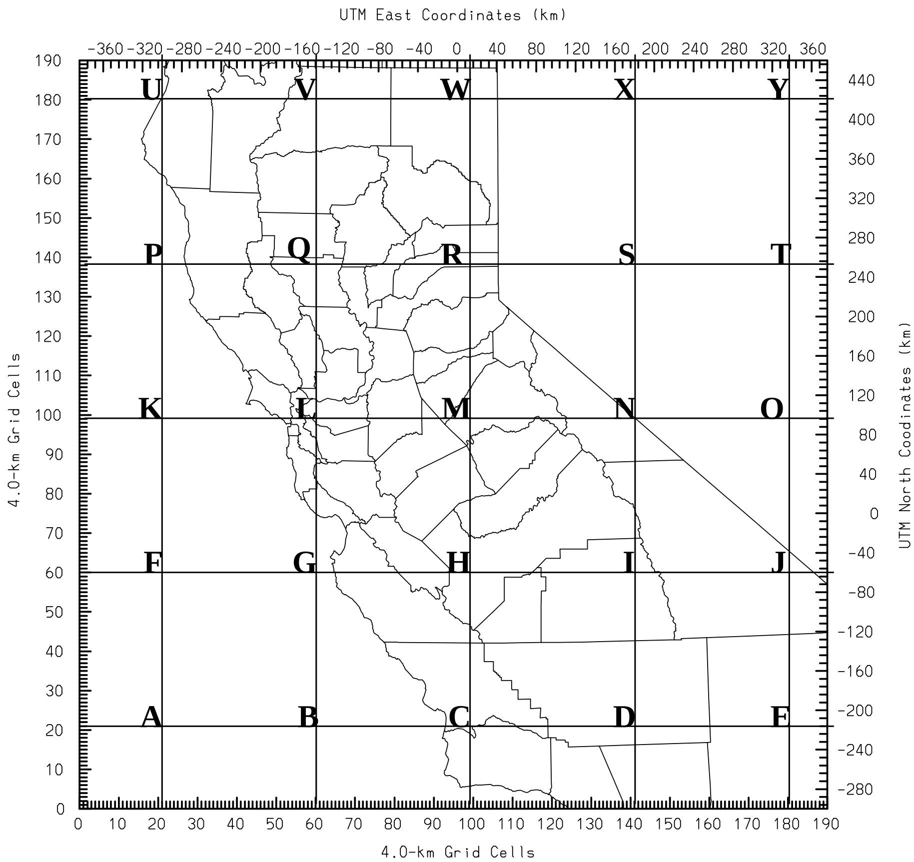
The second function of the program 'mm5fmt' is to generate files containing observations for 'virtual monitoring sites' required in CALMET files. The 3 types of CALMET input files that require observational data are for surface monitoring sites, over-water surface monitoring sites, and upper-air meteorology profiles. A fourth file is also required to identify and locate the 'virtual' sites.

The locations of the 'virtual monitoring sites' are selected at a user-specified spatial interval. For the CCOS modeling domain, the interval was 40 grid cells, resulting in 25 individual sites within the domain (Figure D.3); for simplicity, the surface and upper-air monitoring sites are identical. However, a separate distinction is made for surface sites located over water (based on land use). For the CCOS modeling domain, there were 7 sites over water. To be consistent with CALMET input requirements, the over-water and upper-air profiles are output as individual files, one for each site, in the appropriate formats required for input into CALMET. The surface meteorology parameters were output in a single file, again in the required CALMET input format. The site list and location file is output in a format consistent with the CALMET input control file.

D.5.3.1.3 Utility Programs 'cm_sfmt' and 'cm_contr'

The utility programs 'cm_sfmt' and 'cm_contr' allow the CALMET input files generated from MM5 using 'mm5fmt' to be merged with CALMET input files containing actual observations. The program 'cm_sfmt' reads 2 files, both of which contain hourly surface meteorology observations formatted for CALMET input, and generates a CALMET input file containing the merged observations from both files. The program 'cm_contr' reads the site list file generated by 'mm5fmt' and a CALMET control file. The output of 'cm_cntr' is a new CALMET control file in which the surface and upper-air sites lists from the two input files have been merged.

Figure D.3
Locations of virtual monitoring sites defined for the CCOS modeling domain.



D.5.3.2 Generating the CALMET/MM5 Hybrid Meteorology Fields

The generation of the CALMET/MM5 hybrid meteorological fields for the CCOS modeling domain, once the software described above is in place, was no more difficult than running CALMET by itself. The most difficult task was preparing the CALMET input files using available surface and upper-air meteorological observations (for file requirements and formats, see Earth Tech, 2000). Once these files were prepared, the files generated from MM5 using 'mm5fmt' were merged and CALMET was run (note that if no actual observations are available, the data files generated by 'mm5fmt' are sufficient to run CALMET).

The program 'cm_cntr' merges the site list generated by 'mm5fmt' with the list in the CALMET input control file. However, in the control file, the assigned names of the over-water site files and the upper-air site files must be edited by the user. The CALMET model used for the CCOS domain was modified to accept a file formatted as CALMET output as the input initial guess field. For the CCOS domain, the file output in CALMET format by 'mm5fmt' containing the MM5 wind field was used as this initial guess field.

For the objective analysis and the initial guess fields to be averaged by CALMET, the keyword in the CALMET input file 'IPROG=' must be set to '2' (Input Group 5). The CALMET model averages only the wind components for the 2 meteorological fields. All other parameter fields within the 'initial guess' input file are ignored.

Because the program 'mm5fmt' generates 'virtual' sites at regular intervals throughout the modeling domain, there will be some overlap in coverage between the network of actual meteorological monitoring sites and the 'virtual sites'. However, because the density of the 'virtual sites' is relatively low (at least compared to sites within the Central Valley) the impact of this overlap on the resultant wind fields was expected to be minimal.

D.5.3.3 Application of the CALMET/MM5 Hybrid to the July/August, 2000 CCOS Episode

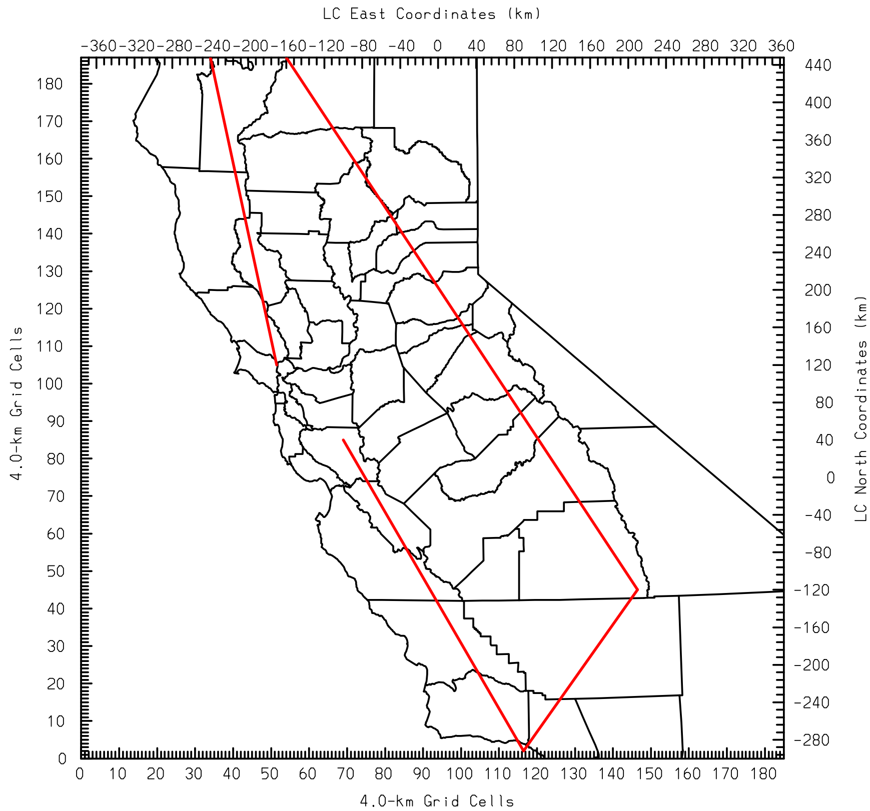
For the July/August, 2000 CCOS episode, meteorological fields required by the CAMx air quality model were developed using the CALMET/MM5 hybrid model. A brief summary of the CALMET model inputs is described within this section.
For the period July 29-August 2, 2000, surface meteorological variables were available at 109 sites, and 21 upper-air meteorological profiles were available. However, the monitoring locations were not distributed uniformly across the modeling domain. Most of the monitoring sites were located within the Central Valley of California, and relatively few were located east and north of the Valley. Also, many of the monitoring sites were clustered in urban areas where adjacent wind speed, direction, and temperature measurements often showed significant differences.

To prepare the surface meteorological measurements for input into CALMET, a subset of the monitoring network was selected. Where wind measurements were clustered, the number of monitoring sites was reduced. Monitoring sites for which measured wind speeds or directions appeared to be influenced by small-scale, local topography were also removed. Ultimately, 86 sites with surface wind measurements were used in the CALMET input file. Surface temperatures were also edited to minimize strong local temperature gradients that could not be accounted for by geography or topography. Interpolation barriers were defined to minimize the extrapolation of observed winds across mountain boundaries (Figure D.4).

The vertical wind measurements from the 21 available monitoring sites were used for CALMET inputs (see Figure D.5). The top of the CALMET modeling domain was set to 5000 magl. However, few of the vertical wind measurements extended that high. Where they did not, the wind speed and direction of the highest level was assigned to 5010 magl and the highest available temperature was extended vertically assuming an adiabatic lapse rate.

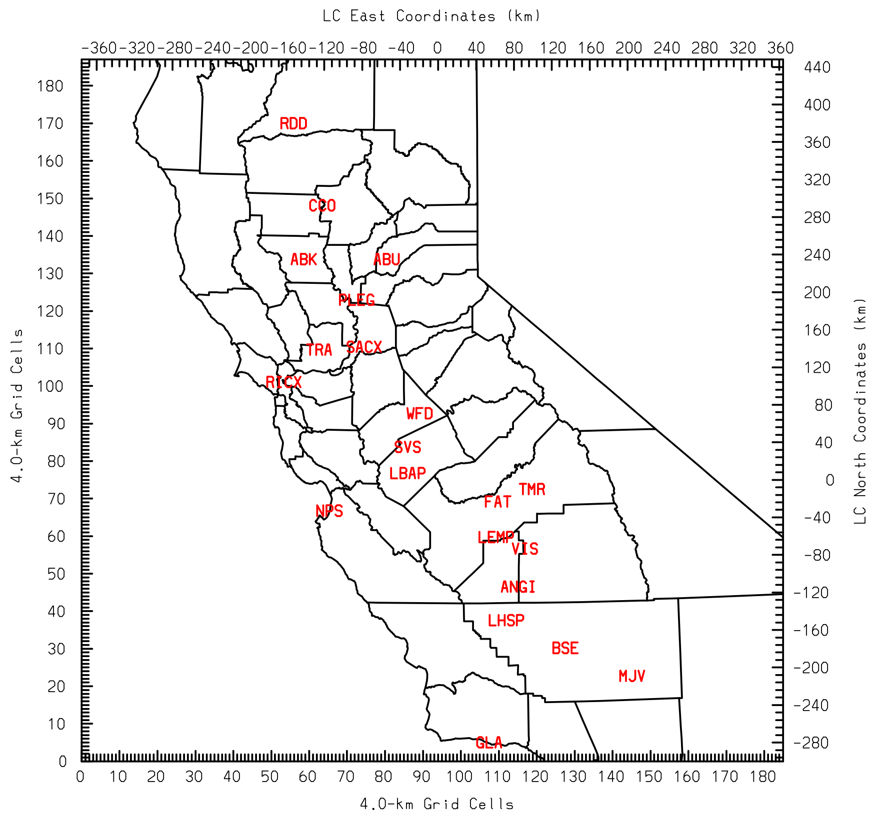
Because of the lack of observed meteorological monitoring sites in some regions of the CCOS modeling domains, and because of the uncertainties in winds higher than a few thousands of meters, CALMET/MM5 hybrid meteorological fields were generated using the methodologies described in subsection D.5.3. The CALMET/MM5 hybrid is an overlay of MM5 generated wind fields with the objective analysis wind fields generated within CALMET. The MM5 wind fields used were a from a simulation run by NOAA (2003) using ETA initialization and no observational FDDA (this MM5 simulation was selected based on a comparison of CAMx simulation results using meteorological fields generated solely from MM5).

Figure D.4
Wind speed and direction interpolation barriers defined within CALMET for the July/August, 2000 CCOS episode.



The program 'mm5fmt' was used to reformat the MM5 model output into a file with a CALMET format and to generate a series of 'virtual' monitoring sites. Virtual monitoring sites were generated at intervals of 40 grid cells, resulting in a total of 25 for the CCOS modeling domain (see Figure 3.2.1). The wind speed and direction, and air temperatures simulated by MM5 at these 25 virtual sites were added to the 86 surface and 21 upper-air sites from the CCOS field study with actual meteorological measurements. The CALMET model was run in 26 hour intervals and the resulting meteorological fields were reformatted for input into the CAMx air quality model.

Figure D.5
The location of upper-air wind measurements in the CCOS modeling domain.



D.5.3.4 Preparation of CAMx Input Meteorological Files

The CAMx air quality model requires 5 input files for meteorological parameters. These files define hourly, 3-dimension horizontal wind speed components, air temperatures, relative humidities, vertical diffusivities, and pressure and height fields. The wind components and air temperatures can be mapped directly from the CALMET output fields. The relative humidities, vertical diffusivities, and pressure vs. height fields must be calculated.

The CALMET output file includes relative humidities, but only for identified surface monitoring sites. To develop 3-dimensional relative-humidity fields, these surface values were extrapolated throughout the modeling domain. For each cell in the surface layer, the nearest surface site was identified and the relative humidity from that site was assigned. For grid cells above the surface, the relative humidity was assumed constant to the mixing height, and then was assumed to be one-half that value above the mixing height.

To calculate vertical diffusivity, algorithms were borrowed from 2 sources. The subroutine for calculating vertical diffusivity was taken from the CALGRID air quality model (Scire, et al., 1989). However, the vertical diffusivity equations for an unstable atmosphere were replaced with those of McRae et.al. (1982). These algorithms calculate vertical diffusivity as functions of the height of the planetary boundary layer (PBL – also known as mixing height). Most meteorological models (including CALMET and MM5) tend to overestimate PBL heights. Therefore, prior to the calculation of vertical diffusivity, PBL heights within the Central Valley were scaled to approximate mid-day values measured at Granite Bay and Parlier using the results from ozonesonde flights.

The CAMx air quality model requires as input a file defining the height and pressure for the vertical boundaries of each grid cell. For the CCOS modeling domain, a fixed-height vertical layer structure was assumed (see Table D-10). However, the CALMET meteorological model does not output atmospheric pressures. To calculate the required pressures, a constant sea-level pressure of 1013 mb was assumed. The adiabatic lapse rate was used to extrapolate the temperature of the surface layer from the cell terrain height to sea level. The hydrostatic equation was then used to extrapolate the sea-level pressure vertically, to the surface, and then above the surface using available grid-cell air temperatures.

D.6 Emissions

One of the necessary inputs to air quality modeling is temporally and spatially resolved emissions estimates. Emissions are broadly categorized into major stationary or point sources, area sources (which include off-road mobile sources), on-road mobile sources, and biogenics. In the following sections, we will describe how the emissions data are estimated and how they were used to develop base case and future year emissions estimates.

Due to the large area covered by CCOS, the development of the emission inventory has been a major effort. In addition to the size of the study domain, the emission inventory needed to support the modeling of the field study data must be much more detailed than the more routine summer seasonal emission inventory. The emission inventory needed to support the CCOS modeling is a series of day-specific, hourly, gridded emission inventories that cover each day of the ozone episodes captured during the field study.

To help coordinate this effort, an Emission Inventory Coordination Group (EICG) was established in February 1999 to determine the process for preparing the emission inventories needed to support air quality modeling for CCOS. Participating in the group were many local air districts, several local councils of government, Caltrans, the California Energy Commission, U.S. EPA, and the ARB. Local air districts that participated included San Joaquin Valley Unified APCD, Bay Area AQMD, Sacramento Metropolitan AQMD, Mendocino County APCD, Northern Sierra AQMD, Yolo-Solano

AQMD, Placer County APCD, San Luis Obispo County APCD, and Monterey Bay Unified APCD. All local air districts in the CCOS region were invited to participate.

The EICG met on a regular basis to discuss CCOS emission inventory development issues into 2002. As modeling inventories became available, the Air Resources Board established a Gridded Inventory Coordination Group (GICG) in February 2003. The GICG consists primarily of government agencies and their contractors that are responsible for the variety of data used to develop gridded emission inventories. Many of the participants in the EICG now participate in the GICG. The purpose of the GICG is to conduct quality assurance of the emissions, and to distribute and coordinate the development of emission inputs for SIP modeling. Minutes from the GICG meetings are provided in section D.9.

D.6.1 Background

California's emission inventory is an estimate of the amounts and types of pollutants emitted from thousands of industrial facilities, millions of motor vehicles, and of hundreds of millions of applications of other products such as paint and consumer products. The development and maintenance of the inventory is a multi-agency effort involving the ARB, 35 local air pollution control and air quality management districts (districts), metropolitan planning organizations (MPOs), councils of governments (COGs), and the California Department of Transportation (Caltrans). The ARB staff is responsible for the compilation of the final, statewide emission inventory, and maintains this information in a complex electronic database. Each emission inventory reflects the best information available at the time.

To produce regulatory, county-wide emissions estimates, the basic principle for estimating emissions is to multiply an estimated, per-unit emission factor by an estimate of typical usage or activity. For example, on-road motor vehicle emission factors are estimated for a specific vehicle type and model year based on dynamometer tests of a small sample of that vehicle type and applied to all applicable vehicles. The usage of those vehicles is based on an estimate of such activities as a typical driving pattern, number of vehicle starts, typical miles driven, and ambient temperature. It is assumed that all vehicles of this type in each region of the state are driven under similar conditions.

Developing emission estimates for stationary sources involves the use of per unit emission factors and activity levels. Under ideal conditions, facility-specific emission factors are determined from emission tests for a particular process at a facility. More commonly, a generic emission factor is developed by averaging the results of emission tests from similar processes at several different facilities. This generic factor is then used to estimate emissions from similar types of processes when a facility-specific emission factor is not available. Activity levels from point sources are measured in such terms as the amount of product produced, solvent used, or fuel used.

As mentioned previously, ARB maintains an electronic database of emissions and other useful information. Annual average emissions are stored for each county, air basin and district. The database is called the California Emission Inventory Development and Reporting System (CEIDARS). Emissions are stored in CEIDARS for criteria and toxic pollutants. The criteria pollutants are total organic gases (TOG), carbon monoxide (CO), oxides of nitrogen (NOx), oxides of sulfur (SOx), and total particulate matter (PM). Reactive organic gases (ROG) and particulate matter 10 microns in diameter and smaller (PM_{10}) are calculated from TOG and PM, respectively. Following are more details on how emissions are estimated for point and area sources, on-road motor vehicles, and biogenics. Additional information on emission inventories can be found at http://www.arb.ca.gov/emisinv/eib.htm.

D.6.2 Point and Area Source Emissions

D.6.2.1 Base Year Emissions

The stationary source component of the emission inventory is comprised of more than 11,000 individual facilities, called "point sources", and over 100 categories of "aggregated point sources". Aggregated point sources are many small point sources that are grouped together and reported as a single source category (gas stations, dry cleaners, and print shops are some examples). These emission estimates are based mostly on area source methodologies or emission models. Thus, the aggregated point sources include emissions data for the entire category of point sources, not each specific facility. Some districts include only the larger stationary sources in the inventory as point sources and include the smaller sources as aggregated point sources, whereas other districts include all stationary sources as point sources.

The area-wide source component includes emissions data only at the aggregated level. Examples of the categories are emissions from consumer products, pesticide applications, and wind-blown dust from agricultural lands. There are several hundred categories of area-wide sources. The emissions for these categories, which are associated with human activity, are located mostly within major population centers. Some of the emissions in these categories come from agricultural centers and from oil production complexes.

The off-road mobile sources are an estimate of the population, activity, and emissions estimate of the varied types of off-road equipment. The major categories of engines and vehicles include agricultural, construction, lawn and garden, and off-road recreation, and includes equipment from hedge trimmers to cranes. The OFF-ROAD model estimates the relative contribution of gasoline, diesel, compressed natural gas, and liquefied petroleum gas powered vehicles to the overall emissions inventory of the state. For more information , see

http://www.arb.ca.gov/msei/off-road/off-road.htm.

Local air districts estimate emissions from point sources. Estimating emissions from area sources is a cooperative effort between ARB and air district staffs. The emission inventory for CCOS will be developed from the 1999 CEIDARS inventory for TOG, NOx, SO_X, CO and PM.

D.6.2.2 Forecasted Emissions

Air pollution programs have always depended on predictive models for gaining a better understanding of what the emissions will be in the future—these predictions are based on expectations of future economic conditions, population growth, and emission controls.

ARB's model to forecast emissions is known as the California Emission Forecasting System (CEFS). A major feature of the model is its ability to track the effects of emission control rules and growth activity for stationary and other mobile sources by linking these factors directly to the emission categories. A key component of the new model is the Rule Tracking Subsystem (RTS), which was developed to link emission control rules to the emission process level (identified by Source Classification Code (SCC) and Standard Industrial Classification (SIC) or Emission Inventory Code (EIC)—which comprises more than 30,000 possible emission process/industry categories statewide).

Reports of forecasted emissions are available on-line. The reports can be generated for a variety of years, pollutants, source types, seasons and geographical areas. The forecasted reports for use in SIP modeling within the Central California Ozone Study (CCOS) domain can be accessed at:

http://www.arb.ca.gov/app/emsinv/ccos/tableofcontent.php

Please note that the reports provided under this link do not take into account day-specific emission adjustments, which are described in section D.6.2.3.

D.6.2.2.1 Growth Factors

Growth factors are derived from county-specific economic activity profiles, population forecasts, and other socio/demographic activity. These data are obtained from a number of sources: data from districts and local COGs are used when they are available; economic activity studies contracted by the ARB; and demographic data (e.g. population survey data from DOF, and VMT data from CALTRANS). Growth profiles are typically associated with the type of industry and secondarily to the type of emission process. For point sources, economic output profiles by industrial sector are linked to the emission sources via SIC. For area-wide and aggregated point sources, other growth parameters such as population, dwelling units and fuel usage may be used.

D.6.2.2.2 Control Factors

Control factors are derived from adopted State and Federal regulations and local district rules that impose emission reductions or a technological change on a particular emission process. These data are provided by the agencies responsible for overseeing the regulatory action for the particular emission categories affected. For example, the ARB staff develops the control factors for sectors regulated by the ARB, such as consumer products and clean fuels; the districts develop control factors for locally enforceable stationary source regulations that affect emissions from such equipment as IC engines or power plant boilers; and the Department of Pesticide Regulation (DPR) supplies control data for pesticides. In general, control factors account for three variables: *Control Efficiency* which estimates the technological efficiency of the abatement strategy; *Rule Effectiveness* which estimates the "real-world" application of the strategy taking into account factors such as operational variations and upsets; and *Rule Penetration* which estimates the degree a control strategy will penetrate a certain regulated sector taking into account such things as equipment exemptions. Control factors are closely linked to the type of emission process and secondarily to the type of industry. Control levels are assigned to emission categories, which are targeted by the rules via emission inventory codes (SCC/SIC, EIC etc.) that are used in CEIDARS.

D.6.2.3 Day-specific Emissions

As part of CCOS, the Emission Inventory Coordination Group (EICG), made up of ARB and district staff to guide inventory development for CCOS, requested that districts within the CCOS domain collect day-specific data from facilities and other sources within their jurisdiction. The EICG requested hourly/daily emission information from:

1) large point sources (> 100 tons per year of NOx or ROG)
2) sources with large variability in emissions (e.g. power plants)
3) unusual events (e.g. source shut down, variances, breakdowns)
4) agricultural or prescribed burning
5) wildfires

D.6.2.3.1 Point Sources

Eleven air districts provided daily or hourly emission estimates for 67 facilities. The districts which provided data were Amador County APCD, Bay Area AQMD, Colusa County APCD, Monterey Bay Unified APCD, Placer County APCD, Sacramento Metro AQMD, San Joaquin Valley Unified APCD, San Luis Obispo County APCD, Shasta County AQMD, Tehama County APCD, and Yolo/Solano AQMD. Day-specific emissions replaced emissions estimated from CEFS. Additionally, the Bay Area AQMD provided emission estimates from unusual events, such as breakdowns. These emissions were added to the modeling inventories on the day when the unusual event occurred.

D.6.2.3.2 Area Sources

Three districts provided day-specific data for agricultural burning. In most districts, no agricultural burning occurred because no-burn days were declared during the episode.

D.6.2.3.3 Wildfires

Emissions were estimated for known wildfires that occurred during the CCOS episodes. Two large wildfires occurred during the July/August 2000 episode: the Manter fire in Tulare County and the Plaskett fire in Monterey County. UC Berkeley's Center for the Assessment and Monitoring of Forest and Environmental Resources (CAMFER) laboratory estimated the emissions for these two fires, in consultation with the ARB. To develop emission estimates, CAMFER implemented the fire emissions module of the USDA Forest Service First Order Fire Effects Model (FOFEM, Reinhardt et al. 1997) within a Geographic Information System (GIS). FOFEM is a standard fire effects model used by federal and state land management agencies. The CAMFER model, called the Emissions Estimation System (EES), was initially devised to develop annual ARB fire emission inventories. CAMFER was tasked to extend the EES to enable the model to estimate temporally resolved emissions for individual fires, for an expanded suite of pollutants.

The CAMFER EES runs within ArcView software and utilizes emission algorithms, emission factors, combustion efficiencies, fuel loadings, and other parameters from FOFEM. In the EES, GIS-based spatial data layers (polygon shapefiles), representing burned areas, are overlayed onto a GIS vegetation data layer in which vegetation community types are coupled with corresponding FOFEM biomass fuel profiles. For each fuel component (there are 10 fuel components representing foliage, litter, and stem diameter classes) in each vegetation type, the EES determines pre-burn fuel loadings (tons per acre), fuel mass consumed by the fire, combustion efficiency, and emissions released. Burning occurs in two distinct phases: flaming and smoldering. The temporal evolution of emissions from a burning area is therefore a function of the phase in which a fire is burning, and the time elapsed since ignition. The FOFEM and CAMFER EES models generate daily emissions from both phases. Emissions generated by the EES from flaming and smoldering phases are combined in the final outputs.

These emissions were then utilized to develop a plume profile, using the techniques outlined in a recent report of the Fire Emissions Joint Forum (FEJF) of the Western Regional Air Partnership (WRAP) (Air Sciences, 2002). The hourly emissions were assigned based on the following standard profile (all values are taken directly from the FEJF report):

Hour	1	2	3	4	5	6	7	8	9	10	11	12
%	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53	2.0	4.0	7.0
Hour	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
%	10.0	13.0	16.0	17.0	12.0	7.0	4.0	0.53	0.53	0.53	0.53	0.53

For each hour of the episode, the wildfire virtual acreage was calculated using the fuel loading factors provided by ARB, and the virtual acreage sizes were used to determine the size classes of the fires. The size classes were then used to determine the parameters required to calculate the plume characteristics:

Class	1	2	3	4	5
Size (virtual acres)	0-10	>=10-100	>=100-1000	>=1000-5000	>=5000
BE (size)	0.4	0.6	0.75	0.85	0.9
Ptop Max (m)	160	2400	6400	7200	8000
Pbot Min (m)	0	300	800	1600	1600

These values, along with the buoyancy efficiency as a function of the hour of the day, were used to calculate the bottom of the plume, the top of the plume, and the proportion of the emissions fumigated into the first layer, for each grid cell in the fire area, and for each hour of the episode.

To model the vertical distribution of the plumes, a series of stack parameters were constructed for each grid cell, and each hour of the episode. The portion of the emissions attributed to the plume, rather than the fumigation layer, was distributed to each of the stack release points, with the fumigation portion going directly to the first layer (zero plume rise). The stack points were inserted into the emissions model at 25, 75, and 100 meters, and then at every 100 meters up to the top of the plume. Emissions were evenly allocated to each release point, beginning in the layer corresponding to the bottom of the plume, and continuing to the top of the plume.

For all other fires, emissions were calculated based on the number of acres of three vegetation types: chaparral, grass, and timber. The U.S. Forest Service provided fuel loading and emission factors. The number of acres, vegetation type, fire duration, and location information were taken from California Department of Forestry (CDF) fire incident reports and newspaper articles. The vertical distributions of the plumes were calculated using the FEJF methodology described above.

D.6.2.4 Temporally and Spatially Resolved Emissions

In addition to forecasting emissions, CEFS can create temporally resolved inventories for modeling purposes, for the base year and future years. The annual average emissions are adjusted to account for monthly and weekly variations. CEFS will generate an inventory for point and area sources (including off-road mobile sources) for a weekday and weekend day in the year and months needed for the CCOS episodes (e.g. July 2000 and August 2000). Emissions will be estimated for each county, air basin and district combination. In addition, information on how the daily emissions are to be distributed to each hour of the day is carried forward to the emissions processor.

D.6.2.5 Terminology

There can be confusion regarding the terms “point sources” and “area sources”. Traditionally, these terms have had two different meanings to the developers of emissions inventories and the developers of modeling inventories. The following table summarizes the difference in the terms. In the context of this document, section 4.2 (point and area source emissions) uses the emission inventory terms. In the remainder of the document, modeling terms are used. In modeling terminology, “point sources” refers to emission sources that exit from a stack and have a potential plume rise. “Area sources” refers collectively to area-wide sources, stationary-aggregated sources, and other mobile sources.

Emission Inventory Term	Examples	Modeling Term
On-Road Mobile	Automobiles	On-road Motor Vehicles
Off-Road Mobile	Farm Equipment, Construction Equipment, Aircraft, Trains	Area
Area-wide	Consumer Products, Architectural Coatings, Pesticides	Area
Stationary - Aggregated	Industrial Fuel Use	Area
Stationary – Point Facilities	Stacks at Individual Facilities	Point
Biogenic	Trees	Biogenic

D.6.3 Surface T and RH Objective Analysis

The calculation of gridded emissions for some categories of the emissions inventory is dependent on gridded air temperature, relative humidity, and solar radiation fields. Biogenic emissions are sensitive to air temperatures and solar radiation, and emissions from on-road mobile sources are sensitive to air temperature and relative humidity. Gridded temperature, humidity, and radiation fields are readily available from prognostic meteorological models such as MM5, used to prepare meteorological inputs for the air quality model. However, analysis of the MM5 outputs prepared for the July/August, 2000 episode revealed poor agreement between simulated humidity and temperature fields and the available measurements.

As an alternative to the data fields generated using the prognostic meteorological model, air temperature and humidity fields for calculation of the emission inventory were prepared by objective analysis. In the objective analysis, hourly temperatures for each grid cell within the study domain were calculated using a distance-weighted average of the nearest three temperature measurements. Because few temperature measurements were available at higher terrain elevations, temperatures were adjusted using the adiabatic lapse rate (-0.0098 C/m) multiplied by elevation differences prior to averaging.

Relative humidity measurements show a wide range of variability. Within the CCOS study domain, it was not unusual to find differences in relative humidity of 40% among sites within a 25 km radius. To reduce large horizontal variations in the relative humidity fields developed for the emission inventory calculations, relative humidity fields were calculated assuming a daily constant absolute humidity for each grid cell, based on an assumed daily maximum relative humidity of 80%.

The solar radiation fields needed for emission inventory calculations were taken directly from the MM5 simulation.

D.6.4 On-Road Mobile Source Emissions

D.6.4.1 Introduction

EMFAC is the ARB approved on-road motor vehicle emission inventory model. The current version is EMFAC2002 v2.2 [1]. This model provides emission estimates for 13 classes of vehicles for exhaust, evaporation, and PM emissions from tire wear and brake wear. EMFAC also produces estimates of fuel consumption, vehicle mile traveled (VMT), and the number of vehicles in use. EMFAC does not output a gridded emission file. However, EMFAC will also produce a file of emission rates that can be used with the Direct Travel Impact Model (DTIM) or other external on-road motor vehicle emission gridding program. These same emission rates are part of the information used by EMFAC to produce emission estimates for California counties or air basins.

It is important to recognize that EMFAC (and its associated activity), and not DTIM, is used to calculate county-specific emissions. DTIM output, using the Integrated Transportation Network (ITN) activity as inputs, were used to create hourly emission *ratios* for each grid-cell in a county. These ratios were used to distribute county-specific, daily EMFAC emissions to each hour and grid cell. A horizontal grid resolution of 4 x 4 kilometers was used.

DTIM4 [2] is the latest version of DTIM, and is used to estimate gridded on-road motor vehicle emissions. In addition to the EMFAC emission rate file, DTIM4 uses digitized roadway segments (links) and traffic analysis zone activity centroids to allocate emissions for travel and trip ends. DTIM4 gridded emission files have fewer categories than EMFAC outputs. Each DTIM4 output category were used to spatially allocate emissions for several EMFAC emission categories. There are also several categories of emissions that EMFAC produces that are not estimated by DTIM4.

DTIM4 is used to estimate both the spatial and temporal distribution of all on-road motor vehicle emissions. The DTIM4 results are used as surrogates to distribute the EMFAC emissions for each category. Below we describe the procedures that were used with EMFAC and DTIM4 to produce day-specific gridded on-road motor vehicle emission estimates. The procedures described here are carried out separately for each of the 53 counties in the CCOS emission modeling region.

D.6.4.2 EMFAC Emission Categories

EMFAC produces emission estimates for the following 13 vehicle classes:

1. LDA Light Duty Autos
2. LDT1 Light Duty Trucks < 3,750 pounds GVW
3. LDT2 Light Duty Trucks > 3,750 - 5,750
4. MDV Medium Duty Vehicles > 5,750 – 8,500
5. LHD1 Light Heavy Duty Vehicles > 8,500 – 10,000
6. LHD2 Light Heavy Duty Vehicles > 10,000 – 14,000
7. MHD Medium Heavy Duty Vehicles > 14,000 – 33,000
8. HHD Heavy Heavy Duty Vehicles > 33,000
9. LHV Line Haul Vehicles
10. SBUS School Bus
11. UBUS Urban Bus
12. MH Motorhomes
13. MCY Motorcycles

Additionally, there are up to 3 technology groups within each vehicle type:

1. Catalyst
2. Non-catalyst
3. Diesel

For each of the combinations of vehicle type and technology there can be many emission categories:

1. Start Exhaust
2. Running Exhaust
3. Idle Exhaust
4. Hot Soak
5. Running Evaporatives
6. Resting Evaporatives
7. Partial Day Resting Evaporatives
8. Multi-Day Resting Evaporatives
9. Diurnal Evaporatives
10. Partial Day Diurnal Evaporatives
11. Multi-Day Diurnal Evaporatives
12. Break Wear PM
13. Tire Wear PM

A DTIM4 preprocessor calculates fleet average emission factors for each EMFAC technology type for each emission category. The vehicle type distribution used to calculate fleet emission factors is an input, so it can be varied as needed.

D.6.4.3 DTIM4 Emission Categories

During DTIM4 operation, all emissions are collapsed into a total of 20 emission categories that depend only on the technology and whether the vehicle is catalyst, non-catalyst or diesel:

SCC	Description
1.	Non TOG Exhaust Emissions
2.	Catalyst Start Exhaust
3.	Catalyst Running Exhaust
4.	Non-catalyst Start Exhaust
5.	Non-catalyst Running Exhaust
6.	Hot Soak
7	Diurnal Evaporatives
8.	Diesel Exhaust
9.	Running Evaporatives
10.	Resting Evaporatives
11.	Multi-Day Resting
12.	Multi-Day Diurnal
13.	PM Tire Wear
14.	PM Brake Wear
15.	Catalyst Buses
16.	Non-catalyst bus
17.	Diesel Bus
18.	Catalyst Idle
19.	Non-catalyst Idle
20.	Diesel Idle

D.6.4.4 Creating the Emission Rate File

EMFAC will create an emission rate file for any desired combination of vehicle speeds, ambient temperatures, and relative humidities. However, DTIM places restrictions on the total array size. The sets of values we use to build the array are:

Speed: 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65

Temp: 30, 45, 60, 70, 75, 80, 85, 90, 100, 110

RH: 0, 30, 50, 70, 80, 90, 100

D.6.4.5 Day-specific EMFAC Inventories

EMFAC is used to produce emission estimates for each day of each episode, by county. County average hourly temperatures, weighted by gridded VMT, are input to EMFAC to produce a 'BURDEN' inventory in a comma separated (.bcd) format. Both DTIM exhaust and evaporative emissions are scaled by category to the EMFAC emissions estimates for each county/air basin area. EMFAC bus and idle emission categories are not estimated by DTIM. These categories are added to the gridded emission files.

D.6.4.6 CCOS Emission Gridding

The method to estimate on-road mobile emissions at the grid cell level is described briefly in the following five steps:

Step 1. Gridded, hourly temperature (T) and relative humidity (RH) fields for each episode day are prepared for input to DTIM. The T and RH fields are derived either from meteorological model predictions, observations, or some hybrid combination of model predictions and observations.

Step 2. EMFAC is run to prepare on-road mobile source emissions factors by speed, temperatures, and relative humidities for each county.

Step 3. DTIM4 is run using data from the Integrated Transportation Network (ITN) and EMFAC to estimate gridded, hourly on-road mobile source emission estimates by day for DTIM categories.

Step 4. EMFAC is run again using episode-specific T and RH data to provide countywide on-road mobile source emission estimates by day for EMFAC categories. The episode-specific meteorological inputs for EMFAC are generated via averaging (VMT-weighted) the gridded, hourly meteorology from Step1 by county and hour.

Step 5. Two sub-steps are taken:

Weekend adjustments. EMFAC currently does not make weekend day estimates, so EMFAC daily emissions are scaled to represent weekend estimates based upon available data. The ITN network has activity estimates for a weekend day. In order to approximate an EMFAC weekend day inventory we scaled each county's EMFAC pollutants, except NOx, by the ratio of DTIM VMT for a weekend day divided by the DTIM VMT for a midweek day. Since heavy-duty diesel VMT is drastically reduced on weekends and their effect is largely on NOx emissions, we reduced the NOx by a factor of 0.536, which represents the average reduction in NOx for a South Coast Air Basin weekend day. This NOx reduction was derived from CalTrans Weigh-in-Motion traffic counts that can differentiate between vehicle types. This NOx factor could be improved by using traffic count data specific to Northern California counties. Monday and Friday EMFAC emissions were also factored by the DTIM VMT for Monday vs. midweek or Friday vs. midweek, for all pollutants.

Spatial/Temporal Distribution. EMFAC daily, countywide emissions (adjusted for weekend days, if needed), are disaggregated by category into grid-cells for each hour of the day using the DTIM output (Step 3) as a spatial and temporal surrogate. The disaggregation follows the equation:

$$E_{p,ij,hr,cat} = EF_{p,cat} * DTIM_{p,ij,hr,cat} / DTIM_{p,daily,cat,cnty}$$

where:

E	= grid cell emissions
EF	= EMFAC emissions
DTIM	= DTIM emissions
P	= pollutant
Ij	= grid cell
hr	= hourly emissions
cat	= Emission Category
daily	= daily emissions
cnty	= county

The 5 steps above are used to generate sets of day-specific, gridded on-road emissions. These emissions are our best estimates at the present time, however future work in two areas will improve the estimates. The most important may be in the allocation of heavy-duty truck emissions. At present, the only heavy-duty transportation modeling is done for Southern California counties. Also, weekend emissions should be considered an approximation since there are no transportation models to describe weekend traffic. Even though we feel that the weekend inventories are approximate at the hour and county level, the lack of weekend transportation models result in the same hourly spatial distribution for each county for both weekday and weekend days. As a result, there is considerable uncertainty in the spatial distribution within each county for weekends. Weekend on-road inventories should be used with caution.

Fleet Emission Factors

An important input to DTIM emissions is the vehicle type weighting for emission rate compositing done in IRS4. We use the vehicle type VMT for each county/air basin output from EMFAC. If we run LM and HDV separately the VMT for LM is the sum of LDA, LDT1, LDT2, MDV, MCY and MH. The HDV VMT is the sum of LHDV1, LHDV2, MHD and HHD.

Besides the composite emission rate file from EMFAC/CNVIRS4/IRS4, DTIM4 needs link and trip end activity files. All activity has been resolved to one-hour periods for each county by Jim Wilkinson of Alpine Geophysics under contract to the ARB. This was done for midweek days, Mondays, Fridays, and an average weekend day. The estimated activity for Mondays, Fridays, and weekend days are different than the midweek activity. The differences are due to the differences seen in traffic counts. When we processed Mondays, Fridays, and weekend days, we scaled the daily emissions according to the ITN county VMT to EMFAC VMT ratio.

D.6.4.7 Evaporative Emissions

DTIM4 and EMFAC use different methods to estimate evaporative emissions. However, as mentioned previously, we use the DTIM4 evaporative emissions as spatial and temporal “surrogates” to resolve EMFAC emission estimates. During processing, we drop the DTIM evaporative categories 11 and 12 (because those emissions are included in EMFAC’s estimates for diurnal and resting emissions) and put all EMFAC resting emissions in category 10, and all diurnal emissions in category 7.

D.6.4.8 Exhaust Emissions

The exhaust emissions from EMFAC are also resolved spatially and temporally by DTIM4 emission estimates. Since transportation models do not estimate VMT for buses or excess idling categories, these are added to DTIM4 emissions. The exhaust CO, NOx, SOx, and PM emissions that DTIM4 allocates to category 1 are reassigned to catalyst starts, non-catalyst starts, catalyst stabilized, non-catalyst stabilized, and diesel exhaust categories according to the appropriate day-specific EMFAC inventory.

D.6.5 Biogenic Emissions

Development of effective ozone control strategies in California requires accurate emission inventories, including biogenic volatile organic compounds (BVOCs) such as isoprene and monoterpenes. Due to the heterogeneity of vegetation landcover, species composition, and leafmass distribution in California, quantifying BVOC emissions in this domain requires an emission inventory model with region-specific input databases and

a high degree of spatial and temporal resolution. In response to this need, the California Air Resources Board (CARB) has developed a GIS-based model for estimating BVOC emissions, called BEIGIS, which uses California-specific input databases with a minimum spatial resolution of 1 square km and an hourly temporal resolution.
The BEIGIS isoprene emission algorithm (Guenther et al. 1991, 1993) is of the form

$$I = I_S \times C_L \times C_T$$

where I is the isoprene emission rate (grams per gram dry leafmass per hour) at temperature T and photosynthetically active radiation flux PAR. I_S is a base emission rate (grams per gram dry leafmass per hour) at a standard temperature of 30 °C and PAR flux of 1000 μmol $m^{-2}s^{-1}$. C_L and C_T are environmental adjustment functions for PAR and temperature, respectively. The monoterpene emission algorithm adjusts a base monoterpene emission rate by a temperature function (Guenther et al. 1993). Methylbutenol (MBO) emissions are modeled with an algorithm developed by Harley et al. (1998) similar to that for isoprene. Dry leaf mass/leaf area ratios, and base emission rates for isoprene, monoterpenes, and MBO, are plant species-specific and assembled from the scientific literature. Modeled BVOC emissions for a given spatial domain therefore represent the contribution by various plant species (through their leaf mass and emission rates) to the total BVOC emissions.

The main inputs to BEIGIS are landuse and vegetation landcover maps, gridded leaf area indices (LAI) derived from AVHRR satellite data (Nikolov 1999), leaf area/dry leaf mass factors, base emission rates, and gridded hourly ambient temperature and light intensity data (from a meteorological model). For urban areas, landuse/vegetation landcover databases were developed from regional planning agency data and botanical surveys (Horie et al. 1990; Nowak 1991; Sidawi and Horie 1992; Benjamin et al. 1996, 1997; McPherson et al. 1998). Natural areas are represented using the GAP vegetation database (also satellite-derived and air photo interpreted) developed by the U.S.G.S. Gap Analysis Program (Davis et al. 1995). Agricultural areas are represented using crop landcover databases developed by the California Department of Water Resources (http://www.waterplan.water.ca.gov). Ground surveys have been funded by ARB to validate the vegetation landcover and LAI input databases used in BEIGIS (Winer et al. 1998; Karlik and McKay 1999; Winer and Karlik 2001, Karlik 2002). Validation using flux measurements in the field is on going.

Using BEIGIS, the ARB developed develop hourly-resolved emissions of isoprene, monoterpenes, and methyl butanol (MBO), gridded at a 1-km resolution. Two additions are then made to the biogenic emissions estimate for input to air quality models.

First, biogenic OVOCs (other VOCs) are added. Biogenic OVOCs comprise around twenty percent of some biogenic inventories and are known to affect air quality modeling predictions (e.g. Hanna et al., 2002). Guenther et al. (1994) estimate that the OVOCs comprise 8-73% of total BVOCs. OVOCs are estimated by ARB as an added fraction of 30%, scaled to the total isoprene, monoterpene, and MBO emissions.

Second, biogenic NO emissions are added. Biogenic NO emissions were estimated using a soil NO algorithm found in BEIS-3. However, due to the large uncertainty associated with these emissions, they were not used in the air quality modeling.

For a more detailed description of the estimation of biogenic emissions, see section D.10.

D.6.6 Emissions Processing

ARB used an emissions processor, such as the EMS-95 emissions modeling system, to develop spatially and temporally resolved emissions for the point and area sources. ARB will chemically speciate the VOC component of the point, area, biogenics and on-road mobile sources. ARB will then reformat the emissions estimates for input to air quality models.

Other data are necessary to prepare emissions estimates for input to air quality models. These data include the following:

- Spatial surrogates
- Assignment of spatial surrogate to area source category
- Organic gas speciation profiles
- Assignment of organic gas speciation profile to source category

The spatial surrogates are used to spatially allocate countywide area source emissions to individual grid cells. In this context, “area source emissions” refers to all source categories that are not point sources, biogenics or on-road motor vehicles. Each area source category is assigned a spatial surrogate.

The organic gas speciation profiles are used to separate the TOG emissions into the individual organic gas components that are modeled within the chemistry processes of the air quality model. Organic gas speciation profiles exist for both the CB-IV and SAPRC99 chemical mechanisms. Each source category, including area, point, biogenics, or on-road motor vehicles is assigned an organic gas speciation profile.

D.6.7 Modeling Files

The development of the inventory for SIP modeling has been a process that has spanned many years and much effort by many people. The first complete set of modeling files that included all source types was available in March 2003. Since then, there have been many revisions of the modeling files to correct errors or include updated data. Emissions summaries from these files were prepared to aid ARB and district staff to QA the information. These modeling files can be found on the ftp site provided by Alpine Geophysics.

A file naming convention was established to track the changes made to each inventory. The files were named according to the following formula:

CCAQS_*Episode_Type_Version_Revision_Chemistry_Model*_MODELFILES.tar.gz

Where:

Episode = JULY2000 (July/August 2000)

Type = ELEV, AR, MV, BI, FIRES (Elevated point, area, motor vehicles, biogenics, or fires)

Version = “V” + date produced (e.g. V050503 for May 5, 2003)
(Note: When emissions data undergo a major revision, the new file is given a version number corresponding to the date it was produced.)

Revision = “R” + revision number (e.g. R001 or R002)
(Note: Minor changes, such as small revisions to only a few sources are noted with a revision number; the version number remains the same.)

Chemistry = CBIV or SAPRC
(Note: Several changes occurred to the version of the chemical mechanism used to produce the files. Following is a description of each version name and its description.

Version	Description
CBIVV01	Initial CBIV without MEOH, ETOH
CBIVV02	CBIV, including MEOH and ETOH
CBIVV03	CBIVV02 with adjustments to split factors for hot soak and agricultural pesticides
SAPRCV1	ARB SAPRC version S01
SAPRCV2	ARB SAPRC version S02
SAPRCV3	SAPRC with adjusted pollutant list, MTBE, MBUT and ETOH not broken out
SAPRCV4	SAPRC with adjusted pollutant list, including MTBE, MBUT and ETOH
SAPRCV5	SAPRCV4 with adjustments to split factors for hot soak and agricultural pesticides

Model = CAMX or SAQM

Following is a list of modeling file names that have been produced since January 2003 and the reason for each revision. This list covers only changes to the base case July/August 2000 episode. It is provided as an example of the changes that have occurred to the emission inventories over time. Similar file changes have occurred to other episodes as well. This information helped ARB and district staff track the latest revision to the inventory for use in modeling and QA. The tables are separated by source type. Rather than list the entire file name, only the version and revision numbers are listed. Follow the naming convention described above to determine the entire name of the modeling file.

Area Sources:

Version and Revision Number	Reason for Change
V030303_R001	CEFS version RF#861
V050503_R001	Revised to include CEFS emissions dropped during original processing
V050503_R002	Adjust TOG and SOx emissions for Bay Area refinery one-time events
V071003_R001	Adjustments to household pesticides; adjustments to Bay Area gas can emissions; adjustment of train emissions; revisions to growth for ag categories
V091203ship_R001	Adds the day-specific shipping emissions

Point Sources:

Version and Revision Number	Reason for Change
V030303_R001	CEFS version RF#861
V050503_R001	Revised to include CEFS emissions dropped during original processing; include revised Bay Area refinery one-time events
V050503_R002	Adjust TOG and SOx emissions for Bay Area refinery one-time events
V050503_R003	Revise stack parameters for flaring emissions in Solano and Contra Costa Counties
V071003_R001	Re-run of all point sources to ensure that all corrections are in place (in conjunction with changes to area sources)
V092703_R001	Added locations for facilities with missing UTMs, especially Solano County refineries (Exxon and Huntway). Added refinery default stack parameters to Exxon facility in Solano County.

Fires:

Version and Revision Number	Reason for Change
V030303_R001	Wildfire and controlled burn emissions, with large wildfires treated as elevated point sources
V060903_R003	Revised plume rise calculation, resulting in higher plume distributions
V100203_R001	Added plume rise for smaller wildfires, in addition to major fires

On-Road Motor Vehicles:

Version and Revision Number	Reason for Change
V032403_R001	Original MV emissions files
V042903_revmet	Revised using CALMET temperatures

Biogenics:

Version and Revision Number	Reason for Change
V010103_R001	Original biogenic emissions files
V042803_revmet	Revised using CALMET temperatures
V060903_remet	Added biogenic NOx
V091703_R001	Revised to correct temporal error in data inputs

D.6.7.1 July/August 2000 Base Case

Below is a list of the names of the modeling files used in the base year modeling runs. The files follow the naming convention described above.

Type	File Name
Point	CCAQS_JULY2000_ELEV_V071003_R001_SAPRCV5_CAMX_MODELFILES.tar.gz
Area	CCAQS_JULY2000_AR_V071003_R001_SAPRCV5_CAMX_MODELFILES.tar.gz
MV	CCAQS_JULY2000_MV_revmet_V042903_R001_SAPRCV5_CAMX_MODELFILES.tar.gz
Bio	CCAQS_JULY2000_BI_revmet_V091703_R002_SAPRCV5_CAMX_MODELFILES.tar.gz
Fires	CCAQS_JULY2000_FIRES_V060903_R003_SAPRCV5_CAMX_MODELFILES.tar.gz

D.6.7.2 July/August 200 Future Year Base Case- 2005

Below is a list of the names of the modeling files used in the 2005 future year base case modeling runs. The files follow the naming convention described above.

Type	File Name
Point	CCAQS_JULYFY_ELEV_V071003_R002_SAPRCV5_CAMX_MODELFILES.tar.gz
Area	CCAQS_JULYFY2005_AREA_V071003_R01R02_SAPRCV5_CAMX_MODELFILES.tar.gz
MV	CCAQS_JULYFYA_MV_V071003_R001_SAPRCV5_CAMX_MODELFILES.tar.gz
Bio	CCAQS_JULY2000_BI_revmet_V091703_R002_SAPRCV5_CAMX_MODELFILES.tar.gz
Fires	Not included

D.6.7.3 July/August 2000 Future Year Base Case- 2010

Below is a list of the names of the modeling files used in the 2010 future year base case modeling runs. The files follow the naming convention described above.

Type	File Name
Point	CCAQS_JULYFY_ELEV_V071003_R002_SAPRCV5_CAMX_MODELFILES.tar.gz
Area	CCAQS_JULYFY2010_AREA_V071003_R01R02_SAPRCV5_CAMX_MODELFILES.tar.gz
MV	CCAQS_JULYFY2010_MV_V071003_R001_SAPRCV5_CAMX_MODELFILES.tar.gz
Bio	CCAQS_JULY2000_BI_revmet_V091703_R002_SAPRCV5_CAMX_MODELFILES.tar.gz
Fires	Not included

D.7 Photochemical Modeling

D.7.1 Domain and Vertical Structure

The CCOS study domain and modeling vertical structure were described in subsection D.5.2. The reader is referred to that section for details. However, here we repeat two tables and one figure from that section for completeness: the description of the modeling domain (Table D-8); a map of the modeling domain (Figure D.6); and the vertical structure of the air quality modeling domain (Table D-9), which is dependent upon the meteorological model used.

Table D-8
Lambert Conical Projection coordinate system used to define the CCOS modeling domain

Reference Latititudes	30 N 60 N
Central Meridian	120.5 W
Northing Offset	768.28 km
Easting Offset	0.0 km
Grid Cell Number	189 x 189
Grid Cell Size	4 km
Northing Origin	-300.0 km
Easting Origin	-384.0 km

Figure D.6
Air quality modeling domain for the CCOS July/August, 2000 episode.

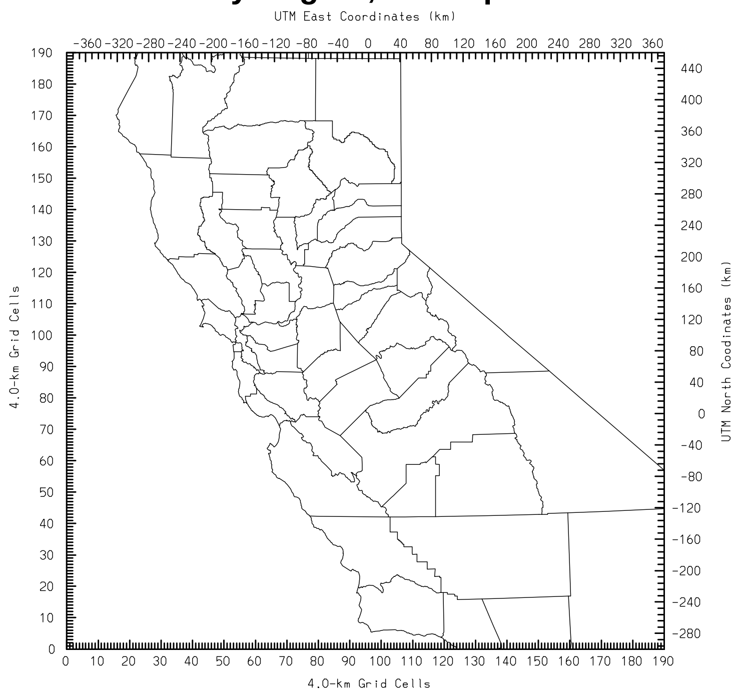


Table D-9
The vertical structure of the air quality modeling domain for the July/August, 2000 CCOS episode based on the MM5 and CALMET meteorological models.

Layer Number	MM5 Thickness (m)	MM5 Height (m AGL)	CALMET Thickness (m)	CALMET Height (m AGL)
1	24	24	20	20
2	26	50	40	60
3	56	106	40	100
4	66	172	100	200
5	74	246	100	300
6	133	379	100	400
7	161	540	200	600
8	182	722	200	800
9	205	927	200	1000
10	232	1159	500	1500
11	265	1424	500	2000
12	356	1780	500	2500
13	488	2268	500	3000
14	666	2934	500	3500
15	926	3860	500	4000
16	1140	5000	1000	5000

D.7.2 Initial and Boundary Conditions

The relatively large size of the CCOS air quality modeling domain was intended to minimize the influence of boundary concentrations. Ideally, modeling domain boundaries should be located where the air is relatively clean, or they should be located sufficiently far away from modeling areas of interest to minimize their impact if the boundary inflow is not clean.

The western boundary and part of the southern boundary of the CCOS modeling domain are located over the Pacific Ocean. Over the Pacific Ocean the air is thought to be clean, therefore boundary concentrations were assigned based on clean air as defined by the U.S. EPA (1991). This clean air definition is comprised of 40 ppb ozone, 2 ppb oxides of nitrogen (NO_x), and approximately 22 ppbC of reactive hydrocarbons (see Table D-10). However, simulation experiments have suggested that the conversion of NO_x to nitrates is such that nitrogen oxide (NO) concentrations over the ocean should be very low with any appreciable residence time. Therefore, nitrogen oxide concentrations were set to zero over the ocean.

The determination of over land boundary concentrations is less certain. Air quality monitoring sites in remote areas are few, and extrapolating existing measurements over long boundaries is fraught with uncertainties. In the 2003 State Implementation Plan update prepared by the South Coast Air Quality Management District (SCAQMD, 2003), a concentration profile was defined for over land, remote areas. This concentration profile, referred to herein as "SCAQMD clean", is similar to the USEPA definition of clean air except that the concentration of reactive hydrocarbons is 60.7 ppbC. This concentration was adopted for over land boundaries of the CCOS domain (see Table D-10). Initial conditions were set equal to the eastern boundary conditions with the exception of VOC. Based on measured data the VOC was multiplied by a factor of two for the San Joaquin Valley only. VOC initial conditions in the SJV were set at 121.4 ppbC.

Defining concentration profiles for the boundary at the top of the modeling domain (note: 5,000 magl – see subsection D.5.2) is confounded by the few air quality measurements above the ground. The few aircraft measurements available recorded concentrations only at a few times, locations, and heights. During the CCOS field study, ozonesondes were launched daily on episode days at Granite Bay and at Parlier. These measurements suggested ozone concentrations of 70 ppb or greater at 5,000 magl that persisted throughout the July/August episode period. Based on these few measurements, the top boundary concentrations selected were based on the clean air profile defined by the U.S. EPA (1991), with the exception that ozone concentrations were set to 70 ppb.

Table D-10
Carbon Bond IV boundary concentration profiles for the July/August, 2000 CCOS episode. These same boundary condition totals were used with SAPRC99

Compound(s)	USEPA (1991) Clean	SCAQMD (2003) Clean
Reactive hydrocarbons	21.9 ppbC	60.7 ppbC
Carbon Monoxide	350 ppm	200 ppm
Oxides of Nitrogen	2.0 ppb	2.0 ppb
Ozone	40.0 ppb	40.0 ppb

D.7.3 Base Year Model Performance Evaluation

The period July 29–August 2, 2000 was simulated using the CAMx air quality model, alternatively with the Carbon Bond IV and SAPRC99f chemical mechanisms. The meteorological models MM5 and the CALMET/MM5 hybrid were also used to provide inputs to CAMx. Overall, model performance of CAMx using the CALMET/MM5 hybrid was superior to those resulting from MM5 alone; therefore, only the results simulated using the CALMET/MM5 hybrid are reported here.

The U.S. EPA (1991) provided guidelines for the evaluation of an ozone air quality model. In these guidelines, three statistical measures are used to compare simulated and observed 1-hour ozone concentrations above a threshold of 60 ppb; unpaired peak ratio (UPR), normalized bias (NB), and gross error (GE). The UPR compares daily peak simulated ozone concentration, unpaired in time and space, with the daily peak observed. Tesche et al. (1990) provide definitions for these and other statistical measures. To meet acceptance criteria, the UPR must be within the range of 0.80 to 1.20. The NB is the average percent difference between observed and simulated ozone concentrations paired in time and space, and the GE is the average absolute percent difference. To meet acceptance criteria, the NB must be within the range of +/- 15% and the GE less than 35%.

The U.S. EPA (1991) performance guidelines allow simulated and observed ozone concentrations for the whole modeling domain to be pooled into one set of statistical measures. However, in a domain as large and geographically diverse as the CCOS modeling domain, pooling all concentrations into a single set of statistical measures would not allow an assessment of model performance across the domain. Therefore, for this analysis, the CCOS domain was subdivided into 9 subregions (Figure D.7) and statistical measures for model performance assessments were calculated for each one.

Statistical measures of ozone model performance for the July/August, 2000 episode are summarized in Table D-11. Simulation results for both the Carbon Bond 4 and SAPRC99f chemical mechanisms are shown. In general, ozone concentrations simulated using the SAPRC99f chemical mechanism are higher than those simulated using Carbon Bond 4. On those days for which a subregion had peak ozone concentrations in excess of 125 ppb, the simulations met model performance guidelines. Several visual and statistical depictions of the base year simulation results are provided in Appendix C (uncirculated--available upon request).

Figure D.7
Performance evaluation subregions for the CCOS air quality modeling domain.

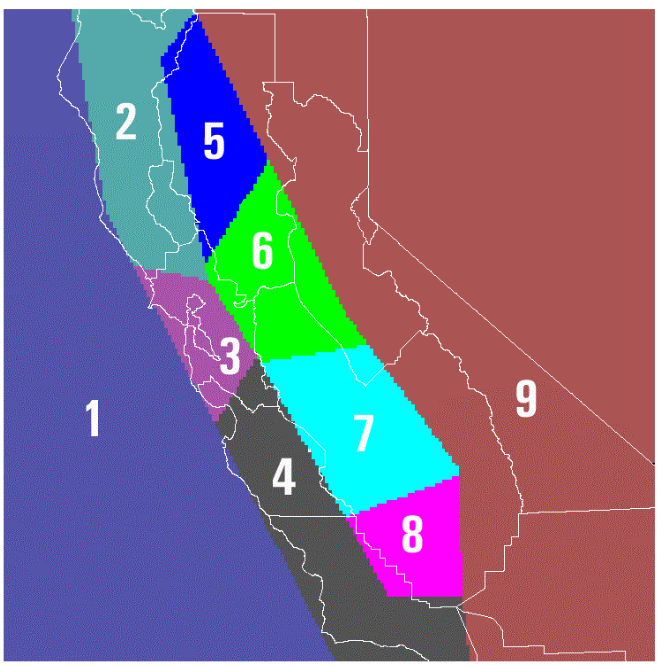


Table D-11
Base year ozone model performance for the July/August CCOS episode (July 29–August 2, 2000) using CAMx with CALMET/MM5 hybrid meteorology. Highlighted statistical measures indicate those meeting U.S. EPA (1991) model performance guidelines.

Subregion	Obs. Peak (ppb)	CAMx/CB4				CAMx/SAPRC99f			
		Sim. Pk. (ppb)	UPR	NB (%)	GE (%)	Sim. Pk. (ppb)	UPR	NB (%)	GE (%)
July 29, 2000									
Zone 3	82	107	1.31	+13	24	102	1.24	+10	24
Zone 6	121	129	1.07	+09	19	147	1.21	+13	22
Zone 7	129	130	1.01	-08	18	144	1.12	-03	17
Zone 8	128	123	0.96	-12	20	149	1.16	-02	25
July 30, 2000									
Zone 3	126	117	0.93	+01	22	124	0.98	+04	22
Zone 6	110	137	1.25	+05	16	149	1.35	+04	17
Zone 7	118	128	1.09	+03	17	138	1.17	+06	18
Zone 8	115	119	1.04	-12	18	132	1.15	-07	20
August 1, 2000									
Zone 3	109	111	1.01	-10	25	121	1.11	-05	28
Zone 6	134	137	1.02	-04	17	145	1.08	-02	19
Zone 7	118	124	1.05	-09	20	132	1.12	-05	21
Zone 8	116	114	0.98	-15	19	120	1.04	-10	19
August 2, 2000									
Zone 3	100	084	0.84	-44	44	90	0.90	-41	41
Zone 6	131	127	0.97	-16	21	137	1.05	-09	20
Zone 7	131	127	0.97	-10	22	137	1.04	-02	22
Zone 8	151	129	0.85	-13	21	140	0.92	-07	20

- UPR = Unpaired Peak Ratio; NB = Normalized Bias; GE = Gross Error
- Subregion assignments:
  Zone 3 = San Francisco Bay Area; Zone 6 = Sacramento/Delta area
  Zone 7 = Fresno area; Zone 8 = Bakersfield area

D.7.4 Base Case Sensitivity to Natural Sources

Biogenic emissions from plants are significant contributors to the hydrocarbon emission inventory, and are known to contribute to ozone concentrations measured within California. In addition to these emissions, wildfires are frequent occurrences in summer and can also generate hydrocarbons that can contribute to observed ozone concentrations. Using the CAMx base case simulation with Carbon Bond IV chemistry, the impact of these natural emissions on ozone concentrations during the July/August, 2000 episode was investigated.

Sensitivity simulations were conducted wherein emissions input into the air quality model were modified. After the air quality model was run, differences from the base-case simulation results were determined to assess impacts. To assess the impact of natural emissions, three emissions scenarios were evaluated: 1) removing all wildfires;

2) increasing biogenic emissions by 25%; and 3) removing all biogenic emissions. The results of the air quality simulations using these scenarios were summarized in Table D-12.

Removing wildfire emissions had little impact on peak simulated ozone concentrations, except in the southern San Joaquin Valley. Simulated ozone concentrations within the SF Bay Area and the Sacramento/Delta regions of the modeling domain were altered by less than 1 ppb for all sites (data not shown). These results suggest that the high ozone concentration in Kern County on August 2 was impacted by fires, since removing the wildfires reduced the simulated ozone peak by approximately 7%.

Increasing biogenic emissions by 25% had a modest impact on simulated ozone concentrations throughout the modeling domain. The largest impact was on July 31; peak ozone concentrations in the San Francisco Bay Area and Sacramento/Delta subregions increased by 4 ppb. At individual sites, the increases were greater (data not shown). The magnitude of these changes approximate the impact of large errors in the temperature fields (~ 3 ºC) used to calculate biogenic emissions.

Removing all biogenic emissions had the greatest impact of all natural sources. Removing all biogenic emissions reduced peak simulated ozone concentrations throughout the modeling domain by as much as 22%; however, the impacts were not as great for all subregions, and on each day.

Table D-12

Differences in peak simulated ozone concentrations using CAMx/CB4 and simulated peak concentrations without wildfires, with a 25% increase in biogenic emissions, and without biogenic emissions for the July/August, 2000 CCOS episode.

	Base Case	No Fires		+25% Biogenics		No Biogenics	
		ppb	% change	ppb	% change	ppb	% change
July 31 (Julian Day 213):							
Zone 3 (SF Bay)	126	0	0	4	3	-22	-17
Zone 6 (Sacramento/Delta)	131	0	0	4	3	-21	-16
Zone 8 (Kern County)	129	0	0	2	2	- 8	- 6
August 1 (Julian Day 214):							
Zone 3 (SF Bay)	119	0	0	1	1	-24	-20
Zone 6 (Sacramento/Delta)	132	0	0	2	2	-27	-20
Zone 8 (Kern County)	119	-2	-2	1	1	- 8	- 7
August 2 (Julian Day 215):							
Zone 3 (SF Bay)	93	0	0	2	2	-10	-11
Zone 6 (Sacramento/Delta)	133	0	0	4	3	-29	-22
Zone 8 (Kern County)	135	-9	-7	1	1	-10	- 7

D.8 References

Air Sciences, Inc. (2002) 1996 Fire Emissions Inventory. Draft Final Report. Lakewood, CO. On-line link: http:/www.wrapair.org/forums/FEJF1/emissions/FEJF1996EIReport_021208.pdf

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D.9 Gridded Inventory Coordination Group Minutes

D.9.1 February 26, 2003 Minutes

Attendees	Affiliation
Amir Fanai, Glen Long, Toch Mangat, Phil Martien	Bay Area AQMD
Bruce Katayama, Aleta Kinnard, Hao Quinn, Greg Tholen	Sacramento Metro AQMD
Cyndi Loomis, Jim Wilkinson	Alpine Geophysics
Vernon Hughes, Ajith Kaduwela, Cheryl Taylor	ARB

Welcome

Cheryl welcomed everyone to the call. Introductions were made.

General Discussion
Purpose of the Coordination Group

This group was formed as an outgrowth of the February 19 modeling conference call, where several districts expressed a desire to review the gridded inventories to be used in modeling for the SIPs. The group agreed that the more people who review the inventories, the more likely they will spot problems quickly. More reviewers can also share the burden of reviewing such large amounts of information. The districts have specific knowledge about the inventories in their regions, so are more likely to discover problems.

Goals/Expectations of the Group

The goal of the group is to provide gridded inventories for review in an easily accessible and coordinated manner. There are several gridded inventories that will be available for review by the group, including episodes for July/August 2000, September 2000, and June 2000. The creation of gridded inventories for July 1999 and a 2002 episode are being considered. ARB, Alpine Geophysics, and Environ are creating pieces of the various gridded inventories. ARB will receive all the pieces and will be assembling them for each episode. The group agreed that inventories should be made available for review whenever they are available, regardless of priority for the SIPs. Cheryl will distribute minutes.

Timeframe for Reviewing Inventories

The group agreed that an email would be broadcast when a new inventory had been posted for review. A period of two weeks for review would begin once the notification had been sent.

Feedback from Reviewers – What Will be the Process to Incorporate/Investigate any Comments or Requested Changes?

It was suggested that there be a structured form for comments; this will be discussed at future meetings. Requests to change emissions should be made through the normal channels, such as the Emission Inventory Branch at ARB. The entire group is to be notified if there are changes to the emissions or if other problems are identified.

Frequency of Meetings

The group did not specifically determine the frequency of the meetings, but they agreed to meet again in three weeks.

Discuss Specifics of How to Review Gridded Inventories

Vernon described the basic steps to creating model-ready gridded inventories. Base year criteria emissions are fed from CEIDARS (California Emission Inventory Development and Reporting System) into CEFS (California Emission Forecasting System). CEFS creates base year and future year inventories by air basin, county, and source category (SIC/SCC for point sources or EIC for all other sources) for either a weekday or a weekend day for a specified month. Day-specific data are then merged in. Next, EMS-95 is used to distribute the emissions both spatially and temporally (down to grid cell by hour). Then the emissions are speciated and reformatted to create model-specific gridded inventories.

The group agreed that the following reports would be useful:

Tabular reports from CEIDARS/CEFS (summary of emissions of criteria pollutants by county/air basin and by 3-digit EIC – base year and forecasted years)
Tabular and graphical (tile plots) reports of the model-ready gridded inventories
Intermediate SAS files (gridded hourly criteria inventory with categories in tact)
Model-ready files
Speciation profiles
Spatial Surrogates
Temporal Profiles

Cyndi said that she already has summary reports that she would be willing to run on the gridded inventories as they become available for review. Gridded inventories for the July/August 2000 episode are available now for review. Vernon emphasized that version control (e.g. version of EMFAC used in the gridded inventory) is very important and needs to be stated clearly for each gridded inventory.

Discuss How to Access Gridded Inventories

Cyndi volunteered Alpine Geophysics to be the repository of information by hosting an ftp site accessed through the Web. ARB may take over this duty in the next few weeks after ARB finalizes its global file directory syntax.

Cyndi and Vernon will discuss the details of exactly what will be posted. ARB will then distribute a one-page proposal to the group for comment. The proposal would detail what reports and version control information would be provided for review. Cyndi will set up a website and post data within a couple of weeks. The group will be notified when data are available and how to access the site. At the next call, the group will discuss the website and reports; changes will be incorporated as agreed.

Other Districts Who May Wish to be Involved?
Phil suggested that Bob Nunes from Monterey Bay Unified APCD might be interested in participating in this group. Vernon will call him.

Jim suggested that representatives from the COGs might also be interested in reviewing the on-road mobile source emissions. Jim has a list of the COG representatives that he has spoken with in preparing the roadway network for the CCOS domain. He will send the list to Vernon who will give them to Ed Yotter for review. Ed will be asked to join this group.

Other Issues
No other issues were discussed.

Plans for Next Meeting
The next conference call is scheduled for Wednesday, March 19.

D.9.2 March 19, 2003 Minutes

Attendees	Affiliation
Amir Fanai, Toch Mangat, Phil Martien	Bay Area AQMD
Bob Nunes	Monterey Bay Unified APCD
Bruce Katayama, Charles Parker, Greg Tholen, Brigette Tollstrup	Sacramento Metro AQMD
Donald Hunsaker, David Nunes, Evan Shipp, Michelle Stanley	San Joaquin Valley Unified APCD
Vincent Liu	Kern COG
Harold Brazil	MTC
Cari Anderson	Earth Matters
Cyndi Loomis, Jim Wilkinson	Alpine Geophysics
Vernon Hughes, Cheryl Taylor, Ed Yotter	ARB

Welcome and Feedback on February 26 Minutes

ARB welcomed everyone to the call. Introductions were made. There were no comments on the February 26 minutes.

Discuss How to Efficiently Transfer and Track Review of Gridded Inventories

Alpine Geophysics described how they propose to set up the ftp site (<u>not</u> a web page) to efficiently transfer and track the review of the gridded inventories. There will be three main parts: “read me” files, a data-tracking log, and the files/reports themselves. The “read me” files and data tracking log are described below; the files/reports are discussed in Item 3.

The “read me” files will contain several pieces of information. One part will discuss the naming convention used to describe each gridded file for review. ARB has developed a naming convention that describes the file. The name will state the domain (CCAQS), episode day, source type (point, area, on-road motor vehicle, or biogenics), source-specific information (e.g. version of EMFAC), when the file was created and the version, chemical mechanism (e.g. SAPRC), speciation version, and model format (e.g. ascii). Another “read me” file will describe the data-tracking log, how to use it, and what to do if you find problems in the gridded inventories. The BAAQMD suggested that a “read me” file include a discussion of what each file contains (e.g. data dictionary) as well as other information such as the units of the emissions. A “read me” file will also describe how Alpine Geophysics developed a model to add commercial VMT to the Integrated Transportation Network (ITN) (see Item 4 below). A “read me” file will describe the differences in VMT between the ITN and EMFAC 2002 (see Item 4 below)

Alpine Geophysics has developed a data-tracking log. The log shows the current inventory, date released, problems identified, who identified the problem and when, how the problem was fixed, and who fixed the problem and when. Per the group's request, Alpine Geophysics will include a list of standard QA procedures that they have implemented in reviewing the inventories to avoid duplication of effort.

ARB will develop a one-page proposal that will detail what information will be posted on the ftp site, and distribute it to the group for comment. ARB reminded everyone that both time and resources are growing shorter, so the number of custom reports may be limited. The San Joaquin Valley district said that they might be able to provide assistance to other districts by providing plots and/or reports.

Discuss New Site for Accessing Gridded Inventories

The ftp site is not available yet for viewing, but should be ready next week. Below is a list of the reports that will be available on the ftp site. Information for the July/August 2000 episode will posted first. Information for other episodes will be posted when available. Episodes that are planned include September 2000, July 1999, and June 2000.

Alpine Geophysics is putting together a report that describes how the gridded on-road motor vehicle inventory was created. The report will describe how the Integrated Transportation Network (ITN) for the entire CCOS/CRPAQS domain was developed. It will also describe how the day-specific data, which were collected by Dr. Deb Niemeier of UC Davis, were incorporated. The report should be available in two weeks and will be distributed to the group a few days prior to the next call.

List of data/reports that will be available on the ftp site:

1) Tabular reports from CEFS, the inventory forecasting system (summary of emissions of criteria pollutants by county/air basin and by 3-digit EIC – base year and forecasted years)
2) Tabular and graphical (tile plots) reports of the model-ready gridded inventories by 3-digit EIC by county
3) Intermediate SAS files (gridded hourly criteria inventory by 3-digit EIC)
4) Model-ready files (will include 4 sets - CAMx and SAQM models each using CB-IV and SAPRC chemical mechanisms)
5) Speciation profiles
6) Spatial surrogates
7) Temporal profiles
8) Day-specific data for point sources
9) Integrated Transportation Network (ITN) (ARC format)
10) DTIM-ready files

Other Issues – On-Road Motor Vehicle Gridded Inventory

Alpine Geophysics briefly described how the on-road gridded inventory was developed. First they developed an Integrated Transportation Network (ITN) that combines demand model networks from agencies such as MTC, SACOG, four COGs in the San Joaquin Valley, and Caltrans' statewide network. The VMT provided by each of these agencies was adjusted in three ways. First, the VMT were adjusted to represent the year 2000. For instance, the statewide network was for year 1995 and was grown to reflect year 2000. Second, the VMT was adjusted to distinguish between weekday and weekend volumes. Third, Alpine Geophysics developed a model to add commercial VMT to the ITN.

Alpine Geophysics compared the VMT for 2000 from the ITN with EMFAC 2002. There were some discrepancies, which Alpine Geophysics understands and will document in a “read me” file.

Plans for Next Meeting

The next conference call will focus on the on-road motor vehicle gridded inventory. The call is scheduled for Monday, April 7.

D.9.3 April 7, 2003 Minutes

Attendees	Affiliation
Toch Mangat, Phil Martien	Bay Area AQMD
Charles Anderson, Matt Jones, Bruce Katayama, Greg Tholen, Brigette Tollstrup	Sacramento Metro AQMD
Donald Hunsaker, David Nunes, Stephen Shaw, Evan Shipp, Michelle Stanley	San Joaquin Valley Unified APCD
Harold Brazil	MTC
Cari Anderson	Earth Matters
Cyndi Loomis, Jim Wilkinson	Alpine Geophysics
Vernon Hughes, Anne Lin, Cheryl Taylor, Ed Yotter	ARB

Welcome and Feedback on March 19 Minutes

ARB welcomed everyone to the call. Introductions were made. There were no comments on the March 19 minutes. The BAAQMD asked if the one-page summary that details the information that will be posted on the ftp site had been distributed (as referenced in the minutes). ARB responded that the summary had not been written yet.

Status of Ftp Site for Accessing Gridded Inventories

Alpine Geophysics described the ftp site (<u>not</u> a web page) that they set up to transfer and track the review of the gridded inventories. To access the information, ftp to agftp.com (host name). The user ID is agftp and the password is pass4ftp.

To review emissions files, change to directory “CCAQS_Emissions”. There are sub-directories for three episodes: June 2000, July 2000, and September 2000. Data are available under July 2000 for the July/August 2000 episode. Under the July 2000 sub-directory are five sub-directories: a) CEFS_files, b) Gridded_SAS_files, c) Modeling_Files, d) Plots and e) Summaries.

a) *CEFS_files*: Contains the actual files provided by the ARB’s Emission Inventory Branch as they come out of CEFS.
b) *Gridded_SAS_files*: Contains the gridded SAS datasets in SAS trans format. This format allows SAS files to be transferred to versions of SAS running on different platforms (i.e. PC, Linux, Sun). Alpine Geophysics will include an example of SAS code that can be used to extract the transport files to your local systems. SAS will be required to access and use these files. The files are broken into source types: area, point, biogenics, on-road, and fires. There is a file for each source type and episode day.
c) *Modeling_Files*: These are the model-ready files for input into SAQM and CAMx. Each model is run using both SAPRC and CBIV chemistry. These files are further

separated into source types (point, area, biogenics, on-road, and fires). These are ASCII (text) format files.
d) *Plots*: These are gif plots (not animated) showing hourly and daily total emissions (kilograms per day) of NOx and ROG for point, area, and on-road sources for August 1, 2000.
e) *Summaries*: There are two reports. One shows county totals for point, area, and on-road. The second report shows point and area source emissions by county by EIC with day-specific data merged in.

Several additions will be posted to the ftp site soon. ARB will develop a one-page summary that will detail what information will be posted on the ftp site. Alpine Geophysics will add a description of the file naming convention. Alpine will post to the ftp site a data-tracking log that shows the current inventory, date released, problems identified, who identified the problem and when, how the problem was fixed, and who fixed the problem and when. The September 2000 point and area source files are ready, so they will be posted to the ftp site. Emissions from soil NO will also be posted.

Gridded On-road Motor Vehicle Emissions

Alpine Geophysics distributed to the group a draft report (available on the ftp site) that describes how the gridded on-road motor vehicle inventory was created. The report describes how the Integrated Transportation Network (ITN) for the entire CCOS/CRPAQS domain was developed. The report describes the addition of a commercial travel model to the ITN. It also describes how the day-specific data were used to create hourly VMT distributions and make adjustments for weekdays and weekend days. Please provide any comments to Jim Wilkinson (Alpine Geophysics).

Other Issues

The group asked how much time is available to review the gridded inventories. ARB has already begun modeling with the emission inventories that have been developed, so any issues that are discovered will need to be addressed as soon as possible. Provide any comments or questions to Cheryl Taylor (cataylor@arb.ca.gov).

Plans for Next Meeting

The next conference call is scheduled for Wednesday, April 23.

D.9.4 April 23, 2003 Minutes

Attendees	Affiliation
Toch Mangat, Phil Martien, Steve Soong	Bay Area AQMD
Bob Nunes	Monterey Bay Unified APCD
Charles Anderson, Matt Jones, Bruce Katayama, Aleta Kennard, Hao Quinn, Greg Tholen	Sacramento Metro AQMD
David Nunes, Stephen Shaw, Michelle Stanley	San Joaquin Valley Unified APCD
Harold Brazil	MTC
Cari Anderson	Earth Matters
Cyndi Loomis	Alpine Geophysics
Daniel Chau, Vernon Hughes, Doug Ito, Bruce Jackson, Anne Lin, Tess Sicat, Cheryl Taylor, Eugene Yang, Ed Yotter	ARB

Welcome and Feedback on April 7 Minutes

ARB welcomed everyone to the call. Introductions were made. There were no comments on the April 7 minutes.

Status of Ftp Site for Accessing Gridded Inventories

Alpine Geophysics described the status of the information on the ftp site. Alpine has placed several items on the ftp site since the last call. 1) Alpine has added the point and area source files for the September 2000 episode. 2) Alpine has placed an example of SAS code that can be used to extract the SAS transport files to your local system. This will enable you to review the gridded SAS files that are in SAS trans format. The file on the ftp site is called "example_import.sas". 3) Alpine has placed a program to convert ASCII to binary that will allow the modeling files to be imported into PAVE, as requested by Sac Metro AQMD. The program on the ftp site is called "binary_convert.tar.gz". [Note: To access the information, ftp to agftp.com (host name). The user ID is agftp and the password is pass4ftp. The emission information can be found under the directory "CCAQS_Emissions". A detailed description of the contents of the CCAQS_Emissions directory can be found in the April 7 minutes.]

Several additions will be posted to the ftp site soon. 1) Alpine will place an overview document that describes what information is posted on the ftp site. 2) Revised on-road motor vehicle and biogenic emissions for the July/August episode will be posted soon. These emissions were recalculated using different meteorological data. 3) Alpine will add a description of the file naming convention. 4) Alpine will post to the ftp site a data-tracking log that shows the current inventory, date released, problems identified, who identified the problem and when, how the problem was fixed, and who fixed the problem and when. 5) Emissions from soil NO will also be posted. 6) Spatial surrogate information (report and graphics) will be posted. 7) The results of a CCOS project to update specific district area source categories will be available. 8) Future year emissions will be posted when they become available.

BAAQMD stated that they would be revising emission and stack data for refineries. Sac Metro AQMD raised questions about inconsistencies in the summary reports. ARB also expressed concerns about discrepancies in county total emissions between the summary reports on the ftp site with reports run in-house by ARB. ARB will work with Alpine to correct and clarify the summary reports. Sac Metro AQMD also expressed concern that their day-specific emissions didn't appear to be incorporated correctly. ARB will work with the district and Alpine to ensure the inclusion of the day-specific data.

Comments on Alpine Geophysics' Report on the Integrated Transportation Network

The group provided comments on the draft report (available on the ftp site) that describes how the gridded on-road motor vehicle inventory was created using the Integrated Transportation Network (ITN). ARB noted that they are working with the COGs to specifically define the hours in the am/pm peaks for their region. ARB will work with Alpine to incorporate any corrections needed to the motor vehicle emission calculations. SJVUAPCD expressed concern about Caltrans' statewide network being used for their four northern counties rather than local data. Earth Matters, who represents the valley COGs, will work with ARB and Alpine to look into acquiring local network data. SJVUAPCD also noted that the ITN represents reality fairly well in the urban areas, but can be off by more than a grid cell in more remote areas like the foothills. Also, Earth Matters sent questions about the commercial travel model that Alpine included; ARB and Alpine will discuss the questions on a separate call. Please provide any additional comments to Jim Wilkinson (Alpine Geophysics).

Other Issues

No other issues were discussed.

Plans for Next Meeting

The next conference call is scheduled for Wednesday, May 7.

D.9.5 May 7, 2003 Minutes

Attendees	Affiliation
Toch Mangat, Phil Martien, Amir Fanai	Bay Area AQMD
Bob Nunes	Monterey Bay Unified APCD
Matt Jones, Greg Tholen	Sacramento Metro AQMD
Donald Hunsaker, David Nunes, Evan Shipp	San Joaquin Valley Unified APCD
Harold Brazil	MTC
Cari Anderson	Earth Matters
Cyndi Loomis, Jim Wilkinson	Alpine Geophysics
Leonard Seitz	Caltrans
Paul Allen, Daniel Chau, Vernon Hughes, Doug Ito, Bruce Jackson, Anne Lin, Cheryl Taylor, Bruce Tuter, Ed Yotter	ARB

Welcome and Feedback on April 23 Minutes

ARB welcomed everyone to the call. Introductions were made. There were no comments on the April 23 minutes.

Status of Ftp Site for Accessing Gridded Inventories

Alpine Geophysics described the status of the information on the ftp site. Alpine has placed several items on the ftp site since the last call:

a) Alpine has posted modeling files that reflect revised on-road motor vehicle and biogenic emissions using CALMET temperatures (higher temperatures) for the July/August 2000 episode. The on-road emissions increased about 10-20% and the biogenic emissions increased about 30% from the previous version. It was noted that the on-road emissions were adjusted so that the county totals match the emissions from EMFAC2002 v2.2. *These emissions were spatially allocated using the output from DTIM, which uses the ITN activity as input, to create hourly emission ratios for each grid cell in a county.* The revised files contain “revmet” in the name.

b) Alpine has posted new summaries of emissions by county and by category (EIC3 level) for point and area sources. The new summaries reflect the correction to the EIC mapping that was causing some point and area source emissions to be dropped. The summaries also reflect a clearer accounting of the processing that occurred from the CEFS output files to the SAS gridded files (e.g. some ag burn emissions are dropped because no burning occurred on the episode day). Close attention should be paid to the files names in order to retrieve the latest version; the revised summaries have V050503 (Version dated May 5, 2003) added to the file name.

c) Alpine has posted point and area source model-ready files (SAPRC format) for January 2001.

d) Alpine has placed the EMS-95 Technical Formulation Documentation on the ftp site under the directory "EMS-95 Technical Formulation Documentation". These are old WordPerfect files that should load into newer versions of WordPerfect and probably into Word. Much of this same information is available on-line at ww.ladco.org/emis/guide/ems95.html.

e) The Emission Inventory Branch at ARB has developed a website with information regarding SIP Baseline Emission Inventory Projections. The site contains report generators for annual average, seasonal average planning, and modeling inventories. There are sections on control rule reports, documentation, and memoranda. This site should be helpful in checking the summary reports from CEFS that are posted on the ftp site. The address is http://www.arb.ca.gov/app/emsinv/ccos/index.php

f) Spatial data are now available on the ftp site. The reports and plots created by Sonoma Technology Inc. (STI) are available for review. A "read me" file describes the files. The directory is called "CCOSI_STI".

g) Future year surrogate information is also available from STI. It is in the directory "NewSurrogates_STI".

h) The results of the project to update specific district area source categories for small districts in the Mountain Counties, Sacramento Valley, and Mendocino can be found in the directory "CCOSII_STI". A "read me" file describes where to find the information.

The BAAQMD noticed as they reviewed the plots that the southern portion of the domain had a different timing for when motor vehicle emissions began than the rest of the domain. ARB is having on-going discussions with the COGs about the definition of “peak hour”. There are multiple period definitions for different networks. ARB is working with Alpine to ensure that the actual hours as defined by am, pm, and off-peak periods are reflected correctly on the Integrated Transportation Network (ITN). The BAAQMD has also created animations of the NOx and TOG plots for on-road motor vehicles and volunteered to post them on the ftp site.

The group discussed the labeling information on the plots. The units are in kg/grid cell for each hour. The time shown is local time (PDT for July 2000). Alpine will check the labels to make sure that the units and a description of the plot are displayed.

Comments on Alpine Geophysics’ Report on the Integrated Transportation Network

Alpine Geophysics received two sets of comments on the draft ITN report. Alpine will draft responses to the comments.

Additionally, the San Joaquin Valley Unified APCD and Earth Matters had expressed concern in previous meetings that the ITN uses the statewide model for the four northern counties in the San Joaquin Valley. The SJVUAPCD is continuing to study the ITN in the northern SJV to determine if the ITN is acceptable as a replacement for local data. ~~The SJVUAPCD and Earth Matters expressed acceptance of the ITN for use in the SIPs.~~ Earth Matters expressed acceptance of the ITN for use in the SIPs. The SJVUAPCD is still discussing in-house the acceptability of the ITN. ARB and SJVUAPCD will discuss the subject further during the next weekly modeling call. Earth Matters agreed to work with ARB to provide updated data for all eight counties in the SJV. There is not sufficient time to incorporate these data into the ITN for use in the upcoming SIPs. Perhaps they can be used for future work, such as transport analysis.

Monterey Bay Unified APCD expressed surprise that local transportation data were not used for the Monterey area since they believe that data were available. AMBAG did not respond to the original request for data from Alpine. Monterey Bay district will look into what data are currently available.

Caltrans noted that they would have a new statewide model available soon that will represent calendar year 2000.

Other Issues

Earth Matters had a question about the TOG emissions for area sources in the San Joaquin Valley. They compared the August 1, 2000 inventory with an average summer day inventory and noticed a large difference (about 1100 tpd). ARB will look into the question.

Plans for Next Meeting

The next conference call is scheduled for Wednesday, May 21.

D.9.6 May 21, 2003 Minutes

Attendees	Affiliation
Toch Mangat, Phil Martien, Amir Fanai	Bay Area AQMD
Bob Nunes	Monterey Bay Unified APCD
Charles Anderson, Matt Jones, Bruce Katayama, Aleta Kennard, Greg Tholen	Sacramento Metro AQMD
David Nunes, Evan Shipp, Michelle Stanley	San Joaquin Valley Unified APCD
Harold Brazil	MTC
Cari Anderson	Earth Matters
Cyndi Loomis, Jim Wilkinson	Alpine Geophysics
Leonard Seitz	Caltrans
Ravi Ramalingam, Cheryl Taylor, Ed Yotter	ARB

Welcome and Feedback on May 7 Minutes

ARB welcomed everyone to the call. Introductions were made. There were two comments on the May 7 draft minutes. The SJVUAPCD did not agree with the statement in Section 3 *“The SJVUAPCD and Earth Matters expressed acceptance of the ITN for use in the SIPs.”* The SJVUAPCD is still discussing in-house the acceptability of the ITN. ARB and SJVUAPCD will discuss the subject further in the next weekly modeling call.

Caltrans questioned the following statement on the ITN in Section 2, part 1): *“These emissions were spatially adjusted using VMT on the Integrated Transportation Network (ITN).”* This statement incorrectly reflected what was said at the meeting. The statement should read *“These emissions were spatially allocated using the output from DTIM, which uses the ITN activity as input, to create hourly emission ratios for each grid cell in a county.”* After discussing the spatial distribution of the emissions, Caltrans was satisfied with the method. ARB will correct the minutes to reflect these comments.

Data on Ftp Site

Alpine Geophysics described the information posted to the ftp site since the last call. [To access the site, ftp to agftp.com (host name). The user ID is agftp and the password is pass4ftp.] Since there have been several revisions to some of the files, Alpine has created a Version_Control_Log (found under CCAQS_Emissions/July 2000/Modeling_Files) that describes the reason for each revision and the revision number. This log will be very helpful in understanding what is in each file.

a) Alpine posted revised point and area source files for the July/August 2000 episode that reflect corrections in the processing of the CEFS output files. There are revised summaries (emissions by county as well as emissions by county and EIC category). There are revised modeling files. All the summaries and modeling files for the revised point and area sources contain the date the version was revised, V050503.

b) There have been changes to the list of species in both the CB-IV and SAPRC chemistries. These changes relate to whether certain species are treated explicitly or are lumped together with other species. The species are methanol (MEOH), ethanol (ETOH), MTBE, and methyl butanol (MBUT). The BAAQMD reminded all that changes to the speciation will cause the modeling files to change, but not the base CEFS files and plots.

Alpine noted that there are several outdated versions of files on the ftp site that could cause confusion to reviewers. They asked if the files could be deleted. ARB requested that the files be moved to a different directory to lessen confusion, but retained for now. Alpine will look into creating a subdirectory for outdated versions. Space on the ftp site may become a concern.

SMAQMD expressed concern that the day-specific emissions may not be processed correctly for begin hour codes of “-1”, which indicate that the emissions are in kg/day rather than kg/hour. This may cause the emissions to be underestimated. ARB will investigate.

BAAQMD noted that some of the day-specific data recently submitted for the Bay Area contained emissions for only certain hours of the day, not the entire day. Following a discussion with Alpine on the methodology for processing the data, BAAQMD was satisfied that the data are being processed correctly.

Comments on Alpine Geophysics’ Report on the Integrated Transportation Network

Alpine Geophysics has placed the raw data files that they used to create the ITN on their FTP site. Each network is contained in its own zip file. The zip files are located in the directory "ITN_2000/Raw Data Used To Develop ITN." The name of the zip files states their relation to the network. ARB noted that the SACOG file was missing; Alpine will post Sacramento to the ftp site.

Alpine also posted a zip file on the FTP site that contains all the documentation and supporting data sets for the gravity model used in the Integrated Transportation Network (ITN). The file is called “ucd_gravity.zip” and is located in the "ITN_2000/Commercial VMT Gravity Model" directory. The gravity model estimates commercial VMT based on trip counts for 2, 3, 4, and 5 axle vehicles. The model uses AADT data from Caltrans and apportions trip counts across the domain. Alpine noted that the commercial VMT using the gravity model was only applied to the portions of the ITN developed with the Caltrans statewide model; local transportation networks already include commercial VMT.

Alpine plans to provide a draft final version of the ITN report on May 23. Alpine will notify the group when the report is available.

Earth Matters asked when Alpine would be responding to their questions about the ITN. Alpine hopes to complete their response by the end of the week.

Earth Matters asked if ARB still wants the latest COG data since it may not be used in the ITN for SIP modeling. ARB would like the data since ARB is creating its own ITN for uses other than SIP modeling. The alternate ITN would be on a different grid system than CCOS, using a Teale Albers projection. Earth Matters said they would request the data from the TPAs.

The BAAQMD mentioned that the time profiles in the on-road inventory of the model-ready files show a noontime “dip” in emissions on the weekend. Alpine pulled up the data and said that the “dip” is caused by the day-specific data that were developed by Dr. Niemeier of UC Davis. The data show a 1-2 hour decrease in emissions around noon and then a return to previous levels. Alpine will post the UC Davis information to the ftp site. Alpine will also post information that was generated to QA the ITN that may be helpful to other reviewers.

Other Issues

No other issues were raised.

Plans for Next Meeting

The next conference call is scheduled for Wednesday, June 4.

D.9.7 June 4, 2003

Attendees	Affiliation
Phil Martien, Amir Fanai	Bay Area AQMD
Charles Anderson, Matt Jones, Bruce Katayama, Greg Tholen	Sacramento Metro AQMD
David Nunes, Stephen Shaw, Michelle Stanley, Jim Sweet	San Joaquin Valley Unified APCD
Harold Brazil	MTC
Leonard Seitz	Caltrans
Cari Anderson	Earth Matters
Cyndi Loomis, Jim Wilkinson	Alpine Geophysics
Paul Allen, Vernon Hughes, Tess Sicat, Cheryl Taylor, Bruce Tuter, Ed Yotter	ARB

Welcome and Feedback on May 21 Minutes

ARB welcomed everyone to the call. Introductions were made. The May 21 and revised May 7 minutes were approved as written.

Data on Ftp Site

Very little new information was posted to Alpine Geophysics ftp site since the last call. [To access the site, ftp to agftp.com (host name). The user ID is agftp and the password is pass4ftp.] When reviewing the various files on the ftp site, check the Version Control Log to determine the version you wish to review. The Version_Control_Log (found under CCAQS_Emissions/July 2000/Modeling_Files) describes the reason for each revision and the revision number.

Alpine will be posting revised area and point source modeling files. A small amount of emissions were being left out because some SIC/SCC combinations were missing a speciation profile assignment. Alpine and ARB should have the problem corrected soon.

In previous meetings, SMAQMD expressed concern that the day-specific emissions may not be processed correctly for begin hour codes of "-1", which indicate that the emissions are in kg/day rather than kg/hour. This may cause the emissions to be underestimated. SMAQMD also expressed concern that emissions reported for multiple hours (rather than a single hour at a time) were being treated for only the first hour. Alpine and ARB investigated the concerns and discovered that SMAQMD was correct. Alpine modified the program to read multiple hours and reformatted the emissions reported with a "-1" to be hourly emissions. The day-specific emissions are now being processed correctly.

Comments on Integrated Transportation Network (ITN) Report

Alpine hopes to complete the draft final ITN report by June13. The group will be notified when it is available for review.

Alpine provided a response on June 3 to comments submitted by Earth Matters on the ITN report. Earth Matters said that they had a couple of questions (editorial comments) about the response. Earth Matters plans to talk to the San Joaquin Valley APCD (SJVUAPCD) and provide a response to Alpine and ARB the week of June 9. Alpine plans to include the response to Earth Matters' comments in the ITN report.

The SJVUAPCD staff continued to express concern about the statewide network being used for the four northern counties of the SJV rather than local transportation networks in the ITN. SJVUAPCD staff has raised the concern to their management. [As a reminder, Stanislaus provided information that couldn't be incorporated and the other three counties did not respond at the time when Alpine gathered the local data for use in the ITN.]

Earth Matters will continue to work with Ed Yotter to provide local networks to the ARB.

At the last meeting, the BAAQMD mentioned that the time profiles in the on-road inventory of the model-ready files show a noontime "dip" in emissions on the weekend. Alpine mentioned that the "dip" is caused by the day-specific data that were developed by UC Davis. The BAAQMD reminded Alpine to post information that was used to QA the ITN, which may be helpful to other reviewers. Alpine will post the information. The BAAQMD also posted animations showing diurnal profiles of Bay Area traffic counts on the ftp site under CCAQS_Emissions\July 2000\Animations.

Other Issues

No other issues were raised.

Plans for Next Meeting

The next conference call is scheduled for Wednesday, June 25.

D.9.8 June 25, 2003 Minutes

Attendees	Affiliation
Charles Anderson, Matt Jones, Bruce Katayama, Greg Tholen, Brigette Tollstrup	Sacramento Metro AQMD
David Nunes, Stephen Shaw, Michelle Stanley, Jim Sweet	San Joaquin Valley Unified APCD
Bob Nunes	Monterey Bay Unified APCD
Wayne Luney	Caltrans Headquarters
Sally Rodeman	Caltrans, District 10
Cari Anderson	Earth Matters
Cyndi Loomis, Jim Wilkinson	Alpine Geophysics
Chris Emery	Environ
Vernon Hughes, Tess Sicat, Cheryl Taylor, Ed Yotter	ARB

Welcome and Feedback on June 4 Minutes

ARB welcomed everyone to the call. There were two comments on the June 4 minutes. First, the minutes stated "Earth Matters will continue to work with Ed Yotter to provide local networks to the ARB." Earth Matters noted that ARB has stated that they are not ready to collect networks at this time. Second, Earth Matters expressed concern about the statement in Section 3: "[As a reminder, Stanislaus provided information that couldn't be incorporated and the other three counties did not respond at the time when Alpine gathered the local data for use in the ITN.] Earth Matters thought it might be better to say that local data were used for four of the eight counties in the SJV.

Data on Ftp Site

Alpine Geophysics reported that information for the September 2000 episode is available on the ftp site. [To access the site, ftp to agftp.com (host name). The user ID is agftp and the password is pass4ftp.] CEFS output files, summaries, plots, intermediate SAS files, and modeling files are available for review.

The temperature and relative humidity fields used to calculate the on-road motor vehicle and biogenic emissions have been posted to the ftp site.

Revised CEFS files (base year and future years) have been provided by ARB for the July/August 2000 episode. Alpine is processing these emissions to create modeling files for 2005, 2006, 2007 and 2010. Alpine will post these files to the ftp site this week and will generate several reports, including emission summaries by county and EIC as well as summaries of speciated emissions for each episode day.

ARB is developing the gridded on-road motor vehicle files for the future years needed for the July/August 2000 episode. ARB plans to provide these files next week to Alpine, who will speciate the emissions.

In previous meetings, SMAQMD expressed concern that some of the day-specific emissions were not being processed correctly. The problems have now been corrected. The day-specific data are being incorporated correctly as the inventories are being reprocessed with the latest emission data.

The June 4 minutes reported a small underreporting of emissions due to missing speciation profile assignments. This problem has now been corrected. Additionally, ARB has provided Alpine with speciation profiles for all the future years.

SJVUAPCD asked whether the modeling emission files reflect Pacific Daylight Time (PDT) or Pacific Standard Time (PST). ARB responded that emissions are usually handled in PDT because the temporal profiles of business activities follow local time (e.g. a business starts operating at 8 am, regardless of which time base it is). Air quality modelers need to be aware that they may need to convert emission data from PDT to PST.

Comments on Integrated Transportation Network (ITN) Report

Alpine Geophysics is working on the draft final ITN report. The group will be notified when it is available for review.

Previously, Alpine provided a response to comments submitted by Earth Matters on the ITN report. Earth Matters provided verbal comments to ARB. ARB will work with Alpine to incorporate the comments. Alpine plans to include the response to Earth Matters' comments in the ITN report.

SJVUAPCD continued to express concern about the statewide network being used for the four northern counties of the SJV rather than local transportation networks in the ITN. SJVUAPCD would like to see all the local SJV networks included in the ITN in time for modeling work to develop future year control strategies for the 1-hour ozone SIP. SJVUAPCD is considering options to provide an updated ITN for all or part of the SJV, perhaps by the middle of July. SJVUAPCD will discuss a course of action for improving the ITN with ARB when a decision has been made, hopefully by the end of the week. The entire group agreed that it is important to keep moving forward to update the ITN.

ARB noted that there is insufficient time to update the ITN and recreate the motor vehicle inventories in time for base year model performance, as it will be completed shortly. ARB reminded the group that the ITN is only used as a sophisticated spatial surrogate; emission estimates for each county come from EMFAC. ARB suggested that the difference between the local networks and the statewide network could be assessed. This could be done in GIS by overlaying the 4 kilometer modeling grid over a local network and summing the VMT by grid cell. The result could be compared to the sum of the VMT by grid cell from overlaying the modeling grid over the statewide network. Comparing the VMT by grid cell would quantify the difference between the local and statewide networks to see if the spatial distribution would be changed significantly.

Alpine Geophysics will be providing training on how the ITN was developed to ARB and other interested parties in Sacramento on July 1, 2, and 3. SJVUAPCD and Earth Matters requested information on the training.

There was some discussion about how each period (for example, am and pm peaks) was distributed on the ITN. Alpine agreed to post a table on their ftp site that lists each county and the hours that each period represents. This table was developed based on data that were provided to Alpine by the local transportation agencies.

As requested at the June 4 meeting, Alpine posted on their ftp site a comparison of weekday and weekend VMT for each county between the UC Davis data, the ITN data, and the DTIM data. The BAAQMD had previously noted that the time profiles in the on-road inventory showed a noontime "dip" in emissions on the weekend, which reflected the day-specific data that were developed by UC Davis.

Other Issues

No other issues were raised.

Plans for Next Meeting

The next conference call is scheduled for Wednesday, July 9.

D.9.9 July 30, 2003 Minutes

Attendees	Affiliation
Phil Martien, Toch Mangat	Bay Area AQMD
Charles Anderson, Bruce Katayama, Greg Tholen	Sacramento Metro AQMD
David Nunes, Stephen Shaw, Michelle Stanley, Jim Sweet	San Joaquin Valley Unified APCD
Leonard Seitz	Caltrans Headquarters
Cari Anderson	Earth Matters
Cyndi Loomis	Alpine Geophysics
Vernon Hughes, Tess Sicat, Cheryl Taylor, Bruce Tuter	ARB

Welcome and Highlights of July 9 Meeting

ARB welcomed everyone to the call. ARB summarized the items discussed at the July 9 meeting. The following paragraph will serve as the minutes of the July 9 meeting.

<u>July 9 Meeting Highlights</u>

Participants represented the Bay Area, Sacramento and San Joaquin districts, Alpine Geophysics, and ARB. Alpine stated that they are producing future year modeling inventories for the CCOS base case modeling for the July/August 2000 and September 2000 episodes. Alpine staff are also producing base year and future year modeling inventories for the July 1999 episode for the Bay Area AQMD and the August 2002 episode for the Sac Metro AQMD. Alpine is progressing on the final ITN report. The Bay Area mentioned that they had reviewed the data regarding the period definition spreadsheet that Alpine had posted on their ftp site (see the June 15 minutes).

Update on Status of Gridded Inventory

Alpine Geophysics reported on the status of the gridded inventories. ARB provided revised point and area source CEFS files for all episodes to Alpine on July 10. Alpine has reprocessed the CEFS files to create revised modeling files for point and area sources. The files are for the base year and future years for the July/August 2000, September 2000, and August 2002 episodes. The file names will contain “V071003_R001”. The revised future year files were inadvertently placed under the CCAQS_Emissions/July_2000/Modeling_Files directory, rather than the CCAQS_Emissions/July_Aug_FY/Modeling_Files directory. Alpine will generate summary reports when time is available.

Regarding the status of on-road motor vehicle emissions, the modeling files for 2005 and 2006 for the July/August episode will be ready on August 4. ARB will be providing files for 2010 to Alpine for processing in the next two to three weeks. ARB will also be providing files for all future years for the September 2000 episode to Alpine for processing in the next two to three weeks. Modeling files for the base year September 2000 episode are posted on the ftp site.

The point, area, and biogenic files for the July 1999 episode (base year) will be completed and posted the week of August 4. The motor vehicle files will be ready the following week.

The version control log has been updated to reflect the available files (found under CCAQS_Emissions/July_2000/Modeling_Files). The version control log also describes the various versions of the CBIV and SAPRC chemical mechanisms. Please check the version control log for a description of each modeling file.

Update on Wildfire Emissions

ARB reported that at the last CCOS Technical Committee (TC) meeting, Gail Tonnesen of UCR mentioned that the day-specific wildfire emissions (in particular, the Manter fire in southeast Tulare County) had a large effect on model performance. The TC asked how the emissions were being treated in the model and if anyone had information on alternative methods that could be used, particularly in distributing the emissions vertically. UC Berkeley's Center for the Assessment and Monitoring of Forest and Environmental Resources (CAMFER) laboratory calculated the emissions in consultation with ARB's Emission Inventory Branch. [More information on CAMFER can be found at: http://camfer.cnr.berkeley.edu/fire/]. Vertical stratification of emissions was done using a method developed for the Fire Emissions Joint Forum (FEJF) of the Western Regional Air Partnership (WRAP). ARB will distribute these methodologies to the group and post them on Alpine's ftp site. The group was asked to provide any additional information they may have.

Other Issues

ARB will contact Alpine Geophysics to estimate a date for the availability of the final ITN report; ARB will notify the group.

Caltrans staff asked about the purpose of the ITN training that Alpine gave in early July. ARB explained that the contract with Alpine specified that Alpine would provide hands-on training to ARB. The purpose was to allow ARB to understand firsthand the method used to develop the ITN and to do a technology capture for future use by ARB.

Caltrans staff asked about any efforts to coordinate/organize future updates to a new ITN, such as incorporating a revised state travel model or more local COG data. No formal coordination has been established; however staff at ARB and Caltrans seemed willing to keep the lines of communication open.

Bay Area staff mentioned that they had reviewed the hourly profiles developed by UC Davis and noticed that cars and trucks were lumped together. ARB reported that UCD did not have sufficient data to warrant the development of distinct hourly profiles that were statistically significant.

San Joaquin Valley staff asked if day-specific train data were included in the CCOS modeling. SJV staff recalled that train traffic was closed west of the mountains between the ocean and valleys during the July/August 2000 episode that may have increased the number of trains operating in the valley. ARB and SJV will investigate sources of information.

San Joaquin Valley staff requested that ARB provide the day-specific data that were used in CCOS modeling, for documentation purposes. ARB will send the data.

Plans for Next Meeting

The next conference call is scheduled for Wednesday, August 13.

D.9.10 August 13, 2003 Minutes

Attendees	Affiliation
Phil Martien	Bay Area AQMD
Charles Anderson, Matt Jones, Bruce Katayama, Greg Tholen	Sacramento Metro AQMD
David Nunes, Stephen Shaw, Michelle Stanley, James Sweet	San Joaquin Valley Unified APCD
Harold Brazil	MTC
Leonard Seitz	Caltrans Headquarters
Cari Anderson	Earth Matters
Cyndi Loomis, Jim Wilkinson	Alpine Geophysics
Chris Emery	Environ
Vernon Hughes, Tess Sicat, Cheryl Taylor, Ed Yotter	ARB

Welcome and Feedback on July 30 Meeting

ARB welcomed everyone to the call. ARB summarized the items discussed at the July 9 meeting. The July 30 minutes were approved as written, with one clarification. The version control log (described in Section 2) applies specifically to the July/August 2000 episode, although the naming convention of the files is consistent between episodes.

Update on Status of Gridded Inventory

Alpine Geophysics reported on the status of the gridded inventories:

July/August 2000 episode – Point and area source modeling files are completed for the base year and future years (2005, 2006, and 2010). Biogenics files are completed. On-road motor vehicle files are completed except 2010, which should be ready next week.

September 2000 episode – Point and area source modeling files are completed for the base year and future years (2005, 2006, and 2010). Biogenics files are completed. On-road motor vehicle files are available for the base year. Alpine said that the future year files for on-road motor vehicles are completed; they will double-check since they are not posted on the ftp site.

July 1999 episode – Point, area, and biogenic modeling files are completed for the base year. On-road motor vehicle files for the base year are currently being processed.

August 2002 episode – Point and area source modeling files are completed for the base year and future years (2005, 2007, 2008, 2010, 2012, and 2018). Biogenics files are completed. On-road motor vehicle files for the base year will be completed in the next week, and subsequently followed by each future year every 2 or 3 days.

Discussion of Wildfire Emissions

As mentioned on the July 30 call, ARB reported that Gail Tonnesen of UCR mentioned at the last CCOS Technical Committee (TC) meeting that the day-specific wildfire emissions (in particular, the Manter fire in southeast Tulare County) had a large effect on model performance. In particular, Gail expressed concern that the emissions from the Manter fire were not distributed nearly high enough (i.e. there were not enough emissions aloft). The TC asked how the emissions were being treated in the model and if anyone had information on alternative methods that could be used, particularly in distributing the emissions vertically. UC Berkeley's CAMFER laboratory calculated the emissions in consultation with ARB's Emission Inventory Branch. Vertical stratification of emissions was done using a method developed for the Fire Emissions Joint Forum of the WRAP. Alpine Geophysics provided a document that described the development of stack parameters and vertical distributions for modeling large wildfires in the CCOS domain. ARB distributed these methodologies to the group and posted them on Alpine's ftp site.

The group discussed the methodology for distributing emissions vertically, based on the information mentioned above. The vertical distribution of emissions is determined by the size of the fire. Members of the group expressed concern that the method that Alpine used limited the size of the fire to the number of acres in a 4 kilometer grid cell, and therefore limited the vertical distribution. Alpine agreed to revisit the methodology using the entire size of the fire for the day.

The group also discussed wildfire emissions in future year inventories, which are not normally included. ARB will put together some initial thoughts on a protocol to handle wildfire emissions in future year modeling.

Biogenic Emissions

Alpine Geophysics received biogenic emissions from ARB for the January 2000 episode. Alpine requested the precise date, start times, and time coordinates for that episode. ARB will provide that information.

Bay Area staff asked about the VOC emissions on August 1 of the July/August 2000 episode since they appeared different than the other days of the episode. They stated that the emissions are fairly high at night and there was a dip in the emissions about 1 p.m. across the entire domain. Bay Area staff agreed to post animations of the biogenic emissions for August 1. Alpine mentioned that the temperature fields used to calculate the emissions are posted on the ftp site. Staff from the Bay Area, Alpine Geophysics, and ARB agreed to look at the temperature fields and the biogenic emissions. The group was reminded that isoprene and methylbutenol (MBO) emissions are sensitive to light and temperature, whereas monoterpene emissions are only sensitive to temperature.

ARB mentioned that SJV staff has expressed concern about the latest biogenic emissions since they are very different than the biogenic estimates made during SARMAP. ARB will discuss the concern further with SJV staff.

Other Issues

After receiving the day-specific data requested from ARB, San Joaquin Valley staff commented that they had not provided day-specific data for CRPAQS. SJV staff will investigate what information they can provide.

Bay Area staff requested conversion programs between latitude/longitude, UTM coordinates, and Lambert Conformal coordinates. Alpine Geophysics and Environ agreed to work with the Bay Area to provide conversion programs.

Plans for Next Meeting

The next conference call is scheduled for Wednesday, September 3.

D.9.11 September 3, 2003 Minutes

Attendees	Affiliation
Phil Martien, Toch Mangat, Amir Fanai	Bay Area AQMD
Charles Anderson, Matt Jones, Bruce Katayama, Greg Tholen	Sacramento Metro AQMD
David Nunes, Stephen Shaw	San Joaquin Valley Unified APCD
Leonard Seitz	Caltrans Headquarters
Cari Anderson	Earth Matters
Cyndi Loomis, Jim Wilkinson	Alpine Geophysics
Vernon Hughes, Tess Sicat, Cheryl Taylor, Bruce Tuter, Ed Yotter	ARB

Welcome and Feedback on August 13 Meeting

ARB welcomed everyone to the call. The August 13 minutes were approved as written.

Update on Status of Gridded Inventory

ARB shared with the group a tracking sheet that shows the status of CCOS and CRPAQS modeling inventories. The group suggested changes and updates. ARB will send out this sheet along with the agenda for future conference calls.

Alpine Geophysics reported on the status of the gridded inventories:

<u>July 1999 episode</u> – Point, area, biogenic, and on-road motor vehicle modeling files are completed for the base year. Biogenics modeling files for the base year are also used as is for all future years (this applies to all episodes). Point and area modeling files for future years should be available next week. On-road motor vehicle files are available for 2005 and 2007. The group discussed which future years were needed for modeling; there was agreement on 2005, 2006, 2007 and 2010.

<u>July/August 2000 episode</u> – Point and area source modeling files are completed for the base year and future years (2005, 2006, and 2010). Biogenics files are completed. On-road motor vehicle files are available for all years.

<u>September 2000 episode</u> – Point, area, biogenic, and on-road motor vehicle modeling files are completed for the base year and future years (2005, 2006, and 2010).

<u>August 2002 episode</u> – Point and area source modeling files are completed for the base year and future years (2005, 2007, 2008, 2010, 2012, and 2018). Biogenics files are completed. On-road motor vehicle files for 2002, 2005, 2007, and 2008 are completed; the remaining future years are planned for completion next week.

Discussion on Wildfire Emissions

After discussion at the previous meeting, Alpine Geophysics revised the methodology for calculating the vertical distribution of fire emissions based on the entire size of the fire for the day rather than limiting the size of the fire to the number of acres in a 4 kilometer grid cell. The revised files are available on Alpine's ftp site.

Various members of the group have gathered information on wildfires. Staff from the San Joaquin Valley and Bay Area agreed to send ARB information, who will distribute it to the group. Alpine recently presented information on wildfires that occurred during the July 1999 and July/August 2000 episodes; ARB will also distribute this to the group.

The group also discussed wildfire emissions in future year inventories. ARB will present information gathered about wildfire emissions at a future conference call of either this group or an all-district modeling call. ARB will also put together some initial thoughts on a protocol to handle wildfire emissions in future year modeling.

Biogenic Emissions

Bay Area staff asked about the VOC emissions on August 1 of the July/August 2000 episode since they appeared different than the other days of the episode. In particular, the emissions are fairly high at night and there was a dip in the emissions about 1 p.m. across the entire domain. Alpine Geophysics and ARB agreed to look at the biogenic emissions and the temperature fields used to develop the emissions.

ARB has two documents related to biogenic emissions that they will distribute to the group. The first is a one-page overview of biogenic VOC emissions using the BEIGIS model. The second is a detailed description of the development of a biogenic hydrocarbon emission inventory for CCOS.

Alpine estimated biogenic NO emissions. These emissions were added to the emissions estimated by ARB using BEIGIS for the July 1999, August 2002, and July/August 2000 episodes. Biogenic NO has not been added to the September 2000 episode. ARB will add a column for biogenic NO to the tracking sheet for SIP modeling inventories.

Alpine used a soil NO algorithm found in BEIS-3 to estimate biogenic NO for modeling purposes. This estimate is about double a previous estimate from UC Berkeley, which is within the uncertainty of the estimation technique. ARB is looking into potential data sources or methods that could be used to validate the emission estimates, such as using California-specific data.

Other Issues

Alpine Geophysics mentioned that they hoped to resume work on the final Integrated Transportation Network (ITN) report soon; a final product is possible in the next two weeks.

Earth Matters asked if updates to VMT on local transportation networks would be used since the final modeling inventories will soon be completed. ARB replied that updates to the VMT could result in changes to EMFAC. For the development of on-road motor vehicle modeling inventories, the ITN is used as a surrogate to spatially distribute EMFAC emissions. Revised emission estimates from EMFAC could be used in developing attainment targets over the next few months. Earth Matters will be sending a letter to ARB providing updates to VMT for the SJV COGs.

Staff from the Bay Area informed the group that Dr. Rob Harley (UCB) recently completed a draft report that applies a fuel-based emissions inventory method to estimate CO, NOx, and NMOC on-road motor vehicle emissions in the Sacramento Valley, San Joaquin Valley, and the Bay Area. In the report, the fuel-based method is compared to EMFAC totals for the same areas. ARB will distribute the report to the group.

It was noted that the emissions summaries produced by Alpine Geophysics have not been updated to reflect revisions to the modeling inventories, especially for the July/August 2000 episode. Alpine will rerun emission summaries, as time becomes available.

Plans for Next Meeting

The next conference call is scheduled for Wednesday, September 17.

D.9.12 September 17, 2003 Minutes

Attendees	Affiliation
Phil Martien, Toch Mangat, Amir Fanai	Bay Area AQMD
Bob Nunes	Monterey Bay Unified APCD
Charles Anderson, Bruce Katayama, Greg Tholen, Brigette Tollstrup	Sacramento Metro AQMD
Donald Hunsaker, Stephen Shaw, Evan Shipp, Michelle Stanley	San Joaquin Valley Unified APCD
Leonard Seitz	Caltrans Headquarters
Cari Anderson	Earth Matters
Cyndi Loomis, Jim Wilkinson	Alpine Geophysics
Vernon Hughes, Ravi Ramilingam, Klaus Scott, Tess Sicat, Cheryl Taylor, Bruce Tuter, Ed Yotter	ARB

Welcome and Feedback on September 3 Meeting

ARB welcomed everyone to the call. Additional clarification was added to the second paragraph under “Other Issues” of the September 3 minutes. Earth Matters clarified that the updates to VMT were in response to an 8/15/03 letter from ARB requesting review. A letter had been sent to ARB providing comments on the VMT for the SJV COGs indicating that four VMT totals needed adjustment.

Update on Status of Gridded Inventory

The group reviewed the latest tracking sheet prepared by ARB that shows the status of the CCOS modeling inventories. Alpine Geophysics mentioned that they have removed all but the most current versions of the modeling files on the ftp site; all the previous files will be sent to ARB on tape and are available if anyone needs them. No other files were removed.

Alpine reported on the status of the gridded inventories:

<u>July 1999 episode</u> – Point, area, biogenic, and on-road motor vehicle modeling files are completed for the base year. Biogenics modeling files for the base year are also used for all future years (this applies to all episodes). Point and area modeling files are available. On-road motor vehicle files are available for the base year, 2005 and 2007. On-road motor vehicle modeling files for 2006 and 2010 will be available in the next couple of days.

<u>July/August 2000 episode</u> – Point source modeling files are completed for the base year (2000) and future years (2005, 2006, and 2010). The base year (2000) area source modeling files have been updated to include day-specific shipping emissions provided by the BAAQMD; the revised files will be posted soon. Area source modeling files for future years remain unchanged since mid-August. Biogenic modeling files have been

revised to correct the error found in the isoprene emissions (see below, section 4. Biogenic Emissions). On-road motor vehicle files are available for all years. Revised summary reports for point and area sources (by county and EIC) that reflect the latest inventories will be posted shortly.

<u>September 2000 episode</u> – Point, area, biogenic, and on-road motor vehicle modeling files are completed for the base year (2000) and future years (2005, 2006, and 2010). Biogenic NO emissions have not been included in the biogenic modeling files for this episode.

<u>August 2002 episode</u> – Point, area, biogenic and on-road motor vehicle modeling files are completed for the base year (2002) and future years (2005, 2007, 2008, 2010, 2012 and 2018).

<u>July 1990 episode</u> – Sacramento Metro AQMD mentioned that some modeling files are available for this episode. They requested that the tracking sheet be updated to reflect this information and report the vintage of the data.

Discussion on Wildfire Emissions

The group discussed the treatment of wildfire emissions in future year inventories. Options discussed by the group included:

Leave the wildfires out of future year modeling (done in past modeling work)
Include the base year wildfires in the future year modeling (same as the base year)
Include an average value of emissions based on some number of past years (e.g. 20 years, 40 years); possibly use map fire return intervals to determine the most likely place for fires to occur
Use a similar method for wildfires to what is being considered by the WRAP for the treatment of prescribed fires (Environ is reportedly looking into this)
Swap out day-specific wildfire emissions for different episodes to determine the effect of fires (e.g. swap fires in August 2000 with fires in August 2002)
Treat in initial conditions/boundary conditions

Participants on the call were encouraged to send to ARB their conceptual solutions or approaches on how to handle wildfire emissions in future year modeling. ARB will summarize the information gathered and provide it to the group for discussion at a future conference call.

Biogenic Emissions

Bay Area staff had previously asked about the VOC emissions on August 1 of the July/August 2000 episode since the hourly distribution appeared different than the other days of the episode. In particular, the emissions are fairly high at night and there was a dip in the emissions about 1 p.m. across the entire domain. Upon review by Alpine Geophysics and ARB, it was discovered that an error had occurred in the processing of the isoprene emissions for August 1. The problem only affected isoprene and only that day was affected. Alpine has corrected the problem and posted revised modeling files on the ftp site. ARB has rerun the air quality model with the revised file and noticed about a 1 ppb difference on August 1.

As mentioned previously, Alpine Geophysics has estimated biogenic NO emissions. These emissions were added to the biogenic emissions estimated by ARB using BEIGIS for the July 1999, August 2002, and July/August 2000 episodes. Biogenic NO emissions have not been added to the September 2000 episode. The tracking sheet for SIP modeling inventories has been updated to reflect whether biogenic NO has been added or not to the modeling inventories.

Alpine used a soil NO algorithm found in BEIS-3 to estimate biogenic NO for modeling purposes. This estimate is about double a previous estimate from UC Berkeley, which is still within the uncertainty of the estimation technique. ARB is looking into potential data sources or methods that could be used to validate the emission estimates such as using California-specific data. This latest biogenic NO estimate is about 2-3% of the total NOx emissions in the domain. ARB is also modeling with and without biogenic NO to determine its impact on ozone concentrations. Once the sensitivity to biogenic NO emissions has been determined, ARB will consider whether to modify the new biogenic NO estimates or leave them as estimated by Alpine Geophysics.

Other Issues

Alpine Geophysics mentioned that the final Integrated Transportation Network (ITN) report has not been completed.

Previously, ARB distributed a draft report by Dr. Rob Harley (UCB) that applies a fuel-based emissions inventory method to estimate CO, NOx, and NMOC on-road motor vehicle emissions in the Sacramento Valley, San Joaquin Valley, and the Bay Area. The fuel-based method is compared to EMFAC totals for the same areas. ARB will compile any comments that members of the group would like to provide.

Dr. Harley's report suggests that NOx emissions from diesel engines could be underestimated in the San Joaquin Valley. Staff from the SJVUAPCD added that emissions from seasonal heavy-duty diesel trucks might not be fully captured in the current on-road motor vehicle inventory. Many of these trucks only operate two months of the year and only travel on local or collector roads. However, little information is available on which to base emission estimates.

ARB staff mentioned that they are looking at a recent heavy-duty truck survey completed by Caltrans. ARB staff is comparing VMT estimates from EMFAC with those from the survey. Preliminary findings are that the statewide VMT in EMFAC are in fairly good agreement with the survey, but that the distribution of VMT by region is different. ARB staff is continuing to investigate. The representative from Earth Matters mentioned that the SJV COGs are working on a truck model that will include commodity flow. The COGs hope to have a working version of the model in the next few months; the status of the model will be given at the next conference call. The topic of heavy-duty truck emissions will be added to the agenda.

BAAQMD staff has been comparing temperature fields used in the models with surface temperature observations for the July/August 2000 episode. BAAQMD staff observed that the temperatures developed through objective analysis by ARB look low compared to observations at some locations in the Bay Area (i.e. there seem to be “cold holes” upwind of Livermore). BAAQMD staff agreed to send the information to ARB for review.

Plans for Next Meeting

The next conference call is scheduled for Tuesday, September 30.

D.9.13 September 30, 2003 Minutes

Attendees	Affiliation
Charles Anderson, Bruce Katayama, Brigette Tollstrup	Sacramento Metro AQMD
David Nunes, Stephen Shaw, Michelle Stanley	San Joaquin Valley Unified APCD
Frank Law	Caltrans
Sally Rodeman	Caltrans District 10
Jason Paukovits	Fresno COG
Cari Anderson	Earth Matters
Cyndi Loomis, Jim Wilkinson	Alpine Geophysics
Chris Emery	Environ
Mark Carlock, Vernon Hughes, Klaus Scott, Tess Sicat, Cheryl Taylor, Ed Yotter	ARB

Welcome and Feedback on September 17 Meeting

ARB welcomed everyone to the call. Introductions were made. The September 17 minutes were approved as written.

Status of Wildfire and Biogenic Emissions

ARB gave a status report on wildfire and biogenic emissions. On previous calls, the group discussed the treatment of wildfire emissions in future year inventories. Several options have been discussed. Participants were encouraged to send to ARB their conceptual solutions or approaches to ARB. ARB has received two comments to date; comments are still requested. ARB will summarize the information gathered and provide it to the group for discussion at a future conference call.

As mentioned previously, the biogenic modeling file for August 1, 2000 has been corrected and posted on Alpine's ftp site. An error occurred during processing of the isoprene emissions that caused the hourly isoprene emissions to be distributed incorrectly over that day. ARB has rerun the air quality model with the revised file and noticed about a 1 ppb change in ozone concentration on August 1.

As mentioned previously, Alpine Geophysics has estimated biogenic NO emissions. These emissions were added to the biogenic emissions estimated by ARB using BEIGIS for the July 1999, August 2002, and July/August 2000 episodes; they were not added to the September 2000 episode.

The biogenic NO emissions estimated by Alpine were about double a previous estimate. ARB modeled with and without biogenic NO to determine its impact on ozone concentrations. ARB reported that they saw negligible impact on ozone concentrations.

ARB will not pursue refinements to the biogenic NO estimates for the SIP modeling for the 1-hour ozone standard. The group agreed to add biogenic NO emissions to the September 2000 episode for consistency with the other episodes.

Discussion of Heavy-duty Truck Emissions

Earth Matters mentioned that an update on the truck model being developed by the San Joaquin Valley COGs was distributed to the group along with a draft report that is available for review. The truck model is jointly managed by Caltrans and the Fresno COG. A final report is scheduled for release in October. A steering committee has been organized to determine how the truck model will be used. Comments on the draft report can be provided to the Fresno COG. ARB asked if the truck model had been compared to EMFAC; Earth Matters will find out if a comparison is planned. ARB also asked to be included for receiving more details on the truck model.

Previously, ARB distributed a draft report conducted under CCOS by Dr. Rob Harley (UCB) that applies a fuel-based emissions inventory method to estimate CO, NOx, and NMOC on-road motor vehicle emissions in the Sacramento Valley, San Joaquin Valley, and the Bay Area. Earth Matters provided comments, which will be included in ARB's comments on the report. At this point, the project stands as an independent, CCOS-based study of on-road motor vehicle emissions and will not directly result in changes to EMFAC.

ARB staff mentioned that they are looking at a recent Caltrans survey of 8200 heavy-duty trucks. SJVUAPCD staff asked if the survey captured seasonal trucks since they do not normally travel on freeways. ARB responded that they are probably not captured in the survey because they were conducted at truck stops. ARB pointed out that the heavy-duty emissions from EMFAC are based on DMV registration. As long as they are registered, the emissions from seasonal trucks are included in EMFAC. SJVUAPCD staff said that the seasonal trucks are registered with DMV. Although the emissions are included in EMFAC, the seasonal variation of the emissions is not well represented. The activity of these trucks is spread over the entire year. The on-road motor vehicle emissions used in modeling for the SIPS may be underestimated. ARB staff has been directed by its upper management to investigate the seasonality of on-road motor vehicle emissions. ARB staff is to determine whether there is a problem for the SIPs and, if so, what is its magnitude. If a problem is determined, ARB will make adjustments. ARB staff has been directed to review San Joaquin Valley first; changes to other areas will be considered after SJV. SJVUAPCD staff commented that modeling results are needed by the first of November. Sac Metro staff expressed similar concerns to San Joaquin about the seasonality of emissions; modeling results are needed by January 1 for Sacramento.

Update on Status of Gridded Inventory

Alpine reported on the status of the gridded inventories. The version control log (for the July/August 2000 episode) is being updated. Revised emission summaries and speciated summaries will be posted soon.

July 1999 episode – Point, area, biogenic, and on-road motor vehicle modeling files are completed for the base year. Biogenics modeling files for the base year are also used for all future years (this applies to all episodes). Point, area, and on-road motor vehicle modeling files are available for 2005, 2006, 2007, and 2010. Point source files have been revised and posted for the base year and all future years. It was discovered that some large facilities were missing UTM coordinates; the default is for the facility to be placed at the center of the county. These large facilities were assigned coordinates and the files reprocessed. The updated files have version V092703 in the file name.

July/August 2000 episode – Point, area, biogenic, and on-road motor vehicle modeling files are completed for the base year (2000) and future years (2005, 2006, and 2010). As described for the July 1999 episode above, base year and future year point source files have been revised and posted. The day-specific file for wildfires in the base year is being revised to vertically distribute the emissions of the smaller wildfires. Previously, only the two large fires (Manter and Plaskett) had vertical distributions.

September 2000 episode – Point, area, biogenic, and on-road motor vehicle modeling files are completed for the base year (2000) and future years (2005, 2006, and 2010). Biogenic NO emissions have not previously been included in the biogenic modeling files for this episode; Alpine Geophysics will add biogenic NO. As described for the July 1999 episode above, base year and future year point source files have been revised and posted. The day-specific file for wildfires in the base year is being revised to vertically distribute the emissions of the smaller wildfires.

August 2002 episode – Point, area, biogenic, and on-road motor vehicle modeling files are completed for the base year (2002) and future years (2005, 2007, 2008, 2010, 2012, and 2018). As described for the July 1999 episode above, base year and future year point source files have been revised and posted. The day-specific file for wildfires in the base year is being revised to vertically distribute the emissions of the smaller wildfires. Previously, only the McNally fire had vertical distribution.
August 1990 episode – Sacramento Metro AQMD mentioned that some modeling files are available for this episode. They requested that the tracking sheet be updated to reflect this information and report the vintage of the data.

Status of Integrated Transportation Network (ITN) Report

Alpine Geophysics reported that they are continuing to work on the final ITN report. ARB reported that the CCOS Technical Committee would like to see the report prior to modeling results. ARB asked Alpine to complete the final report in the next two weeks.

Other Issues

On previous calls, BAAQMD staff mentioned that they have been comparing temperature fields used in the models with surface temperature observations for the July/August 2000 episode. BAAQMD staff observed that the temperatures developed through objective analysis by ARB look low compared to observations at some locations in the Bay Area (i.e. there seem to be “cold holes” upwind of Livermore). BAAQMD staff is comparing RAMS, MM5, and ARB’s objective analysis against observations. At the request of the BAAQMD, Alpine Geophysics has created new biogenic emissions (using BEIGIS) and new on-road motor vehicle emissions using RAMS temperatures. Biogenic emissions generally increased about 5% overall in the Bay Area, although there was a small drop in isoprene in the first three days of the episode due to cloudiness. The rest of the domain showed about a 10% increase in isoprene emissions. For the new on-road motor vehicle emissions, there was a general increase in emissions with three exceptions: 1) In the Sacramento area, the overall TOG emissions were about the same. 2) Also in the Sacramento area, the TOG emissions increased in the first three days and decreased in the last three days. 3) In the Bay Area, the NOx emissions stayed about the same overall, but TOG increased about 5%. Alpine agreed to send ARB the RAMS data. BAAQMD staff is generating graphics that can be shared.

Plans for Next Meeting

The next conference call is scheduled for Wednesday, October 15.

D.9.14 October 15, 2003 Minutes

Attendees	Affiliation
Phil Martien, Amir Fanai	Bay Area AQMD
Bruce Katayama, Greg Tholen, Brigette Tollstrup	Sacramento Metro AQMD
Donald Hunsaker, Tom Jordan, David Nunes, Stephen Shaw, Michelle Stanley	San Joaquin Valley Unified APCD
Dick Fahey	Caltrans District 4
Sally Rodeman	Caltrans District 10
Frank Law, Wayne Luney, Leonard Seitz	Caltrans Headquarters
Cari Anderson	Earth Matters
Jim Wilkinson	Alpine Geophysics
Klaus Scott, Tess Sicat, Cheryl Taylor	ARB

Welcome and Feedback on September 30 Meeting

ARB welcomed everyone to the call. Introductions were made. The September 30 minutes were approved as written.

Freezing Inventory for SIP Planning

ARB mentioned that the future year attainment-level inventories for the July/August 2000 episode need to be frozen. The base case model performance and future base case are frozen. This item will be discussed further at the October 20 all-district modeling call.

Discussion of Heavy-duty Truck Emissions

At previous meetings, the truck model being developed for the San Joaquin Valley COGs was discussed. ARB asked if the truck model had been compared to EMFAC. The representative from Earth Matters said that she believes that a second document exists that discusses emissions; she will send the document to ARB for distribution when it becomes available.

Previously, ARB staff mentioned that they are looking at a recent Caltrans survey of 8200 heavy-duty trucks. Caltrans staff provided additional information about the survey. ARB staff is investigating the use of the Caltrans survey information to possibly redistribute heavy-duty truck activity. Currently in EMFAC, emissions from heavy-duty trucks are based on DMV registration.

During earlier calls, members of the group have expressed concern that seasonal truck activity is not captured well in EMFAC. Although the emissions from seasonal trucks are included in EMFAC since they are registered with DMV, the seasonal variation of the emissions is not well represented. ARB staff is investigating the seasonality of on-road motor vehicle emissions. Sacramento Metro AQMD staff reported at an earlier call that SACOG had studied the seasonal activity of trucks in the Sacramento area. ARB has requested information from SACOG and is waiting for a response. In addition to the seasonal, temporal variation, the spatial variation would also need to be addressed.

Update on Status of Gridded Inventory

ARB reported that few changes have been made since the last call. Following is the status of the inventories for each episode.

<u>July 1999 episode</u> – Point, area, biogenic, and on-road motor vehicle modeling files are completed for the base year. Biogenics modeling files for the base year are also used for all future years (this applies to all episodes). Point, area, and on-road motor vehicle modeling files are available for 2005, 2006, 2007, and 2010. An error has been found in the weekend on-road motor vehicle emissions. Revised modeling files will be posted soon. The weekday on-road motor vehicle emissions were unaffected.

<u>July/August 2000 episode</u> – Point, area, biogenic, and on-road motor vehicle modeling files are completed for the base year (2000) and future base case years (2005, 2006, and 2010).

<u>September 2000 episode</u> – Point, area, biogenic, and on-road motor vehicle modeling files are completed for the base year (2000) and future base case years (2005, 2006, and 2010). Biogenic NO emissions have not previously been included in the biogenic modeling files for this episode; Alpine Geophysics will add biogenic NO.

<u>August 2002 episode</u> – Point, area, biogenic, and on-road motor vehicle modeling files are completed for the base year (2002) and future base case years (2005, 2007, 2008, 2010, 2012, and 2018). An error has been found in the weekend on-road motor vehicle emissions. Revised modeling files for the weekend only have been posted. The weekday on-road motor vehicle emissions remain unchanged.

<u>August 1990 episode</u> – Sacramento Metro AQMD mentioned that some modeling files are available for this episode. They requested that the tracking sheet be updated to reflect this information and report the vintage of the data.

Status of Integrated Transportation Network (ITN) Report

Alpine Geophysics reported that they plan to post the latest revision to the ITN report by October 17. ARB will send a note to the group when the report is available for review.

Other Issues

BAAQMD staff has been comparing temperature fields used in the models with surface temperature observations for the July/August 2000 episode. BAAQMD staff observed that the temperatures developed through objective analysis by ARB look low compared to observations at some locations. BAAQMD staff has prepared a revised temperature field that will be ready today. BAAQMD staff has directed Alpine to create revised biogenic and on-road motor vehicle emissions estimates to determine the change from previous emission estimates. BAAQMD will notify ARB when the revised temperature field is available on Alpine's ftp site. ARB will review the information.

BAAQMD staff said that they have been comparing the emissions summary reports from the ftp site with summer planning emission estimates for the Bay Area for the July/August 2000 episode. They expressed concern about the CO and TOG emissions for the individual days compared to the emissions estimated by ARB available on the web. BAAQMD staff agreed to send ARB and Alpine Geophysics the comparison information for investigation.

The group asked that the status of wildfires be added to the agenda for the next call.

Plans for Next Meeting

The next conference call is scheduled for Wednesday, October 29.

D.9.15 October 29, 2003 Minutes

Attendees	Affiliation
Amir Fanai, Toch Mangat, Phil Martien	Bay Area AQMD
Charles Anderson, Bruce Katayama, Brigette Tollstrup	Sacramento Metro AQMD
Donald Hunsaker, David Nunes, Evan Shipp, Michelle Stanley	San Joaquin Valley Unified APCD
Harold Brazil	MTC
Wayne Luney, Leonard Seitz	Caltrans Headquarters
Cari Anderson	Earth Matters
Cyndi Loomis	Alpine Geophysics
Vernon Hughes, Doug Ito, Anne Lin, Ravi Ramalingam, Tess Sicat, Cheryl Taylor, Bruce Tuter, Ed Yotter	ARB

Welcome and Feedback on October 15 Meeting

ARB welcomed everyone to the call. Introductions were made. San Joaquin staff asked about the accuracy of the write-up related to “Discussion of Heavy-duty Truck Emissions.” After discussion and clarification, the minutes were accepted as written.

Freezing Inventory for SIP Planning

ARB described the overall process for SIP modeling. There are three phases. The first phase is base-case modeling. Meteorology and emissions are developed to simulate as closely as possible the conditions during each day of the episode being modeled. Model performance must meet EPA’s criteria for model performance. ARB has achieved adequate model performance for the July/August 2000 episode. Once adequate base-case model performance is achieved, the model is run using future year emissions that reflect growth in emission categories as well as the effect of adopted control measures. This second phase is base-case future year modeling. Carrying capacity diagrams are developed to aid planners in developing reduction strategies to reach the air quality standard. ARB has completed carrying capacity diagrams for the July/August 2000 CCOS episode and made this information available to the air districts. The third phase is attainment strategy modeling. The model is run using inventories that reflect proposed control measures needed to attain the standard.

ARB is now preparing for attainment modeling (third phase) for the July/August 2000 CCOS episode. At the end of August and early September 2003, ARB sent letters to the districts and COGs requesting any changes to emissions or vehicle activity that would be included in attainment strategy modeling runs. ARB did receive some changes that will be updated. ARB was asked if the first and second phases will be rerun due to changes in the inventory. ARB said no, since adequate model performance has been reached. ARB now considers the inventories for the base-case modeling and base-case future year modeling frozen.

Based upon BAAQMD/ENVIRON modeling, BAAQMD staff have expressed some concerns about the base year and future year inventories at previous meetings of this group and at Bay Area Modeling Advisory Committee meetings. BAAQMD staff wants to resolve their inventory concerns before they move on to attainment strategy runs. However, BAAQMD staff acknowledged that time is short for SJVUAPCD staff to meet SIP deadlines.

ARB asked each district when they would need the results of draft and final attainment modeling runs. Sacramento Metro staff said that they would need draft runs in late January 2004. They will be holding a workshop to discuss proposed control strategies in March and would need final attainment modeling runs completed in May. San Joaquin Valley staff said that they plan to have a workshop in mid-December and would like to have the results of draft attainment runs to share at the workshop. Bay Area staff replied that the schedule for the Bay Area is uncertain; they will get back to ARB.

ARB is developing a spreadsheet for receiving control strategy information from the districts. ARB asked who from each district would be the best contact for requesting this information. Brigette Tollstrup will be the contact for Sacramento, Stephen Shaw will be the contract for San Joaquin, and Jean Roggenkamp will be the contact for Bay Area.

Mobile Source Issues

ARB presented information to the group related to EMFAC and conformity. EMFAC is the official EPA-approved mobile source emission factor model in California. EMFAC is used to estimate on-road mobile source emissions for use in SIP development and transportation conformity determinations. ARB finished a comprehensive update of EMFAC last year (EMFAC2002). While EMFAC will be updated in the future, ARB does not have a schedule for an update at this time. Travel activity data from travel model output provided by local transportation planning agencies were included as part of the EMFAC update, and continue for conformity purposes per federal conformity regulation requirements. As a result of the EMFAC model update, many SIPs in California also had to be updated. Any additional model changes to EMFAC would require model approval by EPA for use in the SIPs and conformity, and could effectively require SIP updates.

As discussed at previous meetings, ARB is studying a Caltrans survey of heavy-duty trucks, and will work closely with the districts and COGs prior to an EMFAC model update that would incorporate any changes. The Caltrans survey indicates a different geographic distribution of heavy-duty truck travel than what is currently in EMFAC2002.

Members of the group continue to express concern that seasonal truck activity is not captured well in EMFAC, causing summertime emissions to be underestimated. ARB staff is investigating the seasonality of on-road motor vehicle emissions, but work is not yet completed. Updated activity normally comes from local travel demand models. ARB staffs believe that the incorporation of seasonal trends would constitute an EMFAC model change. It was suggested that districts who are concerned about this issue should elevate their concerns to their planning managers to initiate policy discussions with ARB's management.

Status of Wildfires

Since the occurrence and extent of wildfires is unpredictable, ARB will exclude wildfire emissions from future year modeling runs. Wildfires have been excluded from the future year base-case runs used to develop carrying capacities. This group has discussed various options on how to treat wildfires in future year modeling runs (both base-case and attainment). Although ARB staff believes that wildfires are likely to occur in future years, no one knows when or where they will occur. The Smoke Management Plan is intended to reduce the likelihood of wildfires by allowing prescribed burning.

San Joaquin Valley staff expressed the opinion that this subject needs more discussion and that this issue is still not decided. They would like to consider putting some average wildfire emissions in the future years. They also asked if sensitivity runs could be made with and without fires. ARB staff suggested that districts' staffs who are concerned about this issue should raise the issue for discussion with upper management at their districts and ARB.

Temperature Fields for July/August 2000 Episode

As mentioned previously, BAAQMD staff observed that the temperatures developed through objective analysis by ARB looked low compared to observations at some locations for the July/August 2000 episode. As a result, BAAQMD staff prepared an alternative temperature field and directed Alpine Geophysics to create revised biogenic and on-road motor vehicle emissions estimates. BAAQMD staff reported that there are differences in the biogenic and on-road motor vehicle modeling inventories, but the impact was not as great as they expected to find. BAAQMD's temperature field is now available on Alpine's ftp site. ARB will review the information. If the ARB agreed to use the BAAQMD's temperature field, it would used for attainment runs. Base-case modeling will not be revisited. ARB will give a status report to the group at the next call on the results of its review of the BAAQMD's temperature field and its possible use in attainment runs.

Update on Status of Gridded Inventory

ARB reported that one change had been made since the last call. Following is the status of the inventories for each episode.

July 1999 episode – Point, area, biogenic, and on-road motor vehicle modeling files are completed for the base year. Biogenics modeling files for the base year are also used for all future years (this applies to all episodes). Point, area, and on-road motor vehicle modeling files are available for 2005, 2006, 2007, and 2010. Previously, an error was found in the weekend on-road motor vehicle emissions. Revised modeling files have been posted. The weekday on-road motor vehicle emissions were unaffected.

July/August 2000 episode – Point, area, biogenic, and on-road motor vehicle modeling files are completed for the base year (2000) and future base-case years (2005, 2006, and 2010).

September 2000 episode – Point, area, biogenic, and on-road motor vehicle modeling files are completed for the base year (2000) and future base-case years (2005, 2006, and 2010). Biogenic NO emissions have not previously been included in the biogenic modeling files for this episode; Alpine Geophysics will add biogenic NO.

August 2002 episode – Point, area, biogenic, and on-road motor vehicle modeling files are completed for the base year (2002) and future base-case years (2005, 2007, 2008, 2010, 2012, and 2018).

August 1990 episode – Sacramento Metro AQMD mentioned that some modeling files are available for this episode. They requested that the tracking sheet be updated to reflect this information and report the vintage of the data.

Status of Integrated Transportation Network (ITN) Report

Alpine Geophysics reported that they plan to post the latest revision to the ITN report by November 7. ARB will send a note to the group when the report is available for review.

Other Issues

During the last call, BAAQMD staff said that they had been comparing the emissions summary reports from the ftp site with summer planning emission estimates for the Bay Area for the July/August 2000 episode. They expressed concern about the CO and TOG emissions for the individual days compared to the emissions estimated by ARB and available on the web. BAAQMD staff sent ARB and Alpine Geophysics the comparison information for investigation. ARB staff responded that they had looked at the emissions comparisons. ARB staff would send the BAAQMD staff the information they had gathered along with an explanation that is hoped to alleviate the BAAQMD's concerns.

BAAQMD staff expressed concern about the volumes of heavy-duty trucks on weekdays versus weekend days. ARB said (this statement was later discovered to be incorrect; please see Important Note below) that the only differences between weekday and weekend emissions are due to day-specific temperatures and relative humidity along with the spatial and temporal variations developed by Dr. Deb Niemeier. Otherwise the emissions from EMFAC are the same for weekdays and weekends. The BAAQMD has received information from MTC showing reduced volumes of trucks on the weekends. Several members of the group expressed concern about the volumes of cars and trucks not being adjusted on weekend days. **[IMPORTANT NOTE:** Since this meeting, ARB staff discovered that they were incorrect about the statements made in the previous paragraph concerning weekday and weekend on-road motor vehicle estimates used in modeling. The following paragraph describes how the motor vehicle emissions from EMFAC are adjusted for a weekend day in the modeling inventories. ARB staff paraphrased this information from a note by Jim Wilkinson, Alpine Geophysics, who developed the ITN and developed the on-road motor vehicle modeling files for many of the episodes.

The on-road motor vehicle emissions are calculated using EMFAC, based on the VMT in EMFAC. However, the weekend VMT to weekday VMT ratio from the ITN is used to scale the EMFAC emissions to a "weekend" estimate. The ITN is comprised of the travel networks that were provided to Alpine Geophysics by CCOS domain transportation agencies. Again to reiterate, EMFAC estimates average weekday emissions based on VMT that resides in EMFAC. To be more specific, the weekend day on-road mobile source CO, TOG, and NOx emissions are less than the weekday emissions by roughly 12% (i.e., the weekend days are equal to about 88% of the weekday on-road mobile source emissions). The exception is for heavy-duty diesel vehicle NOx emissions. Heavy-duty diesel NOx emissions are lower by about 46% on the weekend days. ARB developed the scaling factors (i.e., 0.88 for TOG, NOx, and CO with the exception for HDDV NOx being 0.54) based on the ratio of weekend VMT to weekday VMT.**]**

Plans for Next Meeting

The next conference call is scheduled for Thursday, November 13.

D.10 Development of a biogenic hydrocarbon emission inventory for the Central California Ozone Study domain.

D.10.1 Introduction

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The Biogenic Emission Inventory GIS (BEIGIS) is a spatially and temporally resolved biogenic hydrocarbon emissions inventory model developed by the California Air Resources Board (CARB) that uses California land use/land cover, leaf mass, and emission rate databases within a Geographic Information System (GIS). BEIGIS simulates hourly emissions of isoprene, monoterpenes, and 2-methyl-3-buten-2-ol (MBO, methylbutenol) at a 1 km^2 resolution. Development of BEIGIS has been motivated by a need to account for the state's pronounced plant species diversity and landscape heterogeneity. There are approximately 6000 native plant species in California (25% of the flora of the continental U.S.) distributed over terrain ranging from basins below sea-level to mountain ranges over 3000 m in elevation (Hickman 1993). Plant canopies range from scattered and open canopy structures typical of scrublands and savannas, to more closed canopies typical of coniferous forests. Terrain gradients and proximity to marine influence also give rise to more than a dozen climate zones in the state (CEC 1992). These considerations have prompted the CARB to develop BVOC emission inventory models specific to California.

D.10.2 BEIGIS Inputs

D.10.2.1 Land use/land cover maps

The initial set of inputs to BEIGIS are GIS-based maps of land use and land cover types. A composite land use and land cover GIS map for the Central California Ozone Study (CCOS) domain was compiled from several sources in order to provide sufficient spatial resolution and accuracy to reflect the heterogeneity of vegetation species in the study area.

A biodiversity database and mapping effort undertaken by the U.S. Geological Survey – Biological Resources Division, called the Gap Analysis Project (GAP), was selected to represent natural areas in the California portion of the CCOS domain (Scott et al. 1993; Davis et al. 1995; Chung and Winer 1999). The California GAP database was generated from summer 1990 Landsat Thematic Mapper satellite images, 1990 high altitude color infrared imagery, vegetation maps based on historical field surveys, and other miscellaneous vegetation maps and ground surveys. California's GAP coverage is comprised of approximately 21,000 polygons, aggregated into 272 natural community types. The GAP minimum mapping unit is 100 hectares (1 km^2). Each GAP polygon is comprised of up to three vegetation assemblages (a primary, secondary, and for some polygons, a tertiary assemblage), with each assemblage occupying a fraction of the polygon area. In addition, each assemblage is comprised of up to three co-dominant species, each species contributing ≥ 20% of the assemblage's relative cover. Species canopy cover within individual polygons was estimated as FC × CW, where the parameter FC is the fractional area (ranging between 0 and 1) of the polygon occupied by an assemblage, and CW is a weighting factor for co-dominant species, such that CW = 0.33, 0.50, or 1.0 for assemblages comprised of 3, 2, or 1 species, respectively. For example, a hypothetical 100 km^2 polygon is comprised of primary and secondary assemblages occupying 65% and 35% of the polygon area, respectively. If the primary assemblage is comprised of two species A and B, the co-species weighting factor for each is 0.5 and the canopy cover for each species is ($0.65 \times 0.5 \times 100\ km^2$). If the secondary assemblage is comprised of species B, C and D, the canopy cover for each species is ($0.35 \times 0.33 \times 100\ km^2$). The total canopy cover for species B within the polygon is then $[(0.65 \times 0.5) + (0.35 \times 0.33)] \times 100\ km^2$ or 44 km^2. The estimated canopy cover of a given species in a polygon therefore reflects the weighted contributions from all assemblages in that polygon.

Agricultural areas represented by the GAP data set lack crop species information. Therefore, a land use/land cover GIS map showing crop coverages for the CCOS domain was obtained from scientists of the NASA Ames Research Center. The map was compiled from GIS data sets provided by the California Department of Water Resources (DWR) (http://www.waterplan.water.ca.gov/). Land use/land cover maps were developed by the DWR from periodic ground surveys throughout the state. Counties are surveyed and updated on a rotating basis approximately every seven years. In the DWR crop GIS data set, polygons correspond to individual cultivated fields for which are listed the field area, crop type and the fraction of the field cultivated. Urban areas represented by the GAP data set contain information about urban land use types such as residential and commercial, but lack information about urban vegetation. Urban vegetation databases for three CCOS urban areas (Fresno, Oakland, and Sacramento) were therefore utilized to develop BVOC emission rates for urban areas throughout the CCOS domain.

D.10.2.2 Emission factors, leaf mass and landscape-scale emission rates

For natural areas, GAP plant species were assigned isoprene and monoterpene emission factors ($\mu g\ g^{-1}$ [dry leaf weight] hr^{-1}) from Benjamin et al. (1996) and specific leaf weight factors (SLW, g [dry leaf weight] m^{-2} leaf area) from a database compiled by Nowak and co-workers (2000) (Table 1). Until relatively recently, emission factor data collected in California have been based on branch enclosure rather than leaf cuvette measurement methods. Leaf cuvette-based isoprene emission factors have been found to be 1.75 to 5 times greater than branch enclosure derived emission factors (Guenther et al. 1994 and 1996a; Harley et al. 1998; Geron et al. 2001), ascribed in part to self-shading by leaves within enclosed branches. Since the majority of published emission factor measurements in California were developed using branch enclosure methods, the BEIGIS model used branch enclosure derived emission factors for isoprene and monoterpenes. Branch enclosure derived emission factors for methylbutenol were unavailable, therefore leaf-cuvette derived methylbutenol emission factors from Harley et al. (1998) were used for the MBO emitting conifer species. Within-canopy vertical variation in leaf mass, temperature and solar radiation were not explicitly accounted for in this modeling. Landscape-scale natural area emission rates at reference conditions (30 °C and 1000 umoles m^{-2} s^{-1} photosynthetically active radiation or PAR) for isoprene, monoterpenes and MBO (mg m^{-2} land hr^{-1}) were derived by mapping GAP species fractional canopy cover (FC), co-dominant species weighting factors (CW), specific leaf weight factors (SLW), and emission factors (EF), to 1km^2 grids and multiplying by a remotely-sensed 1 km^2 resolution leaf area index (LAI, m^2 leaf m^{-2} land) GIS layer from Nikolov (1999).

Landscape-scale crop emission rates at reference conditions were derived by first assigning to the crop GIS layer crop BVOC emission factors and crop specific leaf weight (SLW) factors. The DWR land use/land cover map represents 75 agricultural classes or crop types (Table 1). A database was developed listing BVOC emission factors for isoprene and monoterpenes (μg g^{-1} [dry leaf mass] hr^{-1}) at standard conditions of temperature and light (30 °C and 1000 μmol PAR m^{-2} s^{-1}, where PAR is solar irradiance in the 400-700 ηm range) and specific leaf weight factors (SLW, g [dry leaf mass] m^{-2} leaf area) for each crop type (Table 2). Very few crops are isoprene emitters, while some emit monoterpenes. MBO emissions have been observed in a few conifer species. BVOC emission and SLW factors were assigned to crops based upon values reported in the scientific literature. BVOC emission factors were assigned based upon values reported for measured species, or based upon taxonomic relationship to measured species (Benjamin et al. 1996). SLWs were assigned based upon values for measured species, related species, or class. A crop calendar was also consulted to determine which crop types are in cultivation during the summer ozone season. Crop SLW and emission factors were gridded to 1 km^2 resolution and multiplied by the remotely-sensed 1 km^2 resolution leaf area index GIS layer from Nikolov (1999). Urban vegetation survey data for Fresno, Oakland, and Sacramento were utilized to develop landscape-scale isoprene and monoterpene emission rates (mg m^{-2} land hr^{-1}) at reference conditions for urban land uses (Table 3). Urban land use emission rates represent aggregations of plant species for urban land use types in Fresno, Oakland and Sacramento (Sidawi and Horie 1992; Nowak 1991; McPherson 1998) and emission factors as developed by Benjamin et al. (1996).

In addition to isoprene, monoterpenes, and MBO, other organic compounds are emitted by vegetation. Guenther et al. (1994) estimate that the other VOCs (OVOCs) comprise 8% to 73% of total BVOCs. BEIGIS however does not explicitly account for OVOCs at this time, because little data exist from which to construct OVOC emission factors or emission algorithms for California vegetation. An adjustment factor of 30% is applied to the total isoprene, monoterpene and MBO inventory to account for the OVOC fraction, to which is applied a chemical speciation profile from Lamanna et al. (1999) (pers. comm., Paul Allen, CARB, 2001). The OVOC chemical speciation profile is based upon above-canopy ambient air BVOC measurements at Blodgett Experimental Forest, a

1315 m elevation Ponderosa Pine plantation in the central Sierra Nevada of California. The assumed OVOC profile therefore may have limited applicability to natural areas of the CCOS domain, which, in addition to conifer forests, are comprised of savannas, chaparral and scrublands.
Landscape-scale 1 km^2 resolution emission rate layers for natural, urban, and agricultural areas were then aggregated to construct single layers of gridded isoprene, monoterpene, and methylbutenol emission rates at reference conditions for the CCOS domain.

D.10.2.3 Application of environmental correction algorithms

In the BEIGIS model, the effects of spatial variation in ambient air temperature and light intensity on BVOC emissions are taken into account. Isoprene, monoterpene, and MBO emission rate grid layers were environmentally adjusted using emission algorithms (Guenther et al. 1993; Harley et al. 1998) driven by hourly gridded air temperature and solar radiation fields. The isoprene emission algorithm is given as

where I_S is isoprene emission at reference temperature and light conditions and where C_L and C_T are correction factors for ambient temperature and light

$$C_L = \frac{\alpha c_{L1} L}{\sqrt{1+\alpha^2 L^2}}$$

$$C_T = \frac{\exp \frac{c_{T1}(T - T_S)}{RT_S T}}{1 + \exp \frac{c_{T2}(T - T_M)}{RT_S T}}$$

$$\alpha = 0.0027$$
$$c_{L1} = 1.066$$
$$R = 8.314\ J\ K^{-1}\ mol^{-1}$$
$$c_{T1} = 95{,}000\ J\ mol^{-1}$$
$$c_{T2} = 230{,}000\ J\ mol^{-1}$$
$$T_s = 303\ K$$
$$T_M = 314\ K$$

and where T is ambient temperature (K) and L is ambient sunlight in the PAR range.

The monoterpene emission algorithm is given as

$$M = M_s \cdot \exp\left(\beta\left(T - T_s\right)\right)$$

where M_S is monoterpene emission at reference temperature and where

$$\beta = 0.09\ K^{-1}$$

$$T_s = 303\ K$$

Methylbutenol emissions are both temperature and light-dependent,

$$MBO = MBO_S \cdot C_L \cdot C_T$$

where MBO_S is MBO emission at reference conditions of temperature and light and where C_L and C_T are correction factors for ambient temperature and sunlight

$$C_L = \frac{\alpha c_{L1} L}{\sqrt{1+\alpha^2 L^2}}$$

$$\alpha = 0.0011$$

$$c_{L1} = 1.44$$

$$C_T = \frac{E_{opt}\ c_{T2}\ \exp^{C_{T1}\chi}}{c_{T2} - c_{T1}\left(1 - \exp^{C_{T2}\chi}\right)}$$

$$E_{opt} = 1.52$$

$$c_{T1} = 67\ kJ\ mol^{-1}$$

$$c_{T2} = 209\ kJ\ mol^{-1}$$

$$\chi = \left[\left(1/T_{opt}\right) - \left(1/T\right)\right]/R$$

$$T_{opt} = 312.3\ K$$

Hourly temperature and solar radiation fields gridded at 4 $\times$ 4 km resolution for the CCOS domain are generated using the MM5 model (NCAR 2001). PAR is calculated as 0.42 $\times$ SRAD $\times$ (4.6 μmol photons m^{-2} s^{-1} [W m^{-2}]$^{-1}$), where SRAD is full sun (direct + diffuse) radiation (W m^{-2}) in the visible spectrum.

D.10.3 Field data and model comparison

Canopy-level emissions of monoterpenes and methylbutenol were simulated for a 2 km x 2km area surrounding a measurement site at Blodgett Forest Research Station. Located near Georgetown, California, the Blodgett Forest site (38°53’42.9”N, 120°37’57.9”W) is a long-term micrometeorological flux measurement site located on a Ponderosa Pine plantation and operated by the University of California at Berkeley. It is the only site where canopy-level BVOC fluxes have been measured in California (Baker et al. 1999; Dreyfus et al. 2002; Schade and Goldstein, 2001, 2003; Kurpius and Goldstein, 2003; Lamanna and Goldstein 1999; Bauer et al. 2000; Schade et al. 1999; Goldstein et al. 2000; Schade et al. 2000; Goldstein and Schade 2000). MBO emissions were simulated for two cases. In the first case, emissions were simulated using default BEIGIS land cover inputs. In the second case, emissions were simulated using Blodgett Forest site-specific land cover inputs. Meteorological data from the Blodgett site for the period June 2 – September 8, 1999 were used as input for both simulations. Modeled emissions for both cases were compared to measured MBO fluxes for the same period. Monoterpene emissions were simulated using default BEIGIS land cover inputs and compared to measured fluxes of alph-pinene, beta-pinene, and 3-carene for the same period.

The Blodgett site is near the nexus of four 1 km^2 BEIGIS model grid cells labelled A through D), and the boundary of two GAP land cover polygons (GAP id 6658 and 6728) (Figure D.8). In BEIGIS, GAP land cover information are gridded at 1 km^2 resolution, therefore grid cells A and C inherit land cover attributes from GAP polygon 6658, while grid cells B and D inherit attributes from polygon 6728. BEIGIS land cover input data for model grid cells A through D are shown in Tables 4 and 5. While the default gridded BEIGIS model inputs and output are at 1 km^2 resolution, Blodgett land cover and flux measurement data represent an upwind “footprint” of only a few hundred meters. Although measurements and model simulations ostensibly represent different spatial scales, comparisons indicate how variable results can be, based on differences in reasonable estimates of the inputs.

Figure D.9 compares averaged modeled MBO fluxes for BEIGIS model grid cells A through D, with the average measured fluxes at the Blodgett site for the period June 2 – September 8, 1999. The general shape of the diurnal pattern agrees well with the measurements; however, the modeled MBO fluxes for grid cells A and C underpredict emissions by a factor of 2, while grid cell B overpredicts by a factor of 2. Modeled MBO fluxes for grid cell D are slightly overpredicted. Since there are multiple factors contributing to each term in the model (including factors which may not be known), it is not possible to accurately determine errors associated with each. The greatest uncertainty exists in the determination of leaf mass density (LMD), because of the number of factors which can effect it. The emission factor also has uncertainty due to its’ possible seasonal variability. Variability in leaf mass densities and MBO emission factors measured at Blodgett indicate that canopy-scale reference emission rates (i.e. normalized to 30 °C and 1000 μmoles m^{-2} s^{-1} PAR) may have ranged from 1.06 to 6.24

mg C m^{-2} hr^{-1}, with a midvalue of approximately 2.98 mg C m^{-2} hr^{-1} (Baker et al. 1999). The effect of these uncertainties are shown in Figure D.10, where MBO emissions were simulated using Blodgett leaf mass density and emission factor ranges reported in Baker et al. (1999). The figure illustrates that measured leaf mass density and emission factor uncertainties can yield modeled MBO fluxes which are over- or under-predicted by a factor 2. Midvalue inputs yield modeled MBO fluxes which were overpredicted by approximately 25-30%.

Monoterpene fluxes for BEIGIS grid cells A through D were modeled using default BEIGIS land cover inputs and Blodgett meteorological data. Figure D.11 compares averaged modeled monoterpene fluxes (converted from units mg monoterpene m^{-2} hr^{-1} to mg C m^{-2} hr^{-1}) for BEIGIS grid cells A through D, with average measured fluxes of three monoterpene species: alpha- and beta-pinene, and 3-carene, for the period June 2 – September 8, 1999. Monoterpene fluxes were not modeled using Blodgett site-specific inputs, as variability in the monoterpene-emitting leaf mass density and emission factors at this site were not available. For simplicity, the three measured monoterpene species are also combined into a single category for comparison with BEIGIS-modeled monoterpene fluxes (which are not speciated). BEIGIS-modeled monoterpene fluxes for grid cells A and C during midday are slightly greater than measured alpha-pinene and 3-carene fluxes, and slightly lower than measured beta-pinene fluxes. BEIGIS-modeled monoterpene fluxes for grid cell B are a factor 2 to 4 greater than the combined alpha- and beta-pinene + 3-carene category, and individual monoterpene species, respectively. BEIGIS-modeled monoterpene fluxes for grid cell D are a factor 2 greater than the individual measured monoterpene species, and in approximate agreement with the combined alpha- and beta-pinene + 3-carene category. Variability in monoterpene fluxes are of the same order as have been shown for MBO fluxes, and presumably due in part to uncertainties in leaf mass densities and monoterpene emission factors.

D.10.4 Model Uncertainties

Inputs to BEIGIS, such as emission rates, leaf mass factors, land use/land cover maps, and satellite-derived LAI values have been assessed by a number of researchers (Winer et al. 1998; Chung and Winer 1999; Karlik and McKay 1999; Karlik 2001; Winer and Karlik 2001).

Isoprene and monoterpene emission factors utilized by BEIGIS for plant species in California's urban, agricultural, and natural landscapes are derived from in-situ branch enclosure measurements and taxonomic assignments (Benjamin et al. 1996). Although measured emission rates are used where available, assignment of measured emission factors to unmeasured species based upon taxonomic relationship introduces uncertainties. Karlik and Winer (2001) measured isoprene emission factors of plant species to test taxonomically assigned emission factors of Benjamin et al. (1996). They reported measured branch-level isoprene emission factors for 13 of 19 species were within $\pm$ 50% of taxonomically predicted emission factors. Genus-level assignments were in generally good agreement with measured isoprene rates, with the exception of *Quercus*, where emissions varied widely about the predicted mean of 24.8 µg g^{-1} hr^{-1}, from below detection limit for *Q. suber* to 54 µg g^{-1} hr^{-1} for *Q. kelloggii*. The uncertainty associated with the monoterpene and OVOC emissions estimates have not been quantified. OVOCs are an added fraction to the BEIGIS BVOC inventory to which is applied a chemical speciation profile which may not be representative of natural areas in the CCOS domain.

As noted previously, systematic differences have been reported in the literature for leaf cuvette versus branch enclosure derived emission factors. Geron et al. (2001) assessed taxonomic rate assignments of Benjamin et al. (1996) by measuring leaf cuvette isoprene emission factors for a number of eastern U.S. and native California oak species. For *Quercus chrysolepis*, *Q. engelmannii*, *Q. kelloggii*, *Q. falcata* and *Populus trichocarpa*, measured leaf cuvette emissions were approximately a factor of 2 to 5 times greater than the taxonomically predicted branch-level emission factors, attributed in part to differences in enclosure type. Guenther et al. (1996a) also observed that isoprene emissions measured via leaf cuvette ranged between 1.5 to 2 times greater than branch-level measurements, due to differences in leaf orientation, self-shading and other factors.

Plant species composition and abundance predicted by the GAP database have been evaluated for several regions of the state. Field data from 8 sites in the Southern California Ozone Study (SCOS) domain and 6 sites in central California indicate that the GAP database correctly predicted 50% to 70% of the plant species at the sites surveyed (Winer et al. 1998; Chung and Winer 1999; Winer and Karlik 2001). In San Diego County, isoprene and monoterpene emission potentials for 8 polygons estimated according to GAP predicted plant species composition and areal coverage were compared to emission potentials estimated from field sampling (Chung and Winer 1999). For four of the polygons, emission potentials based on GAP predictions were more than 50% different from emission potentials calculated from field data. When summed over all 8 polygons, the total isoprene emission potential based on field data was 7% greater than the total based upon the GAP prediction. The total monoterpene emission potential for the 8 polygons based on field data was 2% lower than the total based upon the GAP prediction.

Modeled BVOC emissions are also sensitive to uncertainties associated with leaf mass density (g [dry leaf weight] m^{-2} land). For natural areas, leaf mass density is computed from remotely sensed leaf area index, fractional canopy cover, co-species weighting factors and plant specific leaf weight factors. Winer and Karlik (2001) found that ground-surveyed leaf area indices measured in California oak savannas (LAI ~ 1.3) agreed with satellite-derived 1 km^2 resolution LAI values (between 1 and 2) for those same sites. In the Winer and Karlik (2001) study, a stand of 14 Blue Oak trees (*Quercus douglasii*) surrounded by open grassland was measured for crown height, crown radii, and diameter at breast height (DBH). All 14 trees were then harvested, and their stem and leaf areas and (fresh and dried) weights recorded. Mean per-tree leaf mass density (LMD) was 730 g m^{-2}, while site leaf mass density, defined as the total leaf mass of the 14 trees divided by the total study area, was 310 g m^{-2}. This site LMD value is in the midrange of LMDs (182 – 643 g m^{-2}) reported by Sidawi and Horie (1992) for oak woodlands in the southern San Joaquin Valley. When the oak leaf mass of the site study area was considered together with surrounding grassland, the LMD decreased by a factor of two. In the BEIGIS model, calculated LMDs for 1 km^2 grid cells in CCOS natural areas are often less than 200 g m^{-2}. Natural area LMDs utilized by Benjamin et al. (1997) for the Southern California Air Quality Management Plan (SCAQMP) domain ranged from 90 (grassland) to 244 (woodland) to 555 g m^{-2} (forest). Although further data analyses are needed, these preliminary results support the use of the satellite-derived LAI database as an input to the BEIGIS model.

Potential leaf mass estimation biases from multiplying plant species SLWs by fractional canopy cover areas and co-species weighting factors together with LAI values for 1 km^2 grid cells are unknown. Computing species leaf mass densities in this manner may over or under-predict a species' contribution to total emissions. The technique may be less problematic for computing leaf masses and emissions of crops, many of which are cultivated in monocultures greater than 1 km^2.

D.10.5 Conclusion

Compared to fluxes measured at the Blodgett Forest site, MBO emissions modeled for four adjacent BEIGIS 1 km^2 grid cells using default BEIGIS inputs were under-predicted in two adjoining 1 km^2 grid cells and over-predicted emissions in one adjoining 1 km^2 grid cell. Modeled MBO emissions in the remaining grid cell were in relatively good agreement with measured MBO fluxes. MBO fluxes modeled using variable Blodgett site-specific inputs for leaf mass density and MBO emission factors showed similar magnitudes of over- and under-prediction, and relatively good agreement when using midvalue inputs. Monoterpene fluxes modeled using default BEIGIS inputs showed a similar pattern of over- and under-prediction, when compared to measured fluxes of specific monoterpene compounds.

Studies have shown that uncertainties in canopy biomass distributions and "flux footprint" determination can confound BVOC emission model validation using micrometeorological flux measurements (Lamb et al. 1996; Guenther et al. 1996; Baldocchi et al. 1999; Huber et al. 1999). Model performance is usually achieved only after detailed parameterization of the BVOC-emitting leaf mass density within the upwind flux "footprint" of the measurement site. At the Blodgett Forest site, Shade et al. (2000) were able to achieve good agreement between modeled and measured MBO fluxes by representing the MBO-emitting Ponderosa Pine leaf mass according to (three) needle leaf age classes, by assigning different emission factors to each age class, by varying the emission factors and leaf mass over the growing season, and by adopting a sunlit vs. shade leaf PAR scheme.

Comparisons between BEIGIS modeled and measured BVOC fluxes are preliminary. Further analyses of BEIGIS performance with Blodgett data are needed. Regional and canopy-scale flux measurements to test model estimates of BVOC emissions for other regions and land cover types of the state are also needed.

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D.10.8 Figures

Figure D.8
Blodgett Forest research site (triangle symbol). Site is near edge of two BEIGIS model GAP polygons and the nexus of four 1 x 1 km BEIGIS model grid cells (labeled A through D).

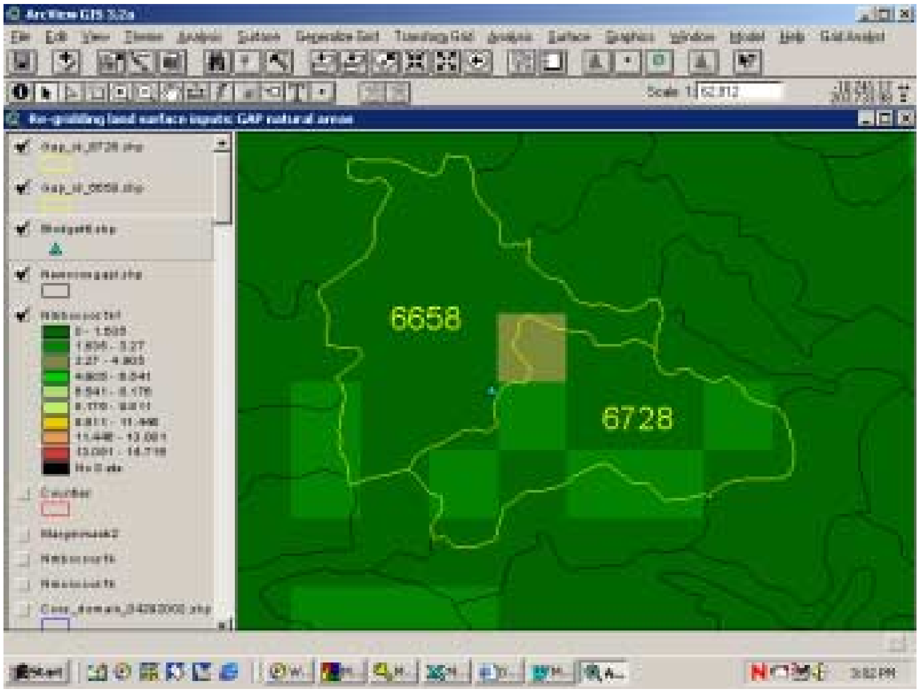

Figure D.9 Measured vs. modeled MBO fluxes.

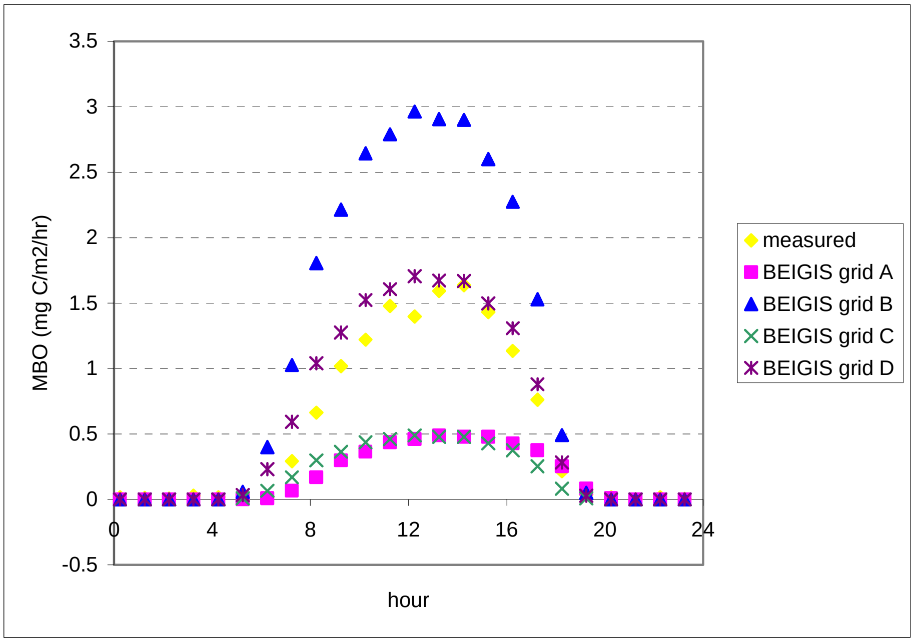

Figure D.10
MBO fluxes modeled with default BEIGIS vs. on-site Blodgett inputs, compared to measured fluxes.

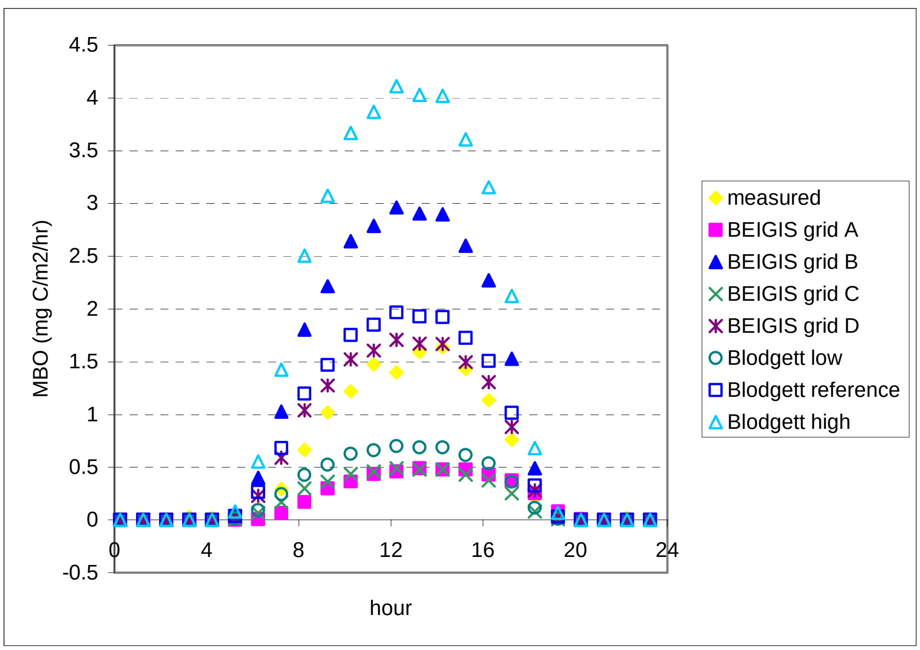

Figure D.11
Monoterpene fluxes modeled with default BEIGIS inputs, vs. measured monoterpene fluxes.

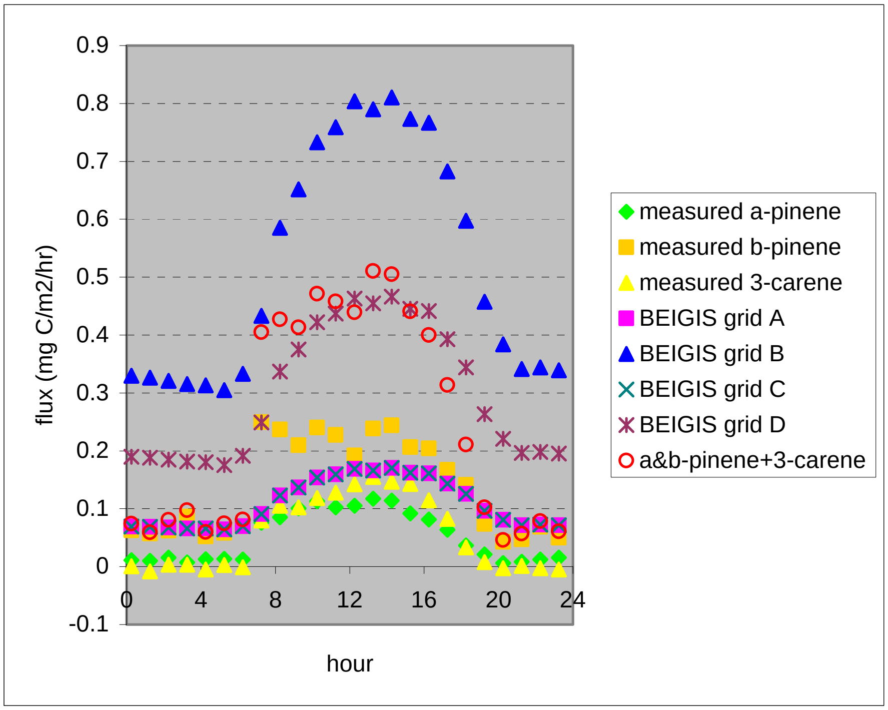

Table 1. BVOC emission and specific leaf weight (SLW) factors assigned to GAP vegetation species.

GAP species code	Common name	Scientific name	Vegetation Class	specific leaf wt g dry leaf/m2 leaf	in-leaf season emission factor ug/g dry leaf wt/hr @ ref conditions		
				SLW	ISO	MONO	MBO
42034	Coulter pine	Pinus coulteri	1	91	0	4	71
42044	Foothill pine	Pinus sabiniana	1	91	0	1	67
41006	Oregon oak	Quercus garryana	3	110	59	1	0
32433	Oregon oak (shrub form)	Quercus garryana var. breweri	3	110	59	1	0
41001	Black oak	Quercus kelloggii	3	103	54	1	0
41015	Willow	Salix spp.	3	62	51	0	0
41009	Quaking aspen	Populus tremuloides	3	89	50	0	0
41012	Fremont cottonwood	Populus fremontii	3	85	36	0	0
41004	Coast live oak	Quercus agrifolia	2	141	35	0	0
41010	Black cottonwood	Populus balsamifera ssp. trichocarpa	3	85	33	0	0
41030	Eucalyptus	Eucalyptus spp.	2	130	28	5	0
42059	Shore pine	Pinus contorta var. contorta	1	149	0	4	25
42014	Lodgepole pine	Pinus contorta var. murrayana	1	149	0	4	25
42015	Ponderosa pine	Pinus ponderosa	1	91	0	4	25
41003	Canyon live oak	Quercus chrysolepis	2	169	26	1	0
32065	Canyon live oak (Shrub form)	Quercus chrysolepis	2	169	26	1	0
32428	Huckleberry oak	Quercus vaccinifolia	**5,2**	110	26	1	0
41002	Blue oak	Quercus douglasii	3	122	26	0	0
41027	Engelmann oak	Quercus engelmannii	3	152	25	1	0
41055		Quercus alvordiana	2	110	25	1	0
32073	Desert scrub oak	Quercus cornelius-mullerii	2	110	25	1	0
32061	Leather oak	Quercus durata	**5,2**	110	25	1	0
32220	Tuckers Oak	Quercus john-tuckeri	3	110	25	1	0
32455	Saddlers oak	Quercus sadleriana	**5,2**	110	25	1	0
11400	Transportation and Utilities		7				
32096	California broom	Lotus scoparius	**5,3-2**	127	22	2	0
32229		Psorothamnus arborescens	**5,2-3**	127	22	2	0
32215		Psorothamnus emoryi	**5,2-3**	127	22	2	0
32230		Psorothamnus polydenius	**5,2-3**	127	22	2	0
41022	Smoke tree	Psorothamnus spinosa	**5,2-3**	127	22	2	0
41013	Valley oak	Quercus lobata	3	101	21	0	0
11100	Residential		7				
11600	Mixed Urban		7				
11700	Other Urban		7				
41005	Interior live oak	Quercus wislizenii	2	158	13	1	0
11200	Commercial and services		7				
41060	Black locust	Robinia pseudoacacia	3	50	12	2	0
32068	Interior live oak (Shrub form)	Quercus wislizenii	2	158	13	1	0
32143	Desert lavender	Hyptis emoryi	**5,2**	127	0	13	0
42043	Brewer spruce	Picea breweriana	1	191	10	2	0
32000	Unidentified chaparral shrubs		6	100	8	4	0
32104	Low sagebrush	Artemisia arbuscula	**5,2-3**	312	0	12	0
32302	California sagebrush	Artemisia californica	**5,2-3**	312	0	12	0
32108	Silver sagebrush	Artemisia cana	**5,2-3**	312	0	12	0
32109	Tarragon	Artemisia dracunculus	**5,2-3**	312	0	12	0
32110	Black sagebrush	Artemisia nova	**5,2-3**	312	0	12	0
32111	Rothrock sagebrush	Artemisia rothrockii	**5,2-3**	312	0	12	0
32112	Bud sagebrush	Artemisia spinescens	**5,2-3**	312	0	12	0
32103	Great basin sagebrush	Artemisia tridentata	**5,2-3**	312	0	12	0
32151	Regeneration shrubs	Artemisia tridentata, Chrysothamnus spp., etc.	**5,2-3**	312	0	12	0
32005	Coyote brush	Baccharis pilularis	**5,2**	192	0	12	0
32102	Rabbitbrush	Chrysothamnus nauseosus	**5,2**	168	0	12	0
32118	Rabbitbrush	Chrysothamnus parryi	**5,2**	168	0	12	0
32119	Rabbitbrush	Chrysothamnus viscidiflorus	**5,2**	168	0	12	0
32033	Mule fat	Baccharis salicifolia	**5,2**	127	0	12	0
41029	Sycamore	Platanus racemosa	3	52	11	0	0
41020	Fan palm	Washingtonia filifera	4	152	10	0	0
42012	Jeffrey pine	Pinus jeffreyi	1	91	0	4	5
42003	Coast redwood	Sequoia sempervirens	1	106	0	9	0
42027	Giant sequoia	Sequoiadendron giganteum	1	106	0	9	0
11500	Industrial and Commercial Complexes		7				
32305	White sage	Salvia apiana	**5,2-3**	250	0	8	0
32507	Desert sage	Salvia dorrii	**5,2-3**	250	0	8	0
32306	Purple sage	Salvia leucophylla	**5,2-3**	250	0	8	0
32307	Black sage	Salvia mellifera	**5,2-3**	250	0	8	0
32318	Pitcher sage	Salvia spathecea	**5,2-3**	250	0	8	0
42009	Sitka spruce	Picea sitchensis	1	191	4	1	0
42017	Mountain hemlock	Tsuga mertensiana	1	60	1	3	0
42005	Douglas fir	Pseudotsuga menziesii	1	55	1	3	0
42058	Western hemlock	Tsuga heterophylla	1	54	1	3	0

GAP species code	Common name	Scientific name	Vegetation Class	specific leaf wt g dry leaf/m2 leaf SLW	in-leaf season emission factor ug/g dry leaf wt/hr @ ref conditions ISO	MONO	MBO
42915	Mid-elevation plantations		8	100	0	4	0
42951	Upper-elevation plantations		6	100	0	4	0
42026	Whitebark pine	Pinus albicaulis	1	91	0	4	0
42013	Knobcone pine	Pinus attenuata	1	91	0	4	0
42011	Foxtail pine	Pinus balfouriana	1	91	0	4	0
42029	Limber pine	Pinus flexilis	1	91	0	4	0
42053	Sugar pine	Pinus lambertiana	1	91	0	4	0
42028	Bristlecone pine	Pinus longaeva	1	91	0	4	0
42030	Single leaf pinyon	Pinus monophylla	1	91	0	4	0
42031	Western white pine	Pinus monticola	1	91	0	4	0
42010	Bishop pine	Pinus muricata	1	91	0	4	0
42040	Torrey pine	Pinus torreyana	1	91	0	4	0
42057	Washoe Pine	Pinus washoensis	1	91	0	4	0
11300	Industrial		7				
42052	Subalpine fir	Abies lasiocarpa	1	165	0	3	0
42045	Incense cedar	Calocedrus decurrens	1	106	0	3	0
22104	Dryland grain crops		8				
22200	Orchards, Vineyards, Nurseries		8				
22201	Evergreen orchard		8				
22202	Deciduous orchard		8				
22400	Other Agricultural Land		8				
22101	Irrigated row and field crops		8				
22100	Cropland and Pasture		8				
22203	Vineyard		8				
42033	Bristlecone fir	Abies bracteata	1	98	0	3	0
42022	White fir	Abies concolor	1	98	0	3	0
42051	Red fir	Abies magnifica	1	98	0	3	0
41033	Box elder	Acer negundo	3	92	0	3	0
42006	Grand fir	Abies grandis	1	72	0	3	0
41053	Mountain maple	Acer glabrum	3	59	0	3	0
41050	Bigleaf maple	Acer macrophyllum	3	59	0	3	0
42046	Noble fir	Abies procera	1	58	0	3	0
41032	California walnut	Juglans californica var. californica	3	57	0	3	0
41043	California black walnut	Juglans californica var. hindsii	3	57	0	3	0
32450	Vine maple	Acer circinatum	3	32	0	3	0
41016	Catclaw	Acacia greggii	**5,2**	240	0	2	0
41019	Mesquite	Prosopis glandulosa	3	215	0	2	0
41051	Screwbean	Prosopis pubescens	3	215	0	2	0
41017	Desert ironwood	Olneya tesota	3	145	0	2	0
32059	Chaparral Pea	Pickeringia montana	**5,2**	127	0	2	0
32018	Mountain whitethorn	Ceanothus cordulatus	**5,2-3**	127	0	2	0
32034	Hoaryleaf ceanothus	Ceanothus crassifolius	**5,2-3**	127	0	2	0
32003	Buckbrush	Ceanothus cuneatus	**5,2-3**	127	0	2	0
32421	Monterey ceanothus	Ceanothus cuneatus var. rigidus	**5,2-3**	127	0	2	0
32416	Cropleaf ceanothus	Ceanothus dentatus	**5,2-3**	127	0	2	0
32035	Desert ceanothus	Ceanothus greggii	**5,2-3**	127	0	2	0
32087		Ceanothus impressus	**5,2-3**	127	0	2	0
32072		Ceanothus incanus	**5,2-3**	127	0	2	0
32017	Deerbrush	Ceanothus integerrimus	**5,2-3**	127	0	2	0
32417	Muskbrush	Ceanothus jepsonii	**5,2-3**	127	0	2	0
32036	Chaparral whitethorn	Ceanothus leucodermis	**5,2-3**	127	0	2	0
32037	Bigpod ceanothus	Ceanothus megacarpus	**5,2-3**	127	0	2	0
32038	Hairy ceanothus	Ceanothus oliganthus	**5,2-3**	127	0	2	0
32042	Jimbrush	Ceanothus oliganthus var. sorediatus	**5,2-3**	127	0	2	0
32039	Palmer ceanothus	Ceanothus palmeri	**5,2-3**	127	0	2	0
32040	Wartleaf ceanothus	Ceanothus papillosus	**5,2-3**	127	0	2	0
32420	Littleleaf ceanothus	Ceanothus parvifolius	**5,2-3**	127	0	2	0
32041	Squaw carpet	Ceanothus prostratus	**5,2-3**	127	0	2	0
32043	Greenbark ceanothus	Ceanothus spinosus	**5,2-3**	127	0	2	0
32095	Ceanothus	Ceanothus spp.	**5,2-3**	127	0	2	0
32422	Bluebrush, Wild lilac	Ceanothus thyrsiflorus	**5,2-3**	127	0	2	0
32071	Woolyleaf ceanothus	Ceanothus tomentosus	**5,2-3**	127	0	2	0
32002	Tobacco brush	Ceanothus velutinus	**5,2-3**	127	0	2	0
32044	Wartystem ceanothus	Ceanothus verrucosus	**5,2-3**	127	0	2	0
32016		Lupinus albicaulus	**5,herb.**	127	0	2	0
32013		Lupinus albifrons	**5,herb.**	127	0	2	0
32022	Yellow bush lupine	Lupinus arboreus	**5,herb.**	127	0	2	0
32012	Bush lupine	Lupinus chamissonis	**5,herb.**	127	0	2	0
32321	Grape soda lupine	Lupinus excubitus	**5,herb.**	127	0	2	0
32323		Lupinus spp.	**5,herb.**	127	0	2	0
32216		Caesalpina virgata	**5,3-2**	91	0	2	0

GAP species code	Common name	Scientific name	Vegetation Class	specific leaf wt g dry leaf/m2 leaf	in-leaf season emission factor ug/g dry leaf wt/hr @ ref conditions		
				SLW	ISO	MONO	MBO
42039	Sargent cypress	Cupressus sargentii	1	127	0	1	0
41044	Tanoak	Lithocarpus densiflorus	2	127	0	1	0
42035	Monterey pine	Pinus radiata	1	91	0	1	0
42019	California juniper	Juniperus californica	1	86	0	1	0
42055	Western juniper	Juniperus occidentalis	1	86	0	1	0
42063	Sierra juniper	Juniperus occidentalis australis	1	86	0	1	0
42054	Utah juniper	Juniperus osteosperma	1	86	0	1	0
42062	Western red cedar	Thuja plicata	1	56	0	1	0
42007	Bigcone spruce	Pseudotsuga macrocarpa	1	55	0	1	0
32322		Eriophyllum staechadifolium	**5,2 herb**	127	0	0	0
41056	California wax myrtle	Myrica californica	**5,2**	345	0	0	0
32074	Sugarbush	Rhus ovata	**5,2**	323	0	0	0
32117	Allscale saltbush	Atriplex polycarpa	**5,3**	256	0	0	0
32454	Beargrass	Xerophyllum tanex	**6, grass**	244	0	0	0
32452	Boxleaf silktassel	Garrya buxifolia	**5,2**	223	0	0	0
32435	Silktassel	Garrya elliptica	**5,2**	223	0	0	0
32050	Pale silktassel	Garrya flavescens	**5,2**	223	0	0	0
32051	Fremont silktassel	Garrya fremontii	**5,2**	223	0	0	0
32052	Veatch silktassel	Garrya veatchii	**5,2**	223	0	0	0
32207	Shadscale	Atriplex confertifolia	**5,2-3**	188	0	0	0
32114	Desert holly	Atriplex hymenolytra	**5,2-3**	188	0	0	0
32115	Lenscale	Atriplex lentiformis	**5,2-3**	188	0	0	0
32116	Saltbush	Atriplex parryi	**5,2-3**	188	0	0	0
32144	Triangle leaf	Atriplex phyllostegia	**5,2-3**	188	0	0	0
32105	Saltbush	Atriplex spp.	**5,2-3**	188	0	0	0
32062	Lemonade berry	Rhus integrifolia	**5,2-3**	183	0	0	0
32501	Skunkbrush	Rhus trilobata	**5,2-3**	183	0	0	0
32094	Scrub oak	Quercus berberidifolia, etc.	2	149	31	0	0
32444	Western azalea	Rhododendron occidentalis	**5,3**	147	0	0	0
41011	California bay	Umbellularia californica	2	145	0	0	0
41018	Joshua tree	Yucca brevifolia	**5,2**	145	0	0	0
32136	Mohave yucca	Yucca schidigera	**5,2**	145	0	0	0
32064	Our lords candle	Yucca whipplei	**5,2**	145	0	0	0
32328	Hawthorn	Craetaegus douglasii	3	133	0	0	0
32049	Fremontia or Flannel bush	Fremontodendron californicum	**5,3**	127	0	0	0
32009	Monkshood	Aconitum columbianum	**5, 3 herb**	127	0	0	0
31048	Arizona three-awn	Aristida hamulosa	**5, grass**	127	0	0	0
31033	Balsam root	Balsamorhiza sagittata	**5, grass**	127	0	0	0
32415	Barbarry	Berberis nervosa	**5,3**	127	0	0	0
31029	Japanese brome (exotic)	Bromus japonicus	**5, grass**	127	0	0	0
31026	Cheatgrass (exotic)	Bromus tectorum	**5, grass**	127	0	0	0
32221	Crucifixion Thorn	Castela emoryi	5	127	0	0	0
31052	Star thistle	Centaurea spp.	**5, 3 herb**	127	0	0	0
32504	Fern bush, desert sweet	Chamaebatiaria millefolium	**5,2-3**	127	0	0	0
32045	Virgins bower	Clematis ligusticifolia	**5, 3 herb**	127	0	0	0
32083	Giant coreopsis	Coreopsis gigantea	**5, herb**	127	0	0	0
32425	Scotchbroom	Cytisus scoparius	**5, 3**	127	0	0	0
31031	One-spike oatgrass	Danthonia unispicata	**5, grass**	127	0	0	0
31054	Pitcher plant bogs	Darlingtonia bogs	**5, 3 herb**	127	0	0	0
31015	California poppy	Eschscholtzia californica	**5, 3 herb**	127	0	0	0
32138		Forestiera neomexicana	**5, 2-3 herb**	127	0	0	0
31032	Wood strawberry	Fragaria vesca	**5, 3 herb**	127	0	0	0
32091	Peak rush-rose	Helianthemum scoparium	**5, 3 herb**	127	0	0	0
31023	Foxtail barley	Hordeum jubatum	**5, grass**	127	0	0	0
32149	Bladderpod	Isomeris arborea	**5,3-2**	127	0	0	0
31044	Desert dandelion	Malacothrix glabrata	**5, 3 herb**	127	0	0	0
32145		Menodora spinescens	**5, 2-3 herb**	127	0	0	0
31024		Nitrophila occidentalis	**5,herb**	127	0	0	0
32228		Nolina parryi	**5,herb**	127	0	0	0
31027	Reed canary grass (exotic)	Phalaris arundinacea	**5, grass**	127	0	0	0
31035	Sandbergs bluegrass	Poa secunda	**5, grass**	127	0	0	0
31051	Water smartweed	Polygonum amphibium	**5, 3 herb**	127	0	0	0
32432		Polygonum davisiae	**5, 3 herb**	127	0	0	0
32509		Ribes aureum	**5,3**	127	0	0	0
32431	Squaw or wax currant	Ribes cereum	**5,3**	127	0	0	0
32442	Sierra gooseberry	Ribes roezlii	**5,3**	127	0	0	0
32511		Ribes spp.	**5,3**	127	0	0	0
32010	Currant	Ribes velutinum	**5,3**	127	0	0	0
32441	Sticky currant	Ribes viscossimum	**5,3**	127	0	0	0
32503	Wood rose	Rosa gymnocarpa	**5,3**	127	0	0	0
31021	Bulrush	Scirpus robustus	**5,herb**	127	0	0	0

GAP species code	Common name	Scientific name	Vegetation Class	specific leaf wt g dry leaf/m2 leaf	in-leaf season emission factor ug/g dry leaf wt/hr @ ref conditions		
				SLW	ISO	MONO	MBO
32001	Chamise	Adenostoma fasciculatum	**5,2**	127	0	0	0
32026	Redshanks	Adenostoma sparsifolium	**5,2**	127	0	0	0
32213		Agave deserti	**5,herb**	127	0	0	0
22600	Great Basin dry farmed grain/rural	Agropyron desertorum, Elyrigia epens, etc.	5	127	0	0	0
41059	Tree of heaven	Ailanthus altissima	3	127	0	0	0
32209	Iodine bush	Allenrolfea occidentalis	**5,3-2**	127	0	0	0
32210	Burro-weed (a ragweed)	Ambrosia dumosa	**5, herb**	127	0	0	0
31055	European beachgrass	Ammophila arenaria	**5, grass**	127	0	0	0
41007	Madrone	Arbutus menziesii	2	127	0	0	0
32402	Manzanita	Arctostaphylos auriculata	**5,2**	127	0	0	0
32403	Hoary manzanita	Arctostaphylos canescens	**5,2**	127	0	0	0
32456	Hairy manzanita	Arctostaphylos columbiana	**5,2**	127	0	0	0
32027	Eastwood manzanita	Arctostaphylos glandulosa	**5,2**	127	0	0	0
32028	Bigberry manzanita	Arctostaphylos glauca	**5,2**	127	0	0	0
32404	Common manzanita	Arctostaphylos manzanita	**5,2**	127	0	0	0
32406	Indian manzanita	Arctostaphylos mewukka	**5,2**	127	0	0	0
32447	Morro manzanita	Arctostaphylos morroensis	**5,2**	127	0	0	0
32089	Ione manzanita	Arctostaphylos myrtifolia	**5,2**	127	0	0	0
32407	Pinemat manzanita	Arctostaphylos nevadensis	**5,2**	127	0	0	0
32408	Eldorado manzanita	Arctostaphylos nissenana	**5,2**	127	0	0	0
32409	Littleberry manzanita	Arctostaphylos nummularia	**5,2**	127	0	0	0
32029	Serpentine manzanita	Arctostaphylos obispoensis	**5,2**	127	0	0	0
32030	Parry manzanita	Arctostaphylos parryana	**5,2**	127	0	0	0
32004	Greenleaf manzanita	Arctostaphylos patula	**5,2**	127	0	0	0
32446	Pecho manzanita	Arctostaphylos pechoensis	**5,2**	127	0	0	0
32410	La panza manzanita	Arctostaphylos pilosula	**5,2**	127	0	0	0
32075	Pink-bracted manzanita	Arctostaphylos pringlei	**5,2**	127	0	0	0
32069	Mexican manzanita	Arctostaphylos pungens	**5,2**	127	0	0	0
32031	Purisima manzanita	Arctostaphylos purissima	**5,2**	127	0	0	0
32055	Refugio manzanita	Arctostaphylos refugioensis	**5,2**	127	0	0	0
32412	Shagbark manzanita	Arctostaphylos rudis	**5,2**	127	0	0	0
32451	Manzanita spp.	Arctostaphylos spp.	**5,2**	127	0	0	0
32032	Woollyleaf manzanita	Arctostaphylos tomentosa	**5,2**	127	0	0	0
32405	Mariposa manzanita	Arctostaphylos viscida var. mariposa	**5,2**	127	0	0	0
32414	Whiteleaf manzanita	Arctostaphylos viscida var. viscida	**5,2**	127	0	0	0
32008	Santa Cruz manzanita	Arctostaphylus andersonii	**5,2**	127	0	0	0
31011	Giant Reed	Arundo donax	**5, herb**	127	0	0	0
31001	Non-native annual grassland	Avena spp., Bromus spp., etc.	**5, grass**	39	0	0.02	0
31010	Wild Mustard	Brassica ssp.	**5, herb**	127	0	0	0
31017	Great Basin bunchgrass vegetation	Bromus tectorum, Festuca idahoensis, etc.	**5, grass**	39	0	0.02	0
31016	Great Basin annual grasses	Bromus tectorum, Taenientherum caput-medusae,	**5, grass**	39	0	0.02	0
31043		Carex nebrascensis	**5, herb**	127	0	0	0
31059	Great Basin wet meadow spp.	Carex spp., Juncus spp.,etc.	**5, herb**	127	0	0	0
31007	Freshwater Sedge - Rush marsh	Carex spp., Juncus, spp.,	**5, herb**	127	0	0	0
32020	Mountain misery	Chamaebatia foliolosa	**5,2**	127	0	0	0
32208	Blackbush	Coleogyne ramosissima	5	127	0	0	0
31020	Pampas grass	Cortaderia jubata	**5, grass**	127	0	0	0
32046	Bush poppy	Dendromecon rigida	**5, herb**	127	0	0	0
31012	Saltgrass	Distichlis spicata	**5, grass**	127	0	0	0
32303	California encelia	Encelia californica	**5,2-3**	127	0	0	0
32120	Brittlebush	Encelia farinosa	**5,2-3**	127	0	0	0
32140	California ephedra	Ephedra californica	**5, herb**	127	0	0	0
32121	Mormon tea	Ephedra nevadensis	**5, herb**	127	0	0	0
32122	Green ephedra	Ephedra viridis	**5, herb**	127	0	0	0
31056		Erharta calycina	5	127	0	0	0
32434	Goldenfleece	Ericameria arborescens	**5,2-3**	127	0	0	0
32502	Goldenbush	Ericameria bloomeri	**5,2-3**	127	0	0	0
32311	Heather goldenbush	Ericameria ericoides	**5,2-3**	127	0	0	0
32127	Narrowleaf goldenbush	Ericameria linearifolius	**5,2-3**	127	0	0	0
32224	Coopers goldenbrush	Ericamerica cooperi	**5,2-3**	127	0	0	0
32139	Ericamerica	Ericamerica spp.	**5,2-3**	127	0	0	0
32047	Yerba santa	Eriodictyon californicum	**5,2**	127	0	0	0
32090	Lompoc yerba santa	Eriodictyon capitatum	**5,2**	127	0	0	0
32048	Thick leafed yerba santa	Eriodictyon crassifolium	**5,2**	127	0	0	0
32025		Eriodictyon tomentosum	**5,2**	127	0	0	0
32084		Eriodictyon trichocalyx	**5,2**	127	0	0	0
32309	Ashyleaf buckwheat	Eriogonum cinerium	**5,herb**	127	0	0	0
32438	Flat-topped buckwheat	Eriogonum deflexum	**5,herb**	127	0	0	0
32301	California buckwheat	Eriogonum fasciculatum	**5,herb**	127	0	0	0
32325		Eriogonum fasciculatum var. fasciculatum	**5,herb**	127	0	0	0
32324		Eriogonum fasciculatum var. polifolium	**5,herb**	127	0	0	0

GAP species code	Common name	Scientific name	Vegetation Class	specific leaf wt g dry leaf/m2 leaf SLW	in-leaf season emission factor ug/g dry leaf wt/hr @ ref conditions ISO	MONO	MBO
32076	Toyon	Heteromeles arbutifolia	**5,2**	127	0	0	0
32128	White burrobush	Hymenoclea salsola	5	127	0	0	0
32326		Isocoma menziesii var. vernioides	**5,2-3**	127	0	0	0
31022	Rush	Juncus balticus	**5, herb**	127	0	0	0
31005	Wet meadow Sedge - Rush	Juncus spp., Eleocharis spp.,etc.	**5, herb**	127	0	0	0
32099		Keckiella cordifolia	5	127	0	0	0
32223	Winterfat	Krascheninnikovia lanata	**5,2-3**	127	0	0	0
32201	Creosote	Larrea tridentata	**5,2**	127	0	0	0
32131	Scalebroom	Lepidospartum squamatum	**5, herb**	127	0	0	0
32098	Prickly flox	Leptodactylon californicum	**5, herb**	127	0	0	0
32056	Granite gilia	Leptodactylon pungens	**5, herb**	127	0	0	0
31018	Great Basin Alkali sink grasses	Leymus cinereus, Distichlis spicata, etc.	**5,herb**	127	0	0	0
32063	Laurel sumac	Malosma laurina	**5,2**	127	0	0	0
31057	Sphagnum bog species	Menyanthes trifoliata, Sphagnum squarrosum, etc.	**5, herb**	127	0	0	0
31014	Ice plant	Mesembryanthemum spp.	**5, herb**	127	0	0	0
32086		Mimulus aurantiacus	**5, herb**	127	0	0	0
32445	Alpine cushion plants	Misc alpine shrubs	**5, herb**	127	0	0	0
31047	Purple needlegrass	Nassella pulchra	**5, grass**	127	0	0	0
41045	Tree tobacco	Nicotiana glauca	**5, herb**	127	0	0	0
32218	Buckhorn cholla	Opuntia acanthocarpa	**5, herb**	127	0	0	0
32204	Jumping cholla	Opuntia biglovii	**5, herb**	127	0	0	0
32217	Golden cholla	Opuntia echinocarpa	**5, herb**	127	0	0	0
32079	Prickly pear	Opuntia littoralis	**5, herb**	127	0	0	0
32212	Pencil cactus	Opuntia ramosissima	**5, herb**	127	0	0	0
32226	Mixed succulents	Opuntia spp., Ferocactus spp., Echinocereus sp	**5, herb**	127	0	0	0
31013	Galleta	Pleuraphis rigida	**5, grass**	127	0	0	0
32202	Arrowweed	Pluchea sericea	**5,3 herb**	127	0	0	0
22500	Great Basin pasture/grainfield	Poa pratensis, Agropyron desertorum, etc.	**5, grass**	127	0	0	0
31046	Braken	Pteridium aquilinum	**5, herb**	127	0	0	0
32101	Antelope bush	Purshia tridentata	**5,2-3**	127	0	0	0
31003	Estuarine emergent wetland	Salicornia virginica, Suaeda californica, etc.	**5, herb**	127	0	0	0
31038	Russian thistle or tumbleweed	Salsola tragus	**5, herb**	127	0	0	0
32015	Blue elderberry	Sambucus mexicana	**5,3**	127	0	0	0
32449	Red elderberry	Sambucus racemosa	**5,3**	127	0	0	0
32448	Elderberry spp.	Sambucus spp.	**5,3**	127	0	0	0
31045	Apricot mallow	Sphaeralcea ambigua	**5, herb**	127	0	0	0
31042	Alkali sacaton	Sporobolus airoides	**5, grass**	127	0	0	0
31002	Native perennial grassland	Stipa spp., Elymus spp., etc.	**5, grass**	39	0	0.02	0
31028	Medusaehead (exotic)	Taeniantherum caput-medusae	6	127	0	0	0
41023	Tamarisk	Tamarix spp.	**3,2,5**	127	0	0	0
32021	Poison oak	Toxicodendron diversilobum	**5,3**	127	0	0	0
31008	Freshwater Sedge-Cat-tail marsh	Typha spp., Carex spp., etc.	**5, herb**	127	0	0	0
31025	Mules ears	Wyethia mollis	**5, herb**	127	0	0	0
32070		Xylococcus bicolor	**5,2-3**	127	0	0	0
32011	Mountain mahogany	Cercocarpus betuloides	**5,2**	123	0	0	0
32106	Mountain mahogany	Cercocarpus ledifolius	**5,2**	123	0	0	0
32113	Four-wing saltbush	Atriplex canescens	**5,2-3**	119	0	0	0
22300	Confined Feeding Operations		8				
22102	Irrigated hayfield		8				
22105	Rice fields		8				
22106	Pasture		8	93	0	0	0
31049	Ruderal spp.		6	93	0	0	0
31060	Northern hardpan vernal pool spp.		6	93	0	0	0
31061	Northern claypan vernal pool spp.		6	93	0	0	0
32007	Rhododendron	Rhododendron macrophyllum	**5,2**	93	0	0	0
32135	Greasewood	Sarcobatus vermiculatus	**5,2**	93	0	0	0
22700	Reclaimed Lakebed/Waterfowl mgmt/ag	Scirpus spp., Typha spp., and cultivated grain	**5, herb**	93	0	0	0
42049	Parry pinyon	Pinus quadrifolia	1	91	0	0	0
32023	Salal	Gaultheria shallon	**5,3 herb**	90	0	0	0
41026	Buckeye	Aesculus californica	3	88	0	0	0
41014	White alder	Alnus rhombifolia	3	86	0	0	0
32401	Seviceberry	Amelanchier utahensis	**3,5**	81	0	0	0
32060	Western choke cherry	Prunus virginiana	3	78	0	0	0
32423	Western redbud	Cercis occidentalis	**5,3**	77	0	0	0
41037	Desert willow	Chilopsis linearis	3	77	0	0	0
41054	Water Birch	Betula occidentalis	3	76	0	0	0
32078	Flowering ash	Fraxinus dipetala	3	72	0	0	0
41040	Oregon ash	Fraxinus latifolia	3	72	0	0	0
32510	Desert peach	Prunus andersonii	3	72	0	0	0
41049	Bitter cherry	Prunus emarginata	3	72	0	0	0
32082	Bitter cherry (Shrub form)	Prunus emarginata	3	72	0	0	0

GAP species code	Common name	Scientific name	Vegetation Class	specific leaf wt g dry leaf/m2 leaf	in-leaf season emission factor ug/g dry leaf wt/hr @ ref conditions		
				SLW	ISO	MONO	MBO
41057	Pacific dogwood	Cornus nuttallii	**3,5**	57	0	0	0
32429	Snowberry	Symphoricarpos rotundifolius	**5,3**	56	0	0	0
32058	Southern honeysuckle	Lonicera subspicata	**5,3**	56	0	0	0
32077	Coffeeberry	Rhamnus californica	**5,3-2**	56	0	0	0
32316	Redberry buckthorn	Rhamnus crocea	**5,3-2**	56	0	0	0
32327	Cascara	Rhamnus purshiana	**5,3-2**	56	0	0	0
32081	Snowberry	Symphoricarpos mollis	**5,3**	56	0	0	0
32053	Ocean spray or Cream bush	Holodiscus discolor	**5,3**	48	0	0	0
32054	Cream bush	Holodiscus microphyllus	**5,3**	48	0	0	0
32430	Huckleberry	Vaccinium ovatum	**5,3**	39	0	0	0
32457	Thimbleberry	Rubus parviflorus	**5,3**	37	0	0	0
32014	California blackberry	Rubus ursinus	**5,3**	37	0	0	0
31058	Northern basalt vernal pool spp.		6	0	0	0	0
31062	Misc. vernal pool spp.		6	0	0	0	0
78000	Mud Flats		6	0	0	0	0
99200	Glaciers		6	0	0	0	0
55400	Bays and estuaries		6	0	0	0	0
77100	Dry Salt Flats		6	0	0	0	0
77200	Beaches		6	0	0	0	0
77300	Sandy areas other than beaches		6	0	0	0	0
55300	Reservoirs		6	0	0	0	0
55210	Intermittent lake		6	0	0	0	0
77401	Bare exposed lava		6	0	0	0	0
77500	Quarries, and gravel pits		6	0	0	0	0
99100	Perennial snowfields		6	0	0	0	0
55310	Intermittent reservoir		6	0	0	0	0
77400	Bare exposed rock		6	0	0	0	0
77600	Transitional bare areas		6	0	0	0	0
77700	Mixed barren land		6	0	0	0	0
77701	Badlands		6	0	0	0	0
55200	Lakes		6	0	0	0	0
55100	Streams and canals		6	0	0	0	0

Vegetation class

1=conifer
2=broadleaf evergreen
3=broadleaf deciduous
4=palm
5=shrub; "5, 2" = shrub, broadleaf evergreen
5=shrub; "5, 2-3" = shrub, broadleaf evergreen to broadleaf deciduous if cold or water stressed
5=shrub; "5, 3-2" = shrub, basically deciduous but can be evergreen if conditions favorable
"5, herb"=herbaceous (rather than woody) shrub
"5, grass" = grass
6=unknown
7=urban land use
8=ag land use

Table 2. Crop BVOC (isoprene, monoterpenes) emission factors (ug Carbon g^{-1} [dry leaf weight] hr^{-1}) at standard conditions (30 C, 1000 umole PAR m^{-2} s^{-1})
Emission factor assignment types: 1 (measured species); 2 (genus average); 3 (family average); 4 (crop class average); 5 (no emission factor assigned)
SLW: Specific Leaf Weight (g [dry leaf weight] m^{-2} leaf area)

Crop Code	Class	Subclass	Species	Family	Isoprene	Monoterpenes	BVOC assignment type	BVOC reference	SLW	SLW reference
G 1	Grain & Hay Crops	barley	Elyhordeum sp.	Poaceae	0.010	0.010	1	h	37.00	ee
G 2		wheat	Triticum sp.	Poaceae	0.000	0.000	1	k	33.70	rr
G 3		oats	Avena sp.	Poaceae	0.010	0.020	1	h	39.00	hh
G 6		misc. & mixed grain and hay		Poaceae	0.007	0.010	3	r	36.57	hh
R	Rice	rice	Oryza sp.	Poaceae	0.000	0.000	1	k	37.00	ff
F 1	Field Crops	cotton	Gossypium hirsutum	Malvaceae	0.000	0.700	1	k	69.44	nn
F 2		safflower	Carthamus tinctorius	Asteraceae	0.000	0.030	1	k	33.30	ee
F 3		flax	Linum usitatissimum	Linaceae			5		33.30	ee
F 4		hops	Humulus lupulus	Cannabaceae	0.000	0.000	1	i	77.00	oo
F 5		sugar beets	Beta vulgaris	Chenopodiaceae	0.000	0.000	1	e	75.00	cc
F 6		corn (field & sweet)	Zea mays	Poaceae	0.000	0.030	2	n	67.00	dd
F 7		grain sorghum	Sorghum bicolor	Poaceae	0.000	0.030	1	k	67.00	dd
F 8		sudan	Sorghum bicolor	Poaceae	0.000	0.030	2	n	67.00	dd
F 9		castor beans	Ricinus communis	Euphorbiaceae	0.000	0.000	1	i	67.00	dd
F10		beans (dry)	Phaseolus vulgaris	Fabaceae	0.000	0.000	2	p	28.25	bb, ss
F11		misc. field			0.000	0.077	4		56.14	Field Crop average
F12		sun flowers	Helianthus sp.	Asteraceae	0.000	0.030	3	m	33.30	ff
P 1	Pasture	alfalfa mix	Medicago sativa	Fabaceae	0.000	0.200	1	k	34.30	ss
P 2		clover	Trifolium repens	Fabaceae	0.000	0.000	1	d	22.20	bb
P 3		mixed pasture		Poaceae	0.000	0.020	1	l	39.00	gg
P 4		native pasture		Poaceae	0.000	0.020	1	l	39.00	gg
P 5		induced high water table native pasture		Poaceae	0.000	0.020	1	l	39.00	gg
P 6		misc. grasses		Poaceae	0.000	0.020	1	l	39.00	gg
P 7		turf farms	Fescue sp	Poaceae	0.000	0.000	1	e	39.00	gg
T 1	Truck, Nursery	artichokes	Cynara scolymus	Asteraceae	0.000	0.030	3	m	33.30	ee
T 2	& Berry Crops	asparagus	Asparagus officinalis	Liliaceae	0.000	0.000	1	i	123.30	ii
T 3		green beans	Phaseolus vulgaris	Fabaceae	0.000	0.000	1	k	28.25	bb, ss
T 4		colecrops	Brassica sp.	Cruciferae	0.000	0.000	1	e	144.30	ii
T 6		carrots	Daucus carota	Umbelliferae	0.000	0.900	1	k	70.00	ii
T 7		celery	Apium graviolens	Umbelliferae	0.000	0.900	3	q	70.00	kk
T 8		lettuce	Latuca sativa	Asteraceae	0.000	0.000	1	j	49.30	ll
T 9		melons, squash, cucumbers		Cucurbitaceae			5		85.47	nn
T10		onion, garlic	Allium sp.	Amaryllidaceae, Liliaceae	0.000	0.000	1	j	123.30	ii
T11		peas	Pisum sativum	Fabaceae	0.000	0.000	3	p	28.25	bb, ss
T12		potatoes	Solanum tuberosum	Solanaceae	0.000	0.010	1	g	35.00	aa
T13		sweet potatoes	Ipomoea batatas	Convolvulaceae			5		35.00	aa
T14		spinach	Spinacia oleracea	Chenopodiaceae	0.000	0.000	3	o	144.30	ii
T15		tomatoes	Lycopersicon esculentum	Solanaceae	0.000	20.000	1	k	80.22	nn
T16		flower, nursery, Christmas tree farm					5			
T17		mixed			0.004	1.447	4		83.08	Truck crop average
T18		misc. truck			0.004	1.447	4		83.08	Truck crop average
T19		bushberries	Rubus ursinus	Rosaceae	0.080	0.000	1	c	37.31	nn
T20		strawberries	Fragaria sp.	Rosaceae	0.000	0.000	1	e	82.99	pp
T21		peppers	Capsicum sp.	Solanaceae	0.000	10.000	3		80.20	qq
T22		broccoli	Brassica oleracia	Cruciferae	0.000	0.000	1	e	144.30	jj
T23		cabbage	Brassica oleracia	Cruciferae	0.000	0.000	1	e	144.30	ii
T24		cauliflower	Brassica oleracia	Cruciferae	0.000	0.000	1	e	144.30	jj
T25		brusselsprouts	Brassica oleracia	Cruciferae	0.000	0.000	1	e	144.30	jj
D 1	Deciduous Fruits	apples	Malus sp.	Rosaceae	0.000	0.100	3	a	86.21	nn
D 2	and Nuts	apricots	Prunus armeniaca	Rosaceae	0.000	0.100	1	a	71.94	nn
D 3		cherries	Prunus avium	Rosaceae	0.000	0.100	1	a	71.94	nn
D 5		peach, nectarine	Prunus persica	Rosaceae	0.000	0.100	1	a	71.94	nn
D 6		pears	Pyrus sp.	Rosaceae	0.000	0.000	2	a	71.94	nn
D 7		plums	Prunus domestica	Rosaceae	0.000	0.030	1	k	71.94	nn
D 8		prunes	Prunus domestica	Rosaceae	0.000	0.030	1	k	71.94	nn
D 9		figs	Ficus carica	Moraceae	27.000	0.200	2	a	81.92	nn
D10		misc. decid. fruit			2.455	0.992	3		81.23	Tree crop average
D12		almonds	Prunus dulcis	Rosaceae	0.000	0.050	1	k	99.50	nn
D13		walnuts	Juglans regia	Juglandaceae	0.000	1.800	1	k	40.20	nn
D14		pistacios	Pistacia vera	Anacardiaceae	0.000	8.400	1	k	154.06	nn

C 1	Citrus	grapefruit	Citrus paradisi	Rutaceae	0.000	1.500	2	a	140.74	nn
C 2	and Subtropical	lemons	Citrus limonia	Rutaceae	0.000	1.500	2	a	140.74	nn
C 3		oranges	Citrus sinensis	Rutaceae	0.000	0.900	2	a	140.74	nn
C 4		dates	Phoenix dactylifera	Arecaceae	15.800	0.000	1	a	290.00	mm
C 5		avocados	Persea americana	Lauraceae	0.000	0.000	1	a	73.39	nn
C 6		olives	Olea europea	Oleaceae	0.000	0.300	1	a	78.34	nn
C 7		misc. subtropical			8.089	1.489	4		143.95	Subtropical average
C 8		kiwis	Actinidia deliciosa	Actinidiaceae			5		77.00	oo
C 9		jojoba	Simmondsia chinensis	Buxacea	0.000	0.000	1	i	225.00	tt
C10		eucalyptus	Eucalyptus sp.	Myrtaceae	57.000	9.200	2	b	129.60	nn
V 1	Vineyards	table grape	Vitis vinifera	Vitaceae	0.000	0.000	1	k	66.18	nn
V 2		wine grape	Vitis vinifera	Vitaceae	0.002	0.002	1	f	66.18	nn
V 3		raisin grape	Vitis vinifera	Vitaceae	0.000	0.000	1	k	66.18	nn
I	Idle	idle		Poaceae	0.000	0.020	3	l	39.00	gg
I 2		idle		Poaceae	0.000	0.020	3	k	39.00	gg

BVOC emission factor reference

a	Benjamin et al. 1996
b	Benjamin et al. 1996 (E. globus)
c	Drewitt et al. 1998
d	Flyckt et al. 1980
e	Hewett and Street 1992
f	Koenig et al. 1995
g	Lamb et al. 1993
h	Lamb et al. 1993 and Pierce et al. 1998
i	Rassmussen 1978
j	Winer et al. 1989
k	Winer et al. 1992
l	Winer et al. 1992 ("grasslands, annual")
m	Winer et al 1992 (safflower)
n	Winer et al 1992 (sorghum)
o	Winer et al. 1989 (beet); Hewitt and Street 1992
p	Winer et al. 1992 (bean)
q	Winer et al. 1992 (carrot)
r	Winer et al. 1992 (wheat)

Specific Leaf Weight (SLW) factor reference

aa	Cao and Tibbitts 1997
bb	Clark et al. 1997
cc	Cole 1974
dd	Danalatos et al. 1994
ee	de la Rosa et al. 2000, sunflower surrogate
ff	de la Rosa et al. 2000
gg	Garnier et al. 1997
hh	Garnier et al. 1997, grass surrogate
ii	Jovanovic et al. 1999
jj	Jovanovic et al. 1999, cabbage surrogate
kk	Jovanovic et al. 1999, carrot surrogate
ll	Jovanovic et al. 1999, lettuce surrogate
mm	Miller and Winer 1984
nn	Nowak 1998
oo	Nowak 1998, structural class
pp	Nowak 1998, Rosaceae average
qq	Nowak 1998, tomato surrogate
rr	Rebetzke and Richards 1999
ss	Robinson et al. 1992.
tt	Wardlaw et al. 1983

Table 3. GAP regional urban land use reference BVOC emission rates.

GAP urban land use code	Description	Urban land use reference BVOC emission rates					
		Isoprene (mg/m2/hr)			Monoterpene (mg/m2/hr)		
		Oakland	Sacramento	Fresno	Oakland	Sacramento	Fresno
11100	residential	1.91	1.28	0.31	0.27	0.76	0.16
11200	commercial + services	0.23	0.00	0.05	0.04	0.29	0.01
11300	industrial	0.23	0.00	0.05	0.04	0.29	0.01
11400	transportation + utilities	1.34	0.01	0.05	0.22	0.00	0.01
11500	industrial and commercial complexes	0.23	0.00	0.05	0.04	0.29	0.01
11600	mixed urban	2.00	1.04	0.11	0.28	0.67	0.05
11700	other urban	2.00	1.04	0.11	0.28	0.67	0.05

Table 4. Canopy-scale reference BVOC emission rates for BEIGIS grid cells A and C, derived from emission factor, specific leaf weight, GAP land cover and satellite LAI inputs

GAP polygon ID 6658

Primary assemblage

		Emission Factor[2]			Primary Assemblage	Co-species	Satellite LAI[3]		Leafmass Density[4]		Emission Rate[5]: cell A			Emission Rate[5]: cell C		
Species	SLW[1]	MON	MBO	ISO	Fractional Cover	Weighting	cell A	cell C	cell A	cell C	MON	MBO	ISO	MON	MBO	ISO
Pinus ponderosa	91	4	25	0	0.45	0.333	1.4	1.4	19	19	0.08	0.48	0	0.08	0.48	0
Abies concolor	98	3	0	0	0.45	0.333	1.4	1.4	21	21	0.06	0	0	0.06	0	0
Quercus kelloggii	103	1	0	54	0.45	0.333	1.4	1.4	22	22	0.02	0	1.17	0.02	0	1.17

Secondary assemblage

		Emission Factor			Secondary Assemblage	Co-species	Satellite LAI		Leafmass Density		Emission Rate: cell A			Emission Rate: cell C		
Species	SLW	MON	MBO	ISO	Fractional Cover	Weighting	cell A	cell C	cell A	cell C	MON	MBO	ISO	MON	MBO	ISO
Pinus lambertiana	91	4	0	0	0.25	0.333	1.4	1.4	11	11	0.04	0	0	0.04	0	0
Pinus ponderosa	91	4	25	0	0.25	0.333	1.4	1.4	11	11	0.04	0.27	0	0.04	0.27	0
Pseudotsuga menziesii.	55	3	0	1	0.25	0.333	1.4	1.4	6	6	0.02	0	0.01	0.02	0	0.01

Tertiary assemblage

		Emission Factor			Secondary Assemblage	Co-species	Satellite LAI		Leafmass Density		Emission Rate: cell A			Emission Rate: cell C		
Species	SLW	MON	MBO	ISO	Fractional Cover	Weighting	cell A	cell C	cell A	cell C	MON	MBO	ISO	MON	MBO	ISO
Ceanothus integerrimus	127	2	0	0	0.35	0.5	1.4	1.4	31	31	0.06	0	0	0.06	0	0
Arctostaphylos viscida	127	0	0	0	0.35	0.5	1.4	1.4	31	31	0	0	0	0	0	0
NA	NA	NA	NA	NA	NA	NA										

Total LMD		Total Emission Rate: cell A			Total Emission Rate: cell C		
cell A	cell C	MON	MBO	ISO	MON	MBO	ISO
151	151	0.33	0.74	1.17	0.33	0.74	1.17

[1] Specific Leaf Weight, g dry leaf weight/m^2 leaf

[2] MON: ug monoterpene/g dry leaf weight/hr, MBO: ug Carbon/g dry leaf weight/hr, ISO: ug isoprene/g dry leaf weight/ at reference conditions 30 C and 1000 micromoles/m^2/s PAR

[3] Leaf Area Index, m^2 leaf area/m^2 land area

[4] LMD, g dry leaf weight/m^2 land area

[5] MON: mg monoterpene/m^2 land/hr, MBO: mg Carbon/m^2 land/hr, ISO: mg isoprene/m^2 land/hr, at reference conditions.

Table 5. Canopy-scale reference BVOC emission rates for BEIGIS grid cells B and D, derived from emission factor, specific leaf weight, GAP land cover and satellite LAI inputs

GAP polygon ID 6658

Primary assemblage

		Emission Factor[2]			Primary Assemblage	Co-species	Satellite LAI[3]		Leafmass Density[4]		Emission Rate[5]: cell B			Emission Rate[5]: cell D		
Species	SLW[1]	MON	MBO	ISO	Fractional Cover	Weighting	cell B	cell D	cell B	cell D	MON	MBO	ISO	MON	MBO	ISO
Pinus ponderosa	91	4	25	0	0.55	0.333	6.6	3.8	110	63	0.44	2.75	0	0.25	1.58	0
Abies concolor	98	3	0	0	0.55	0.333	6.6	3.8	118	68	0.36	0	0	0.20	0	0
Quercus kelloggii	103	1	0	54	0.55	0.333	6.6	3.8	125	72	0.12	0	6.72	0.07	0	3.87

Secondary assemblage

		Emission Factor			Secondary Assemblage	Co-species	Satellite LAI		Leafmass Density		Emission Rate: cell B			Emission Rate: cell D		
Species	SLW	MON	MBO	ISO	Fractional Cover	Weighting	cell B	cell D	cell B	cell D	MON	MBO	ISO	MON	MBO	ISO
Pinus ponderosa	91	4	25	0	0.35	0.333	6.6	3.8	70	40	0.28	1.75	0	0.16	1.01	0
Abies concolor	98	3	0	0	0.35	0.333	6.6	3.8	75	43	0.23	0	0	0.13	0.00	0
Arctostaphylus patula	127	0	0	0	0.35	0.333	6.6	3.8	98	56	0	0	0	0	0	0

Tertiary assemblage

		Emission Factor			Secondary Assemblage	Co-species	Satellite LAI		Leafmass Density		Emission Rate: cell B			Emission Rate: cell D		
Species	SLW	MON	MBO	ISO	Fractional Cover	Weighting	cell B	cell D	cell B	cell D	MON	MBO	ISO	MON	MBO	ISO
Arctostaphylus patula	127	0	0	0	0.15	0.5	6.6	3.8	63	36	0	0	0	0	0	0
Ceanothus cordulatus	127	2	0	0	0.15	0.5	6.6	3.8	63	36	0.13	0	0	0.07	0	0
NA	NA	NA	NA	NA												

Total LMD		Total Emission Rate: cell B			Total Emission Rate: cell D		
cell B	cell D	MON	MBO	ISO	MON	MBO	ISO
722	416	1.55	4.50	6.72	0.89	2.59	3.87

[1] Specific Leaf Weight, g dry leaf weight/m^2 leaf

[2] MON: ug monoterpene/g dry leaf weight/hr, MBO: ug Carbon/g dry leaf weight/hr, ISO: ug isoprene/g dry leaf weight/ at reference conditions 30 C and 1000 micromoles/m^2/s PAR

[3] Leaf Area Index, m^2 leaf area/m^2 land area

[4] LMD, g dry leaf weight/m^2 land area

[5] MON: mg monoterpene/m^2 land/hr, MBO: mg Carbon/m^2 land/hr, ISO: mg isoprene/m^2 land/hr, at reference conditions.