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FINAL VALIDATION OF CENTRAL CALIFORNIA OZONE STUDY (CCOS) FIELD DATA

FINAL REPORT
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EXECUTIVE SUMMARY

The Central California Ozone Study (CCOS) represents the latest in a series of studies intended to provide improved information for understanding the relationships between emissions, transport, and ozone (O_3) concentrations in California. This report documents the methods and results of efforts by Sonoma Technology, Inc. (STI) to quality control (QC) the CCOS portion of the Central California Air Quality Studies (CCAQS) database for the period from June 1 to September 30, 2000. Overall, after both automated QC and detailed examinations were completed, 98% of the data residing in the CCOS data archive were determined to be valid. With only a few minor exceptions, the data residing in the CCOS data archive should be ready for use by data analysts and modelers without further consideration of data quality.

ES.1 SUMMARY OF APPROACH

The goal of the overall data validation effort was to ensure a consistent and reliable set of meteorological and air quality data ready for use by data analysts and modelers. To achieve this goal, we evaluated the entire process of managing, quality-assuring, and quality-controlling the CCOS subset of the CCAQS database archive; documented the quality of the data; and performed additional QC as necessary. The major elements of this evaluation include

- comparing the data that reside in the CCAQS data management system with the data that were planned to have been collected for the CCOS period, as identified in the CCOS planning documents;
- conducting a QC audit of the data by checking data consistency (e.g., measurement methods, time averaging, and reporting units);
- quality-controlling the data by checking for gross outliers and performing detailed QC of selected data (note, we recommend that users give precedence to QC flags from the subjective QC task rather than flags from the gross outlier check); and
- preparing a thorough evaluation of the database in the form of a final report to be used by data analysts and modelers to focus on useful data for model inputs, model evaluations, and investigations of O_3 transport and formation.

ES.2 SUMMARY OF FINDINGS

In general, the comparison of the CCOS field data sets, expected to reside in the CCAQS database as identified in study planning documents, with actual data in the current archive as of April 2005 showed the following:

- Ninety percent of the expected sites reported some air quality data.
- Eighty-three percent of the expected sites reported at least half of the expected air quality parameters.
- Eighty-eight percent of the expected sites reported surface meteorology parameters.

- About 400 additional surface meteorological sites were found that were not documented in the study plans.
- Twenty-six radar wind profiler (RWP) and Radio Acoustic Sounding System (RASS) sites were expected and 26 sites were found, but not necessarily in the same locations reported in the planning documents
- None of the expected NEXRAD or routine radiosonde data were found.
- Seven SOnic Detection And Ranging (SODAR) sites were expected and 9 sites were found.
- All six aircraft reported some data; O_3, NO, NO_y, temperature, wind speed, and wind direction were reported from all aircraft.

Overall, results were excellent, especially for surface air quality data. However, useful air quality data, particularly O_3 and volatile organic compound (VOC), from routine monitoring sites not identified in planning documents were neither expected nor found in the data archive, but they are available elsewhere and should be added to the database. We found that at least 18 routine air quality monitoring sites within the study domain were not included in either the CCOS planning documents or in the archive itself. We also found that most of the routine VOC measurements at Photochemical Assessment Monitoring Stations (PAMS) sites were not included in the archive. Once informed of these discoveries, the California Air Resources Board (ARB) set plans in motion to compile the available data and add them to the archive.

ES.3 RECOMMENDATIONS FOR FURTHER DATA VALIDATION

The following additional data validation efforts are recommended.

- Perform automated QC checks on all data that were added to the CCAQS database after April 2005.
- Perform detailed QC checks on data from intensive operations periods (IOPs) that were added to the CCAQS database after April 2005.
- Develop automated QC checks for and perform QC checks on radiosonde, NEXRAD, and mixing height data if they are added to the CCAQS database.
- Establish a system for tracking and resolving QC issues identified during subsequent data analysis and modeling efforts. The system could be patterned after commonly used “bug” tracking programs to provide a chronological summary of reported QC issues and their dates of resolution so that end users can easily identify data issues and know when to download database updates.

ES.4 RECOMMENDATIONS FOR FUTURE CONSIDERATION

Although outside the normal bounds of a data quality audit, during the course of the audit of the CCOS data archive, we identified a number of issues that we recommend be considered for future database development efforts of this magnitude. Clearly, a significant effort went into

the design and implementation of the CCAQS database, but we believe that the following issues should be considered in future efforts to design and implement similar data archives because they would facilitate the use of data by analysts and modelers.

- Create a table in the database referencing readme-type files and data quality assurance (QA) documents (e.g., instrument methods, calibrations, data validation steps, etc.) and require that data providers provide this information.
- Establish consistent naming and unit conventions or allow export of data using such conventions (e.g., some data are in meters above sea level and some data are in meters above ground level).
- Group all parameters at a site as a single site in the database (the current system does not support the traditional site concept but treats site-sensor height combinations as a unique "support code").

Lastly, while the automated QC checks used in this study were designed to identify the most serious data problems, they cannot detect more subtle problems in the data. For example, they cannot identify improper time zones (i.e., PST versus PDT), errors in site locations, or small biases in data values. These types of issues should be addressed during the QA tasks that are normally performed before data are imported into a database.

1. INTRODUCTION

The Central California Ozone Study (CCOS) represents the latest in a series of studies intended to provide improved information for understanding the relationships between emissions, transport, and ozone (O_3) concentrations in California. CCOS is an integrated effort that includes meteorological and air quality monitoring, emission inventory development, data analysis, and air quality simulation modeling. It is clear that for CCOS to succeed, reliable meteorological and air quality data sets are needed that are (1) at a consistent quality level achieved through quality assurance (QA) and quality control (QC) and (2) ready for immediate use by data analysts and modelers without need for further judgment regarding data quality. This report documents the methods and results of efforts by Sonoma Technology, Inc. (STI) to QC the CCOS portion of the Central California Air Quality Studies (CCAQS) database for the period from June 1 to September 30, 2000.

1.1 BACKGROUND

The goal of the overall data validation effort is to ensure a consistent and reliable set of meteorological and air quality data that are ready for use by data analysts and modelers. The approach to achieve this goal is to evaluate the entire process used to manage and QC the CCOS subset of the CCAQS database archive, to document the quality of the data, and to perform additional QC as necessary. The major elements of this evaluation include

- comparing the data that reside in the CCAQS data management system with the data that were planned to have been collected for the CCOS period, as identified in the CCOS planning documents;
- conducting a QC audit of the data by checking data consistency (e.g., measurement methods, time averaging, and reporting units);
- quality controlling the data by checking for gross outliers and performing detailed QC of selected data; and
- preparing a thorough evaluation of the database in the form of a final report to be used by data analysts and modelers to focus on useful data for model inputs, model evaluations, and investigations of O_3 transport and formation.

1.2 QUALITY ASSURANCE, QUALITY CONTROL, AND DATA VALIDATION

While there are many definitions of QA and QC, we determined a set of operating definitions for use in this project. To manage data quality requires an understanding of the specific quality expectations of the end user and a proactive plan to meet those expectations. A proactive plan contains a number of elements, the most important of which are the QC and QA activities that need to be performed. QC activities are focused on the deliverable itself. QA activities are focused on the process used to create the deliverable. They are both powerful techniques and both must be performed to ensure that the deliverables meet quality requirements.

QC refers to quality-related activities associated with the creation of project deliverables. QC is used to verify that deliverables are of acceptable quality and that they are complete and correct. Examples of quality control activities include deliverable peer reviews and testing processes.

QA refers to the process used to create the deliverables and can be performed by a manager, client, or even a third-party reviewer. Examples of QA include process checklists and audits. If data are audited, for example, an auditor might not be able to tell if the data are acceptable (QC). However, the auditor should be able to tell if the deliverable seems acceptable based on the process used to create it (QA). That is why auditors can perform a QA review even though they may not know the specifics of what is being delivered.

Data validation consists of QC procedures developed to identify deviations from measurement assumptions and procedures. "The purpose of data validation is to detect and then verify any data values that may not represent actual air quality conditions at the sampling station" (U.S. Environmental Protection Agency, 1980). Thorough data validation is vital because serious errors in data analysis and modeling results can be caused by erroneous individual data values. To minimize unnecessary errors and uncertainties, all values in the data set need to be reviewed, evaluated, and flagged. The identification of outliers, errors, or biases is typically carried out in several stages or validation levels. The level of validation is described by a numeric code indicating the degree of confidence in the data. These levels provide some commonality among data collected at various places and quality controlled by different agencies to help ensure that all data have received a comparable level of validation. Various data validation levels applied to air quality and meteorological data have been defined by Mueller and Watson (1982) and Watson et al. (1989). Four levels of data validation are summarized in **Table 1-1**.

1.3 MEASUREMENTS

The CCOS planning documents identified the pollutants and meteorological measurements that were to be collected under CCOS sponsorship:

Surface Air Quality Data

- Ozone (O_3)
- Nitric oxide (NO), nitrogen dioxide (NO_2), oxides of nitrogen (NO_x) and reactive oxides of nitrogen (NO_y), formaldehyde (HCHO), hydrogen peroxide (H_2O_2), and nitric acid (HNO_3)
- Volatile organic compounds (VOCs—hydrocarbons and carbonyl compounds are included in the definition)
- Carbon monoxide (CO) and carbon dioxide (CO_2)

Surface and Upper-air Meteorological Data

- Radar wind profiler (RWP) soundings
- SOnic Detection And Ranging (SODAR) wind data

- Radio Acoustic Sounding System (RASS) virtual temperature (T_v) data
- Routine radiosonde soundings
- Routine Next Generation Weather Radar (NEXRAD) wind data
- CCOS-sponsored surface and radiosonde meteorological data

Aircraft and Ozonesonde Measurements

- O_3, NO, NO_y, temperature, humidity, winds, VOCs, peroxyacetylnitrate (PAN), and nitrogen dioxide (NO_2) measured aloft during aircraft flights
- Vertical profiles of O_3 concentrations measured by aircraft and ozonesondes

Table 1-1. Data validation levels.

Level	Description
0	Level 0 data validation is essentially raw data obtained directly from data acquisition systems in the field. Level 0 data have been reduced and possibly reformatted, but are unedited and unreviewed. These data have not received any adjustments for known biases or problems that may have been identified during preventive maintenance checks or audits. Routine checks are made during the initial data processing and generation of data, including proper data file identification, review of unusual events, review of field data sheets and result reports, instrument performance checks, and deterministic relationships.
1	Level 1 data validation involves quantitative and qualitative reviews for accuracy, completeness, and internal consistency. Quantitative checks are performed by software screening programs, and qualitative checks are performed by analysts who manually review the data for outliers and problems. QC flags, consisting of numbers or letters, are assigned to each datum to indicate its quality. Data are only considered at Level 1 after final audit reports have been issued and any adjustments, changes, or modifications to the data have been made.
2	Level 2 data validation involves comparisons with other independent data sets. This level of validation includes, for example, inter-comparing collocated measurements or making comparisons with other measurement systems or analyses. This level is often part of the data interpretation or analysis process.
3	Level 3 validation involves a more detailed analysis when inconsistencies in analysis and modeling results are caused by measurement errors.

1.4 SUMMARY OF FINDINGS

In general, the comparison of the CCOS field data sets, expected to reside in the CCAQS database as identified in study planning documents, with actual data in the current archive as of April 2005 showed the following:

- Ninety percent of the expected sites reported some air quality data.
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- About 400 additional surface meteorological sites were found that were not documented in the study plans.
- Twenty-six RWP and RASS sites were expected and 26 sites were found, but not necessarily in the same locations reported in the planning documents
- None of the expected NEXRAD or routine radiosonde data were found.
- Seven SODAR sites were expected and 9 sites were found.
- All six aircraft reported some data; O_3, NO, NO_y, temperature, wind speed, and wind direction were reported from all aircraft.

Overall, results were excellent, especially for surface air quality data. However, useful air quality data, particularly O_3 and VOC, from routine monitoring sites not identified in planning documents were neither expected nor found in the data archive, but they are available elsewhere and should be added to the database. We found that at least 18 routine air quality monitoring sites within the study domain were not included in either the CCOS planning documents or in the archive itself. We also found that most of the routine VOC measurements at Photochemical Assessment Monitoring Stations (PAMS) sites were not included in the archive. Once informed of these discoveries, the California Air Resources Board (ARB) set plans in motion to compile the available data and add them to the archive.

Our survey of data users indicated that no additional effort to perform Level 2 or Level 3 validation was made; thus no additional quality-controlled data sets are available to incorporate into the CCAQS archive with the exception of the subjective QC of the remainder of the summertime RWP wind and RASS T_v data currently being completed by National Oceanic and Atmospheric Administration (NOAA) for re-submission to the CCAQS database.

1.5 GUIDE TO THIS REPORT

This report comprises seven sections: Section 1, this introduction; Section 2, a summary of data availability in the CCAQS database as received from the ARB; Section 3, a summary of the results of a survey of data users and data providers regarding their QC efforts; Section 4, QC results of the overall database; Section 5, detailed QC results; and Section 6, conclusions and recommendations. Section 7 lists the references cited in this document. Three appendices provide graphs of data availability accounting for QC level (Appendix A), a description of an electronic data volume (EDV) provided with this report (Appendix B), and a graphic description of the automated data QC process (Appendix C, CCOS QC Database Tables).

2. AUDIT OF CCOS DATA RESIDING IN THE CCAQS ARCHIVE

In this section we describe the CCOS field data sets that were expected to reside in the CCAQS database, as identified in study planning documents, and compare this list with what we actually found in the archive as of April 2005. To make this comparison, we acquired and reviewed the following documents:

- Central California Ozone Study (CCOS) Volume I: Field Study Plan (Fujita et al., 1999)
- California Regional PM_{10}/$PM_{2.5}$ Air Quality Study (CRPAQS) Anchor Site Measurements and Operations (Wittig et al., 2003)
- Central California Ozone Study (CCOS) Volume III: Summary of Field Operations (Fujita et al., 2001)

2.1 SUMMARY OF CCOS DATABASE ARCHIVE AUDIT

A set of comprehensive tables of sites, parameters, instrument vendors and models, methods, detection limits, sampling frequencies (e.g., daily, episodic), sample durations, data reporting averaging times (e.g., 1-hr, 3-hr), sampling platforms (i.e., surface, aloft, aircraft), and the agencies or contractors responsible for samples was compiled. The results of the compilation of expected sites and parameters are summarized in **Tables 2-1, 2-2, and 2-3**.

To determine which CCOS data reside in the CCAQS archive, we obtained a copy from the ARB of the most current CCAQS database (as of April 2005) available in Microsoft SQL Server data file (MDF) format and installed it on an STI server. We developed SQL queries to (1) confirm the existence of expected data, (2) identify missing data, and (3) identify data for additional sites or O_3-related parameters in the CCAQS database that were not identified in study planning documents.

Results of the comparison of expected data with those that actually reside in the archive are listed in **Tables 2-4**, **2-5, and 2-6**. Site maps showing the locations from which existing data are provided are shown in **Figures 2-1, 2-2, and 2-3**.

Table 2-1. Expected surface meteorology and air quality sites and parameters.

Site	Source	Parameters																	
		PAMS hydrocarbons	PAMS carbonyls	Meteorology (WS, WD, T, and RH)	Radiation	O_3	H_2O_2, HCHO	NO, NO_x	NO, NO_y	NO_y, NO_y- HNO_3	NO_2, PANs	NO_3-	NO_2, HNO3	CO, CO_2, CH4, C2-C12 hydrocarbons	C1-C7 carbonyls	C8-C20 hydrocarbons	VOC-auto GC	CO	CO_2
Angiola	CRPAQS			x		x			x					x	x				
Arvin	PAMS, ARB	x		x		x		x	x		x			x					
Arvin	ARB			x		x		x	x		x			x					
Bakersfield-Golden State Hwy	PAMS	x	x																
Bakersfield, California Ave.	PAMS, CRPAQS	x							x										
Bethel Island	BAAQMD			x		x		x	x		x			x	x			x	
Bodega Bay	CRPAQS			x		x			x					x	x				
Camp Parks	BAAQMD			x		x													
Camp Roberts	SLOAPCD			x		x													
Clovis Villa	PAMS	x	x																
Elk Grove	SMAQMD			x		x		x	x					x	x				
Fresno-1st St.	PAMS	x	x																
Granite Bay	DRI			x	x	x		x		x	x	x		x	x	x	x	x	x
Kettleman City	SJVUAPCD			x		x			x										
Lake Chabot	BAAQMD			x		x			x										
Lambie Road	BAAQMD			x		x			x										
Livermore	BAAQMD			x		x		x	x									x	
Madera	PAMS	x																	
McKittrick	SJVUAPCD			x		x			x										
Mobile Van	BAAQMD			x		x			x					x					
Pacheco Pass	CRPAQS			x		x			x					x	x				
Parlier	PAMS, SJVUAPCD	x		x	x	x	x	x		x	x	x	x	x	x	x	x	x	x
Parlier	SJVUAPCD			x	x	x	x	x		x	x	x	x	x	x	x	x	x	x
Patterson Pass	UCB			x		x			x		x			x	x				
Piedras Blancas	SLOAPCD			x		x			x					x	x				
Pt. Reyes	CCOS			x															
Red Hills	SLOAPCD			x		x			x										
Sacramento-Bruceville	PAMS	x																	
Sacramento-Airport Rd.	PAMS	x	x																
Sacramento- Del Paso	PAMS	x	x																
Sacramento- Folsom	PAMS	x																	
San Andreas	ARB			x		x			x					x	x			x	
San Jose 4th St	BAAQMD			x		x		x						x	x			x	
San Leandro	BAAQMD			x		x		x						x	x				
San Martin	BAAQMD			x		x			x										
Shafter	PAMS	x																	
Shasta- Shasta Lake	Shasta APCD			x		x		x	x										
Shasta- Bella Vista	Shasta APCD			x		x			x										
Sloughhouse	SMAQMD			x		x		x		x	x	x		x	x	x	x	x	x
Sunol	BAAQMD, UCB			x	x	x		x		x	x	x		x	x	x	x	x	x
Sutter Buttes	ARB			x		x			x					x	x				
Trimmer (Forest Service)	CRPAQS			x		x			x		x			x	x				
Turlock	SJVUAPCD			x		x		x	x					x	x			x	
Walnut Grove Tower	SMAQMD			x		x		x	x										
White Cloud	ARB			x		x			x					x	x				
TOTAL PARAMETER COUNT		12	5	35	4	34	2	15	26	5	10	5	2	22	19	5	5	10	5

ARB = California Air Resources Board
BAAQMD =Bay Area Air Quality Management District
CCOS = Central California Ozone Study
CRPAQS = California Regional PM_{10}/$PM_{2.5}$ Air Quality Study
DRI = Desert Research Institute
PAMS = Photochemical Assessment Monitoring Stations
Shasta APCD = Shasta Air Pollution Control District
SMAQMD = Sacramento Metropolitan Air Quality Management District
SJVUAPCD = San Joaquin Valley Unified Air Pollution Control District
SLOAPCD = San Luis Obispo Air Quality Management District
UCB = University of California, Berkeley

Table 2-2. Expected aloft meteorology sites and instruments.

Site	Data Provider	Instrument					
		RWP	RASS	SODAR	Radiosonde	NEXRAD	Ozonesonde [a]
Arbuckle	CCOS	x	x				
N of Auburn, S of Grass Valley	CCOS	x	x				
Angel's Camp	CCOS			x			
Angiola	CRPAQS-RWP, CCOS-SODAR	x	x	x			
Beale AFB	BAFB					x	
Humboldt County	NWS					x	
Carizo Plain	CCOS	x	x	x			
Corning	CCOS	x	x				
Sacramento	NWS					x	
Edison	ARB	x	x				
Edwards AFB	EAFB				x	x	
Fresno Air Terminal	CCOS	x	x				
Fresno- First Street	CCOS				x		
Hanford	NWS					x	
Huron	CRPAQS, ARB	x	x				
Lagrange	CCOS	x	x				
Lost Hills	ARB, NOAA	x	x				
Livingston	CRPAQS-RWP, CCOS-SODAR	x	x	x			
Livermore	CCOS	x	x				
Mojave Desert	CRPAQS	x	x				
Mouth Kings River	CRPAQS	x	x				
Monterey	USNPGS	x	x				
Santa Clara	NWS					x	
Point Mugu USN	USN				x		
Oakland airport	NWS				x		
Plesant Grove	CCOS	x	x				
Pt. Reyes	CCOS	x	x				
Reno NWS	NWS				x		
Washoe County	NWS					x	
Richmond	CCOS-p, SODAR	x	x	x			
Sacramento	SMAQMD, ARB	x	x		x		
Shasta	CCOS	x	x				
Santa Nella	CRPAQS, ARB	x	x				
San Martin	CCOS	x	x				
Orange County	NWS					x	
Travis AFB	TAFB	x		x			
Tracy	CCOS	x	x				
Vandenberg AFB	VAFB	x			x		
Orcutt Oil field	VAFB					x	
Visalia	SJVUAPCD	x	x				
Ventura County	NWS					x	
Pittsburg	PG&E	x	x				
Moss Landing	PG&E	x	x				
Parlier	SJVUAPCD						x
Granite Bay	DRI						x
TOTAL INSTRUMENT COUNT		28	26	6	7	10	2

[a] Ozonesondes collected both meteorological and O_3 data.

ARB = California Air Resources Board
BAAQMD =Bay Area Air Quality Management District
BAFB = Beale Air Force Base
CCOS = Central California Ozone Study
CRPAQS = California Regional $PM_{10}/PM_{2.5}$ Air Quality Study
DRI = Desert Research Institute
EAFB = Edwards Air Force Base
NWS = National Weather Service
NOAA = National Oceanic and Atmospheric Administration
PAMS = Photochemical Assessment Monitoring Stations
PG&E = Pacific Gas & Electric
Shasta APCD = Shasta Air Pollution Control District
SJVUAPCD = San Joaquin Valley Unified Air Pollution Control District
SMAQMD = Sacramento Metropolitan Air Quality Management District
SLOAPCD = San Luis Obispo Air Quality Management District
TAFB = Travis Air Force Base
UCB = University of California, Berkeley
USN = U.S. Navy
USNPGS = U.S. Navy Post Graduate School
VAFB = Vandenburg Air Force Base

Table 2-3. Expected aircraft platforms and parameters.

	UCD Cessna 172RG	UCD Cessna 182	STI Piper Aztec	STI Cessna 182	PNNL Gulfstream 160	TVA Havilland Twin Otter
Temperature	x	x	x	x	x	x
Humidity	x	x	x	x	x	x
Dew point			x			
Wind speed	x	x	x	x	x	
Wind direction	x	x	x	x	x	
Pressure					x	
Radiation					x	x
Position	x	x	x	x		x
Altitude			x	x		x
O_3 concentration	x	x	x	x	x	x
NO/NO_y concentration	x	x	x	x		x
PAN/NO_2					x	
Formaldehyde					x	
CO					x	x
CO2						x
Carbonyl compounds	x	x	x	x		x
Hydrocarbons	x	x	x	x	x	x
VOC samples			x	x		

Table 2-4. List of surface meteorology and air quality sites, instruments, and parameters found in the CCOS subset of the CCAQS database. Expected data not found are marked M and highlighted in yellow. Meteorological data found at a nearby site with a name other than the air quality site are marked N. Additional sites highlighted in pink were not expected based on study plans.

	Infared Gas Filter Correlation CO Analyzer	Gas Filter Correlation CO2 Analyzer	Tunable Diode Laser Absorption Spectroscopy System	Tunable Diode Laser Absorption Spectroscopy System	Tunable Diode Laser Absorption Spectroscopy System	Chemiluminescence NO-NO2-NOx Analyzer	NOY Configuration - Trace Level Chemiluminescent Analyzer	Chemiluminescence NO-NO2-NOx Analyzer	Tunable Diode Laser Absorption Spectroscopy System	Chemiluminescence NO-NO2-NOx Analyzer	NO-NO2-NOX Trace Level Chemiluminescent Analyzer	NO/NOY Analyzer with Gas Phase Chemiluminescent Detector	NOY Configuration - Trace Level Chemiluminescent Analyzer	NOY Configuration - Trace Level Chemiluminescent Analyzer	Ozone Monitor - Ultraviolet Absorption	Photoelectric Aerosol Sensor (PAH Analyzer)	Ion Chromatograph	Gas Chromatograph - Mass Spectrometer	Gas Chromatograph/Flame Ionization Detector	High Performance Liquid Chromatograph				
	CO1	CO2	H2O2	HCHO	HNO3	NO	NO	NO2	NO2	NOX	NOX	NOY	NOY	NOYS	O3	PAH	SO2	VOCs	VOCs	VOCs	T	RH	WS	WD
Anderson Stn															X									
Angiola Stn	X	X		X			X						X		X					X	X	X	X	X
Arvin Stn	M	M		X		X	X	X		X			X		X					X	X	X	X	X
Atascadero Stn	X					X		X		X					X						X		X	X
Bakersfield Stn Golden State	X					X		X		X					X					X	X	X	X	X
Bakersfield Stn California Ave	X					X	X	X		X			X		X					M	X	X	X	X
Barstow Stn	X					X		X		X					X						X	N	X	X
Bella Vista Stn (Shasta)							X						X		X						N	N	N	N
Bethel Island Stn	X	X		X		X	X	X		M	M		X		X				X	X	X	X	X	X
Bodega Bay Stn	X	X		X			X						X		X				X	X	N	N	N	N
Camp Roberts															M						M	M	M	M
Capitan Stn/Las Flores Canyon	X					X		X		X					X						X		X	X
Carmel Valley Stn															X						X			
Carpinteria Stn						X		X		X					X						X		X	X
Chabot Stn (Lake Chabot)							M						M		M						X	M	X	X
Chico Stn	X					X		X		X					X						X	X	X	X
Clovis Stn	X					X		X		X					X					M	X	X	X	X
Colusa Stn															X						X	N	X	X
Concord Stn	X					X		X							X						X	X	X	X
Cool Stn															X						X		X	X
Davenport Stn	X					X		X		X					X						X		X	X
Davis/UCD Campus Stn	X					X		X		X					X						X	N	X	X
DL Bliss State Park Stn																	X							
Death Valley IMPROVE Stn															X		X				X	X	X	X
Dome Land Wilderness Stn																	X							
Echo Summit Stn	X					X		X		X					X						X	X	X	X
Edison Stn						X		X		X					X						X		X	X
El Capitan Beach Stn						X		X		X					X						X		X	X
El Rio Mesa School 2 Stn	X					X		X		X					X						X	X	X	X
Elk Grove Stn (Sacramento-Bruceville for PAMS)	M	M				X	X	X		X			X		X						X	X	X	X
Folsom Stn (Sacramento)						X		X		X					X				X		X	X	X	X
Fremont Stn	X					X		X							X						N	N	N	N
Fresno Stn-First St	X					X		X		X		X			X	X		X	X		X	X	X	X
Fresno Stn - Drummond	X					X		X		X					X									
Fresno Stn - North Perimeter															X						X	X	X	X
Fresno Stn - Sierra Skypark	X					X		X		X					X						X		X	X
Gaviota TC-Site B Stn						X		X		X					X						X		X	X
Goleta Stn	X					X		X		X					X						X	X	X	X
Granite Bay Stn	X	X		X	M		X		X		X		X	X	X			X	X	X	N	N	N	N
Grass Valley Stn															X									
Grover City Stn						X		X		X					X								X	X
Hanford Stn						X		X		X					X									
Hollister Stn															X						X	X	X	X
Jackson Stn	X														X						X		X	X
Jerseydale Stn															X						X	X	X	X
Joshua Tree																	X				X	X		
Kaiser-IMPROVE Stn																	X							
Kettlemen City Stn							X						X		X						N	N	N	N
Kregor Peak Stn															X						X		X	X
Lake Gregory-															X							X		
Lakeport Stn															X									
Lambie Road Stn							X						X		X						M	M	M	M
Lancaster Stn	X					X		X		X					X						X		X	X
Lassen Volcanic NP Stn															X		X				X	X	X	X
Lava Beds Natl Monument Stn																	X							
Livermore Stn - Old First St						X		X		M			M		X						N	N	N	N
Livermore Stn-Rincon	X					X		X							X						N	N	N	N
Livermore-Dublin (Camp Parks)															X						N	N	N	N
Lompoc Stn - South H St	X					X		X		X					X						X		X	X
Lompoc Stn - HS & P						X		X		X					X						X		X	X

NOYS = total nitrogen species except nitric acid

Table 2-4. List of surface meteorology and air quality sites, instruments, and parameters found in the CCOS subset of the CCAQS database. Expected data not found are marked M and highlighted in yellow. Meteorological data found at a nearby site with a name other than the air quality site are marked N. Additional sites highlighted in pink were not expected based on study plans.

	Infared Gas Filter Correlation CO Analyzer	Gas Filter Correlation CO2 Analyzer	Tunable Diode Laser Absorption Spectroscopy System	Tunable Diode Laser Absorption Spectroscopy System	Tunable Diode Laser Absorption Spectroscopy System	Chemiluminescence NO-NO2-NOx Analyzer	NOY Configuration - Trace Level Chemiluminescent Analyzer	Chemiluminescence NO-NO2-NOx Analyzer	Tunable Diode Laser Absorption Spectroscopy System	Chemiluminescence NO-NO2-NOx Analyzer	NO-NO2-NOX Trace Level Chemiluminescent Analyzer	NO/NOY Analyzer with Gas Phase Chemiluminescent Detector	NOY Configuration - Trace Level Chemiluminescent Analyzer	NOY Configuration - Trace Level Chemiluminescent Analyzer	Ozone Monitor - Ultraviolet Absorption	Photoelectric Aerosol Sensor (PAH Analyzer)	Ion Chromatograph	Gas Chromatograph - Mass Spectrometer	Gas Chromatograph/Flame Ionization Detector	High Performance Liquid Chromatograph				
	CO1	CO2	H2O2	HCHO	HNO3	NO	NO	NO2	NO2	NOX	NOX	NOY	NOY	NOYS	O3	PAH	SO2	VOCs	VOCs	VOCs	T	RH	WS	WD
Los Padres NF Stn						X		X		X					X						X		X	X
Madera Stn						X		X		X					X						X	X	X	X
Mammoth Lakes	X																				X		X	X
Maricopa School															X						X		X	X
McKittrick Stn							X						X		X						N	N	N	N
Merced Stn															X						X	N	X	X
Mineral King															X						X	X	X	X
Modesto Stn	X					X		X		X					X						X	N	X	X
Mojave Stn						X		X		X					X						X	N	X	X
Monterey/Fort Ord Stn															X						N	N	N	N
Morro Bay Stn															X						N		X	X
Napa Stn	X					X		X							X						X	X	X	X
Nipomo Stn						X		X		X					X						N		X	X
Oildale Stn						X		X		X					X						X		X	X
Ojai Stn						X		X		X					X						X	X	X	X
Olancha Stn	X	X																	X		X	X	X	X
Pacheco Pass Stn	X	X		X			X						X		X				X	X	N	N	N	N
Paradise Stn															X						X		X	X
Parlier Stn	X	X	X	X	X	X		X	X	X			X	X	X			X	X	X	X	X	X	X
Paso Robles Stn															X						X		X	X
Patterson Pass Stn	X	X		X			X		X				X		X				X	X	N	N	N	N
Piedras Blancas Stn	X	X		X			X						X		X				X	X	N	N	N	N
Pinnacles															X		X				X	X	X	X
Piru Stn															X						X	X	X	X
Pittsburg Stn	X					X		X							X						X	X	X	X
Placerville Stn	X														X						X		X	X
Pleasant Grove Stn															X						X	X	X	X
Point Reyes																	X				N	N	N	N
Quincy Stn															X						N	N	N	N
Red Hills							M						M		M						M	M	M	M
Redding Stn															X						N	N	N	N
Redwood City Stn	X					X		X							X									
Redwood NP																	X							
Rocklin Stn															X						X		X	X
Roseville Stn	X					X		X		X					X						X	X	X	X
Sacramento Stn - T St	X					X		X		X					X						X	X	X	X
Sacramento Stn - Del Paso Manor	X					X		X		X					X				X	M	X	X	X	X
Sacramento/Natoma Stn (Sacramento - Airport Rd.)	X					X		X		X					X				X	M	X	X	X	X
Sacramento-North Highlands Stn	X					X		X		X					X									
Salinas Stn	X					X		X		X					X						X	N	X	N
San Andreas Stn	X	X		X			X						X		X				X	X	X	M	X	X
San Francisco Stn	X					X		X							X									
San Jose Stn - 4th St	X	M		X		X		X		M	M				X					X	N	N	N	N
San Leandro Stn	X	X		X		M		M		M	M				M				X	X	N	M	N	N
San Luis Obispo Stn	X					X		X		X					X						X	N	X	X
San Martin Stn							X						X		M						X	X	X	X
San Rafael Stn	X					X		X							X									
San Rafael Wilderness																	X							
Santa Barbara Stn	X					X		X		X					X						X	N	X	X
Santa Clarita Stn	X					X		X		X					X								X	X
Santa Cruz Stn															X						X			
Santa Maria Stn	X					X		X		X					X						X		X	X
Santa Rosa Stn	X					X		X							X						X	N	X	X
Santa Ynez Airport Stn															X						X	N	X	X
Sequoia Stn															X						X	X	X	X
Sequoia National Park																	X							
Shafter Stn						X		X		X					X				X	M	X	N	X	X
Shasta Lake						M	M	M		M			M		M						X	X	X	X
Simi Valley Stn	X					X		X		X					X						X	X	X	X

NOYS = total nitrogen species except nitric acid

Table 2-4. List of surface meteorology and air quality sites, instruments, and parameters found in the CCOS subset of the CCAQS database. Expected data not found are marked M and highlighted in yellow. Meteorological data found at a nearby site with a name other than the air quality site are marked N. Additional sites highlighted in pink were not expected based on study plans.

	Infared Gas Filter Correlation CO Analyzer	Gas Filter Correlation CO2 Analyzer	Tunable Diode Laser Absorption Spectroscopy System	Tunable Diode Laser Absorption Spectroscopy System	Tunable Diode Laser Absorption Spectroscopy System	Chemiluminescence NO-NO2-NOx Analyzer	NOY Configuration - Trace Level Chemiluminescent Analyzer	Chemiluminescence NO-NO2-NOx Analyzer	Tunable Diode Laser Absorption Spectroscopy System	Chemiluminescence NO-NO2-NOx Analyzer	NO-NO2-NOX Trace Level Chemiluminescent Analyzer	NO/NOY Analyzer with Gas Phase Chemiluminescent Detector	NOY Configuration - Trace Level Chemiluminescent Analyzer	NOY Configuration - Trace Level Chemiluminescent Analyzer	Ozone Monitor - Ultraviolet Absorption	Photoelectric Aerosol Sensor (PAH Analyzer)	Ion Chromatograph	Gas Chromatograph - Mass Spectrometer	Gas Chromatograph/Flame Ionization Detector	High Performance Liquid Chromatograph				
	CO1	CO2	H2O2	HCHO	HNO3	NO	NO	NO2	NO2	NOX	NOX	NOY	NOY	NOYS	O3	PAH	SO2	VOCs	VOCs	VOCs	T	RH	WS	WD
Sloughouse Rd_ Stn	M	M			M		X	M		M	M		X	M	X			M			M	M	X	X
Sonora - Five Mile															X						X	X	X	X
Sonora Stn - S Barretta St	X														X						X		X	X
South Lake Tahoe Stn	X					X		X		X					X						X	X	X	X
Stockton Stn - E Mariposa															X						X	X	X	X
Stockton Stn - Hazelton St	X					X		X		X					X						X	X	X	X
Sunol Station Stn	X	X		X	M		X		X		X		X	X	X			X	X	X	X	M	X	X
Sutter Buttes Stn	X	X		X			X						X		M				X	X	M	M	M	M
Thousand Oaks Stn						X		X		X					X						X	X	X	X
Tracy Stn						X		X		X					X						X	N	X	X
Trimmer Stn	X	X		X			X						X		X				X	X	N	N	N	N
Trona Stn						X		X		X					X						X		X	X
Truckee Fire Station Stn															X									
Turlock Stn	X	X		X		X	X	X		X			X		X				X	X	M	M	X	X
Tuscan Butte Stn															X						X		X	X
Vallejo Stn	X					X		X							X						N	N	N	N
Vandenberg STS	X					X		X		X					X						X		X	X
Ventura Co_						X		X		X					X						X		X	X
Ventura Stn						X		X		X					X						X	X	X	X
Victorville Stn	X					X		X		X					X						X		X	X
Visalia Stn	X					X		X		X					X						X	N	X	X
Walnut Grove Tower 122						M	M	M	M	M	M		M	M	X						X	M	X	X
Walnut Grove Tower 244						M	M	M	M	M	M		M	M	X						X	M	X	X
Walnut Grove Tower 366						M	M	M	M	M	M		M	M	X						X	M	X	X
Walnut Grove Tower 488						M	M	M	M	M	M		M	M	X						X	M	X	X
Walnut Grove Tower 9						M	M	M	M	M	M		M	M	X						X	M	X	X
Watsonville															X						X		X	X
White Cloud Mtn_ Stn	X	X		X			X						X		X				X	X	X	X	X	X
Willows Stn															X						X	X	X	X
Woodland Stn															X									
Yosemite NP															X		X				X	X	X	X
Yosemite Village Stn	X	X																	X					
Yreka Stn															X									
Yuba City Stn	X					X		X		X					X						X		X	X

NOYS = total nitrogen species except nitric acid

Table 2-5. List of upper-air meteorology sites and instruments found in the CCOS subset of the CCAQS database. Expected data not found are marked with M and highlighted in yellow. Additional sites marked X (pink) were not expected based on study plans.

Site	RWP	RASS	SODAR	Radiosonde	NEXRAD	Ozonesonde
Arbuckle	X	X				
Angel's Camp			M			
Angiola	X	X	X			
N of Auburn, S of Grass Valley	X	X				
Bakersfield	X	X				
Beale AFB					M	
Bodega Bay	X	X				
Carizo Plain	X	M	X			
Chico	X	X				
Corning	M	M				
Dublin			X			
Edison	M	M				
Edwards AFB				M	M	
Fresno Air Terminal	X	X	X			
Fresno- First Street				M		
Goleta	X	X				
Granite Bay						X
Hanford					M	
Humboldt County					M	
Huron	M	M				
Lagrange	M	M				
Lemoore	X	X				
Livingston	M	M	M			
Livermore	X	X	X			
Los Banos	X	X				
Lost Hills	X	X				
Mojave Desert	X	X				
Monterey	X	X				
Moss Landing	M	M				
Mouth Kings River	M	M				
New Melones Lake			X			
Oakland				M		
Orange County					M	
Parlier						X
Pittsburg	M	M				
Plesant Grove	X	X				
Point Mugu USN				M		
Pt. Reyes	M	M				
Redding	X	X				
Reno NWS				M		
Richmond	X	X	X			
Sacramento ARB	X	X		M		
Sacramento NWS					M	
San Martin	X	X				
Santa Clara					M	
Santa Nella	M	M				
Shasta						
Stevenson	X	X				
Sunol			X			
Tracy	X	X				
Travis AFB	X	X	M			
Trimmer	X	X				
Tuscan Buttes			X			
Vandenberg AFB				M		
Vandenberg - Orcutt Oil field					M	
Ventura County					M	
Visalia	X	X				
Washoe County					M	
Waterford	X	X	X			

Table 2-6. List of aircraft and parameters found in the CCOS subset of the CCAQS database. Data found in the archive are marked X. Expected data not found are marked M and highlighted in yellow. Additional data in the archive, but not expected based on study plans, are marked X and highlighted in pink.

Aircraft/ Parameter	UCD Cessna 172RG	UCD Cessna 182	STI Piper Aztec	STI Cessna 182	PNNL Gulfstream 160[a]	TVA Havilland Twin Otter
Temperature	X	X	X	X	X	X
Humidity	X	X	X	X	M	X
Dew point			X		X	
Wind speed	X	X	X	X	X	
Wind direction	X	X	X	X	X	
Pressure	X	X	X	X	X	X
Radiation			X		X	M
Position	X	X	X	X	X	X
Altitude	X	X	X	X	X	X
O_3 concentration	X	X	X	X	X	X
NO/NO_y concentration	X	X	X	X		X
CO			X		M	X
CO_2						M
Carbonyl compounds	M	M	X	X		M
Hydrocarbons	M	M	X	X	M	M
VOC samples			X	X		

[a] The PNNL Gulfstream 160 aircraft flew only on July 8, 2000.

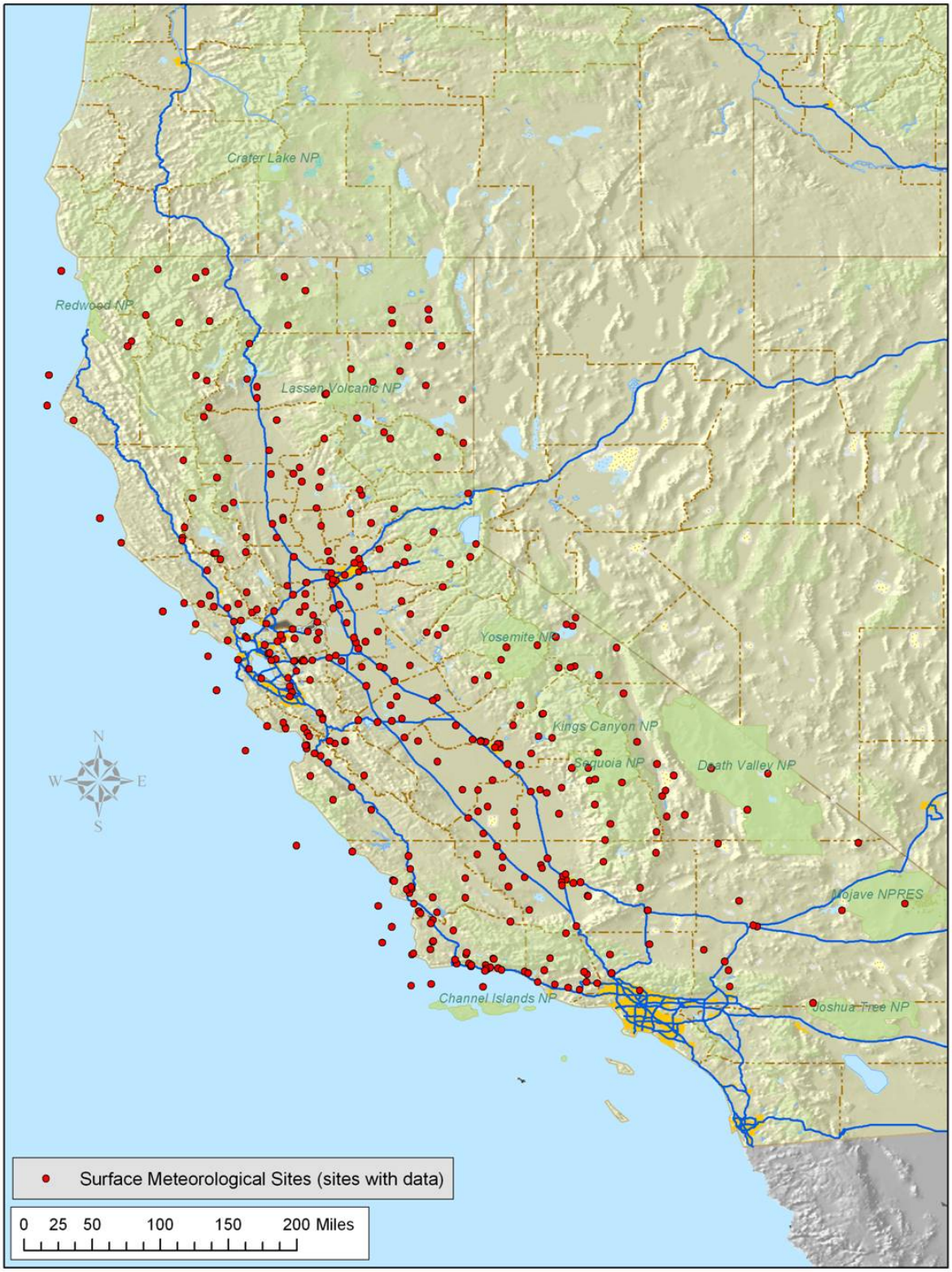


Figure 2-1. Map of sites reporting surface meteorological data found in the database.

Figure 2-2. Map of sites reporting upper-air meteorological data found in the database.

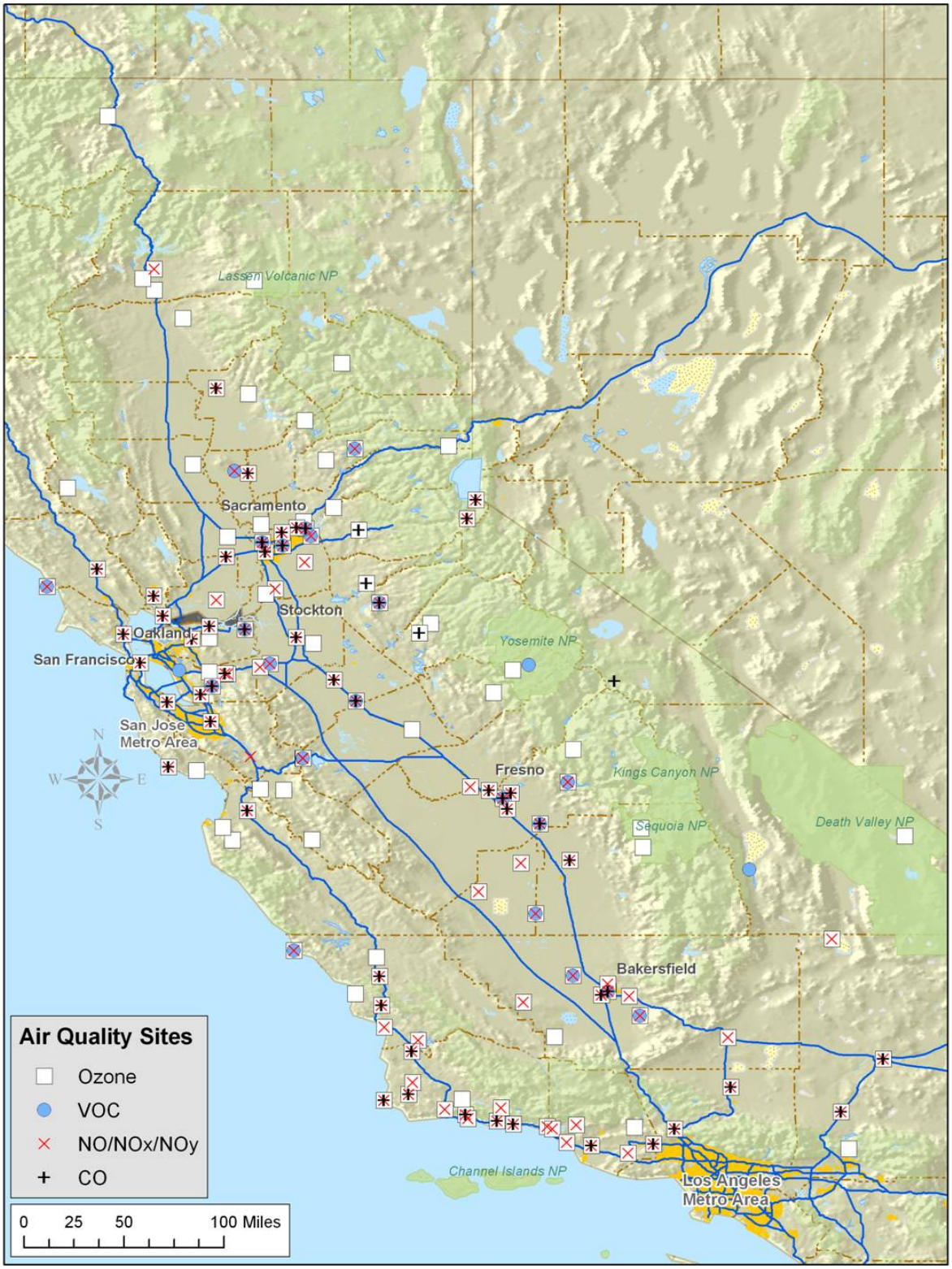


Figure 2-3. Map of sites reporting air quality data found in the database.

2.2 METEOROLOGICAL DATA

This section discusses the results of the inventory of surface and aloft meteorological data residing in the CCOS subset of the CCAQS database.

2.2.1 Surface Meteorological Data

The surface meteorological parameters that were inventoried include temperature, wind direction, wind speed, and relative humidity. The expected versus available surface meteorological data were checked by site and parameter. Field study planning documents listed 41 CCOS-sponsored sites expected to report meteorological data. Of these 41 sites, 36 reported data. In addition to these sites, about 400 sites sponsored by other agencies reported meteorological data in the database. These additional sites are identified in the inventory spreadsheet included in the EDV described in Appendix B. **Table 2-7** lists the sites at which surface meteorological data were expected, but not found, in the database. **Figures 2-4 through 2-7** show the locations of all expected sites reporting data, expected sites without data, and additional sites reporting data not listed in study planning documents.

2.2.2 Aloft Meteorological Data

Aloft meteorological measurements that were inventoried include wind speed, wind direction, and u- and v-wind components from RWPs, T_v from RASS, and wind speed, wind direction, and u-, v-, and w-wind components from SODARs, and data from radiosondes, ozonesondes, and NEXRAD systems. The specific parameters expected from these instruments were not listed in CCOS documentation. Similar to the surface meteorology data, the expected upper-air meteorology data were compared to actual data by site and instrument.

The field study summary listed 28 CCOS-sponsored RWP sites, 26 of which also had a RASS. Of these sites, 16 are present in the archive. An additional 10 RWP and RASS sites not shown in planning documents reside in the final archive:

- Six of the 10 RWP/RASS sites are believed to have been planned changes from those listed in the original planning documents. The additional RWP and RASS sites are shown, along with the nearest listed site where applicable, in **Table 2-8**.
- Two of the 10 sites are inconsistently named (e.g., Mouth of King's River in the study plan is called Trimmer in the database); site operators were contacted to confirm this inconsistency.
- Two of the 10 additional sites—Redding and Goleta—are believed to be true additional sites. They do not appear to be substitutes for any sites that could not be found in the database.
- Two other sites (Pittsburg and Moss Landing) were expected, but no data from these sites were found in the archive. There do not appear to be any substitute sites for these two locations.

Table 2-7. Expected surface meteorology sites not found in the CCOS data set.

Surface Meteorology Site	Comments
Camp Parks	Possibly labeled "Livermore-Dublin"
Camp Roberts	M
Lake Chabot	Possibly labeled "Chabot Stn"
Lambie Road	M
Red Hills	M
San Jose Stn (4th St)	M
Sutter Buttes	M

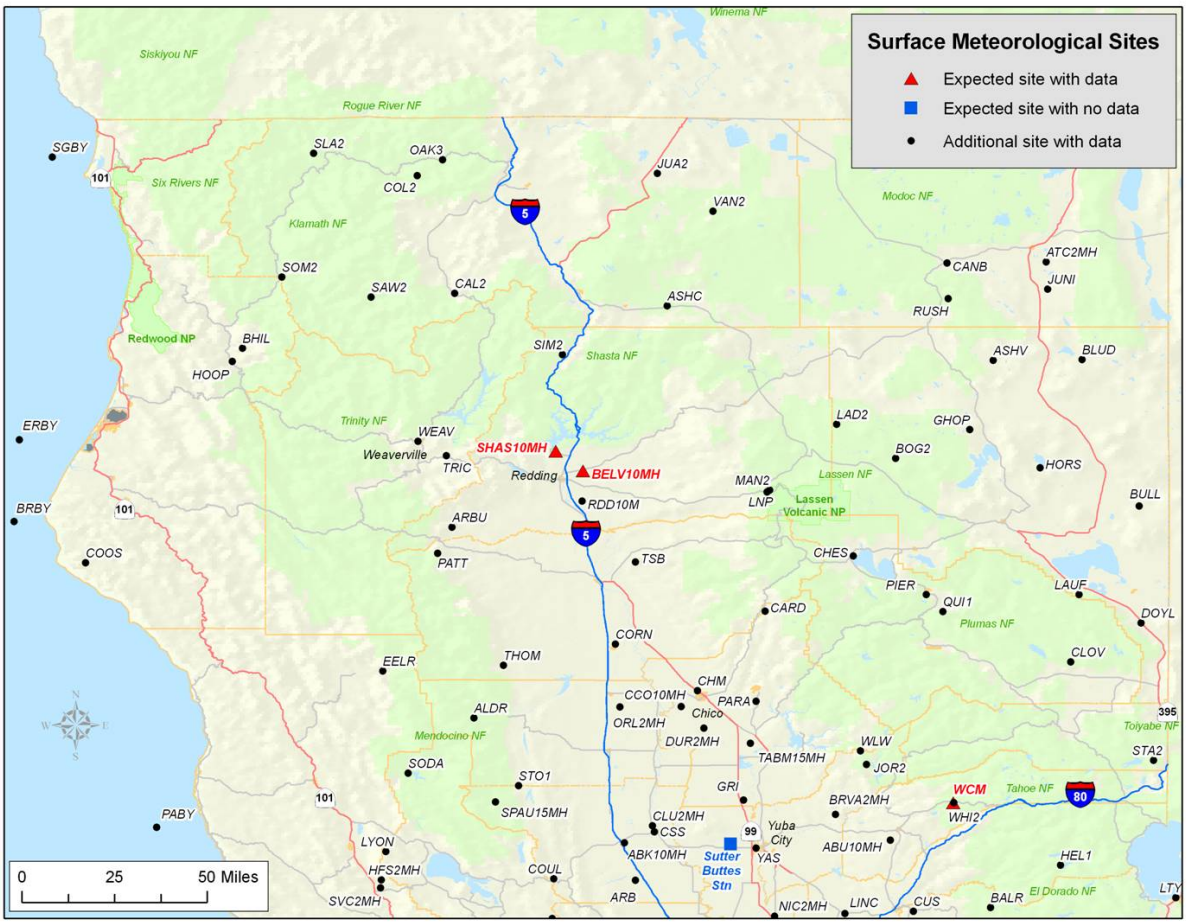


Figure 2-4. Surface meteorological sites in northern California reporting data found in the CCOS subset of the CCAQS database. Expected CCOS-sponsored sites reporting data are identified by red triangles, expected CCOS-sponsored sites from which no data were available are identified by blue squares, and additional sites reporting data are identified by black dots.

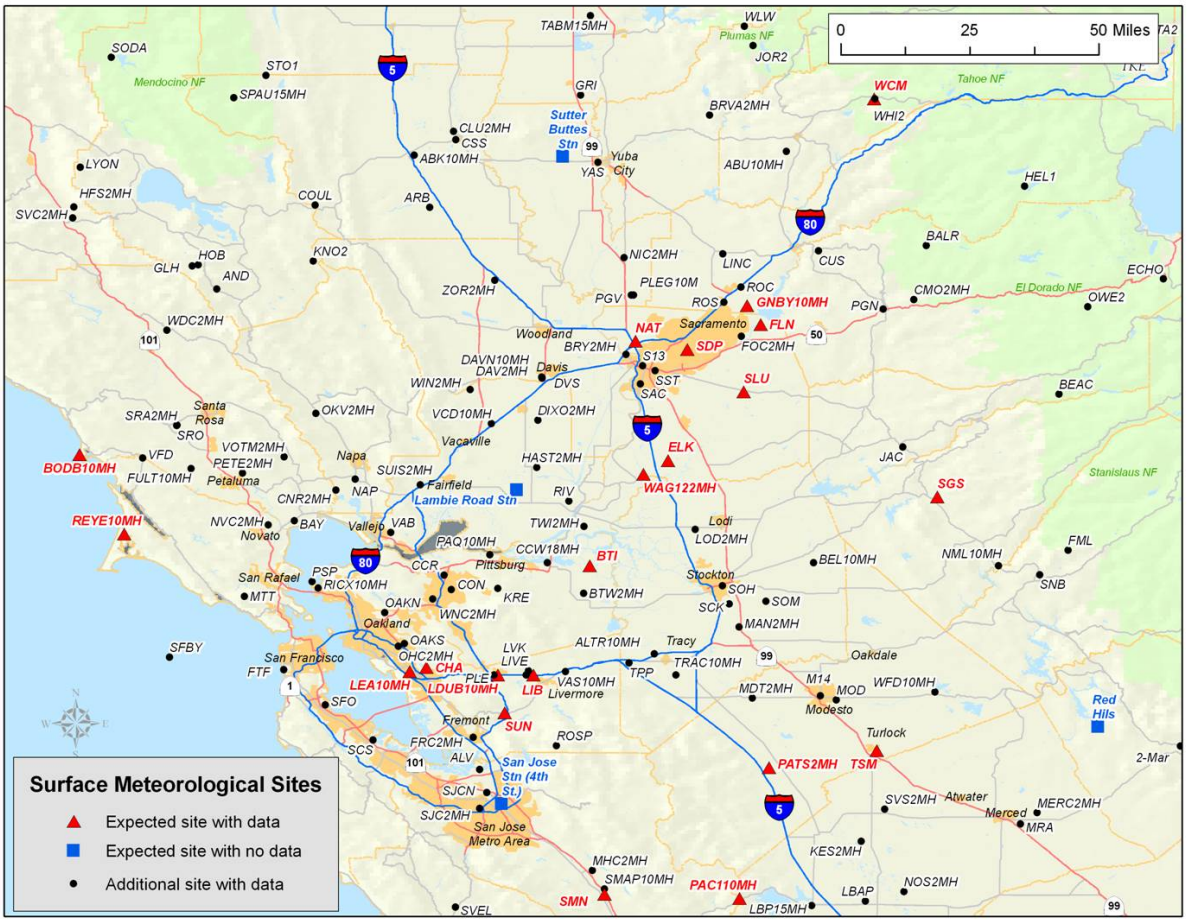


Figure 2-5. Surface meteorological sites in north-central California reporting data found in the CCOS subset of the CCAQS database. Expected CCOS-sponsored sites reporting data are identified by red triangles, expected CCOS-sponsored sites from which no data were available are identified by blue squares, and additional sites reporting data are identified by black dots.

Figure 2-6. Surface meteorological sites in central California reporting data found in the CCOS subset of the CCAQS database. Expected CCOS-sponsored sites reporting data are identified by red triangles, expected CCOS-sponsored sites from which no data were available are identified by blue squares, and additional sites reporting data are identified by black dots.

Figure 2-7. Surface meteorological sites in south-central California reporting data found in the CCOS subset of the CCAQS database. Expected CCOS-sponsored sites reporting data are identified by red triangles, expected CCOS-sponsored sites from which no data were available are identified by blue squares, and additional sites reporting data are identified by black dots.

Table 2-8. Additional RWP and RASS sites and the associated original expected site.

Site Not Listed in the Summary of Field Operations (Fujita et al., 2001)	Expected Site in the Summary of Field Operations (Fujita et al., 2001)	Comment	Site Operator Confirmation
Chico	Corning	Planned site move	Clark King (NOAA)
Bakersfield	Edison	Naming inconsistency	Clark King (NOAA)
Lemoore	Huron	Believed planned site move	No confirmation
Waterford	La Grange	Planned site move	Clark King (NOAA)
Stevinson	Livingston	Planned site move	Clark King (NOAA)
Bodega Bay	Pt. Reyes	Planned site move	Clinton MacDonald (STI)
Los Banos	Santa Nella	Believed planned site move	No confirmation
Trimmer	Mouth of King's River	Naming inconsistency	Clark King (NOAA)
Goleta	–	–	–
Redding	–	–	–

The study documentation lists seven SODAR sites. Of these seven sites, four reported data. In addition to these four sites, six sites not originally expected in the database reported SODAR data. Two of these additional sites were located near an expected site that did not report data, and the site operator confirmed the planned site moves. **Table 2-9** shows these additional SODAR sites and the nearest listed site where applicable. Note that at one site, Tuscan Buttes, SODAR data found in the database actually appear to be surface wind data—they are at one height only and are labeled as surface meteorology data. A map of all upper-air sites, including the CCOS-sponsored sites reporting data, listed CCOS-sponsored sites for which no data were found, and additional sites, are shown in **Figure 2-8**.

Table 2-9. Additional SODAR sites found and the nearest original expected site.

Site Not Listed in the Summary of Field Operations (Fujita et al., 2001)	Nearest Expected Site in the Summary of Field Operations (Fujita et al., 2001)	Comment	Site Operator Confirmation
Waterford	Livingston	–	–
Fresno Air Terminal	–	–	–
New Melones Lake	Angel's Camp	Planned site move	Clark King (NOAA)
Dublin	–	–	–
Sunol	–	–	–
Tuscan Buttes	–	Surface winds only	–
Livermore	–	–	–

Figure 2-8. Upper-air meteorological sites in northern California reporting data found in the CCOS subset of the CCAQS database. Expected CCOS-sponsored sites reporting data are identified by red triangles, expected CCOS-sponsored sites from which no data were available are identified by blue squares, and additional sites reporting data are identified by black dots.

Data for 7 expected radiosonde and 10 expected NEXRAD sites are missing in the database. **Table 2-10** summarizes the missing aloft meteorological data by instrument type.

Table 2-10. Sites expected to report aloft meteorological data but no data were reported.

Instrument Type	Site	Operator
RWP	Pittsburg	PG&E
RWP	Moss Landing	PG&E
RASS	Carrizo Plain	CCOS
RASS	Pittsburg	PG&E
RASS	Moss Landing	PG&E
SODAR	Livingston	NOAA
SODAR	Travis AFB	USAF
NEXRAD	Beale AFB	USAF
NEXRAD	Humboldt County	NWS
NEXRAD	Sacramento	NWS
NEXRAD	Edwards AFB	USAF
NEXRAD	Hanford	NWS
NEXRAD	Santa Clara	NWS
NEXRAD	Washoe County	NWS
NEXRAD	Orange County	NWS
NEXRAD	Vandenberg AFB	USAF
NEXRAD	Ventura County	NWS
Radiosonde	Edwards AFB	USAF
Radiosonde	Fresno – First Street	CCOS
Radiosonde	Point Mugu USN	USN
Radiosonde	Oakland	NWS
Radiosonde	Reno	NWS
Radiosonde	Sacramento	ARB
Radiosonde	Vandenberg AFB	USAF

ARB = California Air Resources Board
CCOS = Central California Ozone Study
NOAA = National Oceanic and Atmospheric Administration
NWS = National Weather Service
PG & E = Pacific Gas & Electric
USAF = U.S. Air Force
USN = U.S. Navy

2.3 SURFACE AIR QUALITY DATA

The air quality parameters that were inventoried include O_3, CO, CO_2, HNO_3, NO, NO_x, NO_y, NO_2, and VOCs. The expected versus available air quality data were checked by site and parameter. Field study planning documents listed 41 CCOS-sponsored sites expected to report air quality data. Of these 41 sites, 37 reported at least one parameter of expected data. Twenty of the 41 sites reported all expected parameters. In addition to these sites, about 100 sites sponsored by other agencies reported air quality data in the database. The additional sites are

shown in pink in Table 2-4. A map of all air quality sites, including sites reporting expected data and additional sites reporting data, are shown in **Figures 2-9, 2-10, and 2-11**. **Table 2-11** summarizes pollutant data missing from the sites. Data from the two ozonesonde sites at Parlier and Granite Bay were expected and found in the archive. Four sites listed in the field study documents but not found in the database were Camp Roberts, Lake Chabot, Red Hills, and Shasta Lake.

Based on PAMS documentation, nine PAMS sites were expected to collect VOC data. These sites were located at Arvin, Bakersfield, Folsom, Fresno, Madera, Parlier, Sacramento-Del Paso Manor, Sacramento-Natomas, and Shafter. Data from all sites, except Madera, were reported in the database. However, it appears that only the Parlier site provided regular PAMS VOC data; the remaining seven sites reported only special (i.e., intensive operating period [IOP]) data in the database.

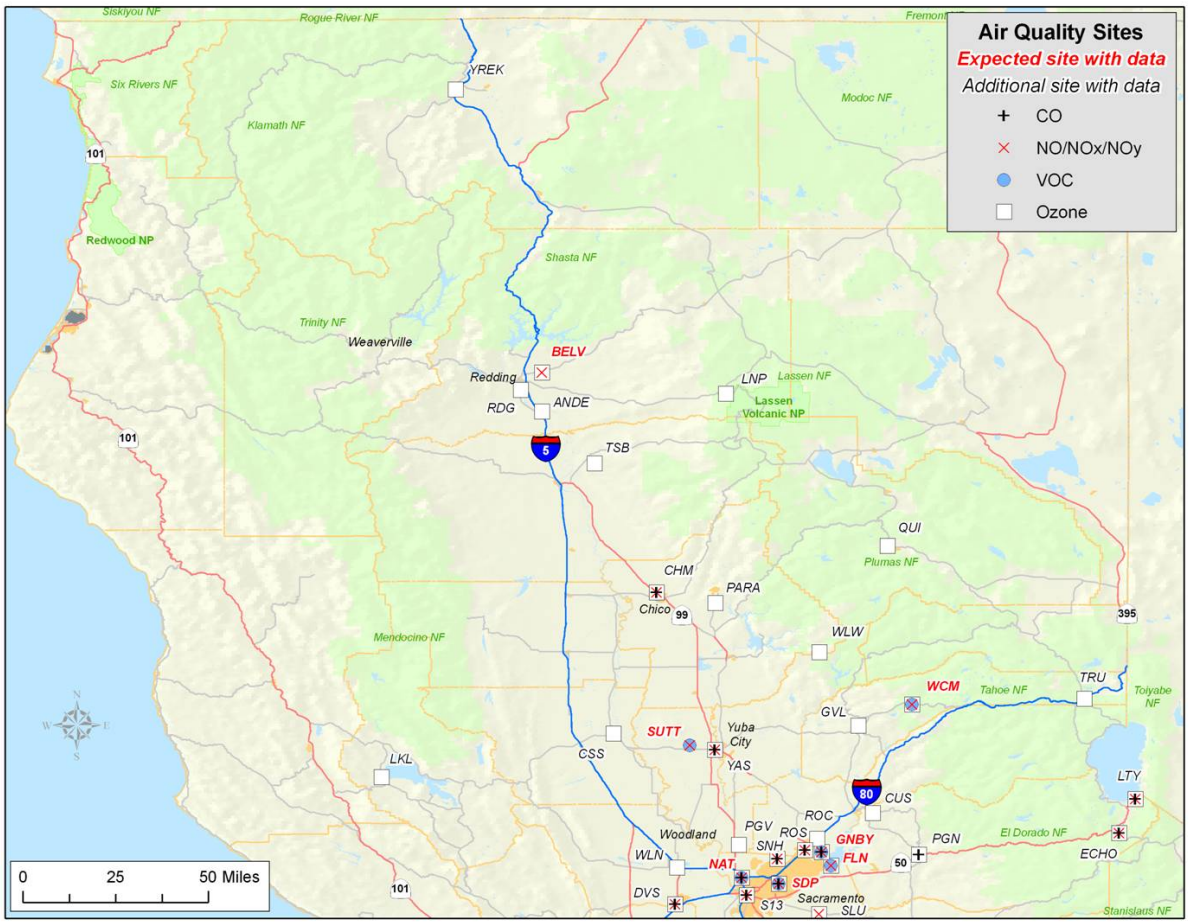


Figure 2-9. Air quality sites in northern California reporting data found in the CCOS subset of the CCAQS database. Expected CCOS-sponsored sites reporting data are denoted in red and additional sites reporting data are denoted in black.

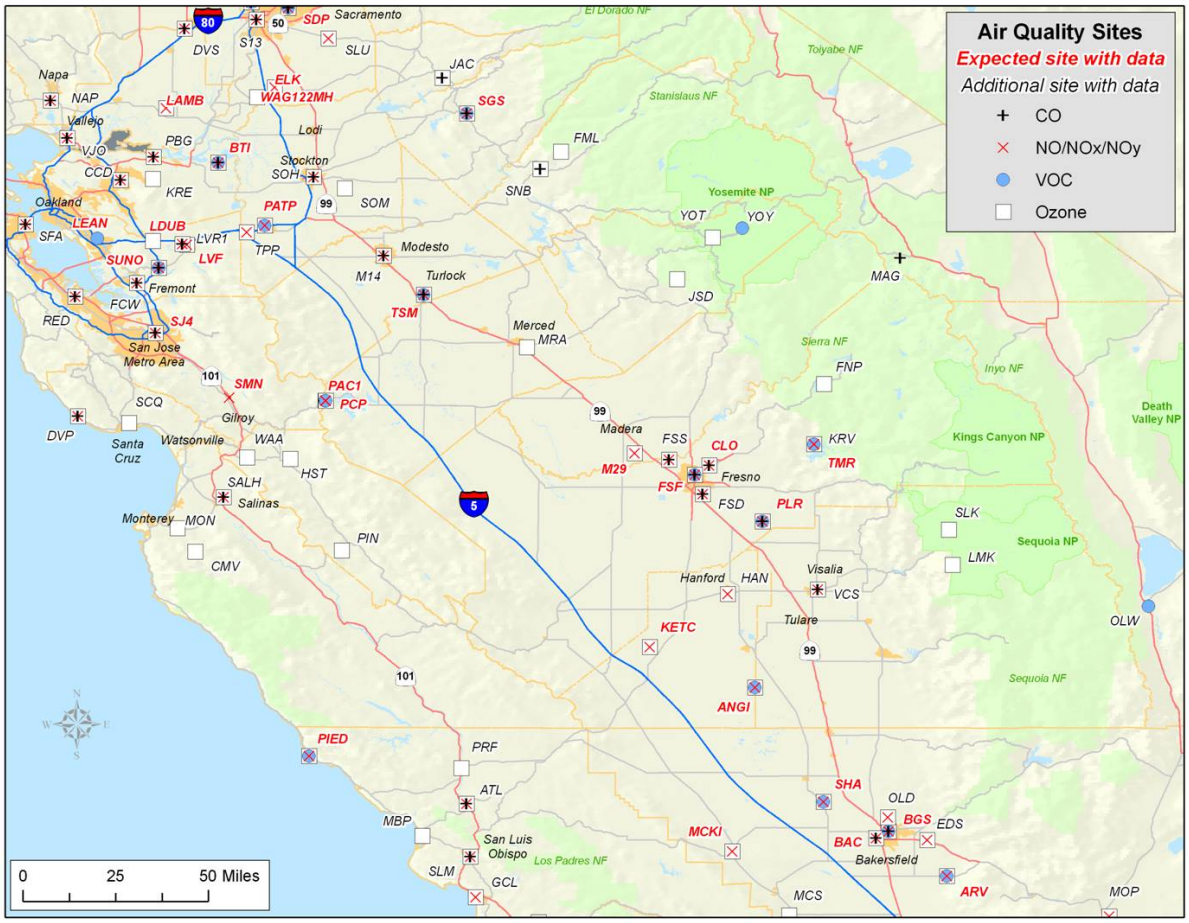


Figure 2-10. Air quality sites in central California reporting data found in the CCOS subset of the CCAQS database. Expected CCOS-sponsored sites reporting data are denoted in red and additional sites reporting data are denoted in black.

Figure 2-11. Air quality sites in southern California reporting data found in the CCOS subset of the CCAQS database. Expected CCOS-sponsored sites reporting data are denoted in red and additional sites reporting data are denoted in black.

Table 2-11. Air quality pollutant data missing (M) from the expected sites.

Site	CO	CO_2	HNO_3	NO	NO_2	NO_x	NO_y	O_3	VOC
Arvin	M	M							
Bakersfield (California Ave.)									M
Bethel Island						M			
Camp Roberts [a]								M	
Chabot [a]				M			M	M	
Clovis									M
Elk Grove (Bruceville)	M	M							M
Granite Bay			M		M				
Livermore – Old First St						M	M		
Red Hills [a]				M			M	M	
San Jose – 4th St.		M				M			
San Leandro				M	M	M		M	
San Martin								M	
Shasta Lake [a]				M	M	M	M	M	
Sloughhouse	M	M	M		M	M			
Sunol			M						
Sutter Buttes								M	
Walnut Grove				M	M	M	M		

[a] Denotes site where expected data were not found.

2.4 AIRCRAFT DATA

The aircraft data air quality parameters that were inventoried include O_3, NO/NO_y, CO, CO_2, carbonyl compounds, hydrocarbons, and VOCs. The meteorological parameters collected by aircraft that were inventoried include temperature, dew point temperature, relative humidity, wind speed, wind direction, and radiation. The expected versus available data were checked by aircraft and parameter. Field study planning documents listed six CCOS-sponsored aircraft expected to report air quality and meteorology data. All expected O_3, NO/NO_y, VOC, and temperature data were found in the database. In addition, all aircraft reported either dew point temperature or relative humidity. Of the six aircraft from which hydrocarbon data were expected and the five aircraft from which carbonyl compound data were expected, only the two aircraft reported hydrocarbon and carbonyl compound data. The missing parameters listed by aircraft are summarized in Table 2-6.

3. SUMMARY OF PRIOR QA/QC

Thorough understanding of the quality of the CCOS data, the QA/QC procedures, and associated documentation is vital for data analysts and modelers using the data. The CCOS field study documentation defined the required QC levels for data submittals to the CCAQS databases. All reporting agencies and contractors were expected to perform Level 0 validation prior to initial data submittal (raw data). Data validated to Level 1 should have been re-submitted subsequently. A search for documentation of QA or QC for the CCOS data was performed but the only reports identified were those submitted to ARB by STI for its aircraft and anchor site data (Buhr et al., 2002; Wittig et al., 2003).

Another objective of this overall review of prior QA/QC was to determine if any Level 2- or Level 3-validated data may have been available from data analysts and modelers who accessed and used the data (although resubmittal of these data to the CCAQS databases was not required). To achieve this objective, documentation of data validation efforts was reviewed; data users were queried about their experiences using the CCAQS databases; and the QC codes, data validation levels, and dates of submittal of selected data sets were checked.

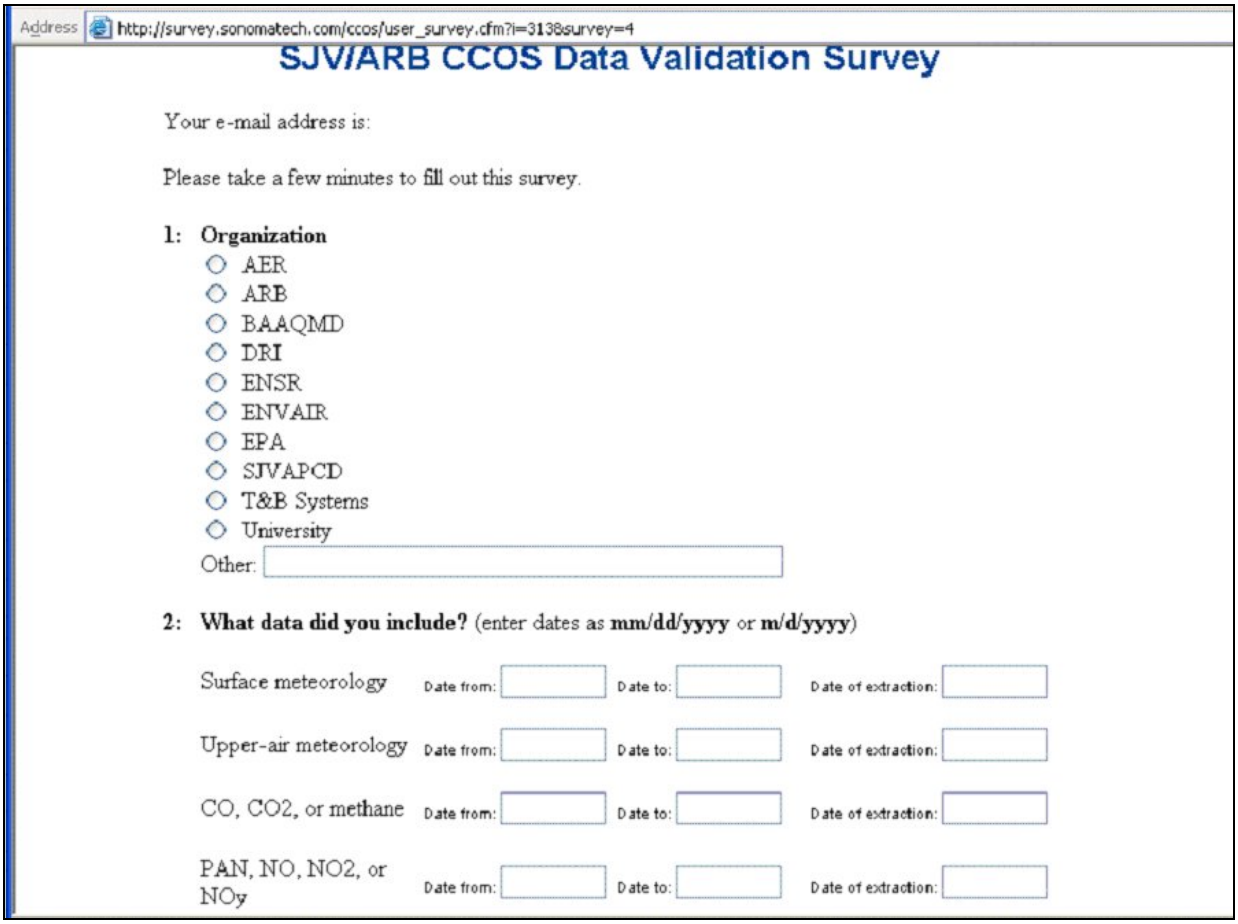
3.1 IDENTIFICATION OF EXTRA DATA VALIDATION EFFORTS

A contact list of individuals who accessed the CCAQS database or who were key researchers in the CCOS field study was assembled with the assistance of the ARB. The contact list included CCAQS database users who requested O_3, O_3 precursor, and meteorological data prior to March 1, 2005, and key researchers listed in the title pages of the CCOS Field Study Plan (Fujita et al., 1999). The contact list comprised 70 individuals from 20 organizations. Each individual was contacted via e-mail and asked to complete an on-line survey (illustrated in **Figures 3-1, 3-2, and 3-4**). Information buttons provided additional wording to describe the information needed from the participants (see **Figure 3-3**). Survey responses were automatically stored in a database for summary and review.

Despite repeated reminders via e-mail and personal contact, the voluntary survey response rate was poor with less than 20% of the potential responses. Those who did respond provided the following information:

- Several respondents reported that they did not perform any validation of the CCOS data that they had acquired.
- Two respondents stated that they used the extracted data for episode/case study analyses, modeling, and summary statistics.
- One respondent noted apparent data gaps, but was not specific about the nature or extent of the gaps, or which pollutants were affected.
- Don Lehrman of Technical & Business Systems (T&B) mentioned that T&B previously reported issues with RWP-derived mixing heights and indicated specific levels of confidence in the mixing heights for specific RWP sites.

- Additional documentation of validation procedures was provided by Wendy Goliff of the Desert Research Institute (DRI) and Rei Rasmussen of the Biospherics Research Corporation (BRC) for the VOC samples collected for CCOS by DRI and BRC.[1]
- John Bowen (DRI) reported that DRI's data validation steps for continuous air pollutant data were not formally documented.
- Respondents generally stated that they used the CCAQS QC flags as defined in the database documentation.
- Jim Wilczak (NOAA) reported that NOAA staff (1) objectively quality-controlled all the data for which they were responsible and submitted the quality-controlled data to the CCAQS database; (2) subjectively quality-controlled data from two IOPs and submitted the quality-controlled data to the CCAQS database; and (3) are currently performing subjective QC of the remainder of the summertime RWP wind and RASS T_v data and expect to resubmit the data to the CCAQS database.


Address http://survey.sonomatech.com/ccos/user_survey.cfm?i=3138survey=4

SJV/ARB CCOS Data Validation Survey

Your e-mail address is:

Please take a few minutes to fill out this survey.

1: **Organization**
- AER
- ARB
- BAAQMD
- DRI
- ENSR
- ENVAIR
- EPA
- SJVAPCD
- T&B Systems
- University

Other:

2: **What data did you include?** (enter dates as **mm/dd/yyyy** or **m/d/yyyy**)

Surface meteorology	Date from:	Date to:	Date of extraction:
Upper-air meteorology	Date from:	Date to:	Date of extraction:
CO, CO2, or methane	Date from:	Date to:	Date of extraction:
PAN, NO, NO2, or NOy	Date from:	Date to:	Date of extraction:

Figure 3-1. On-line survey of CCOS key researchers and CCAQS database users, page 1.

[1] The original BRC documentation was incomplete due its author's unexpected death.

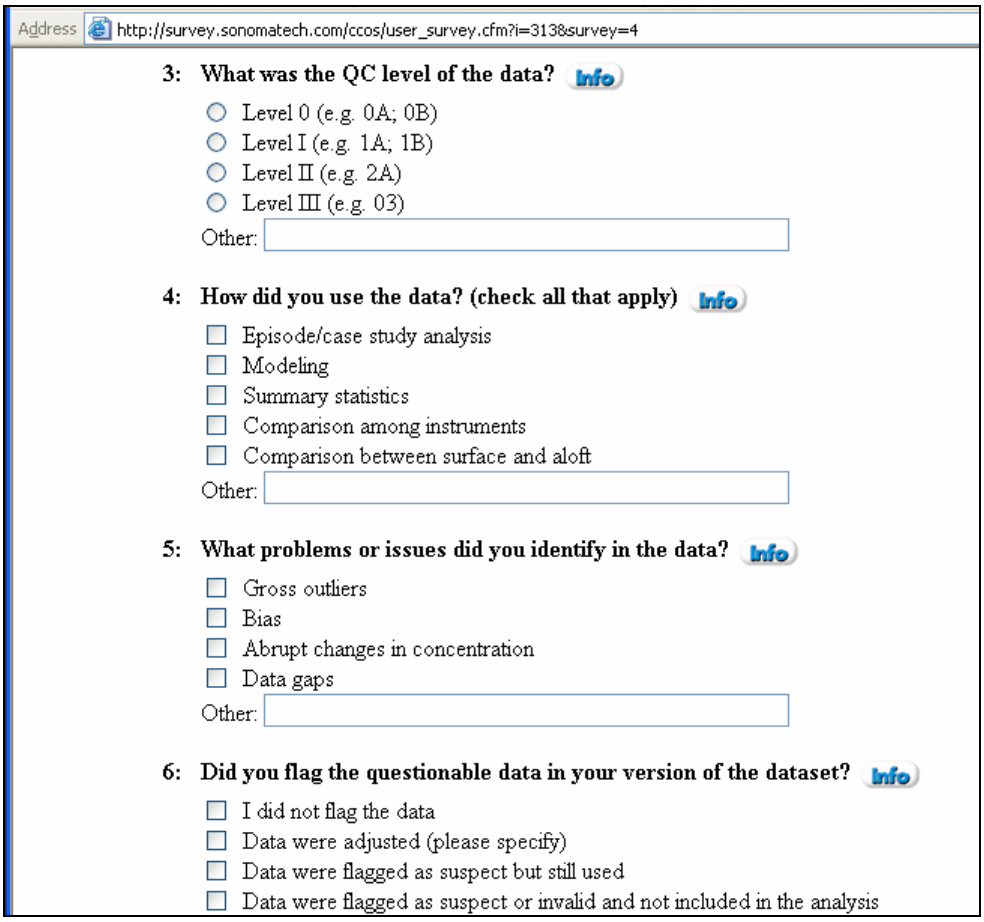


Figure 3-2. On-line survey of CCOS key researchers and CCAQS database users, page 2.

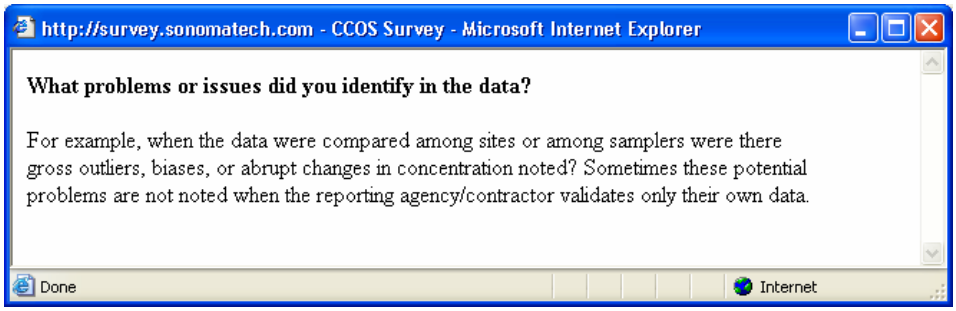
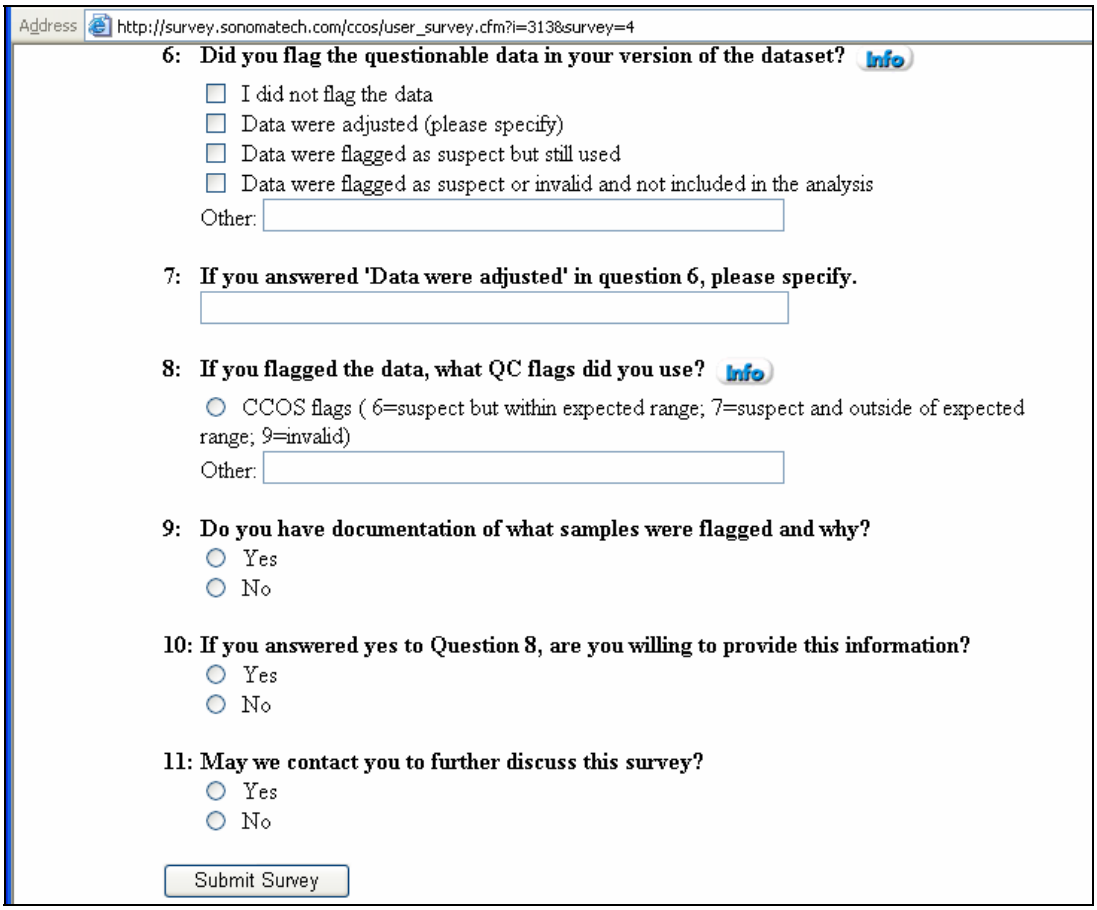


Figure 3-3. Example of on-line help available from the information buttons of the on-line survey.



Address http://survey.sonomatech.com/ccos/user_survey.cfm?i=313&survey=4

6: Did you flag the questionable data in your version of the dataset? Info

- ☐ I did not flag the data
- ☐ Data were adjusted (please specify)
- ☐ Data were flagged as suspect but still used
- ☐ Data were flagged as suspect or invalid and not included in the analysis

Other:

7: If you answered 'Data were adjusted' in question 6, please specify.

8: If you flagged the data, what QC flags did you use? Info

- ○ CCOS flags (6=suspect but within expected range; 7=suspect and outside of expected range; 9=invalid)

Other:

9: Do you have documentation of what samples were flagged and why?

- ○ Yes
- ○ No

10: If you answered yes to Question 8, are you willing to provide this information?

- ○ Yes
- ○ No

11: May we contact you to further discuss this survey?

- ○ Yes
- ○ No

Submit Survey

Figure 3-4. On-line survey of CCOS key researchers and CCAQS database users, page 3.

3.2 SUMMARY

In summary, documentation of data validation steps was not readily available for much of the CCOS data submitted to the CCAQS databases. Survey responders indicated that they believed the CCAQS databases already contained the most highly quality-assured/quality-controlled CCOS data available; therefore, no additional efforts perform Level 2 or Level 3 validation was performed and thus no additional quality-controlled data sets should be incorporated into the CCAQS archive with the exception of the subjective QC of the remainder of the summertime RWP winds and RASS T_v currently being completed by NOAA for resubmission to the CCAQS database in early fall 2005.

4. AUTOMATED DATA VALIDATION

4.1 OVERVIEW

The objective of the automated data validation task was to identify and flag gross data outliers for O_3, its precursors, and meteorological data collected during the CCOS period. The purposes of undertaking this task were to (1) identify and flag "suspect" data in the CCAQS database and (2) prepare the quality-assured data for resubmission into the CCAQS database. For this task, we defined "suspect" as data that do not fit the expected normal physical, spatial, and temporal characteristics of the parameter. **Table 4-1** provides a summary of the types of automated data checks that the entire CCOS period (June 1–September 30, 2000) data were subjected to by STI.

STI's approach to performing this task comprised four steps:

1. Define meaningful QC checks using measurement expert guidance.
2. Use our in-house database experts and QC software tools to create algorithms to automatically and efficiently perform the checks and to flag gross outliers.
3. Create new data flags to identify what specific QC check(s) the data failed, if any. Set all data run through the gross check to QC Level 1C as directed by ARB.
4. Review results, identify particularly problematic data sets, and discuss remediation options with the ARB.
5. Prepare the selected data sets for resubmission into the CCAQS database.

Overall, results were excellent, especially for surface air quality data. More than 98% of all the data passed the automated QC checks. Of the small percentage of points that failed the gross checks, most failed because the nomenclature was inconsistent or the stringency of the automated check caused an otherwise valid data point to be flagged suspect. The most common reasons for flagging data as suspect were (1) coastal meteorological sites failing the sticking check for relative humidity, temperature, and/or dew point temperature under foggy conditions; (2) rural air quality sites failing the sticking check for low CO values; and (3) sites failing maximum check and sticking check for missing data labeled "999", which does not conform to database standards of "-999" or "NULL".

Table 4-1. Summary of the types of automatic data checks applied to the CCOS data.

Check	Description	Parameter(s)
Range: Check of maximum values by site and sampling period.	If [parameter] > maximum or < minimum, then parameter is flagged as a gross outlier.	O_3, O_3 precursors, surface and aloft meteorology
Buddy: Comparison of a data value to an average value of surrounding stations with similar monitoring environment (urban, rural, etc.).	If [parameter–Buddy] > criteria, then parameter is flagged as suspect. If the value being checked is not within the user-specified range (typically 20-40 ppb for ozone) of the Buddy value average, the data are flagged as suspect. A minimum number of Buddy sites (typically two to four are defined) are necessary for the check to be performed.	O_3, O_3 precursors, surface meteorology
Rate of Change: Typically applied to continuous data—compares the rate of change in parameter from one hour to the next; when the difference (or change) exceeds criteria set for each hour and for each site, the data are flagged as suspect.	If [parameter(hr x) – parameter(hr x-1)] > criteria, then parameter is flagged as suspect.	O_3, O_3 precursors, surface and aloft meteorology
Sticking: Check to determine whether values remain unchanged for a specified number of sampling periods. The check can be tailored for specified time periods. For example, ozone values below X ppb (typically 40 ppb) often remain at a fixed value during overnight hours and thus will not be checked.	If [parameter] < X, then sticking check not applied. If [parameter] > X and Y continuous hours (typically 3) occur with no change in value, then parameter value is flagged as suspect.	O_3, O_3 precursors, surface meteorology
Species Consistency: Check to determine consistency between species by checking ratios and sum of species	Checks include the following expectations (if not met, flag as suspect): $NO_x \geq NO + NO_2$ $NO_y \geq NO_x$ Total VOC ≥ sum of identified VOCs Typically abundant VOCs present above detection (e.g., toluene, ethane, i-pentane)	O_3 precursors

4.2 APPROACH

Overall, the approach was to create algorithms to automatically and efficiently perform the checks and to flag gross outliers; initialize an STI QC flag field with flags set to valid; compare STI flags to original flags; only "worsen" these original flags with our actions; and keep a log of changes.

The first step was to define QC checks for the species of interest. The meteorology and air quality species most relevant to air quality analyses and modeling were measured at most sites in the database. These species include temperature, relative humidity and/or dew point temperature, and wind speed and direction for meteorology data, and O_3, CO, CO_2, oxides of nitrogen (NO, NO_x and NO_y), HNO_3, formaldehyde, and hydrogen peroxide for air quality data.

Some additional species were collected at a few selected sites, and were not subjected to automated QC. VOC measurements are a good example of these additional measurements. VOC data were not checked as part of the automated checking procedure, but instead were subjected to a manual data validation procedure. Aircraft data were not checked as part of this automated QC but were subjected to both automated and/or manual review in the detailed QC discussed in Sections 5.3 and 5.4.

The thresholds applied during the automated QC checks are listed in **Table 4-2**. The checks are designed to identify gross outliers by analyzing the data from spatial, temporal, chemical, and physical perspectives. Some variation in applications of the automated checking procedures was applied. For example, not all sites had a buddy site with which to compare data values. In addition, allowances were made for differences between urban and rural sites and time ranges. For example, the trigger for maximum NO_x concentrations at a rural site was 300 ppb, while the trigger for maximum NO_x concentrations at an urban site was 700 ppb. Similarly, solar radiation was triggered if it exceeded 2 watts/m^2 at night.

While these automated QC checks were designed to identify the most serious data problems, they cannot detect more subtle problems in the data. For example, they cannot identify improper time zones (i.e., PST versus PDT), errors in site locations, or small biases in data values. These types of issues must be addressed during the QA tasks that should be performed prior to importing the data into a database. However, because of the large number of sources of data used to compile the CCAQS/CCOS database and the lack of QA documentation, it is uncertain if these types of problems can be remediated after the fact without considerable additional effort.

To automate the gross checks, we used Microsoft SQL Server queries. After the gross checks were defined, they were entered into a database table. An SQL Server-stored procedure used the defined gross checks for data validation, applied a data QC flag, logged data that failed the check, generated a QC note that identified why the data failed the check (e.g., failed maximum value check), and produced summary reports. QC note entries are shown in **Table 4-3**. Summary reports include how many points for each species were flagged as suspect at a given site for a given check. After the initial run, the summary reports were reviewed by measurement experts who then decided which criteria needed to be refined. This process was repeated until we were satisfied that minimal data were flagged incorrectly.

All data that were run through the gross outlier check were assigned a QC level of 1C for resubmission to the CCOS database. The gross outlier QC flag was only applied if it “worsened” the data. For example, if data were originally flagged invalid due to a site audit but the values passed the gross outlier check, the QC flag was left as invalid.

Table 4-2. Threshold data checks applied to the CCOS data.

Type	Parameter	Unit	Range Type	Range Hour1[a]	Range Hour2[a]	Range Max[b]	Range Min[b]	Rate of Change[c]	Sticking Apply To[b]	Sticking Hours Over	Sticking Start Hour[a]	Sticking End Hour[a]	Buddy Check	Buddy Within[b]
SFGAS	CO	ppm				15	0.07	10		8			N	
SFGAS	CO_2	ppm				1000	358	100		5			N	
SFGAS	H_2O_2	ppb				5	-1		>0.1	3			N	
SFGAS	HCHO	ppbC				20	-1		>1	3			N	
SFGAS	HNO_3	ppb				25	-1						N	
SFGAS	NO	ppb	Rural			300	-1	30	>5	3			Y	30
SFGAS	NO	ppb	Urban			700	-1	50	>5	3			Y	30
SFGAS	NO_2	ppb	Rural			300	-1	30	>5	3			N	
SFGAS	NO_2	ppb	Urban			700	-1	50	>5	3			N	
SFGAS	NO_X	ppb	Rural			300	-1	30	>5	3			Y	30
SFGAS	NO_X	ppb	Urban			700	-1	50	>5	3			Y	30
SFGAS	NO_Y	ppb	Rural			300	-1	30	>5	3			Y	30
SFGAS	NO_Y	ppb	Urban			700	-1	50	>5	3			Y	30
SFGAS	NOYS	ppb	Rural			300	-1	30	>5	3			Y	30
SFGAS	NOYS	ppb	Urban			700	-1	50	>5	3			Y	30
SFGAS	O_3	ppb				200	-5	50	>40	5	7	23	Y	40
SFMET	Air pressure	mb				1040	800	5		5			Y	30
SFMET	Temperature	Deg_C		0	7	50	0	10		3	8	20	Y	5
SFMET	Temperature	Deg_C		8	19	50	10	10		3	8	20	Y	5
SFMET	Temperature	Deg_C		20	23	50	0	10		3	8	20	Y	5
SFMET	Station pressure	mb				1040	770	5		5			Y	5
SFMET	Dew point temperature	Deg_C		0	7	26	0	10		3	8	20	Y	5
SFMET	Dew point temperature	Deg_C		8	19	50	0	10		3	8	20	Y	5
SFMET	Dew point temperature	Deg_C		20	23	26	0	10		3	8	20	Y	5
SFMET	Net radiation	W/m^2		0	5	50	-150			3			N	
SFMET	Net radiation	W/m^2		6	18	1200	-20			3			N	
SFMET	Net radiation	W/m^2		19	23	50	-150			3			N	
SFMET	Relative humidity	%				102	5		<99	3			Y	10
SFMET	Scalar wind speed	m/s				20	0			12			Y	10
SFMET	Total radiation	W/m^2		0	4	2	-2						N	
SFMET	Total radiation	W/m^2		7	18	1500	20			3	8	18	N	
SFMET	Total radiation	W/m^2		21	23	2	-2						N	
SFMET	Vector wind speed	m/s				20	0			12			Y	10
SFMET	Virtual temperature	Deg_C				45	0	5		3			Y	3
UPMET	Scalar wind speed	m/s				20	0	10		6			Y	5
UPMET	Scalar wind speed	m/s				30	0	10		6			Y	5
UPMET	Scalar wind speed	m/s				30	0	10		6			Y	5
UPMET	Scalar wind speed	m/s				40	0	10		6			Y	5
UPMET	Virtual temperature	Deg_C				45	0	5		3			Y	3

[a] Range Hour1, Range Hour2, Sticking Start Hour, and Sticking End Hour are hours of the day expressed in local standard time.
[b] Range Max, Range Min, Sticking Apply To, and Buddy Within are all expressed in the units shown for each species in the Unit column.
[c] Rate of Change is expressed in units per hour.

Table 4-3. QC note codes and descriptions.

Field Flag Code	Description
VIS	Visual inspection
MIN	Minimum value check – Is data value below a QC value?
MAX	Maximum value check – Is data value above a QC value?
RCT	Range check temporal – The difference between the current data value and the previous data value in a defined time period is greater than the QC allowed amount
STK	Sticking check – Data value has remained the same over a defined period of time
BUD	Buddy check – The difference between the current data value and the average data value of two or more related sites is greater than the QC allowed amount

4.3 RESULTS OF QC CHECKS

At the completion of the automated QC, more than 98% of the data remained valid. Of the small percentage of points that were flagged suspect, the majority were surface meteorology data. The surface air quality data performed very well in the gross outlier checks. Note, however, that even some data points flagged suspect by the automated QC checks were originally intended as "missing" but were coded incorrectly (i.e., missing data from many of the C-Man stations were entered as "999" instead of "NULL" or "-999" which are database standards). These points were flagged by the gross QC check for failing the maximum range check.

Rather than providing thousands of lines of output, **Table 4-4** lists only those site-parameter pairs in for which greater than 25% of the available data points have been flagged suspect. Table 4-4 provides those site-parameter combinations that failed a particular test often because the data truly are suspect, while **Table 4-5** provides similar results, but for those site-parameters that we believe are actually valid. The identification of valid data as suspect occurred mainly at coastal surface meteorology stations where temperature and dew point temperature would often have the same value for several hours or days under foggy conditions. We did not feel we could increase the sticking-check hour limit without potentially compromising the integrity of the test for non-coastal data. A complete summary by site and parameter that shows the number of points checked for each test and the number of points that failed that test is provided in the EDV described in Appendix B.

Table 4-4. Site-parameter listing of data that failed a particular gross outlier check at least 25% of the time.

Name	Site	Parameter	Test Failed	Explanation
Pt. Arena	AREN	Dew point temp. (DEW)	Max, Sticking	Missing DEW denoted as '999'
Pt. Arguello	ARGU	Dew point temp. (DEW)	Max, Sticking	Missing DEW denoted as '999'
Ash Creek	ASHV	Total radiation (TOT)	Max	TOT exceeds max range at night (2 w/m2)
Bakersfield	BAC	Total radiation (TOT)	Max	TOT exceeds max range at night (2 w/m2)
Bear Peak	BEAR	Total radiation (TOT)	Max	TOT exceeds max range at night (2 w/m2)
Santa Barbara	BEBY	Dew point temp. (DEW)	Max, Sticking	Missing DEW denoted as '999'
Bakersfield	BGS	Total radiation (TOT)	Min, Sticking	TOT stuck at 0
Blunts Reef	BRBY	Dew point temp. (DEW)	Max, Sticking	Missing DEW denoted as '999'
Branch Mountain	BRMR	Scalar wind speed (SCA)	Sticking	SCA stuck at 0
Callahan	CAL2	Scalar wind speed (SCA)	Sticking	SCA stuck at 0
San Martin	CSBY	Dew point temp. (DEW)	Max, Sticking	Missing DEW denoted as '999'
Cuyama	CUY2MH	Total radiation (TOT)	Min	TOT does not meet min range at night (-2 w/m2)
Doyle	DOYL	Total radiation (TOT)	Max	TOT exceeds max range at night (2 w/m2)
Echo Summit	ECHO	Station pressure (BST)	Sticking	BST stuck regularly
Eel River	ERBY	Dew point temp. (DEW)	Max, Sticking	Missing DEW denoted as '999'
Five Points	FIV2MH	Total radiation (TOT)	Min	TOT does not meet min range at night (-2 w/m2)
Folsom	FLN	Total radiation (TOT)	Max	TOT exceeds max range at night (2 w/m2)
Goleta	GNF	Station pressure (BST)	Sticking	BST stuck regularly
Green Valley	GVR2MH	Dew point temp. (DEW)	Min	DEW does not meet min range (0 °C)
Half Moon Bay	HMBY	Dew point temp. (DEW)	Max, Sticking	Missing DEW denoted as '999'
Horse Lake	HORS	Total radiation (TOT)	Max	TOT exceeds max range at night (2 w/m2)
Horse Lake	HORS	Total radiation (TOT)	Min	TOT stuck below 10 starting July 30, 2000
Jordan Creek	JOR2	Scalar wind speed (SCA)	Sticking	SCA stuck at 0-2
Juniper Creek	JUNI	Total radiation (TOT)	Max	TOT exceeds max range at night (2 w/m2)
South Lake Tahoe	LTY	Station pressure (BST)	Sticking	BST stuck regularly
Orland	ORL2MH	Dew point temp. (DEW)	Min	DEW does not meet min range (0 °C)
Pt. Arena	PABY	Dew point temp. (DEW)	Max, Sticking	Missing DEW denoted as '999'
Pt. Conception	PCBY	Dew point temp. (DEW)	Max, Sticking	Missing DEW denoted as '999'
Pt. Conception	PCBY	Scalar wind speed (SCA)	Max, Sticking	Missing SCA denoted as '99'
Quincy	QUI1	Total radiation (TOT)	Min, Sticking	TOT stuck at 0
Rose Peak	ROSP	Total radiation (TOT)	Max	TOT exceeds max range at night (2 w/m2)
Rose Peak	ROSP	Total radiation (TOT)	Min	TOT stuck below 15 starting July 10, 2000
San Francisco	SFBY	Dew point temp. (DEW)	Max, Sticking	Missing DEW denoted as '999'
St. Georges	SGBY	Dew point temp. (DEW)	Max	Missing DEW denoted as '999'
Simi Valley	SIM	Total radiation (TOT)	Max	TOT exceeds max range at night (2 w/m2)
Tracy	TRAC2MH	Net radiation (NET)	Sticking	NET stuck regularly at 0
Valley of the Moon	VOTM2MH	Dew point temp. (DEW), Net radiation (NET), Scalar wind speed (SCA), and Total radiation (TOT)	Sticking	DEW, NET, SCA, TOT all go to 0 on July 8, 2000
Walker Pass	WALK	Total radiation (TOT)	Max	TOT exceeds max range at night (2 w/m2)
Yosemite	YOT	Total radiation (TOT)	Max	TOT exceeds max range at night (2 w/m2)

Table 4-5. Surface meteorological data that failed particular gross outlier checks frequently but are believed to be valid.

Name	Site	Parameter	Test Failed	Comment
Pt. Arena	AREN	Temperature (AMB)	Sticking	Coastal site, influenced by marine layer
Pt. Arguello	ARGU	Temperature (AMB), Dew point temperature (DEW)	Sticking	Coastal site, influenced by marine layer
Arroyo Grande	ARR	Temperature (AMB)	Sticking	Coastal site, influenced by marine layer
Santa Barbara	BEBY	Temperature (AMB)	Sticking	Coastal site, influenced by marine layer
Bodega Bay	BOBY	Temperature (AMB), Dew point temperature (DEW)	Sticking	Coastal site, influenced by marine layer
Blunts Reef	BRBY	Temperature (AMB)	Sticking	Coastal site, influenced by marine layer
Santa Barbara	BWBY	Temperature (AMB), Dew point temperature (DEW)	Sticking	Coastal site, influenced by marine layer
Capitan	CA1	Carbon monoxide (CO1)	Sticking	Rural site, regularly stuck at 0.1-0.2
San Martin	CSBY	Temperature (AMB)	Sticking	Coastal site, influenced by marine layer
Pt. Arguello	DPBY	Temperature (AMB), Dew point temperature (DEW)	Sticking	Coastal site, influenced by marine layer
Eel River	ERBY	Temperature (AMB)	Sticking	Coastal site, influenced by marine layer
Half Moon Bay	HMBY	Temperature (AMB)	Sticking	Coastal site, influenced by marine layer
Lompoc	LOM	Carbon monoxide (CO1)	Min, Sticking	Rural site, regularly stuck at 0.1-0.2
Monterey	MOBY	Temperature (AMB), Dew point temperature (DEW)	Sticking	Coastal site, influenced by marine layer
Pt. Arena	PABY	Temperature (AMB)	Sticking	Coastal site, influenced by marine layer
Pt. Conception	PCBY	Temperature (AMB)	Sticking	Coastal site, influenced by marine layer
San Francisco	SFBY	Temperature (AMB)	Sticking	Coastal site, influenced by marine layer
St. Georges	SGBY	Temperature (AMB)	Sticking	Coastal site, influenced by marine layer
Pt. San Luis	SLBY	Temperature (AMB), Dew point temperature (DEW)	Sticking	Coastal site, influenced by marine layer
Santa Maria	SMBY	Temperature (AMB), Dew point temperature (DEW)	Sticking	Coastal site, influenced by marine layer
Vandenburg	VBS	Carbon monoxide (CO1)	Min, Sticking	Rural site, regularly stuck at 0.1-0.3

4.4 SUMMARY OF GROSS OUTLIER CHECK

All data run through the gross outlier checks have been flagged at QC Level 1C for resubmission to the database. We feel that the surface meteorology and surface air quality data are in excellent shape and are of sufficient quality for use in modeling. The upper-air meteorology data are in relatively good shape with regard to the tests that were applied in this task.

As noted previously, the automated QC checks were designed to identify the most serious data problems but they cannot detect more subtle problems in the data. These types of issues must be addressed during the QA tasks that are performed before importing data into a database.

Appendix C describes the tables used to perform automated gross outlier checks against selected CCAQS/CCOS hourly data.

5. DETAILED QUALITY CONTROL

The objective of this task was to examine air quality and meteorological data from selected episodes to ensure the data are ready for immediate use by data analysts and modelers. The data should be usable without need of further judgment regarding their quality in understanding O_3 formation processes and emission control effectiveness.

Enhanced monitoring, where routine measurements were supplemented with aircraft, ozonesonde, and additional VOC measurements, was conducted during eight IOPs in spring, summer, and autumn 2000:

- June 14 and 15
- July 23 and 24
- July 30 through August 2
- August 14
- September 14
- September 17 to 21
- September 23 and 24
- September 30 through October 2

A high priority period (HPP) for photochemical modeling, defined by the CCOS Technical Committee as the five-day period from July 29 to August 2, 2000, was selected by the CCOS Technical Committee for detailed QC. The parameters subjected to the detailed QC for this period included O_3-related air quality measurements and meteorological data collected at the surface and aloft.

For detailed data validation, we focused on 1-hr average data for continuous air quality and meteorological measurements, various time averages for the VOC canister data, and nearly instantaneous averaging times for the aircraft measurements. The result of the QC effort is a new set of QC flags applied to the data that are either the same as the existing data flags or have been updated to reflect more appropriate validation based on our QC. We did not change any data previously flagged as suspect or invalid; if a record was suspect or invalid at the outset, it remained suspect or invalid regardless of our findings.

Prior to performing Level 1 validation, we created a separate database and initially set all QC flags to valid, ignoring any previous QC flags, including those set by the automated gross outlier check. As a result, there may be cases where a record was flagged by the gross outlier check but was left valid in the more intensive, visual QC inspection because the analyst had more information available, such as data patterns or concentrations of other species at the same time. The data we are resubmitting contain comments for each flagged record that failed specific tests. We did not remove the suspect flag from the gross outlier check if a record was valid in the detailed QC tasks. We recommend that users give precedence to valid QC flags from the subjective QC task rather than suspect flags from the gross outlier check. Finally, QC flags applied in this task only “worsened” the original QC flag; that is, if a point was originally flagged invalid, we did not change it to valid.

The following subsections describe the procedures used for detailed QC of the air quality, meteorology, and aircraft data. In addition, the results of the validation for each data subset are discussed.

5.1 SURFACE AIR QUALITY DATA

5.1.1 Approach for O_3, NO, NO_x, and NO_y Validation

For QC of the surface air quality data, STI performed Level 1 and Level 2 validation of O_3, NO, NO_x, and NO_y. These validation steps were a visual review of the data that includes checks for internal (Level 1) and external (Level 2) consistency and reasonableness of data from each site for each hour.

For Level 1 validation, we used in-house software (SurfDAT) to analyze time-series plots and scatter plots of the data to identify any abnormalities. Data points that failed screening criteria developed by STI experts were visually examined to determine the quality level of the data point. We used range checks and rates of change specific to urban and rural sites. In addition, we looked for unreasonable spikes or dips in the data. An example of a suspect data spike in NO and NO_x is shown in **Figure 5-1**.

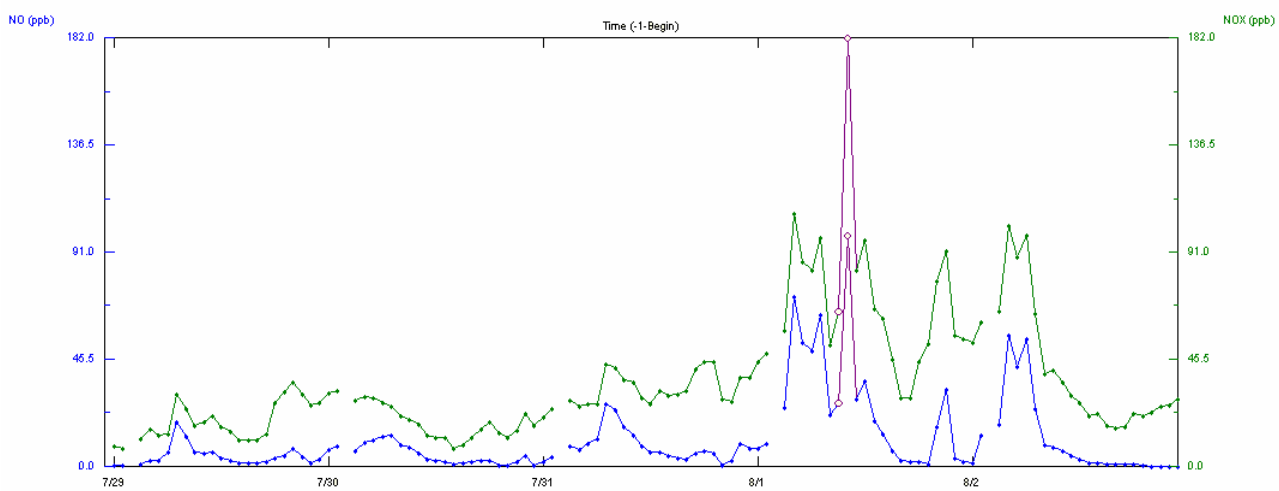


Figure 5-1. Example of time-series display used to QC surface air quality data. At left is NO (ppb) in blue and at the right is NO_x (ppb) in green. NO_x shows a high concentration level spike, while also having a point-to-point variation exceeding 50 ppb. Suspected data points are highlighted in purple.

For the Level 2 validation of the surface air quality data, an air quality analyst subjectively reviewed data for external consistency through comparison with collocated and/or nearby measurements. For surface data, time series plots of each species at nearby sites were compared to determine if (1) concentrations showed similar magnitudes and (2) diurnal patterns

were consistent among sites. Concentrations and diurnal patterns were examined based on urban and rural designations. In addition, multiple species were examined simultaneously to check for expected relationships. For example, when looking at NO and NO_y, we expect NO_y always to be greater than NO (NO_y equals the sum of all reactive oxidized nitrogen species).

5.1.2 Results for O_3, NO, NO_x, and NO_y

The results of the detailed QC for surface air quality data are summarized in **Table 5-1**. Nearly all O_3 results were valid. Expected diurnal patterns indicated O_3 peaking in the mid- to late afternoon and having its lowest concentrations in the nighttime. During the HPP, only two O_3 records were flagged for forty sites with almost 4,000 total records. The two flagged records were at the Walnut Grove Tower, 366 m height (~1200 ft). NO, NO_x, and NO_y showed expected diurnal patterns. Eight NO_x/NO data pairs were flagged. These flags resulted from greater than expected point-to-point variation (based on urban or rural designation) and unexpected high concentrations compared to the surrounding diurnal pattern.

5.1.3 Approach for Surface VOC Data

STI performed Level 1 and Level 2 validation (see Section 1.2) on VOC species by site. These validation steps were a visual review of the data that included checks for internal (Level 1) and external (Level 2) consistency and reasonableness of the data from each site and sample. To better assess the limited number of measurements taken during the HPP, all VOC data measured between June 15 and September 15, 2000, were reviewed.

For Level 1 and Level 2 validation, we used in-house software (VOCDat) to analyze scatter plots of the available data. Scatter plots enable investigation of the relationship among species. Screening criteria were developed to highlight expected species relationships (see **Table 5-2**). Data points that did not meet the screening criteria were flagged as suspect and further inspected. Outlier points that showed abnormal behavior in the scatter plots were also flagged. Examples of suspect data points that do not match expected source relationships are shown in **Figures 5-2 and 5-3**.

Table 5-1. Summary of the detailed QC of surface air quality data. Shown by site and parameter are the percentage of records flagged suspect. Parameters that had less than 5% suspect values are highlighted in green, 5-25% suspect are highlighted in yellow, and greater than 25% suspect are highlighted in orange.

Site	Species									
	O_3	NO	NO_2	NO_x	NO_y	CO	CO_2	H_2O_2	HCHO	HNO_3
Angiola Stn [a]	0	0			0					
Arvin Stn	0	0	0	0	0					
Bakersfield Stn (1128 Golden State)	0	0	0	0		0.9				
Bakersfield Stn (5558 California Ave)	0	1.7	0	0	0	0				
Bella Vista Stn	0	0			0					
Bethel Island Stn	0	0	0		0	0				
Bodega Bay Stn		0			0					
Clovis Stn (908 N Villa Ave.)	0	1.8	0	1.8		0				
Elk Grove Stn (Bruceville Rd.)	0	0	0	0	0					
Folsom Stn (Natoma St.)	0	0	0	0						
Fresno Stn (3425 First St.)	0	0	0	0	0	0				
Granite Bay Stn	0	0		0		0	0			
Kettlemen City Stn	0	0			0					
Lambie Road Stn	0	0			0					
Livermore Stn (Old First St.)	0	0	0							
Livermore-Dublin Stn	0									
Madera Stn (29 1/2 No. of Ave 8)	0	0	0	0						
McKittrick Stn	0	0			0					
Pacheco Pass Stn	0	0			0					
Parlier Stn	0	0	0	0		0	0	0	0	0
Patterson Pass Stn	0	0			0					
Piedras Blancas Stn	0	0			0					
Sacramento Stn (Del Paso Manor)	0	0	0.9	0		0				
Sacramento/Natoma Stn (3801 Airport Rd.)	0	0	0	0		0				
San Andreas Stn (Gold Strike Rd.)	0	0			0	0				
San Jose Stn (4th St.)	0	0	0			0				
San Martin Stn		0			0					
Shafter Stn (Walker St.)	0	0	0	0						
Sloughouse Rd. Stn	0	0			0					
Sunol Station Stn	0	1.7		1.7		0	0			
Sutter Buttes Stn		0			0					
Trimmer Stn	0	0			0					
Turlock Stn (900 S Minaret)	0	0	0	0	0	0				
Walnut Grove Tower 122 Meter Height	0									
Walnut Grove Tower 244 Meter Height	0									
Walnut Grove Tower 366 Meter Height	1.7									
Walnut Grove Tower 488 Meter Height	0									
Walnut Grove Tower 9 Meter Height	0									
White Cloud Mtn. Stn	0	0			0					

[a] Angiola O_3 statistics are based on ten data records only.

Table 5-2. Screening criteria for VOC data.

Species	Expectation
Ethane	Greater than ethene
Propane	Greater than propene
i-pentane	Greater than n-pentane
Sum of m- and p-xylenes	Greater than o-xylene
Toluene	Greater than benzene
Total nonmethane hydrocarbon (TNMHC)	Greater than total alkanes, total alkenes, total aromatics, or total unidentified hydrocarbons

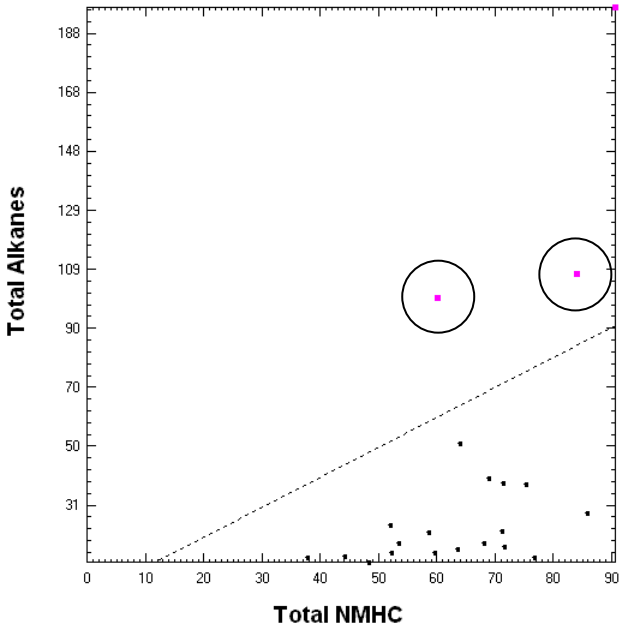


Figure 5-2. Scatter plot of TNMHC and total alkanes concentrations (ppbC) from the Angiola site. Suspect data points (circled) show concentrations of total alkanes greater than TNMHC.

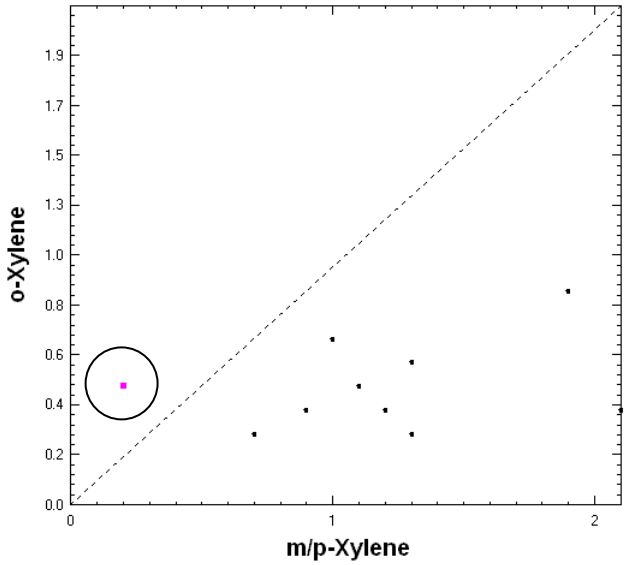


Figure 5-3. Scatter plot of m/p-xylene and o-xylene concentrations (ppbC) from the Bodega Bay site. The suspect data point (circled) shows a concentration of o-xylene significantly greater than that of m/p-xylene.

5.1.4 Results for Surface VOC Data

The VOC data available included only data collected on CCOS episode days when measurements were made at both routine PAMS sites and special studies sites. Validation efforts were somewhat hampered by inconsistent sets of VOC species measured across sites, the small number of samples, and the fact that most samples were 24-hr averages. Detailed QC of VOC data relied on objective screening criteria as well as subjective visual inspections and comparisons between urban and rural sites. Overall the VOC data were determined to be of good quality; only a few species or samples were flagged as suspect.

The most common data problems were the absence of key abundant species (i.e., isopentane, propylene, propane, etc.) and overly truncated or rounded concentration values. Note that all the VOC data we ultimately flagged as suspect (see **Table 5-3**) were originally flagged as valid in the CCOS database.

Additionally, we found that high ethane concentrations (hundreds of ppbC) were observed at a few, mostly rural, sites. The data appear to be real concentrations (and were thus not flagged) but the source of the ethane is unclear. Further investigation indicated those data are likely valid.[2]

[2] Sites reporting high ethane concentrations were located in rural areas where the emission inventory indicates significant ethane emissions should emanate from animal waste decomposition.

Table 5-3. Summary of results for the detailed VOC data QC. Shown by site and parameter are the percentage of records flagged suspect. Parameters that had less than 5% suspect values are highlighted in green, 5-25% suspect are highlighted in yellow, and greater than 25% suspect are highlighted in orange. Blank cells indicate the species was not observed.

Site	# VOC Samples	Species											
		Benzene	Ethane	Ethene	I-Butane	I-Pentane	M/P-Xylene	N-Butane	N-Pentane	O-Xylene	Propane	Propene	Toluene
Angiola Stn	21	0	0		0	0	0	0	0		0	0	0
Arvin Stn [a]	23	0	0	0	9		0	0	0	4	4	0	9
Bakersfield Stn (1128 Golden State) [a]	20	0	0	0	5		0	0	0	0	0	0	5
Bethel Island Stn	23	0	0	0	4	4	0	0	4	0	0	0	4
Bodega Bay Stn	47	9	0		0	0	2	7	8	8	0	0	0
Folsom Stn (Natoma St.) [a]	12	0	0	0	0		0	0	0	0	0	0	0
Fresno Stn (3425 First St.) [a]	14	0	0	0	0		7	0	0	0	0	0	0
Granite Bay Stn	195	0	0	0	0	0	0	0	0	0	0	0	0
Olancha Stn (Walker Creek Rd.)	12	0	0		0	0	0	0	0	0	0	0	0
Pacheco Pass Stn	28	0	0		0	0	0	0	0		0	0	0
Parlier Stn [a]	246	0	0	0	0	0	0	0	0	0	0	0	0
Patterson Pass Stn	24	0	0	0	0	0	0	0	0	0	0	0	0
Piedras Blancas Stn	11	0	0		10		0	0	0		0	0	0
Sacramento Stn (Del Paso Manor) [a]	10	0	0	0	0		0	0	0	0	0	0	0
Sacramento/Natomas Stn (Airport Rd) [a]	10	0	0	0	0		0	0	0	0	0	0	0
San Andreas Stn (Gold Strike Rd.)	26	0	0		0	0	4	0	0	0	0	0	0
San Leandro Stn	22	0	0	0	0	0	0	0	0	0	0	0	9
Shafter Stn (Walker St.) [a]	16	0	0	0	6		6	0	0	0	0	0	0
Sunol Station Stn	246	0	0	0	0	0	0	0	0	0	0	0	0
Sutter Buttes Stn	19	0	0	0	0	0	0	0	0	0	0	0	0
Trimmer Stn	24	0	0	0	0	0	0	0	0	0	0	0	0
Turlock Stn (900 S Minaret)	27	0	0		0	0	4	6	0	0	0	0	0
White Cloud Mtn. Stn	24	0	0	0	0	0	0	0	0	0	0	0	0
Yosemite Village Stn	12	0	0		0	0	5	0	8	9	0	17	8

[a] Denotes a PAMS site.

The key data validation findings follow:

- Almost two-thirds of the species-specific hydrocarbon data were at or below the minimum detection limit (MDL). The MDL was typically either 0.5 or 1 ppbC for each target compound. The high percentage of data at or below the MDL reduces the amount of information available for later analysis. However, these species occur in relatively low concentrations (i.e., less than 1 ppbC) and are not likely to be important individual contributors to the formation of O_3.

- Data points were rounded and/or truncated to one or two significant figures. Rounded or truncated data reduce the information available (e.g., lower precision) and artificially smooth data trends. Higher resolution measurements may be required to detect trends in species changes on the order of the measurement resolution.

A final important note is that the routinely collected PAMS data were not included in the CCOS database; these data should be added. McCarthy et al. (2005)documented validation and analysis of the PAMS data collected by the San Joaquin Valley Unified Air Pollution Control District (SJVUAPCD) from 1998 through 2003.

5.2 SURFACE METEOROLOGICAL DATA

5.2.1 Approach

STI performed Level 1 and Level 2 validation of the temperature, dew point, relative humidity, wind speed and direction, radiation, and pressure data. Additional parameters were available at a few sites, such as vector wind speed and net radiation, which we validated as well. These validation steps were a subjective review that included checks for internal (Level 1) and external (Level 2) consistency and reasonableness of the data from each site for each hour. Because of the vast number of sites reporting surface meteorological data (see Table 2-4), we limited the detailed QC to the 36 CCOS-sponsored sites.

For Level 1 validation, we used in-house software to analyze time-series plots of the data to identify any abnormalities, which were then flagged suspect (see **Figure 5-4**). We looked for problems such as incorrect wind directions, relative humidity measurements above 100%, solar radiation measurements greater than 0 at night, instrument setup problems, and unreasonable spikes in the data. Examples of bad total radiation data and an unusual data spike are shown in **Figure 5-5**.

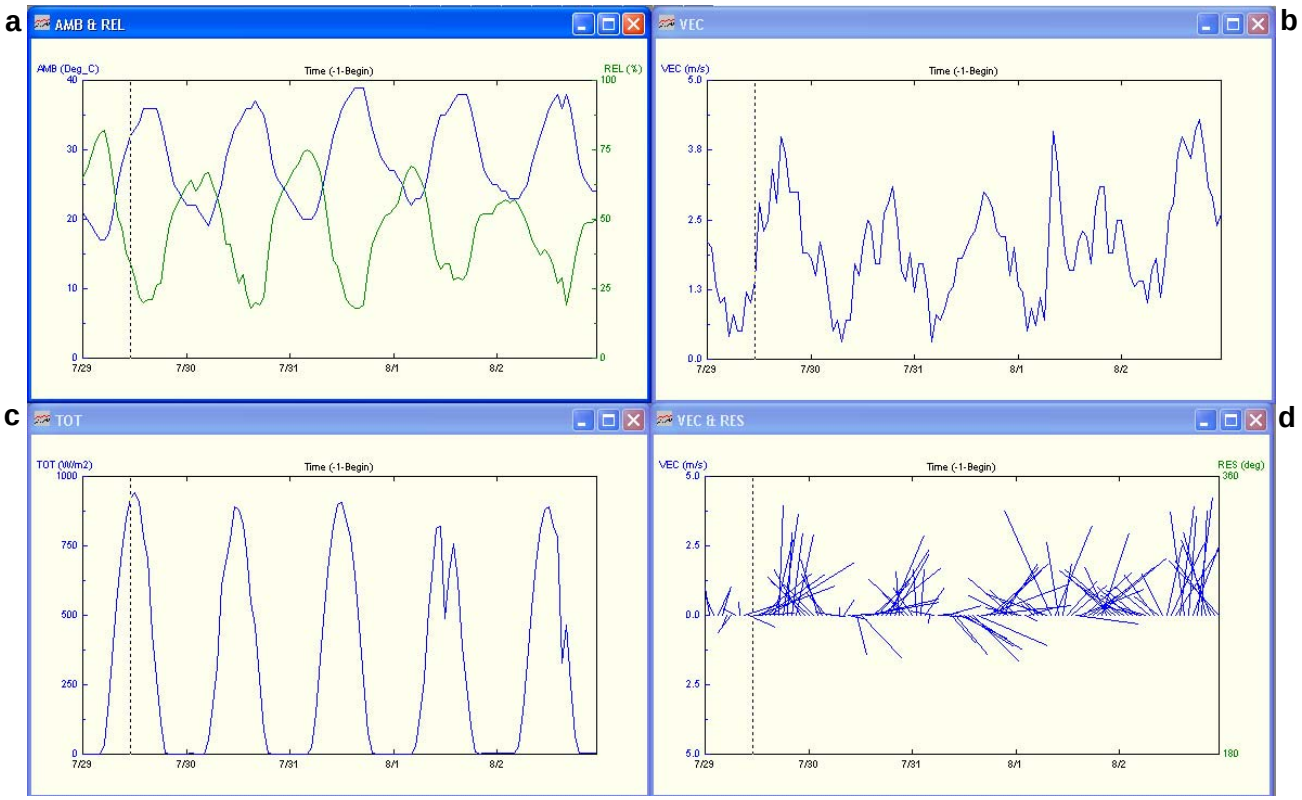


Figure 5-4. Example of time series display used to QC surface meteorological data. At top left (a) is temperature (°C) in blue and relative humidity (%) in green, top right (b) is wind speed (m/s), bottom left (c) is total radiation (w/m^2), and bottom right (d) is wind direction and speed (m/s).

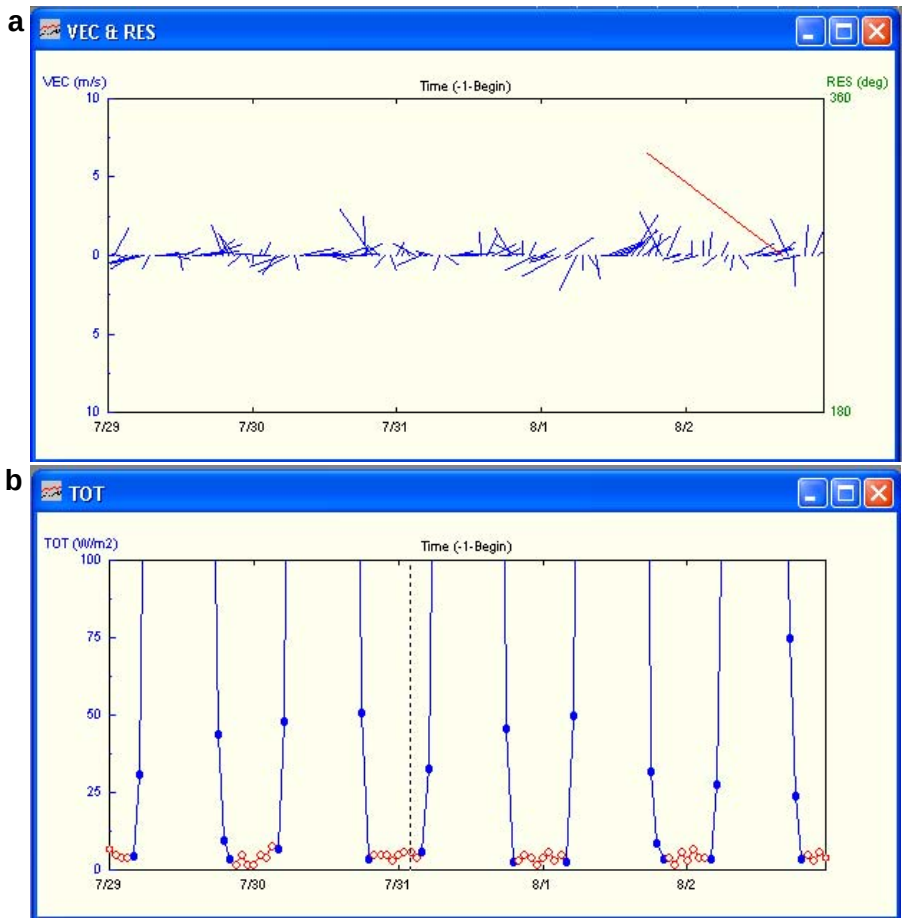


Figure 5-5. Examples of data that were suspect. The top panel (a) shows wind speed and wind direction; a data value suspect because it is inconsistent with other values is shown as a red line on the whisker plot. The bottom panel (b) shows total solar radiation; suspect data that were too high at night are shown in red.

For the Level 2 validation of the meteorological data, an experienced meteorologist subjectively reviewed the data for external consistency and reasonableness by comparing collocated and nearby measurements. For surface data, time series plots of each species at nearby sites were compared to determine if values were similar and trended in the same way. In addition, different parameters were inspected in combination with each other. For example, when looking at temperature, dew point, and relative humidity, high relative humidity would be expected when temperature and dew point values are close together. **Figure 5-6** shows an example of temperature and relative humidity data at two neighboring sites.

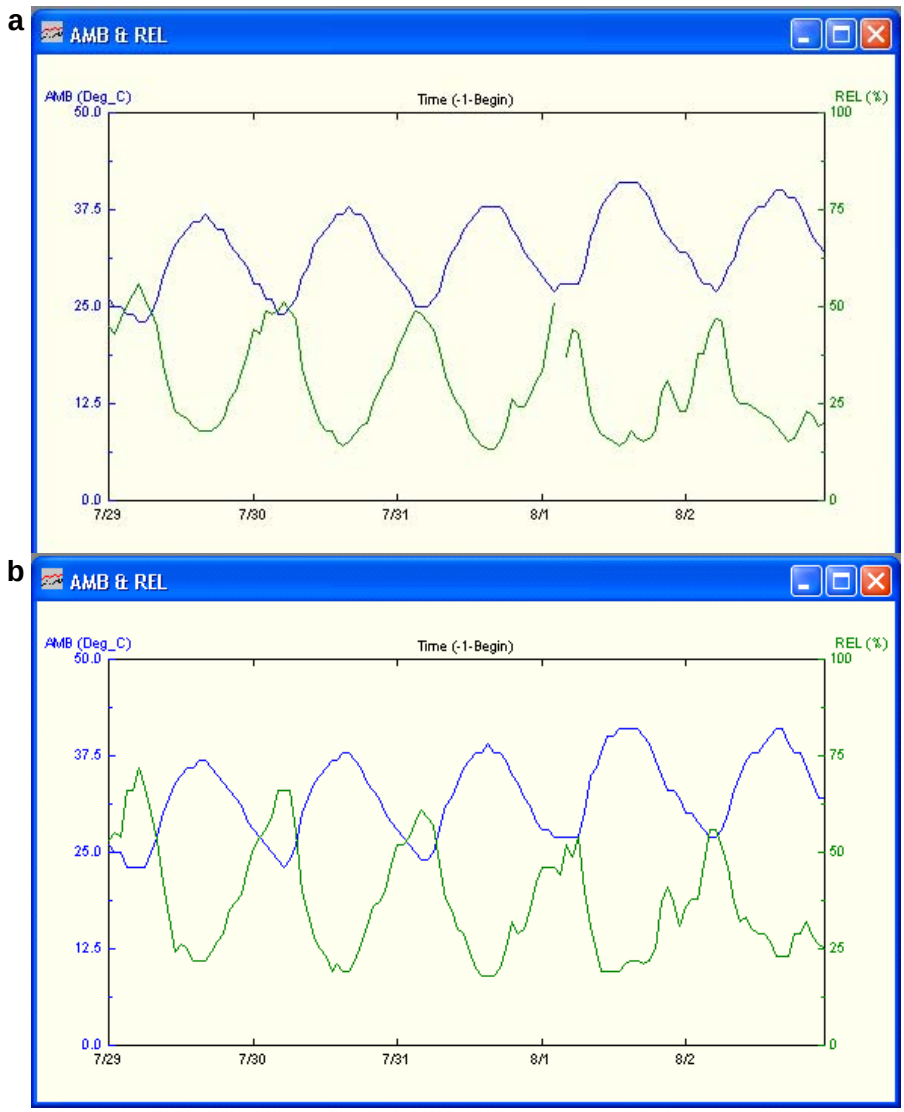


Figure 5-6. Site-to-site comparison of temperature and relative humidity data. The top plot (a) shows data from the Bakersfield – Golden State site, and the bottom plot (b) shows data from the Bakersfield – California Avenue site.

5.2.2 Results

The results of the detailed QC of surface meteorological data are summarized in **Table 5-4**. All temperature, dew point temperature, scalar wind speed, net radiation, and station pressure records were found to be valid. Nearly all the resultant wind direction and vector wind speed data were flagged valid; only one record out of 120 for each parameter at one site was flagged suspect. The only parameters showing significant data quality issues were total radiation and net radiation. At three sites, greater than 25% of the data were flagged suspect because the overnight values were too high, exceeding 2 W/m^2. However, these nighttime biases may indicate a minor calibration error and the data may be used with caution.

Table 5-4. Summary of results for the detailed QC of surface meteorological data. Shown by site and parameter are the percentage of records flagged suspect. Parameters with less than 5% suspect values are highlighted in green, 5-25% suspect are highlighted in yellow, and greater than 25% suspect are highlighted in orange.

	Meteorological Parameters									
Site	Temperature	Dew Point	Relative Humidity	Resultant Wind Directions	Scalar Wind Speed	Average Wind Direction	Vector Wind Speed	Total Radiation	Net Radiation	Station Pressure
Angiola Tower	0	0	0	0	0		0			0
Angiola Tower 23 Meter	0	0	0	0	0		0			
Angiola Tower 43 Meter	0	0	0	0	0		0			
Angiola Tower 72 Meter	0	0	0	0	0		0			
Angiola Tower 98 Meter	0	0	0	0	0		0			
Arvin Stn	0		0	1			1	0		0
Bakersfield Stn (1128 Golden State)	0		0	0			0			0
Bakersfield Stn (5558 California Ave)	0		0	0			0	32		0
Bella Vista	0		0		0		0			
Bethel Island Stn	0			0	0		0	0		
Bodega Bay Tower	0	0	0	0	0				0	
Chabot Stn	0			0	0		0			
Clovis Stn (908 N Villa Ave.)	0				0	0		0		0
Elk Grove Stn (Bruceville Rd.)	0		0	0			0	0		0
Folsom Stn (Natoma St.)	0		0	0			0	29		
Fresno Stn (3425 First St.)	0		0	0	0		0	0		0
Granite Bay	0		0		0		0			
Kettlemen City	0		0		0		0			
Livermore Stn	0	0	0	0	0		0			
Livermore-Dublin Tower	0		0	0	0				13	
Madera Stn (29 1/2 No. of Ave 8)	0		0	0			0	0		0
McKittrick	0		0		0		0			
Pacheco Pass	0		0	0	0		0	0	0	0
Parlier Stn	0		0		0	0		1		0
Patterson	0	0	0	0	0		0	0	0	
Piedras Blancas	0		0		0		0			
Point Reyes National Seashore	0		0		0		0			
Sacramento Stn (Del Paso Manor)	0		0	0			0	37		
Sacramento/Natoma Stn	0		0	0			0	0		
San Andreas Stn	0			0			0			
San Leandro	0			0	0					
San Martin Stn	0	0	0	0	0		0	0		
Shafter Stn (Walker St.)	0			0			0			
Shasta Lake	0		0		0		0			
Sloughouse Rd. Stn				0			0			
Sunol Stn	0			0	0		0			
Trimmer	0		0	0	0		0	0	0	0
Turlock Stn (900 S Minaret)					0	0				
Walnut Grove Tower 122 Meter	0			0	0		0			
Walnut Grove Tower 366 Meter	0			0	0		0			
Walnut Grove Tower 488 Meter	0			0	0		0			
Walnut Grove Tower 9 Meter	0			0	0		0			
White Cloud Mtn. Stn	0		0	0			0			

5.3 ALOFT METEOROLOGICAL DATA

5.3.1 Approach

For QC of the aloft meteorological data, STI performed Level 1 validation of the RASS data and Level 2 validation of the RWP and SODAR data. RASS data included $T_{v,}$ and RWP and SODAR data included wind speed and wind direction. This validation was a subjective review that included checks for internal (Level 1) and external (Level 2) consistency and reasonableness of the data from each site for each hour. All sites with RASS, RWP, and SODAR data in the database were validated.

For Level 1 validation of the RWP and SODAR data, we used in-house software to analyze time-height plots of wind barbs (**Figure 5-7**). We flagged as suspect data with problems such as interference from migrating birds or precipitation, ground clutter, velocity folding, errors associated with the processing method, and instrument setup. An example of suspect SODAR data is shown in **Figure 5-8**.

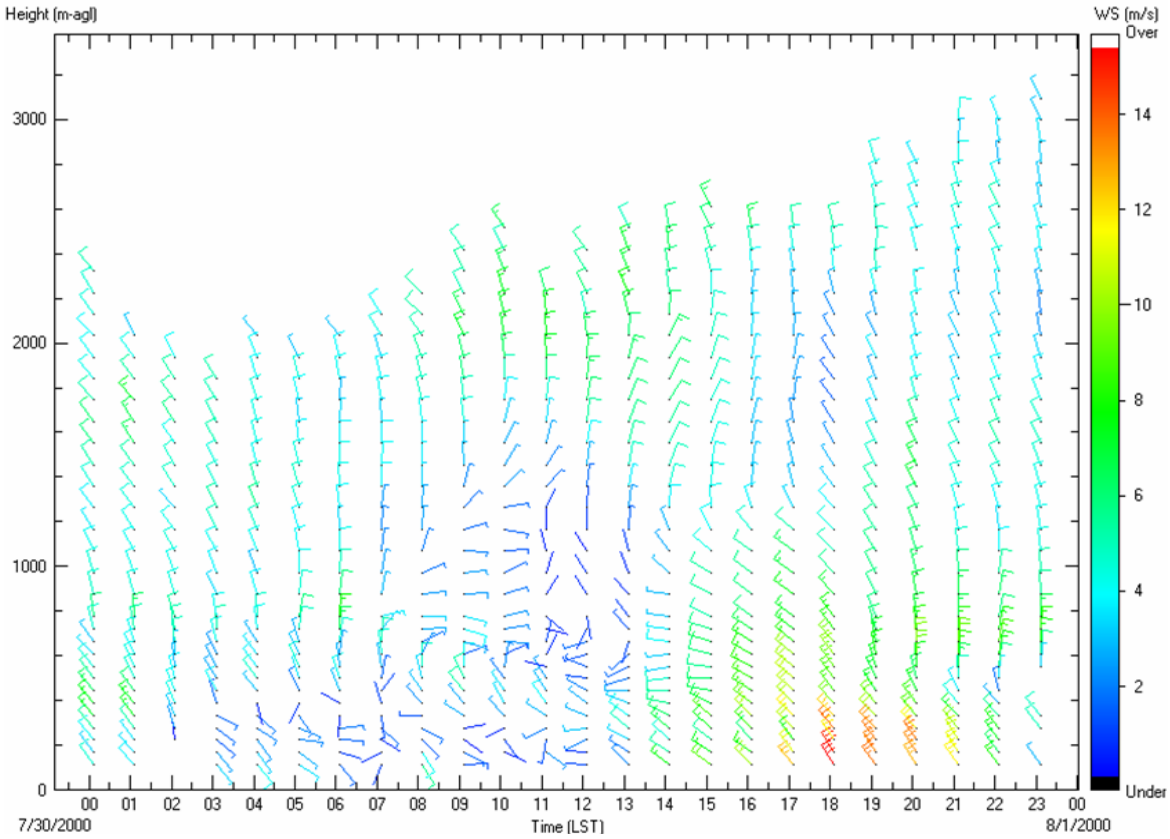


Figure 5-7. Time-height display of winds at Bodega Bay on July 30, 2000.

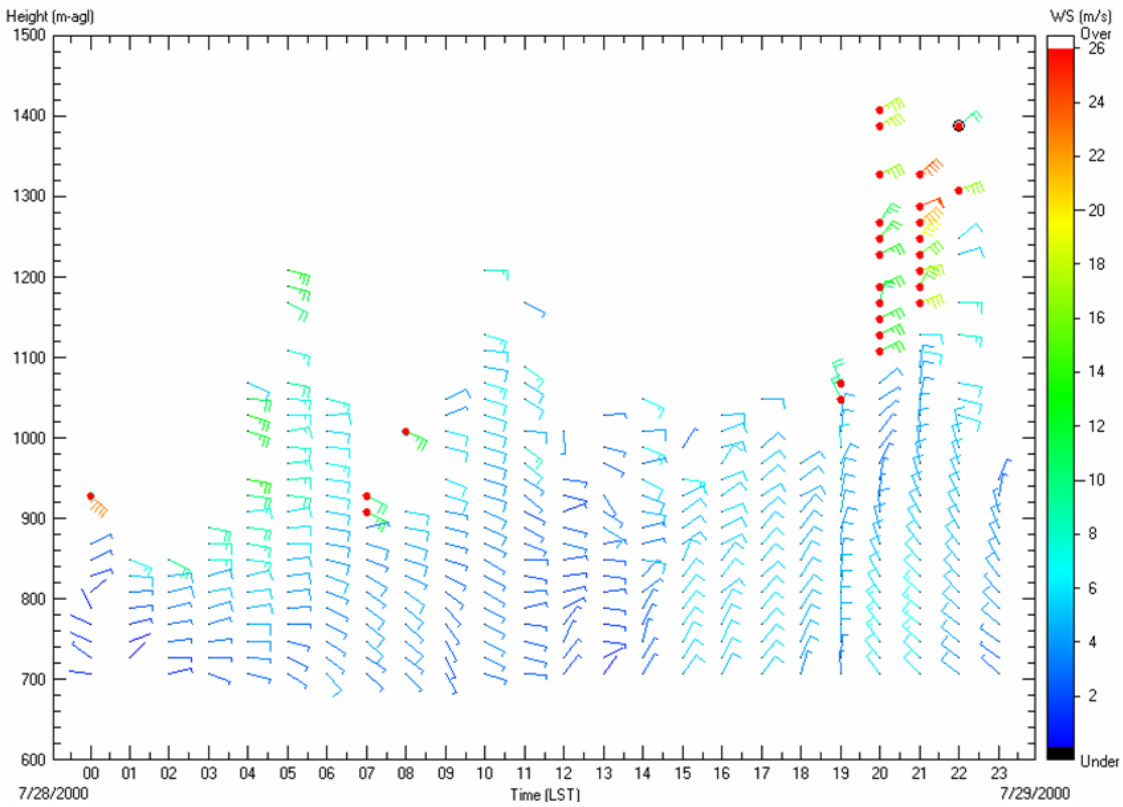


Figure 5-8. Example SODAR wind plot with suspect data. Suspect points are highlighted in red. These points were all flagged because wind speed and direction changed too rapidly relative to surrounding points.

For Level 1 validation of the RASS data, we used in-house software (LAPDat) to analyze time-height plots of T_v (**Figure 5-9**). We flagged as suspect data with problems such as inappropriate temperature range setting, radio interference, cold bias, and inaccurate measures of vertical velocity and instrument setup. An example of a suspect RASS profile is shown in **Figure 5-10**.

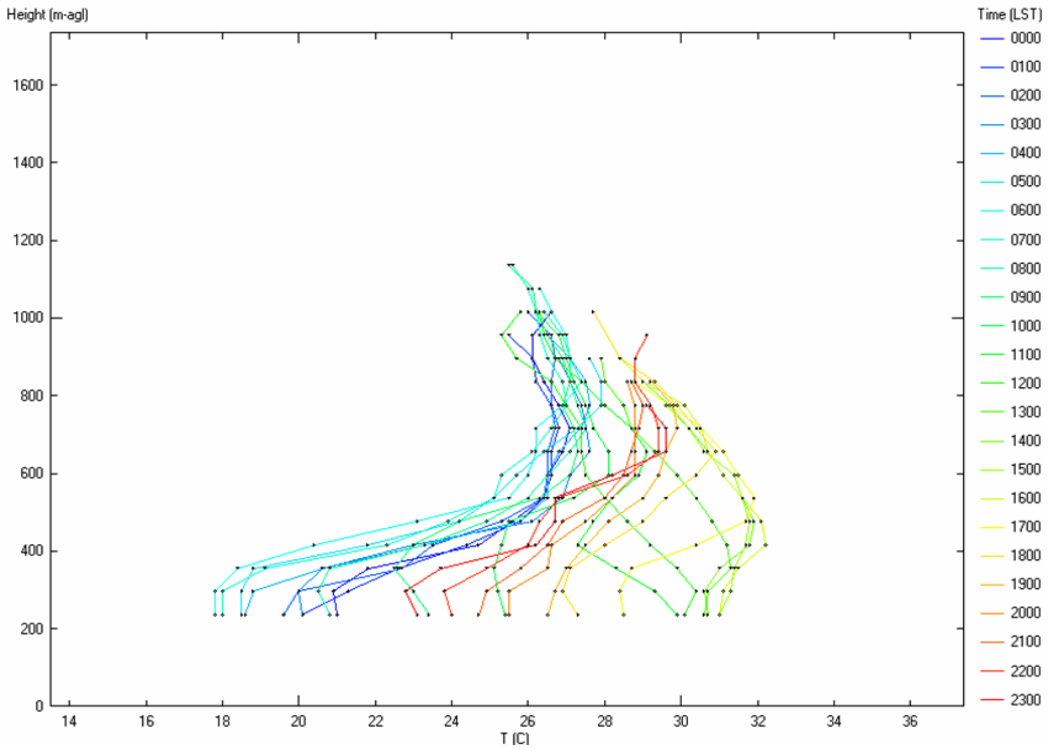


Figure 5-9. Example time-height plot of T_v.

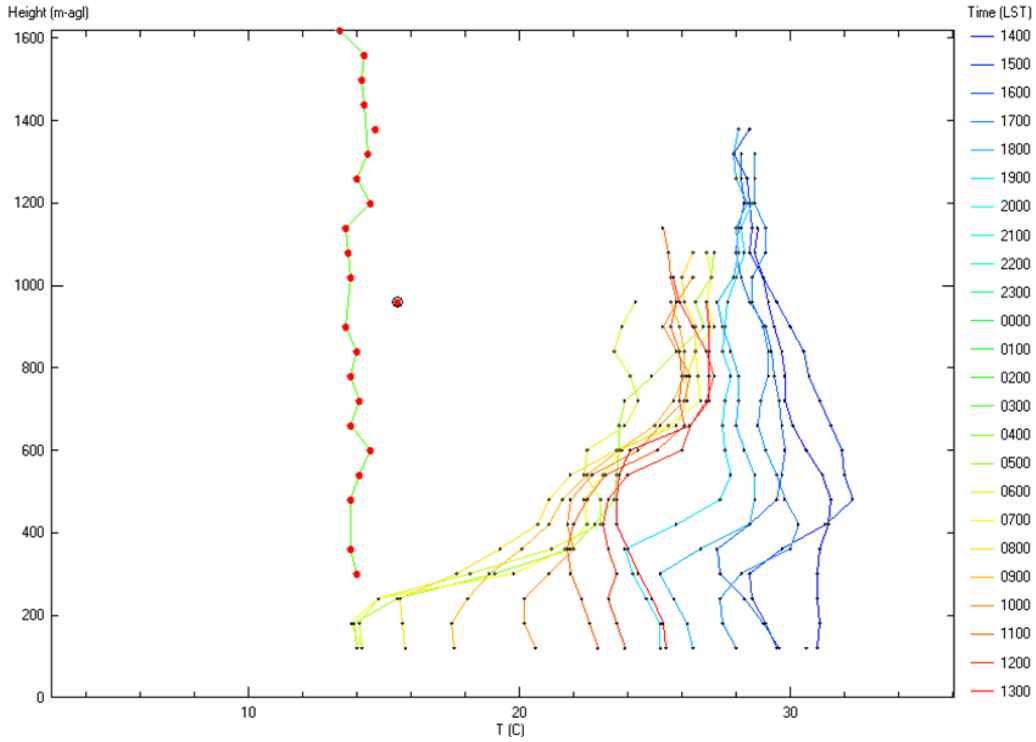


Figure 5-10. Example time-height plot of T_v data. Points in red are suspect.

For the Level 2 validation of the RWP and SODAR data, an experienced meteorologist subjectively reviewed the data for external consistency and reasonableness by comparing collocated and nearby measurements, where possible. Due to the widespread network, a site was not always available for comparison. Time-height plots of winds at nearby sites were compared to determine if the flows were similar and trended in the same way. In addition, we looked at different instruments at the same site were looked at in combination with each other. For example, RWP and SODAR data were compared to each other for consistency (see **Figure 5-11**). RASS data did not undergo Level 2 validation.

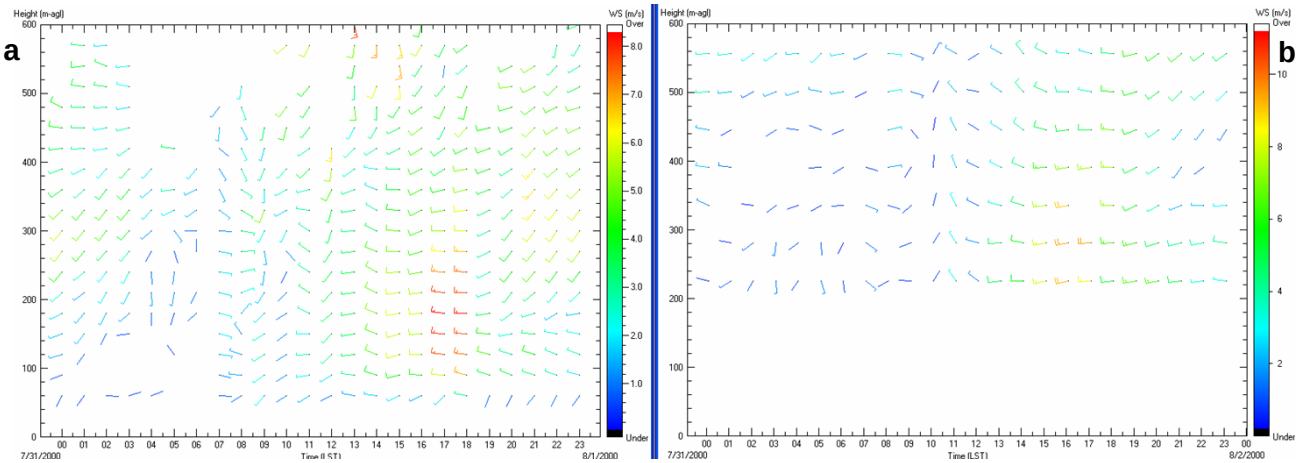


Figure 5-11. Example of Level 2 QC. Shown at left (a) is a plot of SODAR data; at right (b) are RWP data from the same date and site.

5.3.2 Results

The results of the detailed QC of aloft meteorological data are summarized in **Table 5-5**. The RWP and SODAR data were generally in very good condition. A few data points were flagged at most sites, but at only 3 of the 28 sites were more than 5% of the data flagged. The Dublin RWP site produced excellent data, and no points beyond those originally flagged in the database were flagged suspect. Of those sites at which more than 5% of the data were flagged, some of those data were points flagged in the original database. For example, a total of 53% of the Sunol SODAR data were flagged suspect by this process, while only 14% of the data were flagged valid in the original database.

Table 5-5. Summary of results for the detailed QC of aloft meteorological data. Shown by site and parameter are the percentage of records flagged suspect. Parameters that had less than 5% suspect values are highlighted in green, 5-25% suspect are highlighted in yellow, and greater than 25% suspect are highlighted in orange.

	Wind direction			Wind speed			Virtual Temperature		
SupportName	% suspect - total	% suspect - new	% suspect - orig	% suspect - total	% suspect - new	% suspect - orig	% suspect - total	% suspect - new	% suspect - orig
Angiola Stn	1.1	0.9	0.3	1.1	0.9	0.3	17.9	12.6	5.3
Arbuckle Stn	0.1	0.1	0	0.1	0.1	0	9.4	9.4	0
Bakersfield (Southeast) Stn	1.8	1.7	0.1	1.8	1.7	0.1	6.7	4.3	2.4
Bodega Bay Stn	0.3	0.3	0	0.3	0.3	0	0	0	0
Carrizo Plain Stn *	9.2	8.9	0.4	9.2	8.9	0.4	No data		
Chico Stn	0.7	0.5	0.1	0.7	0.5	0.1	10.0	4.7	5.2
Dublin Stn	0	0	0	0	0	0	No data		
Fresno Air Terminal Stn	4.6	2.8	1.8	4.6	2.8	1.8	16.1	1.4	14.7
Goleta Stn	4.7	3.2	1.5	4.7	3.2	1.5	9.6	7.0	2.6
Lemoore Stn	0.8	0.7	0.1	0.9	0.8	0.1	7.8	5.6	2.2
Livermore Airport Stn	7.8	5.4	2.4	7.8	5.4	2.4	No data		
Livermore-Dublin Stn	2.9	2.9	0	2.9	2.9	0	0	0	0
Los Banos_ARB Stn	1.3	1.3	0.1	1.3	1.3	0.1	4.2	2.8	1.3
Lost Hills Stn	2.4	2.4	0.1	2.4	2.4	0.1	8.9	5.5	3.3
Mojave_CRPAQS Stn	5.3	4.9	0.4	5.3	4.9	0.4	12.7	6.7	6.0
Monterey/Fort Ord Stn	1.3	1.2	0.1	1.3	1.2	0.1	20.9	10.7	10.2
N. of Auburn/S. of Grass Valley Stn	3.3	1.7	1.7	3.3	1.7	1.7	31.2	24.0	7.1
New Melones Lake Stn	1.4	1.4	0	1.4	1.4	0	No data		
Pleasant Grove Stn	3.3	3.0	0.3	3.3	3.0	0.3	35.7	29.3	6.5
Redding Municipal Airport Stn	1.6	1.4	0.2	1.6	1.4	0.2	21.2	16.2	5.0
Richmond Stn	4.7	4.1	0.6	4.7	4.1	0.6	14.4	11.4	3.1
Sacramento Stn	1.5	1.3	0.2	1.5	1.3	0.2	11.0	7.5	3.5
San Martin-South County Airport Stn	1.6	1.6	0	1.6	1.6	0	0.1	0.1	0
Stevinson Stn	2.3	1.9	0.4	2.3	1.9	0.4	18.5	15.4	3.1
Sunol Station Stn	53.9	14.2	39.7	53.9	14.2	39.7	No data		
Tracy Stn	0.3	0.3	0	0.3	0.3	0	4.5	4.5	0
Travis AFB Stn	2.6	2.6	0	2.6	2.6	0	10.7	6.7	4.0
Trimmer Stn	4.1	3.2	0.9	4.1	3.2	0.9	17.3	11.4	5.9
Visalia Municipal Arpt. (AWOS) Stn	1.6	0.8	0.8	1.6	0.8	0.8	16.3	11.1	5.2
Waterford Sth.	8.5	5.0	3.5	8.5	5.0	3.5	22.4	17.9	4.5

* Issues with Carrizo Plain RWP data could not be resolved within the scope of this project. All data flagged suspect for this site were SODAR data.

The most significant RWP data issue occurred at the Carrizo Plain site. We discovered what appears to be five different RWP data sets all labeled "Carrizo Plain" in the database. These data sets include both low-mode and high-mode RWP wind data. Investigating the database showed that all five sets were submitted to the database at the same time with the same QC level and QC change date. There were extreme differences among the data sets with regard to wind speed and direction (see **Figure 5-12**). Because all five data sets had the same quality flags and dates, we were unable to determine which set contained the final validated data. As a result of this finding, we did not QC the data from this site. To resolve this data issue, we recommend that all the RWP data currently in the database for Carrizo Plain be removed or invalidated and the original data set be re-imported.

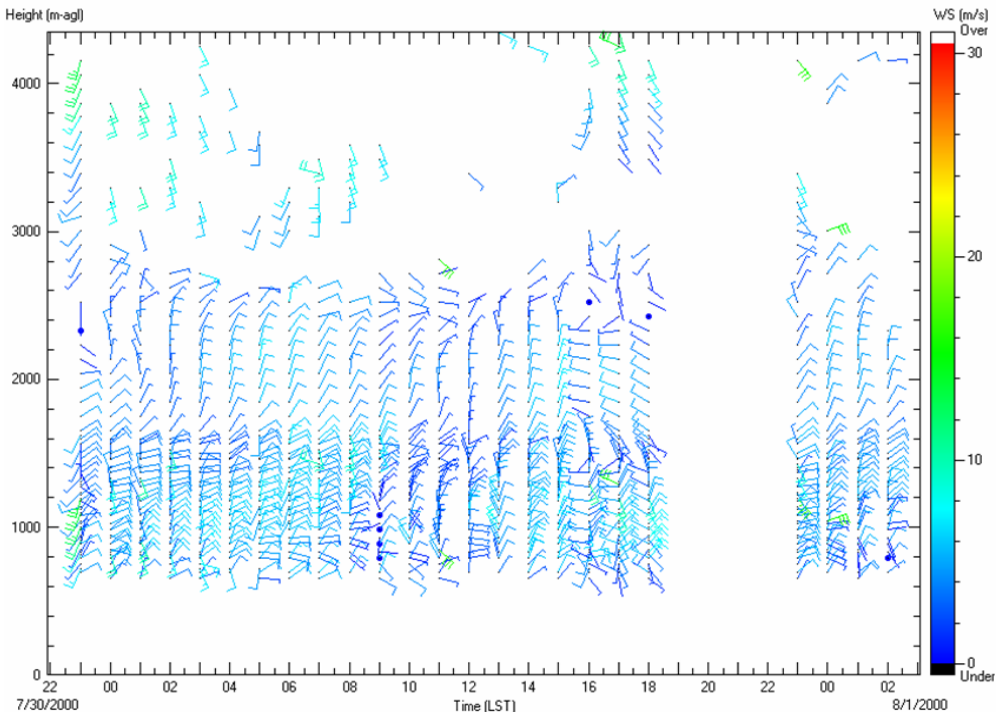


Figure 5-12. High-mode RWP data from the Carrizo Plain site on July 31, 2000, showing extra data points and conflicting wind directions.

Five of the 26 RASS sites produced excellent data, with less than 5% flagged suspect. At the majority of sites, between 5 and 25% of the data were flagged suspect; more than 25% of the data from two sites were flagged suspect. These suspect data are partially due to a data format issue we discovered while visually quality-controlling the data. Many of the data were resubmitted with a new QC level and QC change date. However, when the data were resubmitted, the time stamp was altered, so it was not apparent that these data were updates of older data. In addition, not all the data were resubmitted; only valid data were resubmitted. As a result, if an older, valid data point was changed to invalid, the invalid point does not appear in the database as invalid, so the user is not aware of this update. When we extracted the RASS data for reformatting them for our QC software, we initially queried for the most recent QC change date at a given site, height, parameter, and start time. Because the time stamp was altered, the old data that were not resubmitted with invalid QC flags were extracted along with the more recent data. As a result, many erroneous points (see **Figure 5-13**) appeared as separate RASS data profiles.

Finally, the Level 2 validation showed good consistency among sites and instruments. No additional data were invalidated as a result of the Level 2 validation.

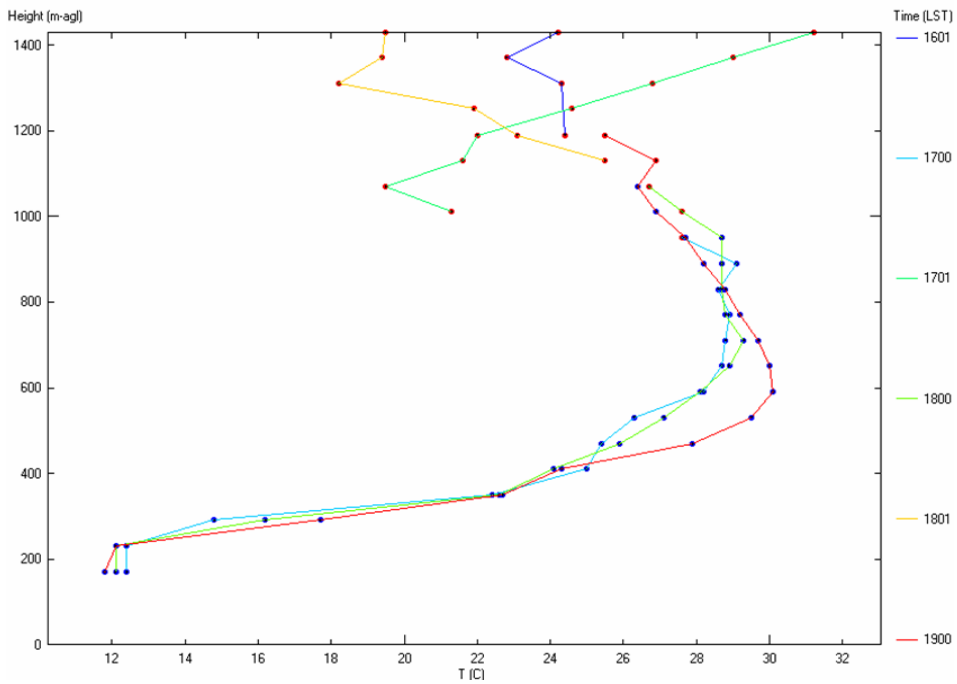


Figure 5-13. Example of RASS data on July 30, 2000, at Monterey with altered time stamps resulting in extra profiles. Points highlighted in red were flagged suspect.

5.4 ALOFT AIR QUALITY DATA

This section describes the methods and results of our detailed review of air quality aloft measured during the HPP with continuous onboard aircraft instruments, VOC canister samples, and ozonesondes launched periodically from two locations. While the PNNL Gulfstream 160 aircraft was identified in Table 2-6 as providing data during CCOS, it flew only on July 8, 2000, and that flight did not occur during the HPP.

5.4.1 Aircraft Continuous Air Quality Measurements

Depending on the aircraft platform, continuous measurements of O_3, NO, NO_x, NO_2, NO_y, sulfur dioxide (SO_2), and/or CO were made. The measurements made during each flight are summarized in **Table 5-6**. Measurements of O_3, NO, NO_x, NO_2, and NO_y were reviewed using three methods: (1) automated QC checks using the criteria shown in **Table 5-7**, (2) plots of vertical concentration profiles for flight segments identified as “spirals”, and (3) integrated spatial plots of concentrations from multiple flights.

Table 5-6. Summary of aircraft flights during the CCOS HPP. An X under each species indicates it was measured and present in the database.

Flight Information					Species Measured						
No.	Flight Description	Date	Start	End	O_3	NO	NO_x	NO_y	NO_2	SO_2	CO
1	STIAZTEC Flight A7	7/30/2000	4:59 AM	9:02 AM	X	X		X			X
2	STIAZTEC Flight A8	7/30/2000	12:14 PM	3:53 PM	X	X		X			X
3	STIAZTEC Flight A9	7/31/2000	4:31 AM	8:15 AM	X	X		X			X
4	STIAZTEC Flight A10	7/31/2000	12:08 PM	4:25 PM	X	X		X			X
5	STIAZTEC Flight A11	8/1/2000	11:55 AM	4:27 PM	X	X		X			X
6	STICESSN Flight C5	7/30/2000	4:39 AM	8:35 AM	X	X		X			
7	STICESSN Flight C6	7/30/2000	12:28 PM	4:37 PM	X	X		X			
8	STICESSN Flight C7	7/31/2000	4:35 AM	8:06 AM	X	X		X			
9	STICESSN Flight C8	7/31/2000	12:30 PM	2:54 PM	X	X		X			
10	STICESSN Flight C9	8/1/2000	12:49 PM	4:43 PM	X	X		X			
11	TVAOTTER Flight 1	7/29/2000	2:02 PM	5:09 PM	X	X	X	X	X	X	X
12	TVAOTTER Flight 2	7/30/2000	10:24 AM	4:15 PM	X	X	X	X	X	X	X
13	TVAOTTER Flight 3	7/31/2000	10:08 AM	5:47 PM	X	X	X	X	X	X	X
14	TVAOTTER Flight 4	8/1/2000	8:47 AM	4:57 PM	X	X	X	X	X	X	X
15	UCD172 Flight UD1721(1)	7/30/2000	4:59 AM	8:22 AM	X	X		X			
16	UCD172 Flight UD1721(2)	7/31/2000	5:02 AM	8:22 AM	X	X		X			
17	UCD172 Flight UD1721(3)	8/1/2000	4:59 AM	8:22 AM	X	X		X			
18	UCD172 Flight UD1722(1)	7/30/2000	12:28 PM	4:25 PM	X	X		X			
19	UCD172 Flight UD1722(2)	7/31/2000	12:28 PM	3:57 PM	X	X		X			
20	UCD172 Flight UD1722(3)	8/1/2000	12:39 PM	4:03 PM	X	X		X			
21	UCD182 Flight UD1821(1)	7/30/2000	5:57 AM	8:24 AM	X	X		X			
22	UCD182 Flight UD1821(2)	7/31/2000	5:22 AM	8:22 AM	X	X		X			
23	UCD182 Flight UD1821(3)	8/1/2000	5:02 AM	8:11 AM	X	X		X			
24	UCD182 Flight UD1822(1)	7/30/2000	12:30 PM	3:47 PM	X	X		X			
25	UCD182 Flight UD1822(2)	7/31/2000	12:30 PM	3:55 PM	X	X		X			
26	UCD182 Flight UD1822(3)	8/1/2000	12:41 PM	4:16 PM	X	X		X			

Table 5-7. Initial criteria used to screen aircraft data records. Data outside the inclusion ranges were labeled as suspect.

Parameter	Time of Day	Initial Inclusion Criteria
O_3	0800 – 1959 PDT (Day)	O_3 >= -0.5 ppb and O_3 <= 200 ppb
O_3	2000 – 0759 PDT (Night)	Altitude >= 500 m and O_3 >= 25 ppb and O_3 <= 200 ppb Altitude <= 500 m and O_3 >= -0.5 ppb and O_3 <= 200 ppb
NO	All	Altitude <= 1000 m and NO >= -0.5 ppb and NO <= 500 ppb Altitude >= 1000 m and NO >= -0.5 ppb and NO <= 20 ppb
NO_y	All	Altitude <= 1000 m and NO_y >= -0.5 ppb and NO_y <= 500 ppb Altitude >= 1000 m and NO_y >= -0.5 ppb and NO_y <= 100 ppb
NO_2 and NO_x	All	Same as NO_y
Longitude	All	Longitude < 0

In addition to the initial screening criteria, the following consistency checks for nitrogen species were performed and the data flagged as suspect if any of the criteria were not met within ± 0.5 ppb.

- $NO_y > NO + NO_2$
- $NO_x >= NO + NO_2$
- $NO <= NO_x$
- $NO <= NO_y$
- $NO_2 < NO_x$
- $NO_2 < NO_y$
- $NO_x <= NO_y$

A summary of records not meeting the range and consistency screening criteria is provided in **Table 5-8.** Because these data were subhourly, they were not subjected to automated flagging. Instead, a complete listing of suspect records is provided in the EDV described in Appendix B.

Most records passed the screening criteria for the longitude check, and only a very small number of records reported longitude as positive instead of negative (e.g., 120.0 instead of -120.0). However, latitude values appear to have been substituted for longitude in the records of TVA Otter Flight 2; therefore, these latitude records are unusable.

A significant number of O_3 records from the University of California Davis (UCD) flights (particularly the Cessna 172) were flagged as suspect. A closer review of those records indicated that most were clearly bad data with large negative (e.g., -400 ppb) and positive (e.g., 900 ppb) values. O_3 records from STI Aztec Flight A7 were flagged because of low concentrations (< 25 ppb) at elevations above 500 m. We investigated these measurements further and found that the flagged values were all measured during a dolphin flight pattern approximately 150 km offshore and are consistent with concentrations throughout the marine boundary layer in that region. As an additional check, the flight log and pre- and post-flight calibration reports were reviewed and showed no unusual biases in the O_3 measurements.

While a significant number of NO records were flagged as suspect for all the UCD Cessna 182 flights, a review of those records indicated that most of those records were flagged because the NO values were slightly negative (-1 or -2 ppb), which may suggest a slight error in zeroing the instrument. Only a few hundred records for NO_x, NO_y, and NO_2 were flagged as suspect—quite small considering the aircraft sampling frequencies were 5 seconds or less and the total flight time was over 100 hours for the 26 flights.

It is recommended that the ARB flag aircraft data as suspect by applying the initial screening criteria with the following exception: O_3 should be flagged suspect when concentrations are less than -0.5 ppb or greater than 250.0 ppb for all altitudes and times of day. This approach will ensure that the bad records in the UCD flights are flagged.

Table 5-8. Summary of aircraft data records reporting data out of range.

Flight Information					Number of Records Out of Range					
No.	Flight Description	Date	Start	End	Longitude	O_3	NO	NO_x	NO_y	NO_2
1	STIAZTEC Flight A7	7/30/2000	4:59 AM	9:02 AM	3	2060				
2	STIAZTEC Flight A8	7/30/2000	12:14 PM	3:53 PM	4					
3	STIAZTEC Flight A9	7/31/2000	4:31 AM	8:15 AM	4					
4	STIAZTEC Flight A10	7/31/2000	12:08 PM	4:25 PM	4					
5	STIAZTEC Flight A11	8/1/2000	11:55 AM	4:27 PM	4					
6	STICESSN Flight C5	7/30/2000	4:39 AM	8:35 AM	3					
7	STICESSN Flight C6	7/30/2000	12:28 PM	4:37 PM	3					
8	STICESSN Flight C7	7/31/2000	4:35 AM	8:06 AM	1					
9	STICESSN Flight C8	7/31/2000	12:30 PM	2:54 PM	3					
10	STICESSN Flight C9	8/1/2000	12:49 PM	4:43 PM						
11	TVAOTTER Flight 1	7/29/2000	2:02 PM	5:09 PM						2
12	TVAOTTER Flight 2	7/30/2000	10:24 AM	4:15 PM	2268		4	75		226
13	TVAOTTER Flight 3	7/31/2000	10:08 AM	5:47 PM						
14	TVAOTTER Flight 4	8/1/2000	8:47 AM	4:57 PM						
15	UCD172 Flight UD1721(1)	7/30/2000	4:59 AM	8:22 AM		31				
16	UCD172 Flight UD1721(2)	7/31/2000	5:02 AM	8:22 AM		58				
17	UCD172 Flight UD1721(3)	8/1/2000	4:59 AM	8:22 AM		678				
18	UCD172 Flight UD1722(1)	7/30/2000	12:28 PM	4:25 PM		2371				
19	UCD172 Flight UD1722(2)	7/31/2000	12:28 PM	3:57 PM		51				
20	UCD172 Flight UD1722(3)	8/1/2000	12:39 PM	4:03 PM		55				
21	UCD182 Flight UD1821(1)	7/30/2000	5:57 AM	8:24 AM		3	2761		19	
22	UCD182 Flight UD1821(2)	7/31/2000	5:22 AM	8:22 AM		109	4640		63	
23	UCD182 Flight UD1821(3)	8/1/2000	5:02 AM	8:11 AM		21	4359			
24	UCD182 Flight UD1822(1)	7/30/2000	12:30 PM	3:47 PM		8	3634		53	
25	UCD182 Flight UD1822(2)	7/31/2000	12:30 PM	3:55 PM			3799			
26	UCD182 Flight UD1822(3)	8/1/2000	12:41 PM	4:16 PM		13	4508		1	

Plots were made using only aircraft data that passed the automated QC checks and were reviewed visually. No significant problems with the data were noted during these reviews. An example plot showing O_3, NO, and NO_y concentrations with height for a spiral flight pattern is shown in **Figure 5-14** All concentration plots of aircraft spirals are provided in the EDV described in Appendix B.

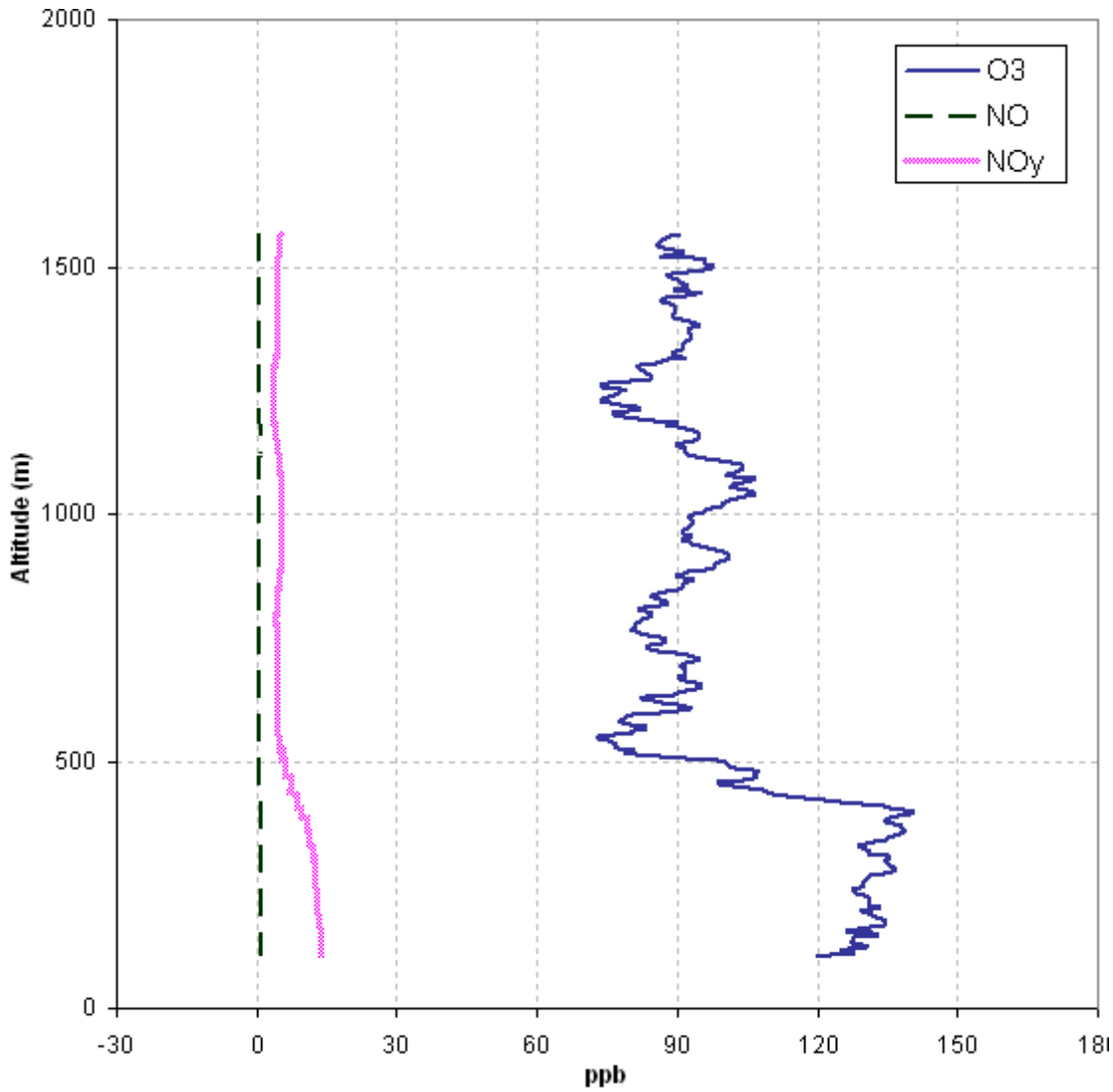


Figure 5-14. Example concentration profile plot of O_3, NO, and NO_y from an aircraft spiral on August 1, 2000.

Spatial plots depicting O_3, NO, NO_2, or NO_2 concentrations as colored-coded dots along flight paths were prepared and reviewed to assess the spatial consistency of aircraft measurements. **Figure 5-15** shows an example of this type of plot. In this example, O_3 concentrations are color-coded, the outer edge of the flight path is plotted with a gray-scale that changes with aircraft elevation (see legends in Figure 5-15), and the flight path is periodically annotated with time and aircraft elevation. Only one flight was plotted at a time so

as not to obscure the flight information. Plots for all flights during a day were reviewed together for spatial consistency of measurements between different aircraft flights. No significant inconsistencies were noted during this review. All the spatial plots prepared are provided in the EDV described in Appendix B.

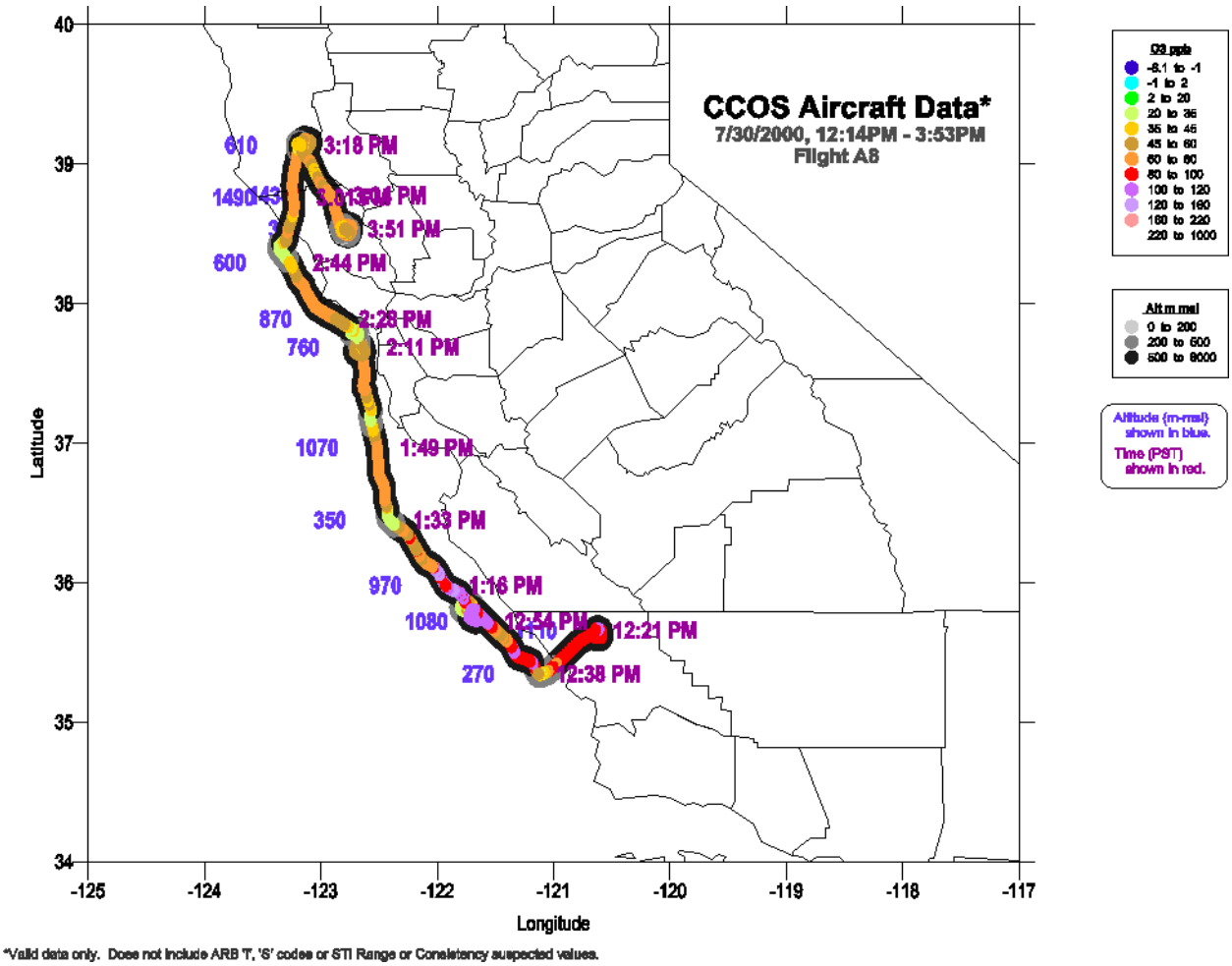


Figure 5-15. Example spatial plot used to compare measurements from multiple flights.

5.4.2 Aloft VOC Data

Thirty-two aloft VOC samples were collected during the CCOS HPP. The concentrations of acetylene, benzene, xylenes (mp_xylene and o_xylene), propene, toluene, ethane, and total non-methane, non-ethane hydrocarbons were inspected along with continuous NO_y measurements and calculated ratios of NMHC to NO_y, xylenes to benzene, toluene to benzene, and benzene to acetylene. These data are summarized in **Table 5-9**. Based on our review, the following observations are made.

- Ethane values on Flight C5 appear high, especially since they occurred all on the same flight, but were not seen in the first canister on Flight A7, which occurred between two of the C5 flight samples. The differences in locations between Flights C5 and A7 may explain this discrepancy. However, these values are the same order of magnitude as ground-based measurements of ethane in several rural areas and, therefore, were not flagged as suspect.
- Benzene, propene, and toluene data usually appear anywhere acetylene is measured, so their absence in many samples is suspect.
- The NMHC-to-NOy ratios for the most part are reasonable, although a few flights (A7 at 06:46 AM and A9 at 07:03 AM) showed very high ratios. However, both NMHC and NO_y concentrations themselves are reasonable so the data were not flagged as suspect.
- The benzene-to-acetylene ratio on Flight A11 at 02:07 PM is low and the acetylene from this sample should be considered suspect.
- The xylene-to-benzene ratios vary considerably but seem reasonable for aircraft data.
- For Flight C9 at 04:18 PM, the high concentrations of acetylene and propene but very low xylenes seem unusual. However, because those species plus ethane and NMHC are high, it may be that the xylenes are too low.

Table 5-9. Summary of aircraft VOC samples collected during the CCOS HPP. VOC concentrations are in units of ppbC.

Sample Information					Concentrations									Ratios			
Flight	Date-Time	Height (m msl)	Latitude	Longitude	Acetylene	Benzene	Mp_Xylene	O_Xylene	Propene	Toluene	NMHC	NO_y (ppb)	Ethane	NMHC/NO_y (ppbC/ppb)	Xylenes/ Benzene	Toluene/ Benzene	Benzene/ Acetylene
C5	7/30/2000 5:07:01 AM	391	35.3283	-119.4638	0.2		0.3				92.4	6.7	1067.6	13.7			
C5	7/30/2000 5:35:53 AM	787	35.9367	-119.5502	0.3		0.4				90.1	5.0	666.3	17.9			
A7	7/30/2000 6:46:51 AM	487	36.3858	-123.7680	5.7				1.3		64.3	0.8	2.3	81.7			
C5	7/30/2000 7:18:54 AM	781	35.9728	-120.1305	0.6		0.1				95.6	3.9	894.4	24.3			
A7	7/30/2000 7:40:56 AM	786	34.5863	-122.6433	0.2						13.7	0.9	0.2	15.5			
A7	7/30/2000 8:09:36 AM	432	34.9503	-121.9442	0.1						7.4	1.0	0.1	7.6			
A8	7/30/2000 12:56:58 PM	778	37.3605	-120.6083	0.3						15.3	5.5	0.3	2.8			
A8	7/30/2000 1:03:30 PM	278	37.3253	-120.5607	0.2						6.4	2.9		2.2			
A8	7/30/2000 2:11:01 PM	763	37.1027	-121.5627							12.4	1.4	0.2	8.7			
C6	7/30/2000 2:12:03 PM	786	36.9912	-120.1047	1.2	10.7	23.4		5.1	3.4	85.4	2.7	1.2	31.4	2.2	0.3	8.9
A8	7/30/2000 2:13:47 PM	733	37.0653	-121.5780	3.4						16.3	1.4	0.7	11.5			
C6	7/30/2000 3:43:10 PM	799	35.9318	-119.5310	0.1						21.8	3.3	0.3	6.6			
C6	7/30/2000 4:12:47 PM	802	35.5518	118.8673	0.1	0.6	0.1				66.6	5.8		11.4	0.2		6.0
C7	7/31/2000 5:03:00 AM	416	35.3345	-119.4927	1.7		0.2		0.4		41.4	6.9	1	6.0			
C7	7/31/2000 5:29:12 AM	806	35.9365	-119.5158	2.1						29.4	5.2	0.6	5.6			
A9	7/31/2000 6:14:11 AM	820	37.3800	-121.1135	0.1						23	1.6	0.4	14.3			
A9	7/31/2000 6:21:17 AM	374	37.3493	-121.0605							19.8	1.6	0.2	12.3			
C7	7/31/2000 6:40:26 AM	785	36.9938	-120.1388	0.2		0.3				25.8	6.2	0.4	4.1			
A9	7/31/2000 7:03:05 AM	802	37.4502	-120.6780	0.2	0.7	0.7		0.5	0.3	79.6	1.4	0.3	56.1	1.0	0.4	3.5
A9	7/31/2000 7:11:01 AM	394	37.4877	-120.6655	0.4						20.4	2.5	0.3	8.3			
A10	7/31/2000 1:02:03 PM	770	37.3838	-120.5370	0.1						15.7	2.0	0.2	7.9			
A10	7/31/2000 1:38:03 PM	787	37.0487	-121.0928	0.2					0.2	34	4.4	0.2	7.8			
C8	7/31/2000 2:01:40 PM	799	36.9923	-119.6532	0.3		0.1				20.4	8.5	1	2.4			
A10	7/31/2000 2:03:44 PM	768	37.0570	-121.5543	0.6	1.2	0.7		0.3	0.4	60.7	6.4	0.5	9.5	0.6	0.3	2.0
A10	7/31/2000 2:27:28 PM	1511	37.2437	-121.3573	0.3						24.9	2.9	0.3	8.5			
A11	8/1/2000 12:55:31 PM	789	37.4068	-120.5588	0.1		0.1				22.4	4.2	0.2	5.4			
A11	8/1/2000 1:36:31 PM	800	37.079	-121.1170	0.1						23.8	10.4	0.5	2.3			
A11	8/1/2000 2:07:31 PM	768	37.0508	-121.6132	0.4	0.3	0.3				31.9	18.7	0.6	1.7	1.0		0.8
C9	8/1/2000 2:10:50 PM	801	37.006	-119.9358	0.2		0.1				20.7	4.0	0.4	5.2			
A11	8/1/2000 2:32:01 PM	1576	37.2568	-121.3437	0.1						18.2	6.6	0.3	2.7			
C9	8/1/2000 3:38:20 PM	791	35.9408	-119.5195	0.3						18.8	4.2	0.6	4.5			
C9	8/1/2000 4:18:20 PM	808	35.3063	-118.7833	34.2		0.3		19.2		65.5	9.2	15.9	7.1			

5.4.3 Ozonesondes

The data from each ozonesonde released from Granite Bay (GNBY) and Parlier (PLR) during CCOS were plotted and visually inspected to assess data quality and consistency. An example plot is shown in **Figure 5-16**. Because the number of ozonesondes launched during CCOS was limited, we reviewed all 96 soundings taken during summer 2000 instead of those taken only during the HPP. The vertical plots of all O_3 soundings and data sets containing ozonesonde data with updated QC flags are provided in the EDV described in Appendix B. Data quality issues that pertain to individual soundings are detailed in **Table 5-10**.

The diurnal cycle of near-surface and boundary layer O_3 concentrations depicted in the soundings is generally consistent with the expected O_3 diurnal cycle, with the lowest values apparent in the early morning (0500 PST) soundings, and the highest values apparent in the afternoon (1700 PST) soundings. Aloft, most soundings exhibited vertical structure at multiple scales. Some elevated features persisted through two or more consecutive soundings, while other structures were more transient in nature.

Data quality issues with the CCOS ozonesondes generally fell into four categories: spurious (outlier) points, data gaps, excessive data scatter, and incorrect time stamps. Most of the outlier points were discovered at the very top (i.e., the last one to three points) of the sounding. A total of 45 soundings from both Granite Bay and Parlier had outliers at the sounding top. The values of these outlier points were typically near zero, while O_3 concentrations just below these outlier points were always much higher. A few soundings contained single outlier points at other locations, including the surface. A few soundings (e.g., sounding 2) had groups of consecutive data points that broke the continuity of the sounding with physically unreasonable O_3 concentrations. Negative near-surface O_3 concentrations were also noted in three soundings.

In some cases, outlier points occurred in a sounding that also contained data gaps and enhanced scatter. Sounding 33 is an example of such a case. In the vicinity of the data gaps and outliers, data points in the file are continuous in time, but not continuous in altitude, resulting in data with random jumps in altitude instead of data with a consistently increasing altitude. Such a scenario may be indicative of a general degradation of the radio signal.

While most data from CCOS ozonesondes exhibited little scatter, O_3 data in some soundings indicated more scatter than usual, especially in the higher altitudes of the sounding. Usually this scatter was less than 2 ppb; but in some soundings, the scatter was more significant. Since this issue was more prevalent in the upper altitudes, radio transmission difficulties may have resulted in data degradation.

Five ozonesondes collected data for more than one hour. In each case, after the first data point in the second hour, the time stamp did not iterate forward, but instead reverted to the sounding start time and iterated forward from there. The result is that some data points have duplicate time stamps (but unique altitudes). This error likely does not result in data degradation, as the data from these soundings look physically realistic, but it causes the altitudes in the data file to oscillate between a lower-level and upper-level data point, as data are organized in ascending time order.

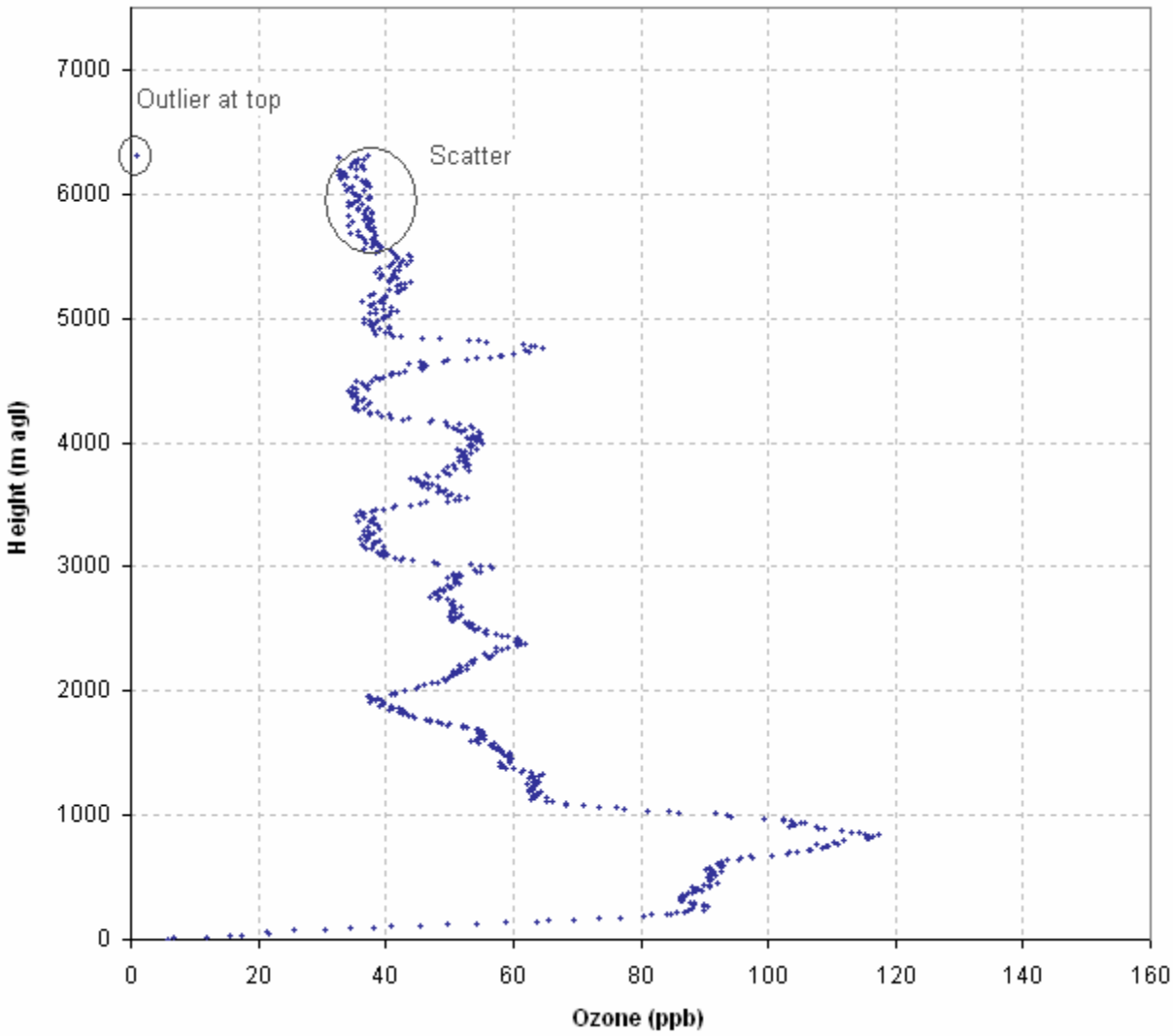


Figure 5-16. Example ozonesonde plot from Parlier on September 17, 2000, at 2200 PST.

Table 5-10. Summary of data quality for CCOS ozonesondes.

Sounding Number	Location	Date	Time (PST)	Comments
1	GNBY	7/23/00	0500	Spurious values at sounding top
2	GNBY	7/23/00	1100	Discontinuity at 700m; suspicious data below 700m; spurious values at top; for data after 1200 PST, time stamp is behind by 1 hour
3	GNBY	7/23/00	2200	Spurious values at sounding top
4	GNBY	7/24/00	0500	Spurious values at sounding top
5	GNBY	7/24/00	1100	Spurious values at sounding top
6	GNBY	7/24/00	1700	Max height only 1874 m
7	PLR	7/23/00	0500	Scatter above 6 km; data gap until top point at 7155 m; for data after 0600 PST, time stamp is behind by 1 hour
8	PLR	7/23/00	1100	Spurious values at sounding top; scatter above 4600 m
9	PLR	7/23/00	1700	Spurious values at sounding top; for data after 1800 PST, time stamp is behind by 1 hour
10	PLR	7/23/00	2200	Spurious values at sounding top
11	PLR	7/24/00	0500	Spurious values at sounding top
12	PLR	7/24/00	1100	Spurious values at sounding top; for data after 1200 PST, time stamp is behind by 1 hour
13	PLR	7/24/00	1700	Spurious values at sounding top
14	GNBY	7/30/00	0500	Spurious values at sounding top
15	GNBY	7/30/00	1100	OK
16	GNBY	7/30/00	1700	OK
17	GNBY	7/30/00	2200	OK
18	GNBY	7/31/00	1100	OK
19	GNBY	7/31/00	1700	OK
20	GNBY	7/31/00	2200	OK
21	GNBY	8/1/00	0500	Spurious values at sounding top
22	GNBY	8/1/00	1100	OK
23	GNBY	8/1/00	1700	Small discontinuity near 3500 m
24	GNBY	8/2/00	0800	Max height 4822 m; gaps near 300 and 3200 m; possible outlier near 3600 m
25	GNBY	8/2/00	1500	Small discontinuities near surface, 4500 m, and 5700 m
26	PLR	7/30/00	0500	Spurious values at sounding top; negative values at surface; for data after 0600 PST, time stamp is behind by 1 hour
27	PLR	7/30/00	1100	Max height only 3146 m
28	PLR	7/30/00	1700	Spurious values at sounding top; small discontinuity at surface
29	PLR	7/30/00	2200	Spurious values at sounding top
30	PLR	7/31/00	0500	Negative values at surface
31	PLR	7/31/00	0800	Spurious values at sounding top
32	PLR	7/31/00	1100	Spurious value at top; noise and gaps above 5 km; spurious point near 5 km
33	PLR	7/31/00	1400	Spurious values near 3500, 4300, and 4700m; gaps and scatter above 4300 m
34	PLR	7/31/00	1700	Spurious values at sounding top
35	PLR	7/31/00	2200	Spurious values at sounding top; small data gap near surface
36	PLR	8/1/00	0500	Spurious values at sounding top
37	PLR	8/1/00	1100	Spurious values at sounding top, and possibly one at bottom of sounding
38	PLR	8/1/00	1400	Spurious values at sounding top
39	PLR	8/1/00	1700	Spurious values at sounding top; some scatter throughout profile

Table 5-10. Summary of data quality for CCOS ozonesondes.

Sounding Number	Location	Date	Time (PST)	Comments
40	PLR	8/2/00	0800	Some scatter above 4 km
41	PLR	8/2/00	1500	OK
42	GNBY	8/14/00	0500	Spurious values at sounding top
43	GNBY	8/14/00	1100	One spurious value at bottom of sounding
44	GNBY	8/14/00	1400	Spurious values at bottom and top of sounding; spurious points near 200 m
45	GNBY	8/14/00	1700	Spurious values at sounding top
46	PLR	8/14/00	0500	Spurious values at sounding top; possible spurious value near 5 km (not flagged)
47	PLR	8/14/00	1100	Spurious values at sounding top
48	PLR	8/14/00	1400	Spurious values at sounding top
49	PLR	8/14/00	1700	Spurious value at bottom of sounding; some scatter above 5.5 km
50	GNBY	9/17/00	0500	OK
51	GNBY	9/17/00	1100	Spurious values at sounding top
52	GNBY	9/17/00	1400	Possibly spurious points at surface and near 1.0 km (not flagged)
53	GNBY	9/17/00	1700	Spurious values at sounding top
54	GNBY	9/17/00	2200	OK
55	GNBY	9/18/00	0600	No sounding
56	GNBY	9/18/00	1100	OK
57	GNBY	9/18/00	1400	OK
58	GNBY	9/18/00	1700	OK
59	GNBY	9/18/00	2200	OK
60	GNBY	9/19/00	0500	OK
61	GNBY	9/19/00	1100	OK
62	GNBY	9/19/00	1400	Possible outlier near surface (not flagged)
63	GNBY	9/19/00	1700	OK
64	GNBY	9/19/00	2200	Some scatter near 2 km (may be real structure)
65	GNBY	9/20/00	0500	Spurious values at sounding top; some scatter at 1.8 km
66	GNBY	9/20/00	1100	OK
67	GNBY	9/20/00	1400	Spurious values at sounding top
68	GNBY	9/20/00	1700	Some scatter in boundary layer
69	GNBY	9/21/00	0500	Small gap at 6 km
70	GNBY	9/21/00	1100	OK
71	GNBY	9/21/00	1400	OK
72	GNBY	9/21/00	1700	Some scatter (>= 2 ppb) throughout sounding (not flagged)
73	PLR	9/17/00	0500	Zero O_3 in lowest 100 m (not flagged)
74	PLR	9/17/00	1100	Spurious values at sounding top
75	PLR	9/17/00	1400	OK
76	PLR	9/17/00	1700	Spurious values at sounding top
77	PLR	9/17/00	2200	Spurious values at sounding top; noisy sounding, esp. above 5 km (not flagged)
78	PLR	9/18/00	0500	Spurious values at sounding top
79	PLR	9/18/00	1100	Spurious values at sounding top; some scatter near 1 km and 4.8 km
80	PLR	9/18/00	1400	OK
81	PLR	9/18/00	1700	OK
82	PLR	9/18/00	2200	OK
83	PLR	9/19/00	0500	Spurious values at sounding top
84	PLR	9/19/00	1100	OK

Table 5-10. Summary of data quality for CCOS ozonesondes.

Sounding Number	Location	Date	Time (PST)	Comments
85	PLR	9/19/00	1400	Spurious values at sounding top
86	PLR	9/19/00	1700	Spurious values at sounding top
87	PLR	9/19/00	2200	OK
88	PLR	9/20/00	0500	Spurious values at sounding top
89	PLR	9/20/00	1100	OK
90	PLR	9/20/00	1400	OK
91	PLR	9/20/00	1700	Spurious values at sounding top
92	PLR	9/20/00	2200	OK
93	PLR	9/21/00	0500	Possible outlier near 5700 m
94	PLR	9/21/00	1100	Noisier than most other soundings
95	PLR	9/21/00	1400	Spurious values at sounding top
96	PLR	9/21/00	1700	OK

5.4.4 Summary of Aloft Air Quality QC Results

In general, the aloft air quality measurements were of high quality with few problems. The most severe problems were the incomplete location information for one of the TVA flights and a moderate number of suspect O_3 values from the UCD Cessna 182 flights. While some of the VOC data may be suspect, few measurements are available to inter-compare and these data should be used with some caution. Except for spurious values at the top of soundings and occasional data gaps and/or scatter in the data, ozonesonde data showed reasonable internal and external consistency. For a few ozonesondes that lasted more than an hour, the time stamps were off by an hour, which we corrected in the EDV compiled on the CD that accompanies this report.

The location data from the TVA flight should be recoverable from the original data submitted. While it was not within the scope of this project to flag subhourly data, flagging the suspect data records should be done using the electronic lists provided with this report to ensure these data are not used inadvertently by data analysts or modelers.

6. CONCLUSIONS AND RECOMMENDATIONS

Overall, after both automated quality control and detailed examinations were completed, 98% of the data residing in the CCOS data archive were determined to be valid. With only a few minor exceptions, the data residing in the CCOS data archive should be ready for use by data analysts and modelers without further consideration of data quality. Appendix A provides a visual summary of the results of the QC audit of the entire CCOS period (June 1–September 30, 2000) and detailed QC of the HPP data from July 25–August 2, 2000.

6.1 SUMMARY OF APPROACH

The goal of the overall data validation effort was to ensure a consistent and reliable set of meteorological and air quality data ready for use by data analysts and modelers. To achieve this goal, we evaluated the entire process of managing, quality-assuring, and quality-controlling the CCOS subset of the CCAQS database archive; documented the quality of the data; and performed additional QC as necessary. The major elements of this evaluation include

- comparing the data that reside in the CCAQS data management system with the data that were planned to have been collected for the CCOS period, as identified in the CCOS planning documents;
- conducting a QC audit of the data by checking data consistency (e.g., measurement methods, time averaging, and reporting units);
- quality-controlling the data by checking for gross outliers and performing detailed QC of selected data (note, we recommend that users give precedence to QC flags from the subjective QC task rather than flags from the gross outlier check); and
- preparing a thorough evaluation of the database in the form of a final report to be used by data analysts and modelers to focus on useful data for model inputs, model evaluations, and investigations of O_3 transport and formation.

6.2 SUMMARY OF FINDINGS

In general, the comparison of the CCOS field data sets, expected to reside in the CCAQS database as identified in study planning documents, with actual data in the current archive as of April 2005 showed the following:

- Ninety percent of the expected sites reported some air quality data.
- Eighty-three percent of the expected sites reported at least half of the expected air quality parameters.
- Eighty-eight percent of the expected sites reported surface meteorology parameters.
- About 400 additional surface meteorological sites were found that were not documented in the study plans.

- Twenty-six RWP and RASS sites were expected and 26 sites were found, but not necessarily in the same locations reported in the planning documents
- None of the expected NEXRAD or radiosonde data were found.
- Seven SODAR sites were expected and 9 sites were found.
- All six aircraft reported some data; O_3, NO, NO_y, temperature, wind speed, and wind direction were reported from all aircraft.

Overall, results were excellent, especially for surface air quality data. During the course of the study, we found that at least 18 routine air quality monitoring sites within the study domain were not included in either the CCOS planning documents or in the archive itself. Once informed of these discoveries, the ARB set plans in motion to compile the available data and add them to the archive.

Our survey of data users indicated that no additional effort to perform Level 2 or Level 3 validation was made; thus no additional quality-controlled data sets are available to incorporate into the CCAQS archive with the exception of the subjective QC of the remainder of the summertime RWP wind and RASS T_v data currently being completed by NOAA for resubmission to the CCAQS database.

6.3 IDENTIFICATION OF PROBLEMS

Despite the overall good quality of the data in the archive, there were a number of site-specific or parameter-specific data quality issues and data archive issues, or data recovery issues that should be addressed as listed below.

6.3.1 Data Recovery Issues

- VOC data available from some routine PAMS sites are not included in the archive except for those from IOPs.
- O_3 measurements at many routine monitoring sites were not included in the archive.
- For Arvin, although CO and VOC were measured from the same canister, only VOC measurements were reported.
- For Granite Bay, Sloughhouse Road, and Sunol Station sites, nitric acid monitors were listed, but no data were reported.
- For Livermore, NO data were reported, but NO_x and NO_y data were not.
- For the Walnut Grove tower, at various heights, we expected to see NO, NO_x, or NO_y but no oxides of nitrogen data were found.
- Some surface data labeled as T_v are actually wind direction (e.g., the parameter ID is T_v but the method is wind direction).
- Some data labeled vector wind speed appear to be wind speeds but are in units of degree.

- For Angiola, data labeled dew point temperature and appearing to look like dew point data are in units of percent.
- Some TVA aircraft data records have incorrect location information, preventing any geographic assignments of the data.
- For most RWP sites, minimal data were recovered above 3000 m, likely the result of a dry air mass over the study domain.

6.3.2 Data Archive Issues

- Subhourly aircraft data exist in the "Air_Obs_Hourly" table; more than 100,000 data records of subhourly non-aircraft data exist in the "Air_Obs_Hourly" table.
- "Sample_Duration_Code"and "Sample_Frequency_Code" fields exist in both tables "Methods" and "Air_Obs_Hourly". However, related records (matching "Method_ID") in the two tables have different values for these fields.
- "Obs_Type_Code" is also duplicated in both "Methods" and "Air_Obs_Hourly" tables but identical values appear to exist in both systems. Thus the field in one of these tables is redundant.
- A small number of records with "OBS_Value" of -950 were flagged "valid" in the original CCOS data archive.
- A variety of "Obs_Value" has been used for missing data, including but not limited to –950, –999, and NULL.
- Some data are in meters above sea level and some data are in meters above ground level.

6.3.3 Specific Sites or Parameters of Concern

- All NOAA-sponsored, upper-air RASS data from the HPP have duplicate profiles in the database:
  - data submitted first with a lower QC level have time stamps of hh:01;
  - data were then resubmitted after further QC;
  - resubmitted data have time stamps of hh:00 (offset 1-minute from original submissions); and
  - not all points in each profile were replaced with resubmitted data. We believe that the points, which were invalidated in the more recent QC process, were not resubmitted to the database, thus leaving the original valid value in the profile. Unfortunately, there is no way to determine that the data were later invalidated, especially if the user has no knowledge of the most recent QC Change Date for a given data set.
- RWP data at Carrizo Plain consist of five unique sets of data for each mode (low and high) instead of one in the database. All are evenly spaced high- or low-mode data sets, but only one matches the data on the NOAA web site. All five sets of data have the same QC level and the parameter, QC_Change_Date. The extra sets do not match data for any other site in the CCOS database.

6.4 RECOMMENDATIONS FOR FURTHER DATA VALIDATION

The following additional data validation efforts are recommended.

- Perform automated QC checks on all data that were added to the CCAQS database after April 2005.
- Perform detailed QC checks on data from IOPs that were added to the CCAQS database after April 2005.
- Develop automated QC checks for and perform QC checks on radiosonde, NEXRAD, and mixing height data if they are added to the CCAQS database.
- Establish a system for tracking and resolving QC issues identified during subsequent data analysis and modeling efforts. The system could be patterned after commonly used "bug" tracking programs to provide a chronological summary of reported QC issues and their dates of resolution so that end users can easily identify data issues and know when to download database updates.

6.5 RECOMMENDATIONS FOR FUTURE CONSIDERATION

Although outside the normal bounds of a data quality audit, during the course of the audit of the CCOS data archive, we identified a number of issues that we recommend be considered for future database development efforts of this magnitude. Clearly, a significant effort went into the design and implementation of the CCAQS database, but we believe that the following issues should be considered in future efforts to design and implement similar data archives because they would facilitate the use of data by analysts and modelers.

- Create a table in the database referencing readme-type files and data QA documents (e.g., instrument methods, calibrations, data validation steps, etc.) and require that data providers provide this information.
- Establish consistent naming and unit conventions or allow export of data using such conventions (e.g., some data are in meters above sea level and some data are in meters above ground level).
- Group all parameters at a site as a single site in the database (the current system does not support the traditional site concept but treats site-sensor height combinations as a unique "support code").

Lastly, while the automated QC checks used in this study were designed to identify the most serious data problems, they cannot detect more subtle problems in the data. For example, they cannot identify improper time zones (i.e., PST versus PDT), errors in site locations, or small biases in data values. These types of issues should be addressed during the QA tasks that are normally performed before data are imported into a database.

7. REFERENCES

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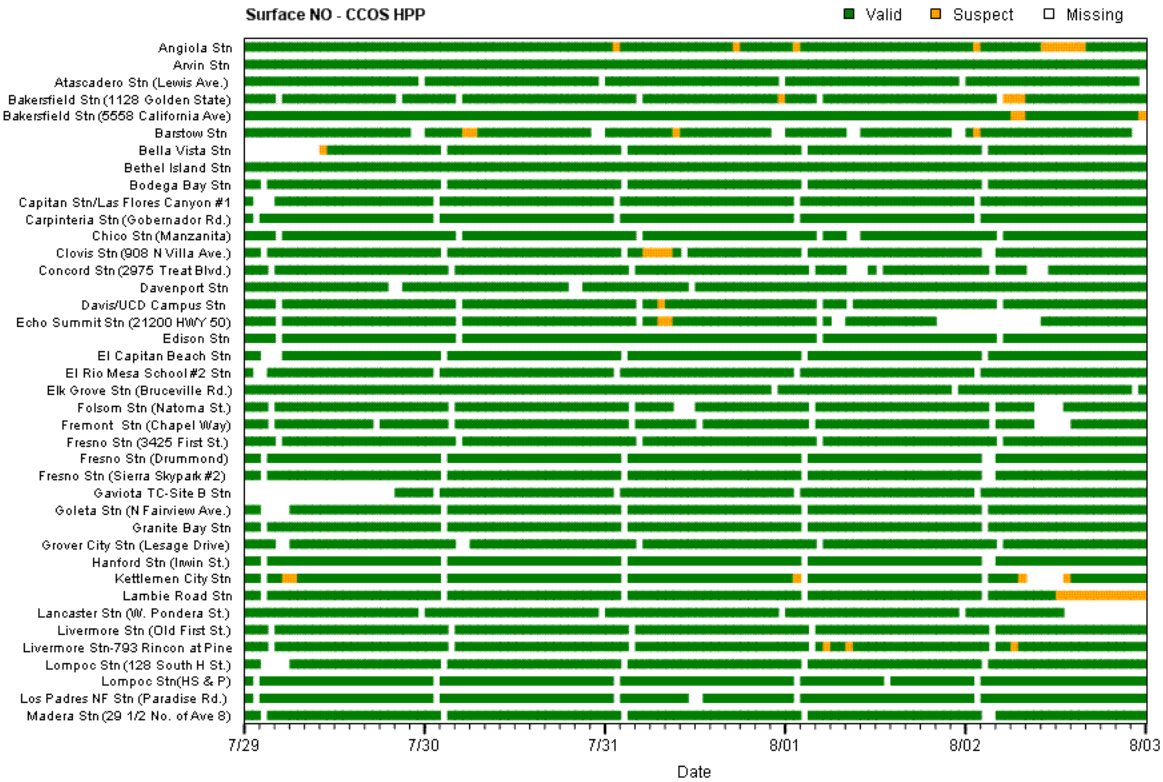
APPENDIX A

SUMMARY OF DATA

The following plots summarize data availability and status in the CCOS database after QC by parameter and site. Valid, suspect, and missing data are indicated by color code. Pages A-3 to A-10 cover the high priority period (July 29–August 2, 2000) while pages A-11 to A-18 cover the entire period subjected to automated QC (June 1–September 30, 2000).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Lambie Road Stn
Lancaster Stn (W. Pondera St.)
Livermore Stn (Old First St.)
Livermore Stn-793 Rincon at Pine
Lompoc Stn (128 South H St.)
Lompoc Stn(HS & P)
Los Padres NF Stn (Paradise Rd.)
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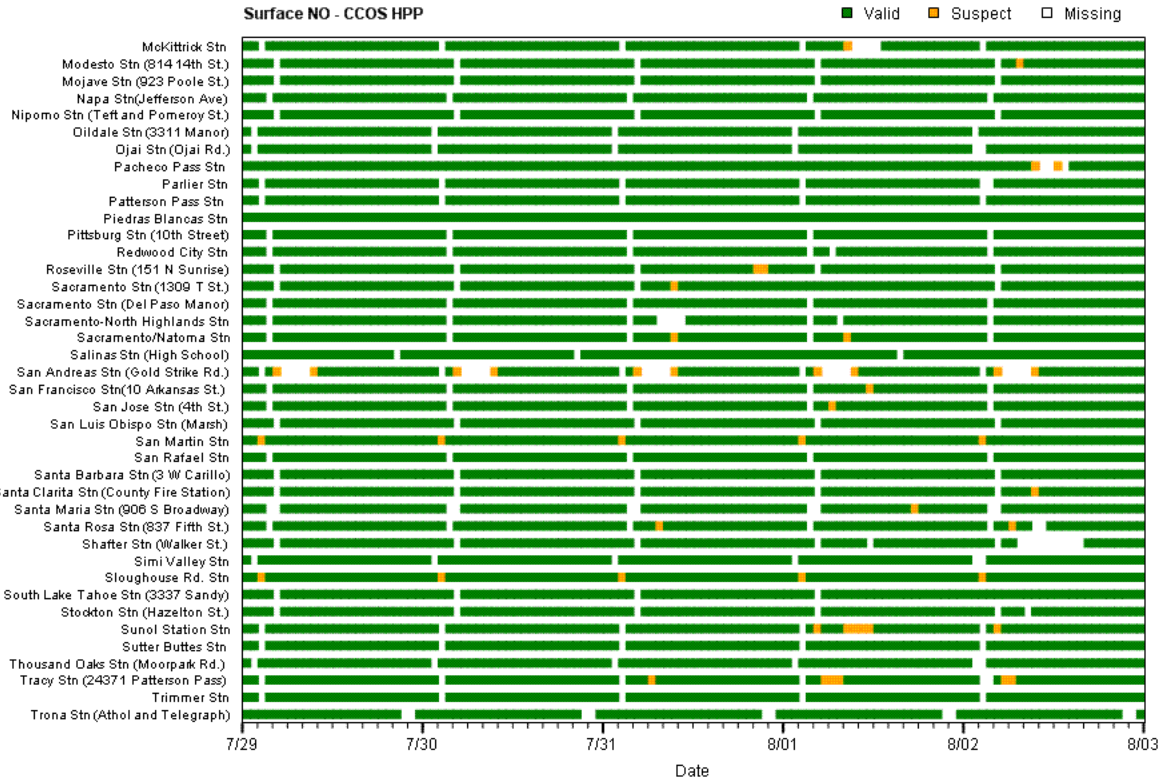
7/29
7/30
7/31
8/01
8/02
8/03
Date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Ojai Stn (Ojai Rd.)
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Patterson Pass Stn
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Sacramento/Natoma Stn
Salinas Stn (High School)
San Andreas Stn (Gold Strike Rd.)
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San Jose Stn (4th St.)
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Stockton Stn (Hazelton St.)
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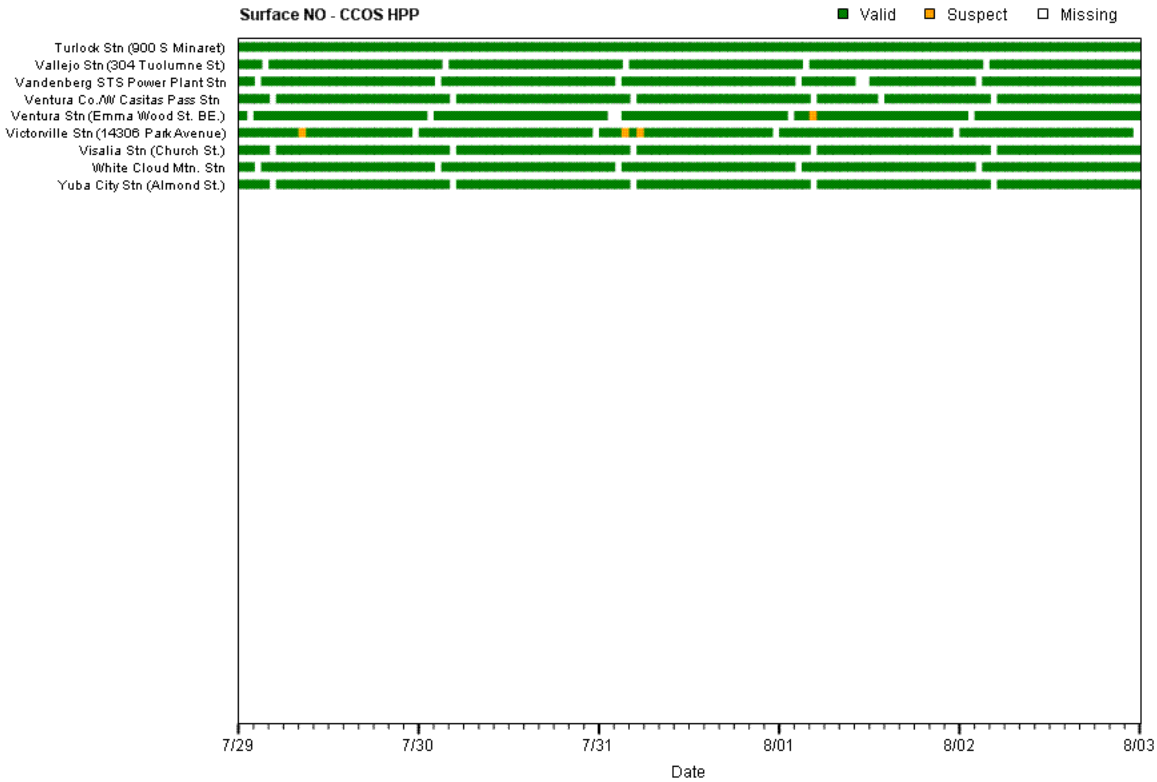
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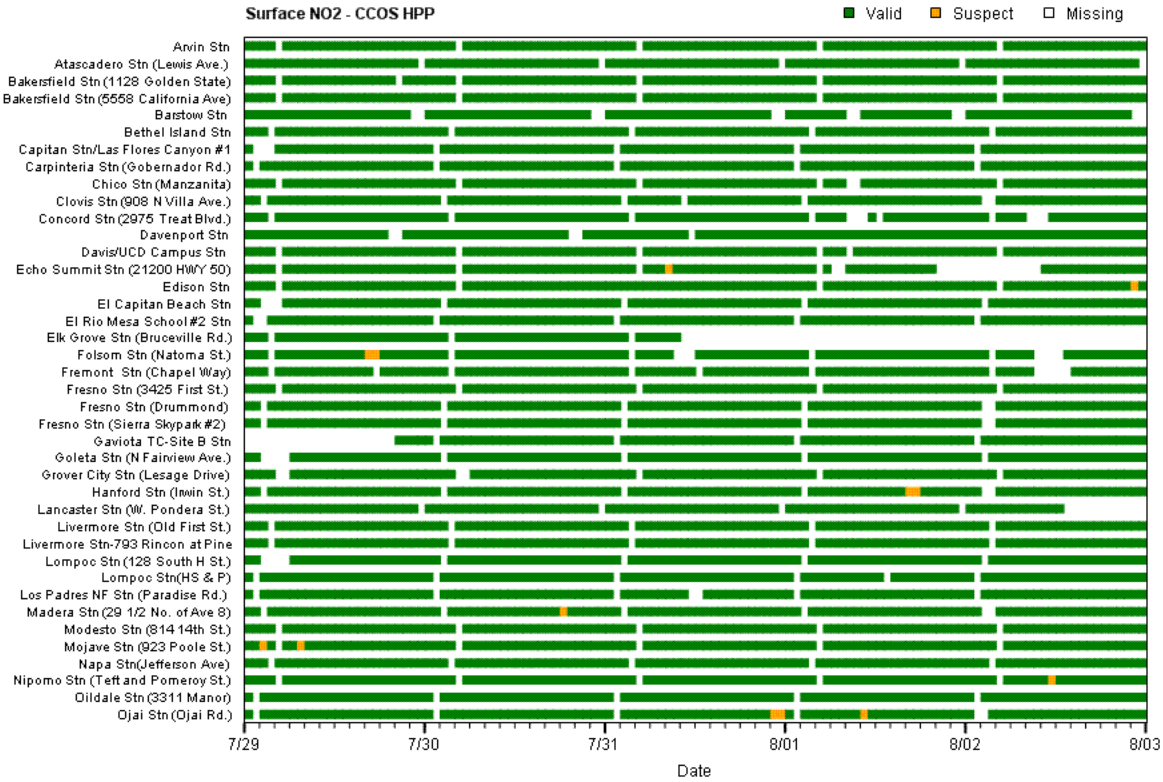
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Chico Stn (Manzanita)
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Concord Stn (2975 Treat Blvd.)
Davenport Stn
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Echo Summit Stn (21200 HWY 50)
Edison Stn
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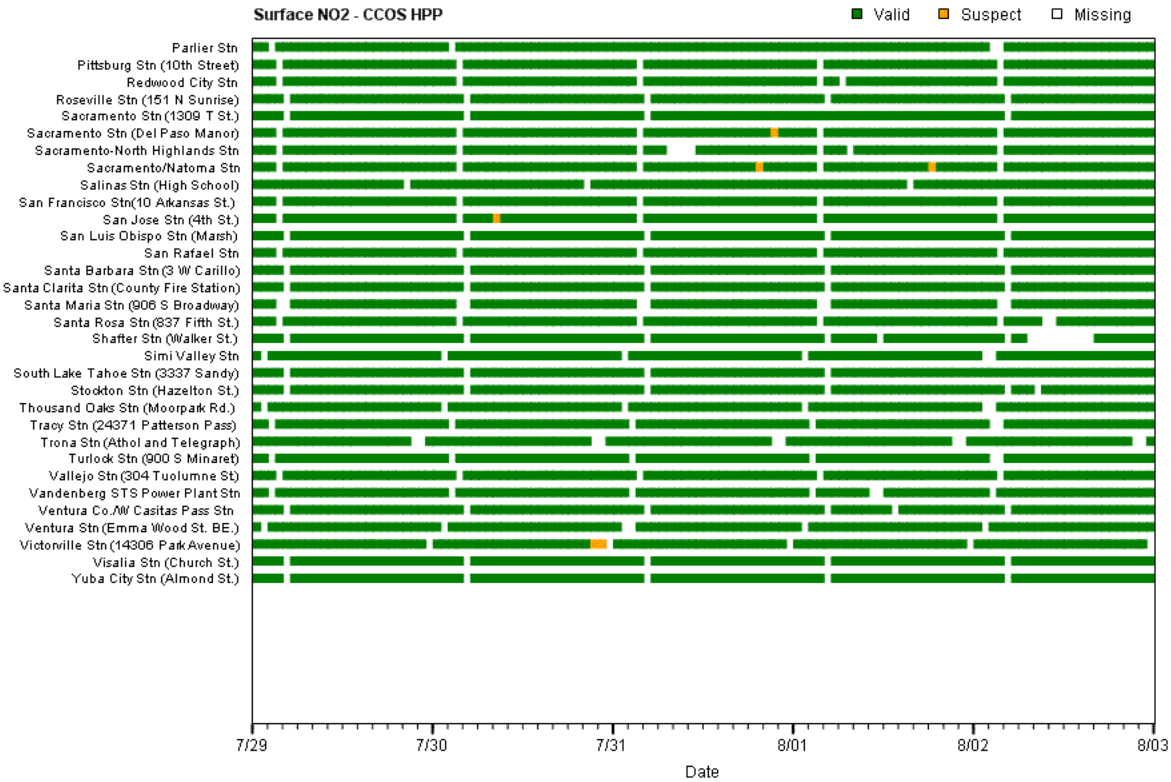
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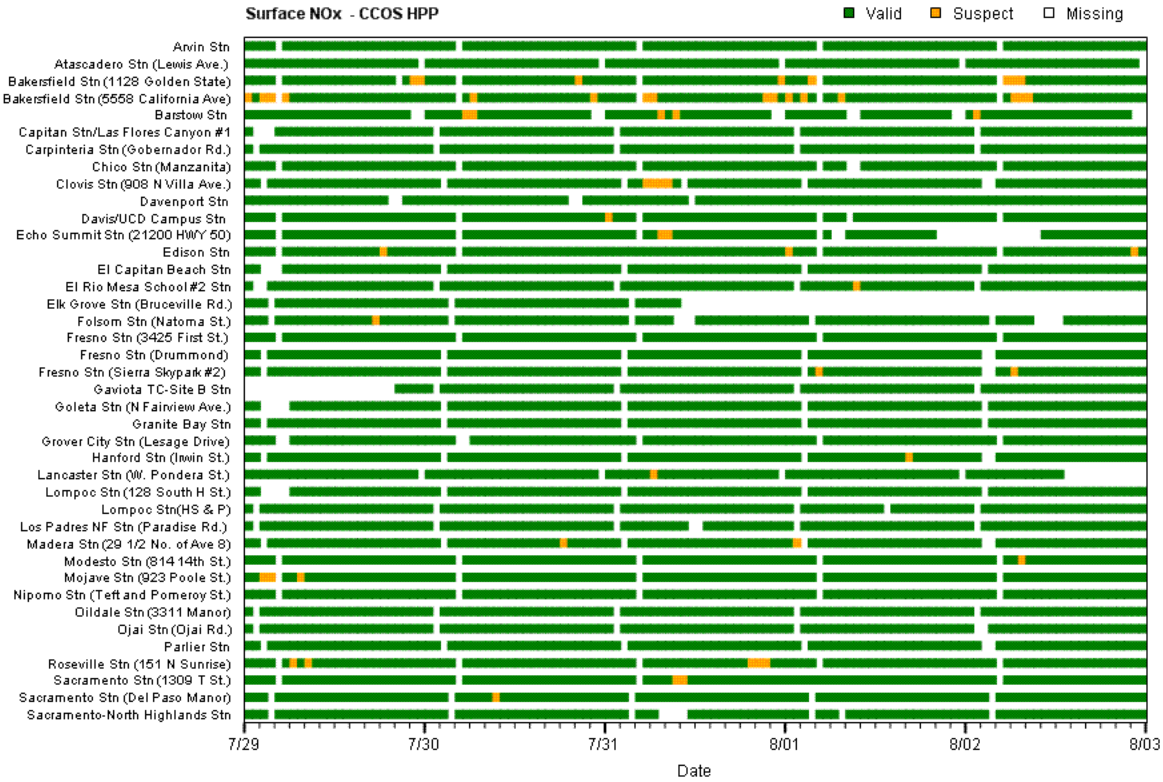
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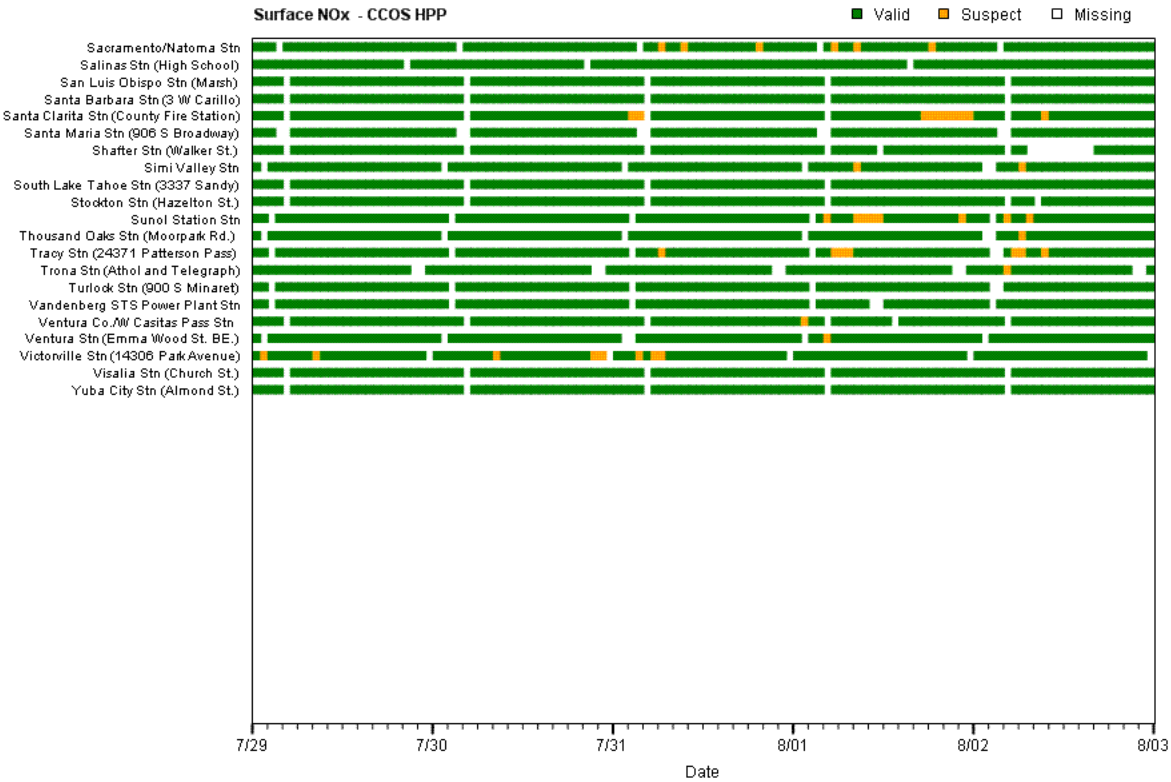
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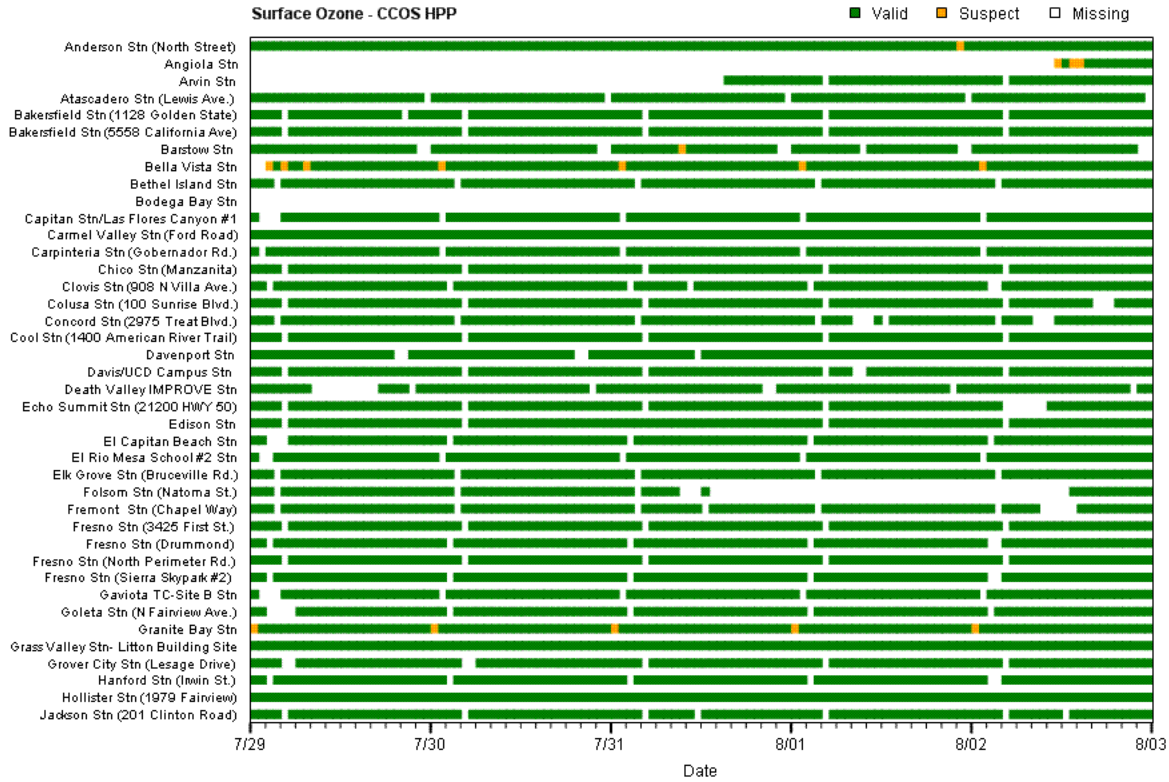
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Clovis Stn (908 N Villa Ave.)
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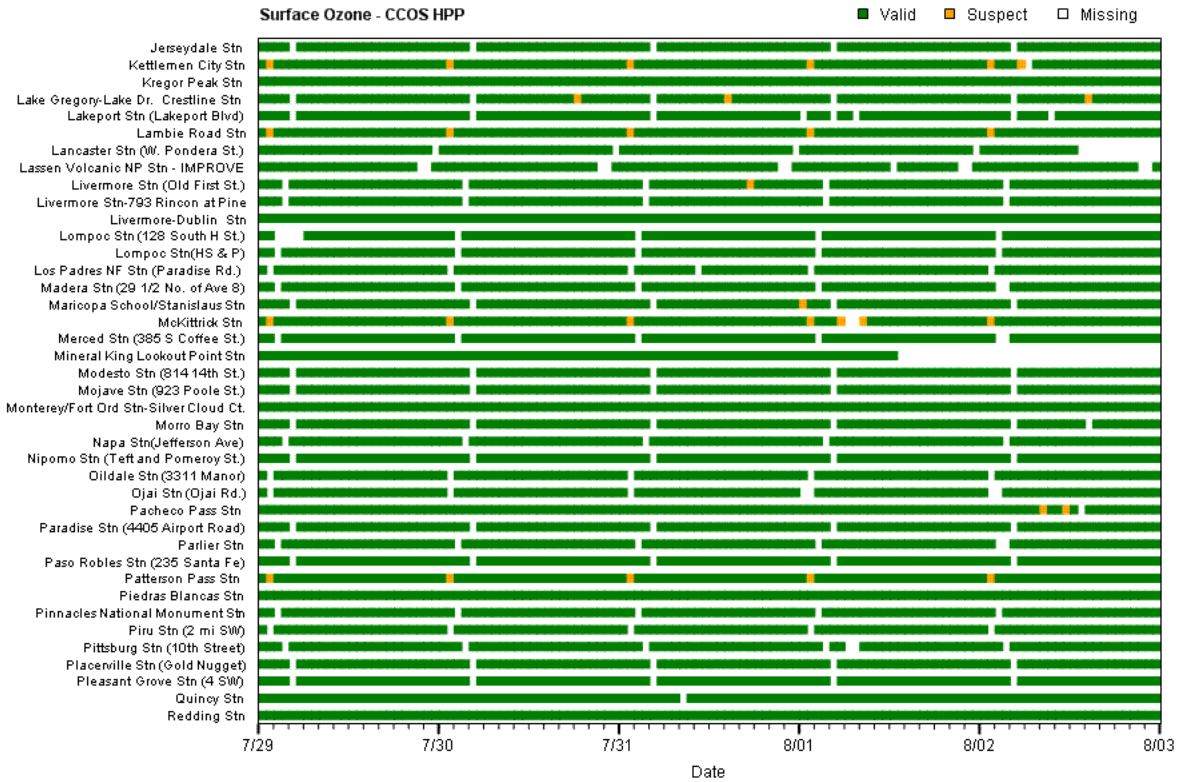
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Pinnacles National Monument Stn
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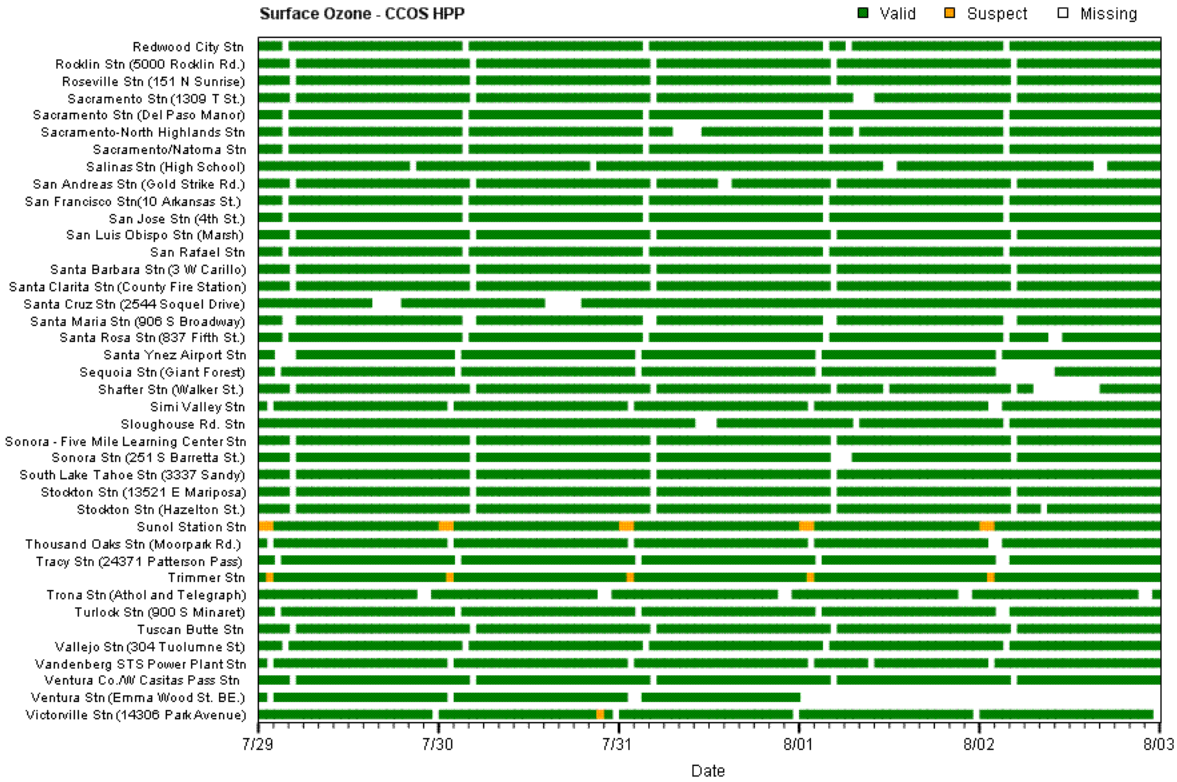
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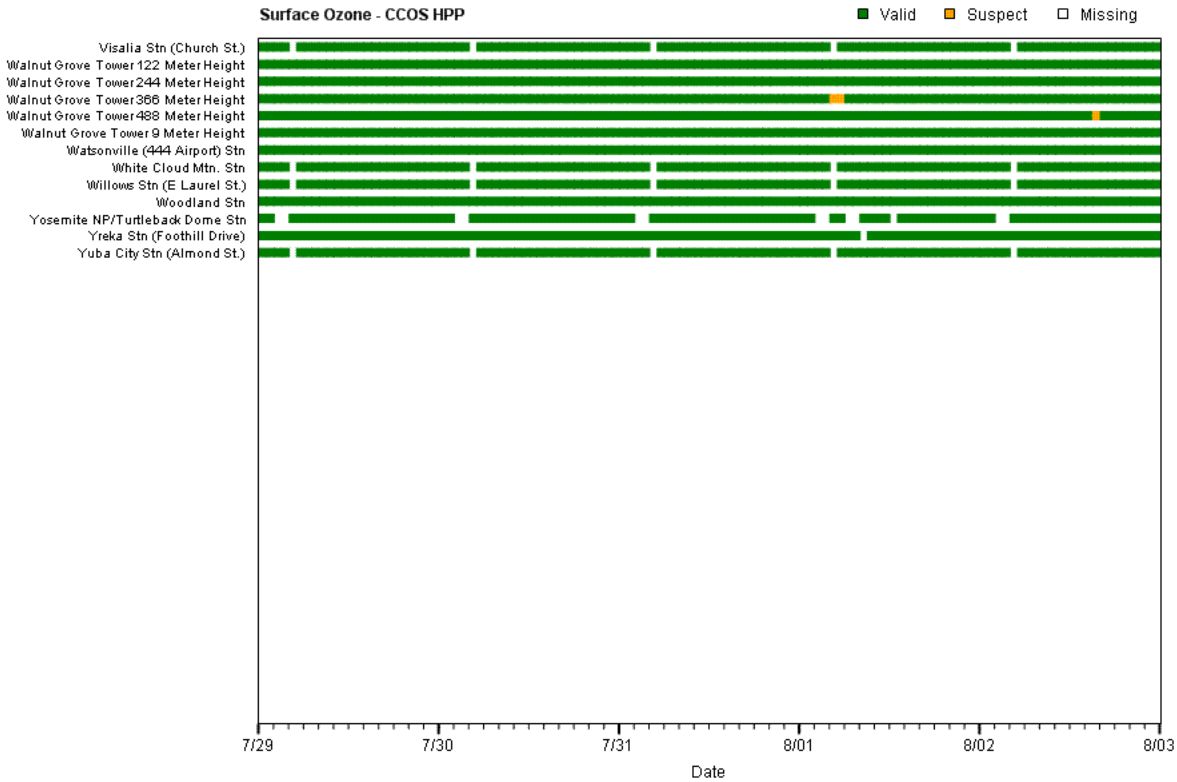
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Woodland Stn
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Yreka Stn (Foothill Drive)
Yuba City Stn (Almond St.)
7/29
7/30
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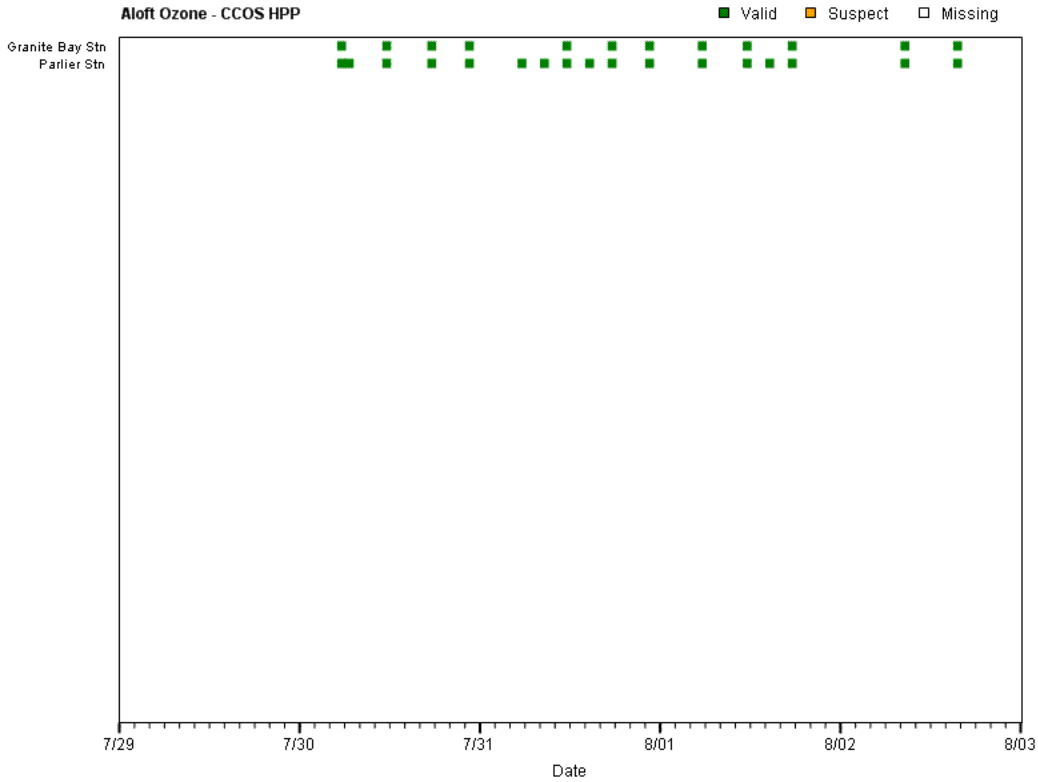
8/01
8/02
8/03
Date


Aloft Ozone - CCOS HPP
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Granite Bay Stn
Parlier Stn
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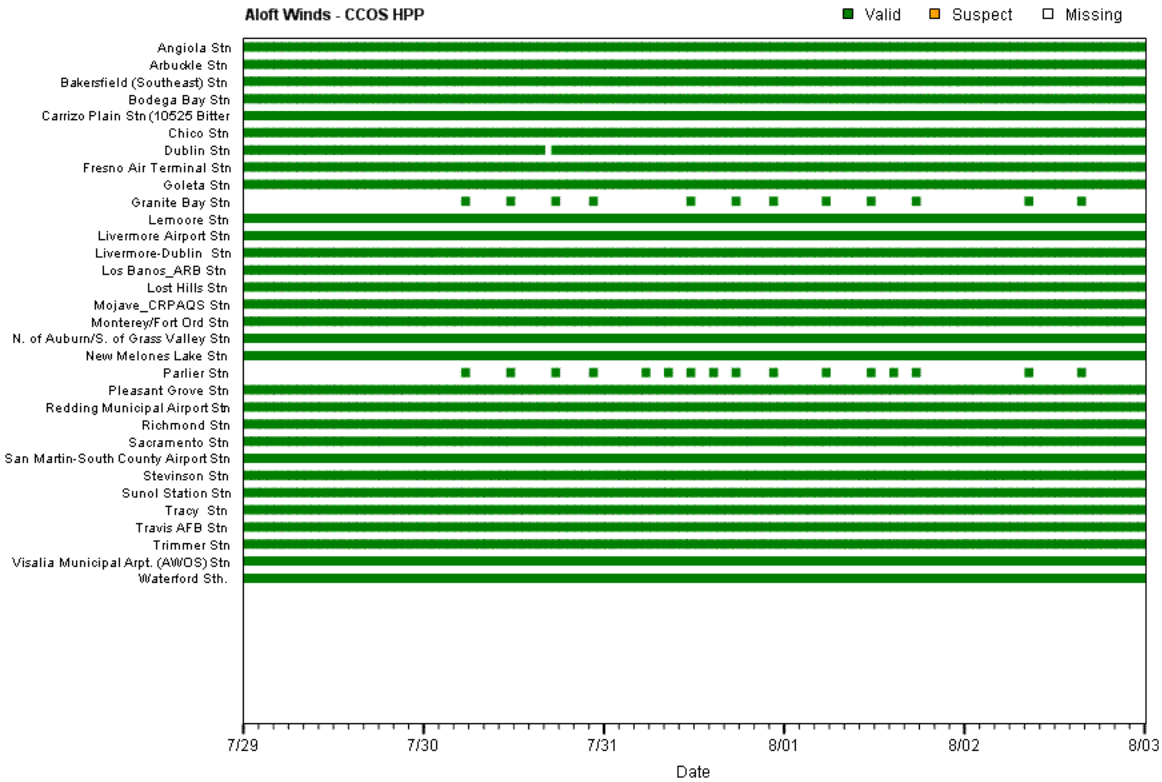
7/31
8/01
8/02
8/03
Date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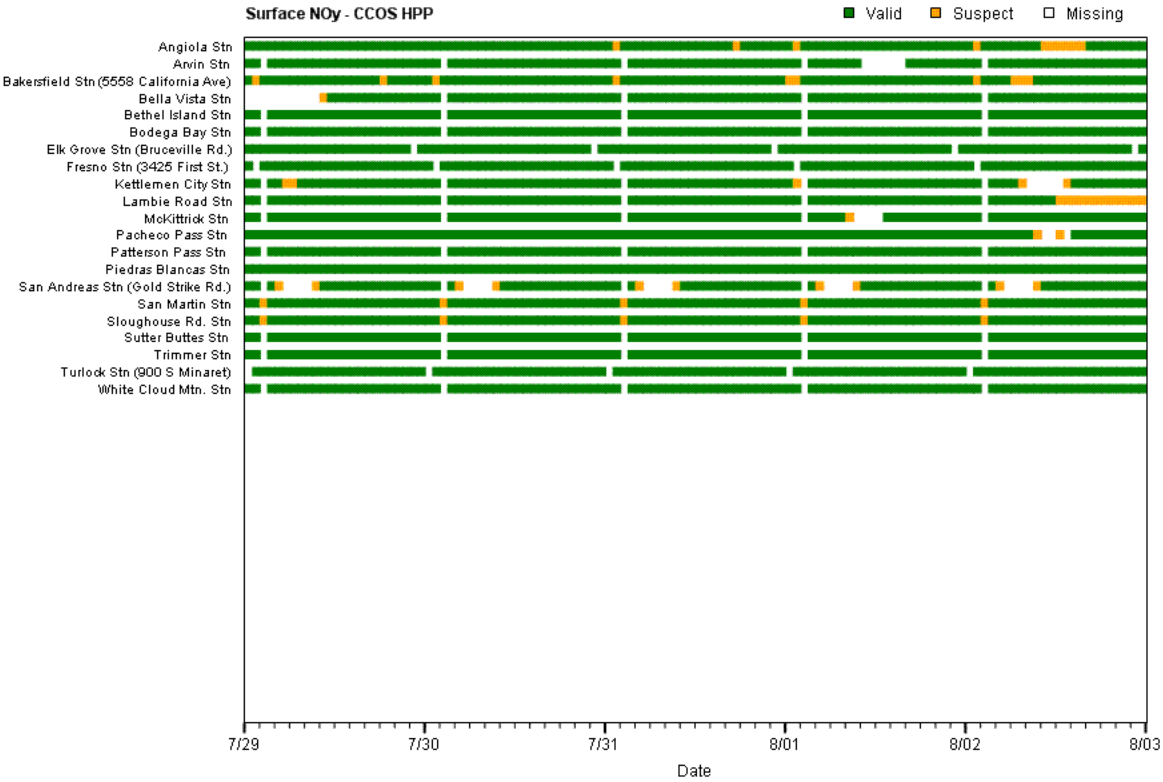
Arbuckle Stn
Bakersfield (Southeast) Stn
Bodega Bay Stn
Carrizo Plain Stn (10525 Bitter
Chico Stn
Dublin Stn
Fresno Air Terminal Stn
Goleta Stn
Granite Bay Stn
Lemoore Stn
Livermore Airport Stn
Livermore-Dublin Stn
Los Banos_ARB Stn
Lost Hills Stn
Mojave_CRPAQS Stn
Monterey/Fort Ord Stn
N. of Auburn/S. of Grass Valley Stn
New Melones Lake Stn
Parlier Stn
Pleasant Grove Stn
Redding Municipal Airport Stn
Richmond Stn
Sacramento Stn
San Martin-South County Airport Stn
Stevinson Stn
Sunol Station Stn
Tracy Stn
Travis AFB Stn
Trimmer Stn
Visalia Municipal Arpt. (AWOS) Stn
Waterford Sth.
7/29
7/30
7/31
8/01
8/02
8/03
Date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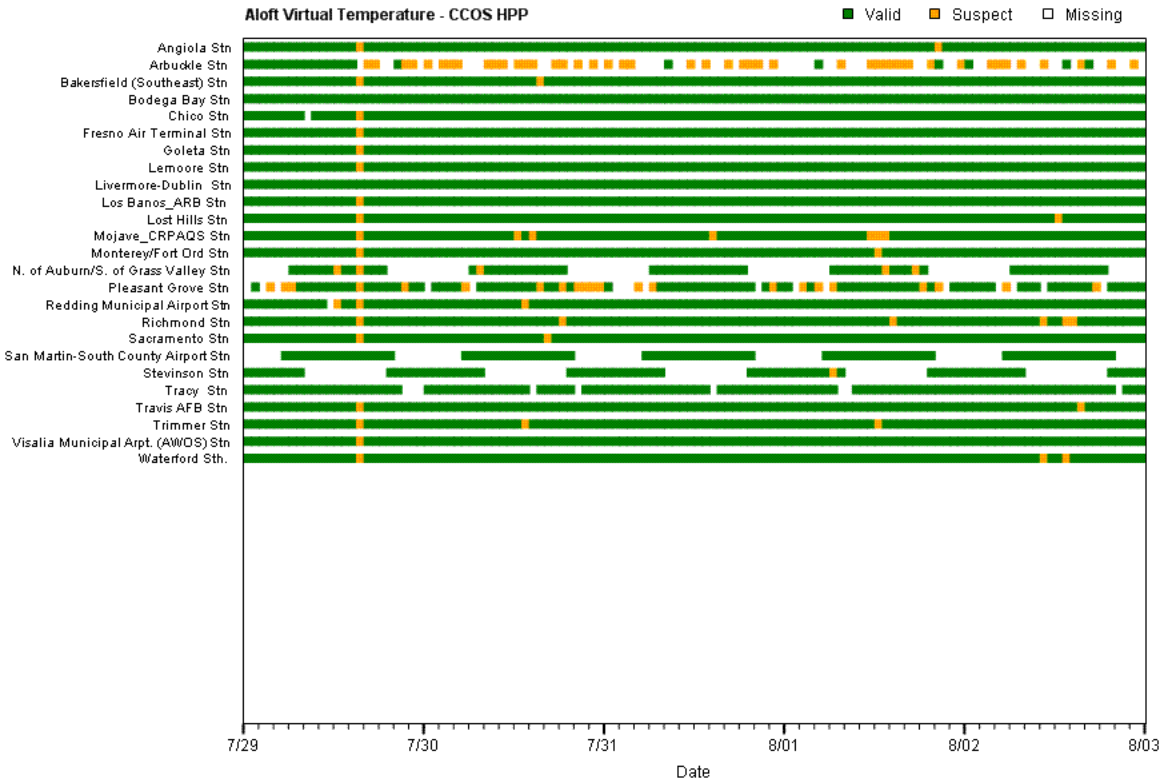
Arvin Stn
Bakersfield Stn (5558 California Ave)
Bella Vista Stn
Bethel Island Stn
Bodega Bay Stn
Elk Grove Stn (Bruceville Rd.)
Fresno Stn (3425 First St.)
Kettlemen City Stn
Lambie Road Stn
McKittrick Stn
Pacheco Pass Stn
Patterson Pass Stn
Piedras Blancas Stn
San Andreas Stn (Gold Strike Rd.)
San Martin Stn
Sloughouse Rd. Stn
Sutter Buttes Stn
Trimmer Stn
Turlock Stn (900 S Minaret)
White Cloud Mtn. Stn
7/29
7/30
7/31
8/01
8/02
8/03
Date


Aloft Virtual Temperature - CCOS HPP
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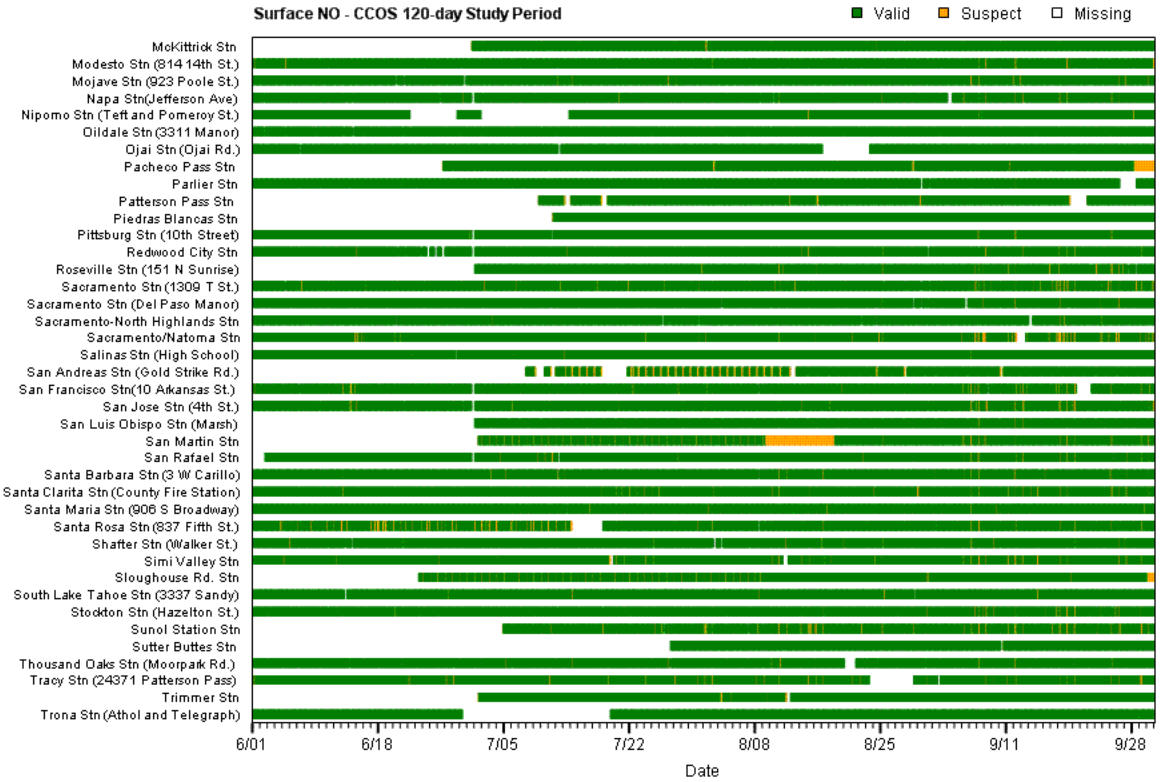
Bodega Bay Stn
Chico Stn
Fresno Air Terminal Stn
Goleta Stn
Lemoore Stn
Livermore-Dublin Stn
Los Banos_ARB Stn
Lost Hills Stn
Mojave_CRPAQS Stn
Monterey/Fort Ord Stn
N. of Auburn/S. of Grass Valley Stn
Pleasant Grove Stn
Redding Municipal Airport Stn
Richmond Stn
Sacramento Stn
San Martin-South County Airport Stn
Stevinson Stn
Tracy Stn
Travis AFB Stn
Trimmer Stn
Visalia Municipal Arpt. (AWOS) Stn
Waterford Sth.
7/29
7/30
7/31
8/01
8/02
8/03
Date

Surface NO - CCOS 120-day Study Period
Valid
Suspect
Missing
Angiola Stn
Arvin Stn
Atascadero Stn (Lewis Ave.)
Bakersfield Stn (1128 Golden State)
Bakersfield Stn (5558 California Ave)
Barstow Stn
Bella Vista Stn
Bethel Island Stn
Bodega Bay Stn
Capitan Stn/Las Flores Canyon #1
Carpinteria Stn (Gobernador Rd.)
Chico Stn (Manzanita)
Clovis Stn (908 N Villa Ave.)
Concord Stn (2975 Treat Blvd.)
Davenport Stn
Davis/UCD Campus Stn
Echo Summit Stn (21200 HWY 50)
Edison Stn
El Capitan Beach Stn
El Rio Mesa School #2 Stn
Elk Grove Stn (Bruceville Rd.)
Folsom Stn (Natoma St.)
Fremont Stn (Chapel Way)
Fresno Stn (3425 First St.)
Fresno Stn (Drummond)
Fresno Stn (Sierra Skypark #2)
Gaviota TC-Site B Stn
Goleta Stn (N Fairview Ave.)
Granite Bay Stn
Grover City Stn (Lesage Drive)
Hanford Stn (Irwin St.)
Kettlemen City Stn
Lambie Road Stn
Lancaster Stn (W. Pondera St.)
Livermore Stn (Old First St.)
Livermore Stn-793 Rincon at Pine
Lompoc Stn (128 South H St.)
Lompoc Stn(HS & P)
Los Padres NF Stn (Paradise Rd.)
Madera Stn (29 1/2 No. of Ave 8)
6/01
6/18
7/05
7/22
8/08
8/25
9/11
9/28
Date


Surface NO - CCOS 120-day Study Period
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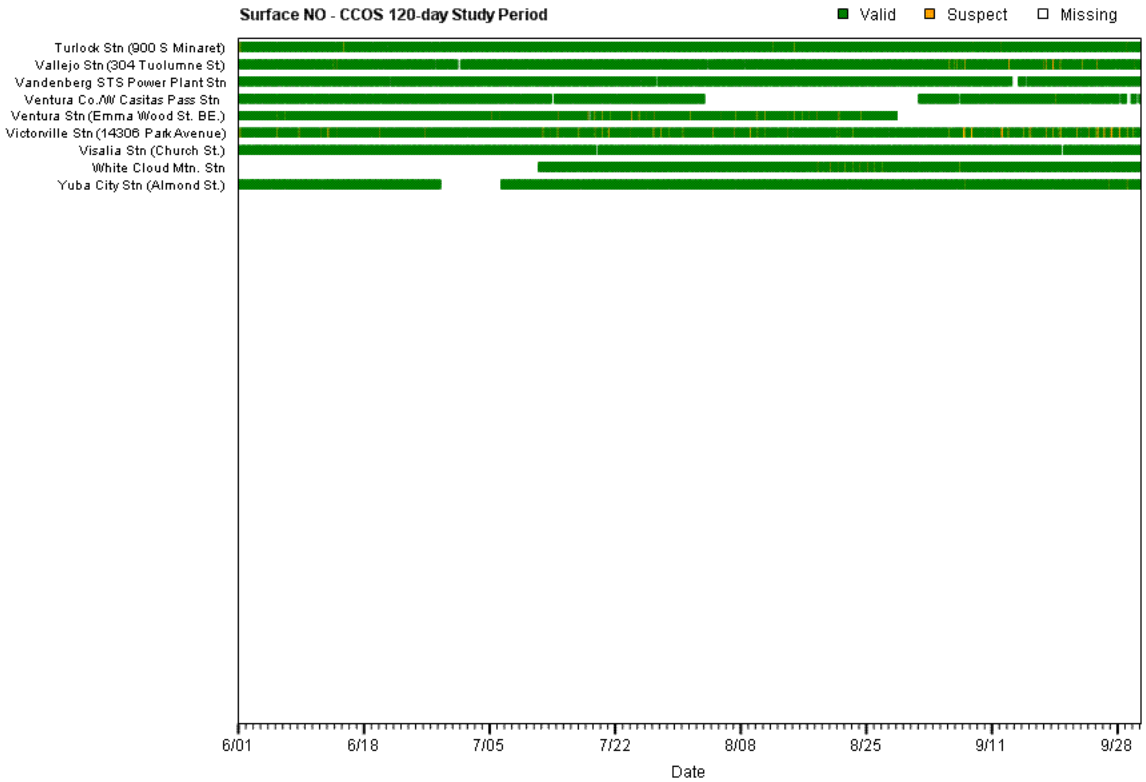
Mojave Stn (923 Poole St.)
Napa Stn(Jefferson Ave)
Nipomo Stn (Teft and Pomeroy St.)
Oildale Stn (3311 Manor)
Ojai Stn (Ojai Rd.)
Pacheco Pass Stn
Parlier Stn
Patterson Pass Stn
Piedras Blancas Stn
Pittsburg Stn (10th Street)
Redwood City Stn
Roseville Stn (151 N Sunrise)
Sacramento Stn (1309 T St.)
Sacramento Stn (Del Paso Manor)
Sacramento-North Highlands Stn
Sacramento/Natoma Stn
Salinas Stn (High School)
San Andreas Stn (Gold Strike Rd.)
San Francisco Stn(10 Arkansas St.)
San Jose Stn (4th St.)
San Luis Obispo Stn (Marsh)
San Martin Stn
San Rafael Stn
Santa Barbara Stn (3 W Carillo)
Santa Clarita Stn (County Fire Station)
Santa Maria Stn (906 S Broadway)
Santa Rosa Stn (837 Fifth St.)
Shafter Stn (Walker St.)
Simi Valley Stn
Sloughouse Rd. Stn
South Lake Tahoe Stn (3337 Sandy)
Stockton Stn (Hazelton St.)
Sunol Station Stn
Sutter Buttes Stn
Thousand Oaks Stn (Moorpark Rd.)
Tracy Stn (24371 Patterson Pass)
Trimmer Stn
Trona Stn (Athol and Telegraph)
6/01
6/18
7/05
7/22
8/08
8/25
9/11
9/28
Date


Surface NO - CCOS 120-day Study Period
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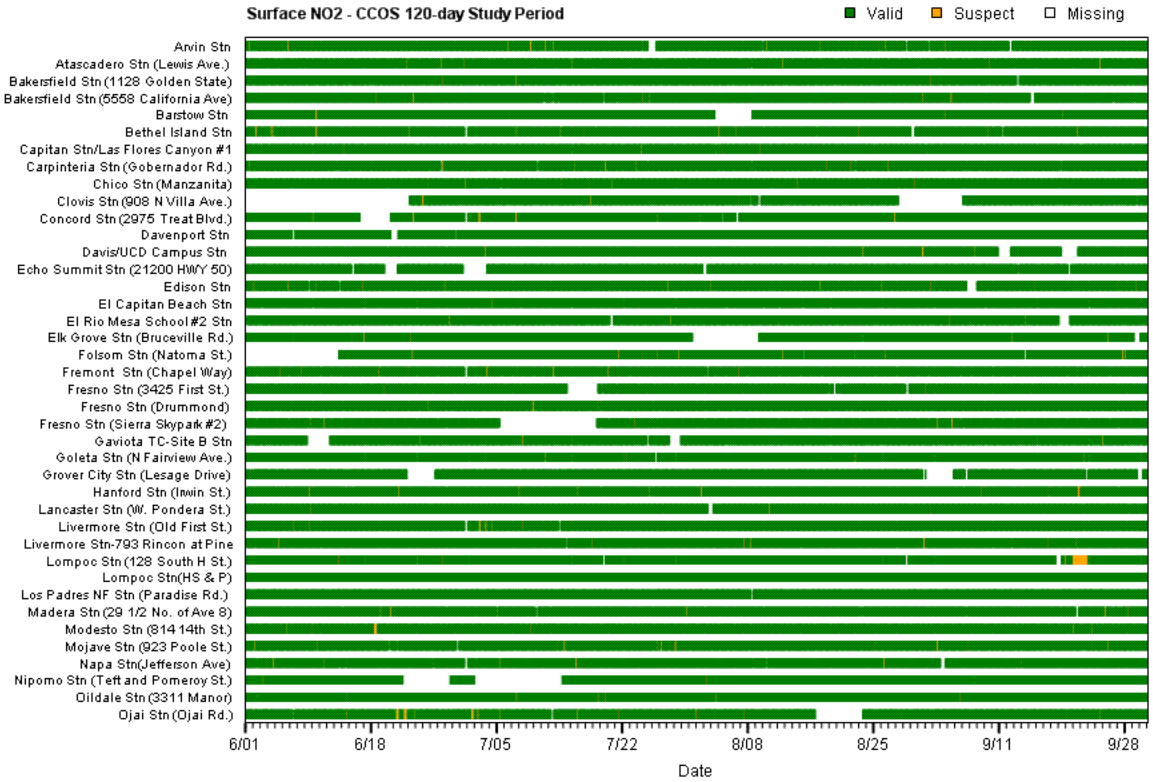
Turlock Stn (900 S Minaret)
Vallejo Stn (304 Tuolumne St)
Vandenberg STS Power Plant Stn
Ventura Co./W Casitas Pass Stn
Ventura Stn (Emma Wood St. BE.)
Victorville Stn (14306 Park Avenue)
Visalia Stn (Church St.)
White Cloud Mtn. Stn
Yuba City Stn (Almond St.)
6/01
6/18
7/05
7/22
8/08
8/25
9/11
9/28
Date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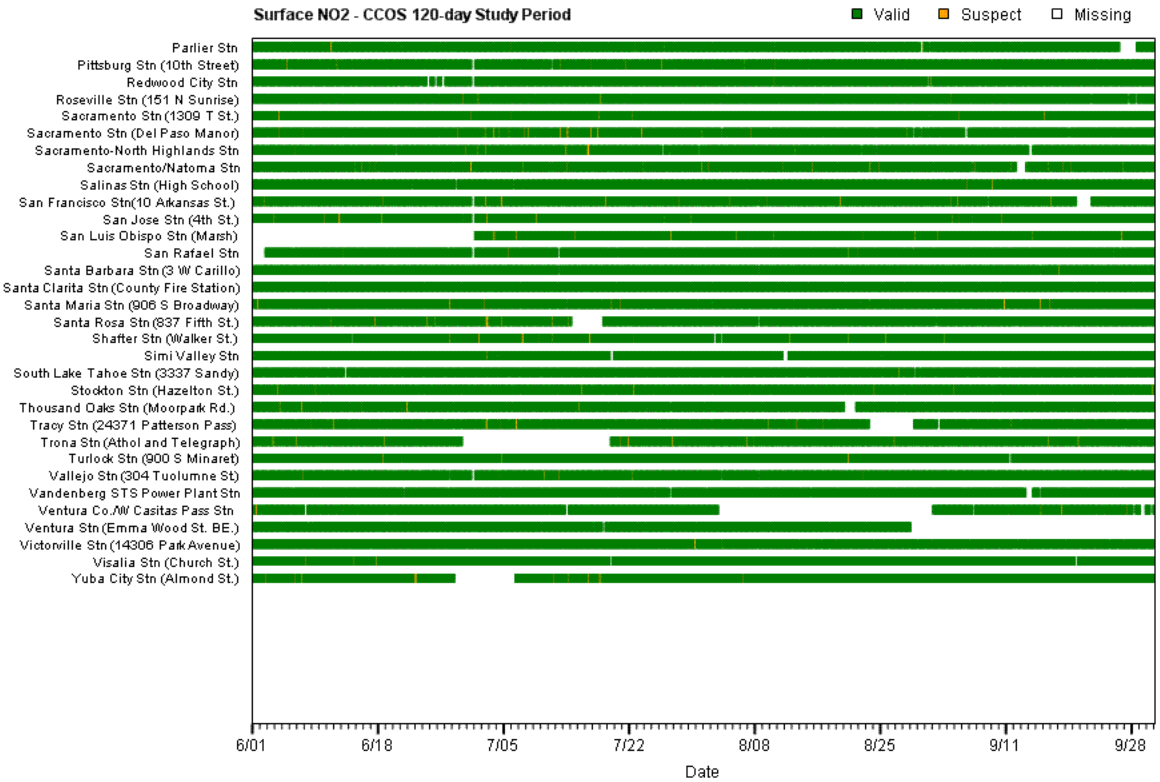
Atascadero Stn (Lewis Ave.)
Bakersfield Stn (1128 Golden State)
Bakersfield Stn (5558 California Ave)
Barstow Stn
Bethel Island Stn
Capitan Stn/Las Flores Canyon #1
Carpinteria Stn (Gobernador Rd.)
Chico Stn (Manzanita)
Clovis Stn (908 N Villa Ave.)
Concord Stn (2975 Treat Blvd.)
Davenport Stn
Davis/UCD Campus Stn
Echo Summit Stn (21200 HWY 50)
Edison Stn
El Capitan Beach Stn
El Rio Mesa School #2 Stn
Elk Grove Stn (Bruceville Rd.)
Folsom Stn (Natoma St.)
Fremont Stn (Chapel Way)
Fresno Stn (3425 First St.)
Fresno Stn (Drummond)
Fresno Stn (Sierra Skypark #2)
Gaviota TC-Site B Stn
Goleta Stn (N Fairview Ave.)
Grover City Stn (Lesage Drive)
Hanford Stn (Irwin St.)
Lancaster Stn (W. Pondera St.)
Livermore Stn (Old First St.)
Livermore Stn-793 Rincon at Pine
Lompoc Stn (128 South H St.)
Lompoc Stn(HS & P)
Los Padres NF Stn (Paradise Rd.)
Madera Stn (29 1/2 No. of Ave 8)
Modesto Stn (814 14th St.)
Mojave Stn (923 Poole St.)
Napa Stn(Jefferson Ave)
Nipomo Stn (Teft and Pomeroy St.)
Oildale Stn (3311 Manor)
Ojai Stn (Ojai Rd.)
6/01
6/18
7/05
7/22
8/08
8/25
9/11
9/28
Date


Surface NO2 - CCOS 120-day Study Period
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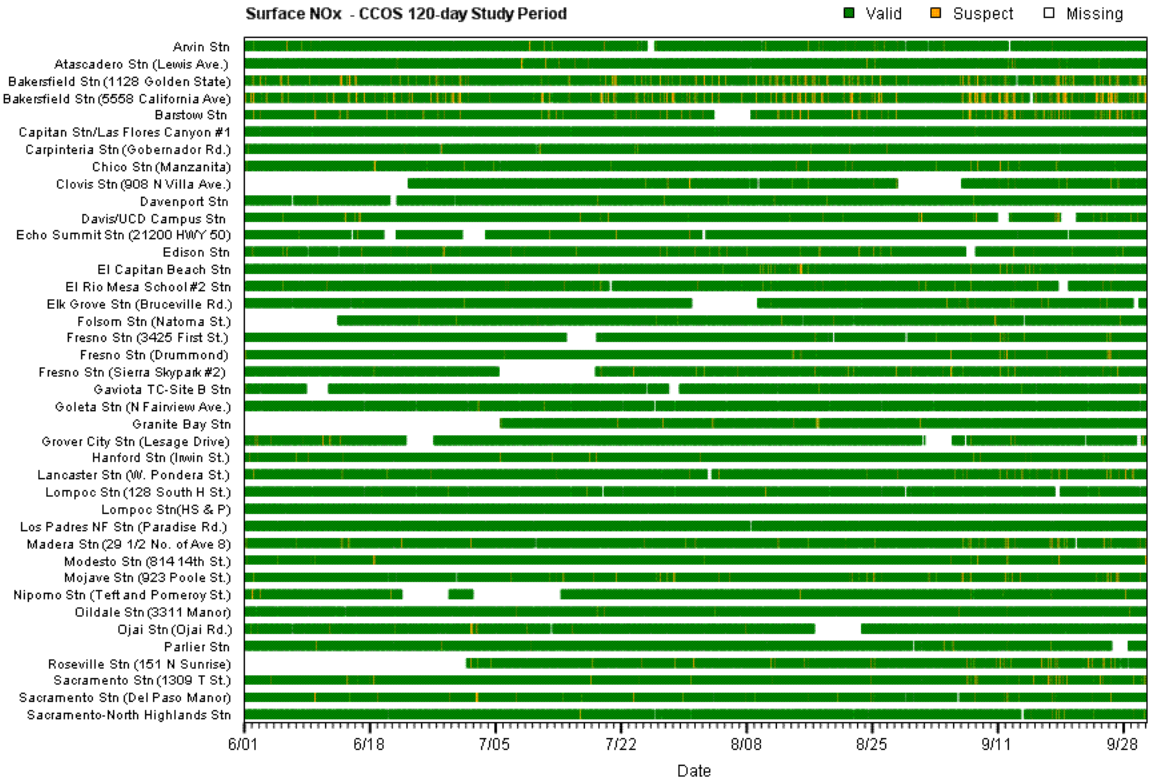
Parlier Stn
Pittsburg Stn (10th Street)
Redwood City Stn
Roseville Stn (151 N Sunrise)
Sacramento Stn (1309 T St.)
Sacramento Stn (Del Paso Manor)
Sacramento-North Highlands Stn
Sacramento/Natoma Stn
Salinas Stn (High School)
San Francisco Stn(10 Arkansas St.)
San Jose Stn (4th St.)
San Luis Obispo Stn (Marsh)
San Rafael Stn
Santa Barbara Stn (3 W Carillo)
Santa Clarita Stn (County Fire Station)
Santa Maria Stn (906 S Broadway)
Santa Rosa Stn (837 Fifth St.)
Shafter Stn (Walker St.)
Simi Valley Stn
South Lake Tahoe Stn (3337 Sandy)
Stockton Stn (Hazelton St.)
Thousand Oaks Stn (Moorpark Rd.)
Tracy Stn (24371 Patterson Pass)
Trona Stn (Athol and Telegraph)
Turlock Stn (900 S Minaret)
Vallejo Stn (304 Tuolumne St)
Vandenberg STS Power Plant Stn
Ventura Co./W Casitas Pass Stn
Ventura Stn (Emma Wood St. BE.)
Victorville Stn (14306 Park Avenue)
Visalia Stn (Church St.)
Yuba City Stn (Almond St.)
6/01
6/18
7/05
7/22
8/08
8/25
9/11
9/28
Date


Surface NOx - CCOS 120-day Study Period
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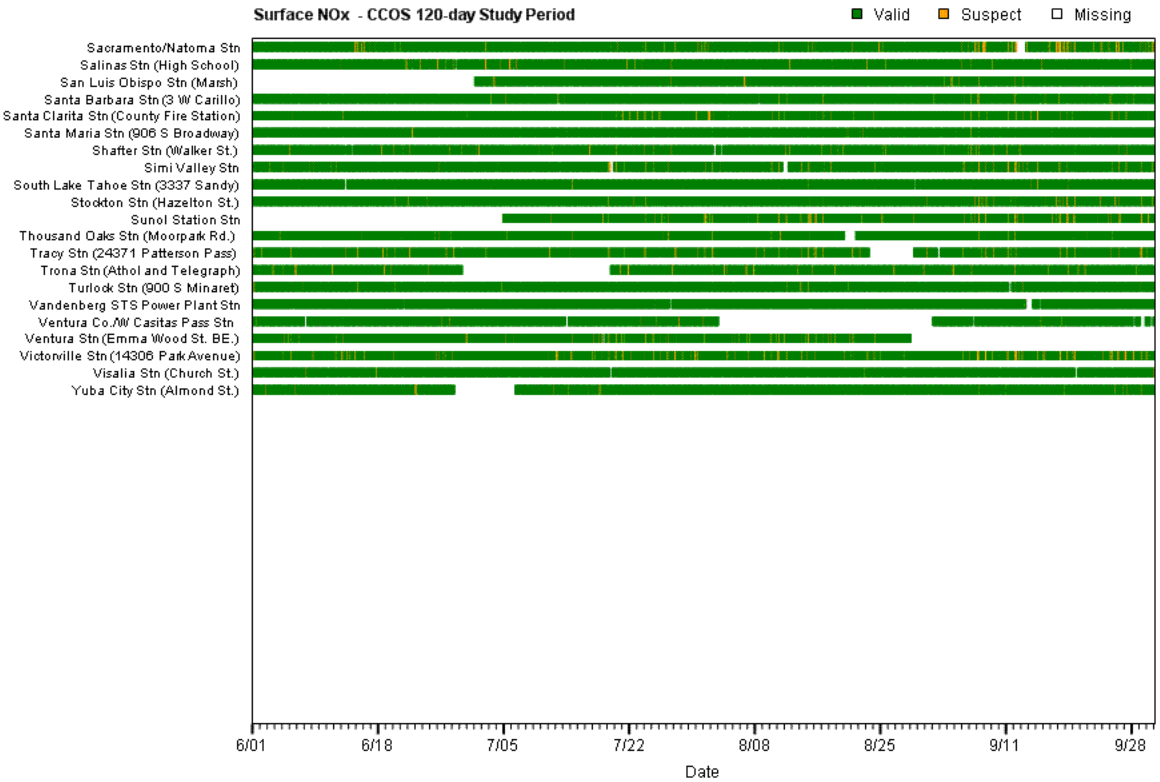
Bakersfield Stn (1128 Golden State)
Bakersfield Stn (5558 California Ave)
Barstow Stn
Capitan Stn/Las Flores Canyon #1
Carpinteria Stn (Gobernador Rd.)
Chico Stn (Manzanita)
Clovis Stn (908 N Villa Ave.)
Davenport Stn
Davis/UCD Campus Stn
Echo Summit Stn (21200 HWY 50)
Edison Stn
El Capitan Beach Stn
El Rio Mesa School #2 Stn
Elk Grove Stn (Bruceville Rd.)
Folsom Stn (Natoma St.)
Fresno Stn (3425 First St.)
Fresno Stn (Drummond)
Fresno Stn (Sierra Skypark #2)
Gaviota TC-Site B Stn
Goleta Stn (N Fairview Ave.)
Granite Bay Stn
Grover City Stn (Lesage Drive)
Hanford Stn (Irwin St.)
Lancaster Stn (W. Pondera St.)
Lompoc Stn (128 South H St.)
Lompoc Stn(HS & P)
Los Padres NF Stn (Paradise Rd.)
Madera Stn (29 1/2 No. of Ave 8)
Modesto Stn (814 14th St.)
Mojave Stn (923 Poole St.)
Nipomo Stn (Teft and Pomeroy St.)
Oildale Stn (3311 Manor)
Ojai Stn (Ojai Rd.)
Parlier Stn
Roseville Stn (151 N Sunrise)
Sacramento Stn (1309 T St.)
Sacramento Stn (Del Paso Manor)
Sacramento-North Highlands Stn
6/01
6/18
7/05
7/22
8/08
8/25
9/11
9/28
Date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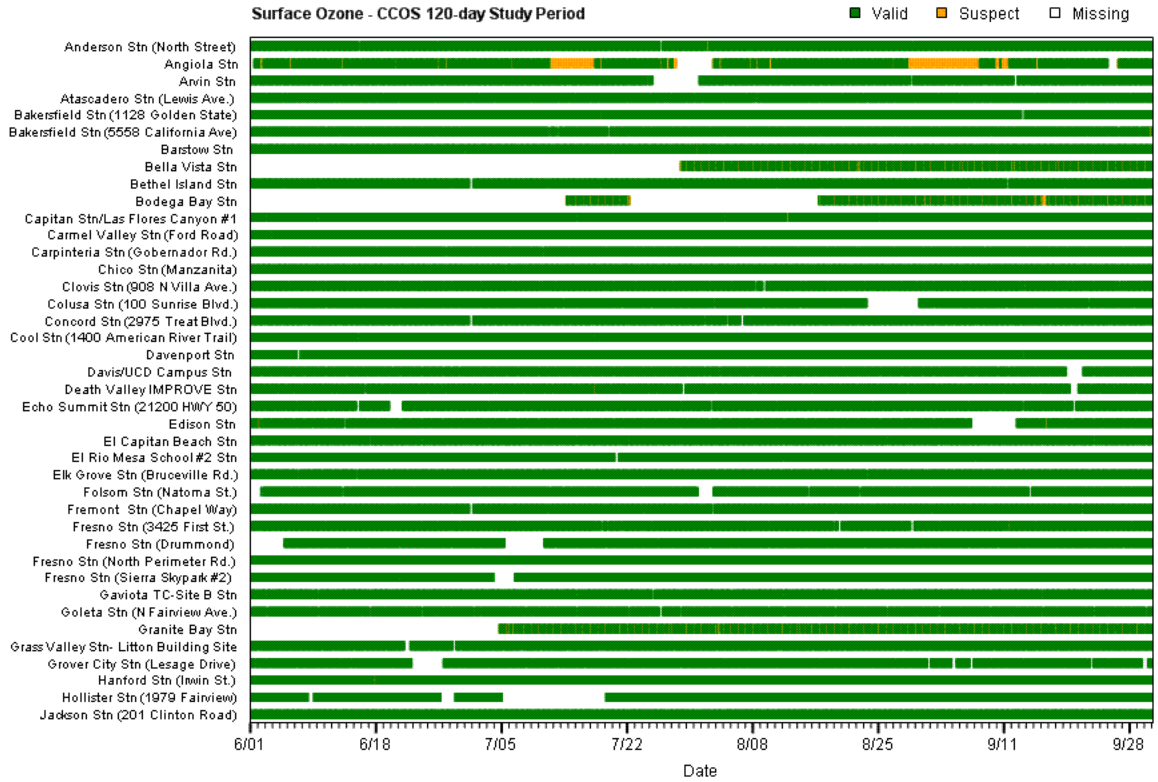
Salinas Stn (High School)
San Luis Obispo Stn (Marsh)
Santa Barbara Stn (3 W Carillo)
Santa Clarita Stn (County Fire Station)
Santa Maria Stn (906 S Broadway)
Shafter Stn (Walker St.)
Simi Valley Stn
South Lake Tahoe Stn (3337 Sandy)
Stockton Stn (Hazelton St.)
Sunol Station Stn
Thousand Oaks Stn (Moorpark Rd.)
Tracy Stn (24371 Patterson Pass)
Trona Stn (Athol and Telegraph)
Turlock Stn (900 S Minaret)
Vandenberg STS Power Plant Stn
Ventura Co./W Casitas Pass Stn
Ventura Stn (Emma Wood St. BE.)
Victorville Stn (14306 Park Avenue)
Visalia Stn (Church St.)
Yuba City Stn (Almond St.)
6/01
6/18
7/05
7/22
8/08
8/25
9/11
9/28
Date


Surface Ozone - CCOS 120-day Study Period
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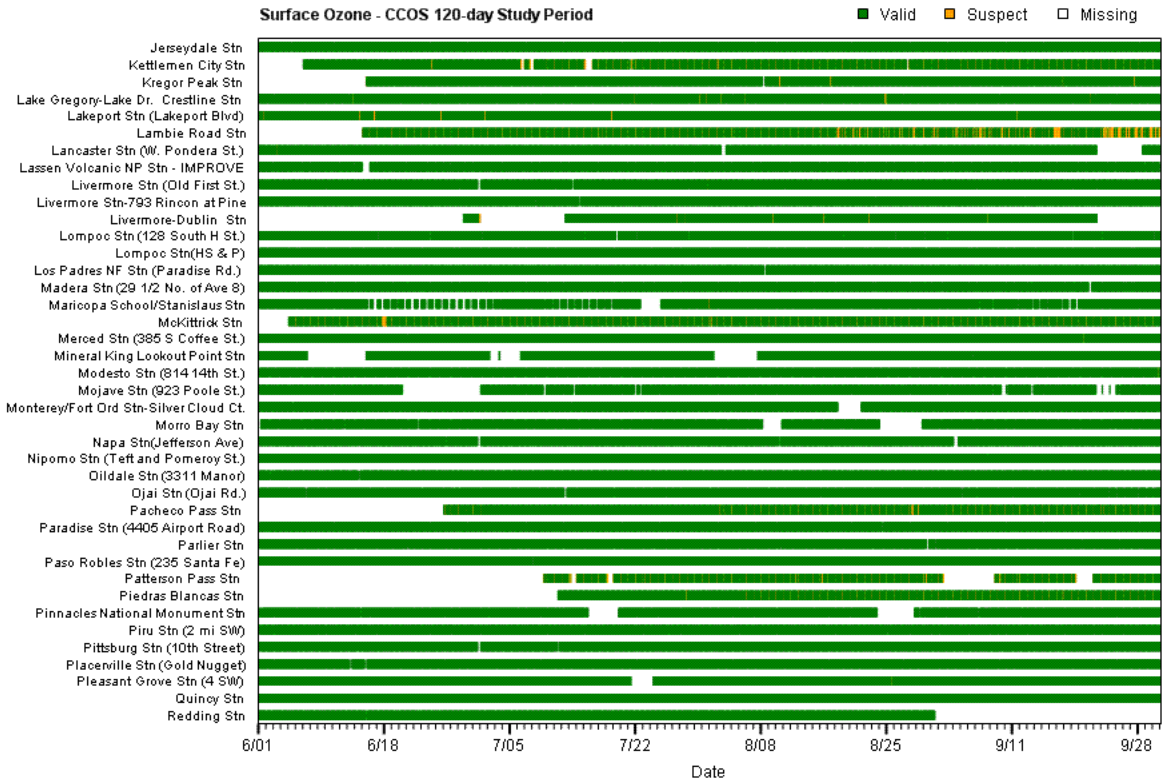
Bakersfield Stn (5558 California Ave)
Barstow Stn
Bella Vista Stn
Bethel Island Stn
Bodega Bay Stn
Capitan Stn/Las Flores Canyon #1
Carmel Valley Stn (Ford Road)
Carpinteria Stn (Gobernador Rd.)
Chico Stn (Manzanita)
Clovis Stn (908 N Villa Ave.)
Colusa Stn (100 Sunrise Blvd.)
Concord Stn (2975 Treat Blvd.)
Cool Stn (1400 American River Trail)
Davenport Stn
Davis/UCD Campus Stn
Death Valley IMPROVE Stn
Echo Summit Stn (21200 HWY 50)
Edison Stn
El Capitan Beach Stn
El Rio Mesa School #2 Stn
Elk Grove Stn (Bruceville Rd.)
Folsom Stn (Natoma St.)
Fremont Stn (Chapel Way)
Fresno Stn (3425 First St.)
Fresno Stn (Drummond)
Fresno Stn (North Perimeter Rd.)
Fresno Stn (Sierra Skypark #2)
Gaviota TC-Site B Stn
Goleta Stn (N Fairview Ave.)
Granite Bay Stn
Grass Valley Stn- Litton Building Site
Grover City Stn (Lesage Drive)
Hanford Stn (Irwin St.)
Hollister Stn (1979 Fairview)
Jackson Stn (201 Clinton Road)
6/01
6/18
7/05
7/22
8/08
8/25
9/11
9/28
Date


Surface Ozone - CCOS 120-day Study Period
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Suspect
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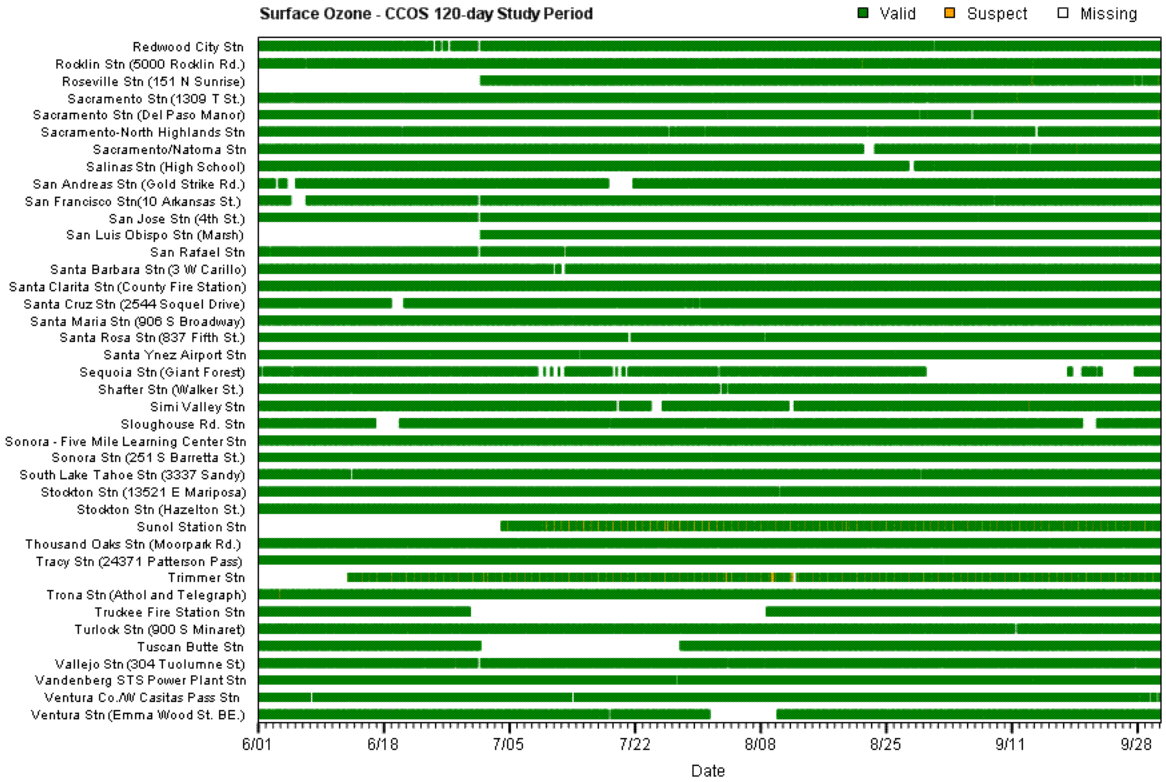
Kettlemen City Stn
Kregor Peak Stn
Lake Gregory-Lake Dr. Crestline Stn
Lakeport Stn (Lakeport Blvd)
Lambie Road Stn
Lancaster Stn (W. Pondera St.)
Lassen Volcanic NP Stn - IMPROVE
Livermore Stn (Old First St.)
Livermore Stn-793 Rincon at Pine
Livermore-Dublin Stn
Lompoc Stn (128 South H St.)
Lompoc Stn(HS & P)
Los Padres NF Stn (Paradise Rd.)
Madera Stn (29 1/2 No. of Ave 8)
Maricopa School/Stanislaus Stn
McKittrick Stn
Merced Stn (385 S Coffee St.)
Mineral King Lookout Point Stn
Modesto Stn (814 14th St.)
Mojave Stn (923 Poole St.)
Monterey/Fort Ord Stn-Silver Cloud Ct.
Morro Bay Stn
Napa Stn(Jefferson Ave)
Nipomo Stn (Teft and Pomeroy St.)
Oildale Stn (3311 Manor)
Ojai Stn (Ojai Rd.)
Pacheco Pass Stn
Paradise Stn (4405 Airport Road)
Parlier Stn
Paso Robles Stn (235 Santa Fe)
Patterson Pass Stn
Piedras Blancas Stn
Pinnacles National Monument Stn
Piru Stn (2 mi SW)
Pittsburg Stn (10th Street)
Placerville Stn (Gold Nugget)
Pleasant Grove Stn (4 SW)
Quincy Stn
Redding Stn
6/01
6/18
7/05
7/22
8/08
8/25
9/11
9/28
Date


Surface Ozone - CCOS 120-day Study Period
Valid
Suspect
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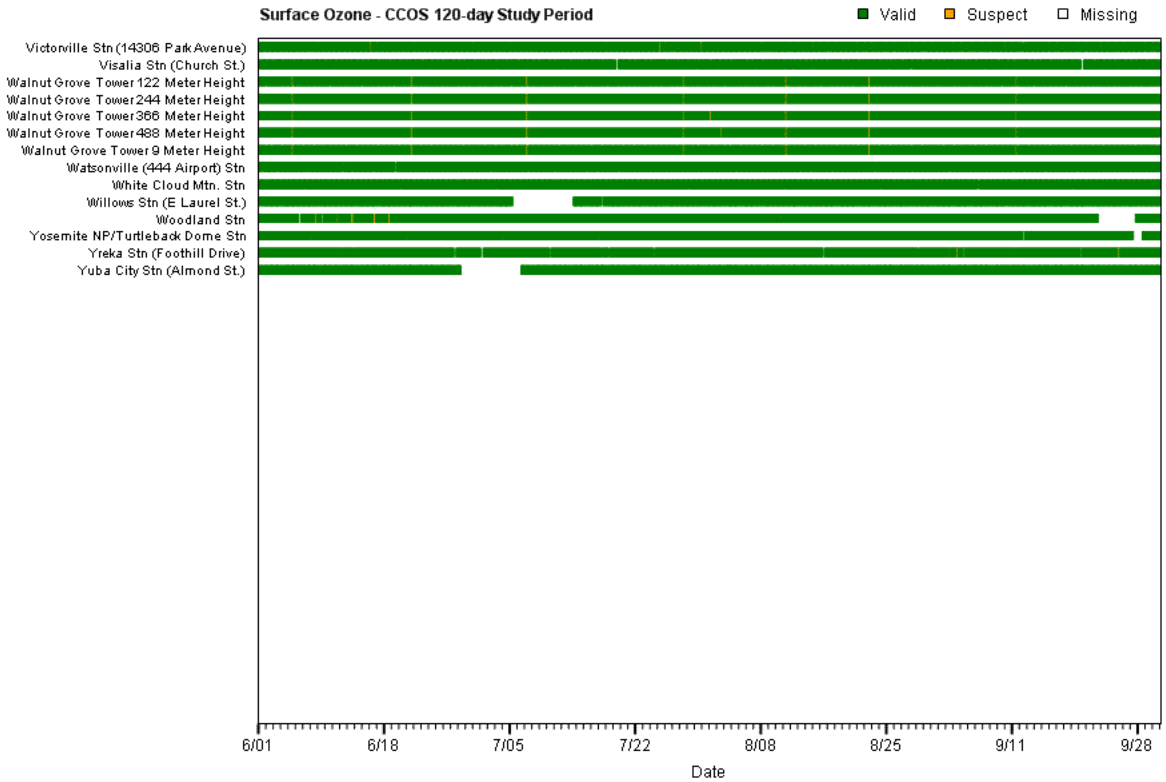
Redwood City Stn
Rocklin Stn (5000 Rocklin Rd.)
Roseville Stn (151 N Sunrise)
Sacramento Stn (1309 T St.)
Sacramento Stn (Del Paso Manor)
Sacramento-North Highlands Stn
Sacramento/Natoma Stn
Salinas Stn (High School)
San Andreas Stn (Gold Strike Rd.)
San Francisco Stn(10 Arkansas St.)
San Jose Stn (4th St.)
San Luis Obispo Stn (Marsh)
San Rafael Stn
Santa Barbara Stn (3 W Carillo)
Santa Clarita Stn (County Fire Station)
Santa Cruz Stn (2544 Soquel Drive)
Santa Maria Stn (906 S Broadway)
Santa Rosa Stn (837 Fifth St.)
Santa Ynez Airport Stn
Sequoia Stn (Giant Forest)
Shafter Stn (Walker St.)
Simi Valley Stn
Sloughouse Rd. Stn
Sonora - Five Mile Learning Center Stn
Sonora Stn (251 S Barretta St.)
South Lake Tahoe Stn (3337 Sandy)
Stockton Stn (13521 E Mariposa)
Stockton Stn (Hazelton St.)
Sunol Station Stn
Thousand Oaks Stn (Moorpark Rd.)
Tracy Stn (24371 Patterson Pass)
Trimmer Stn
Trona Stn (Athol and Telegraph)
Truckee Fire Station Stn
Turlock Stn (900 S Minaret)
Tuscan Butte Stn
Vallejo Stn (304 Tuolumne St)
Vandenberg STS Power Plant Stn
Ventura Co./W Casitas Pass Stn
Ventura Stn (Emma Wood St. BE.)
6/01
6/18
7/05
7/22
8/08
8/25
9/11
9/28
Date


Surface Ozone - CCOS 120-day Study Period
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Suspect
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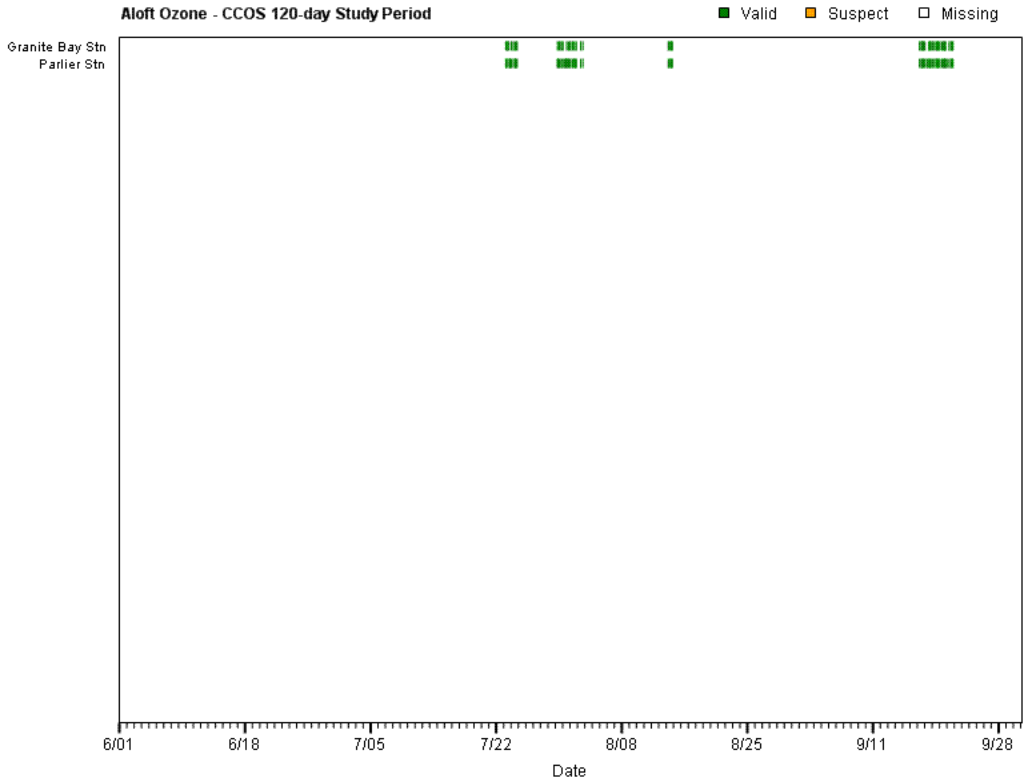
Victorville Stn (14306 Park Avenue)
Visalia Stn (Church St.)
Walnut Grove Tower 122 Meter Height
Walnut Grove Tower 244 Meter Height
Walnut Grove Tower 366 Meter Height
Walnut Grove Tower 488 Meter Height
Walnut Grove Tower 9 Meter Height
Watsonville (444 Airport) Stn
White Cloud Mtn. Stn
Willows Stn (E Laurel St.)
Woodland Stn
Yosemite NP/Turtleback Dome Stn
Yreka Stn (Foothill Drive)
Yuba City Stn (Almond St.)
6/01
6/18
7/05
7/22
8/08
8/25
9/11
9/28
Date


Aloft Ozone - CCOS 120-day Study Period
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Suspect
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Parlier Stn
6/01
6/18
7/05
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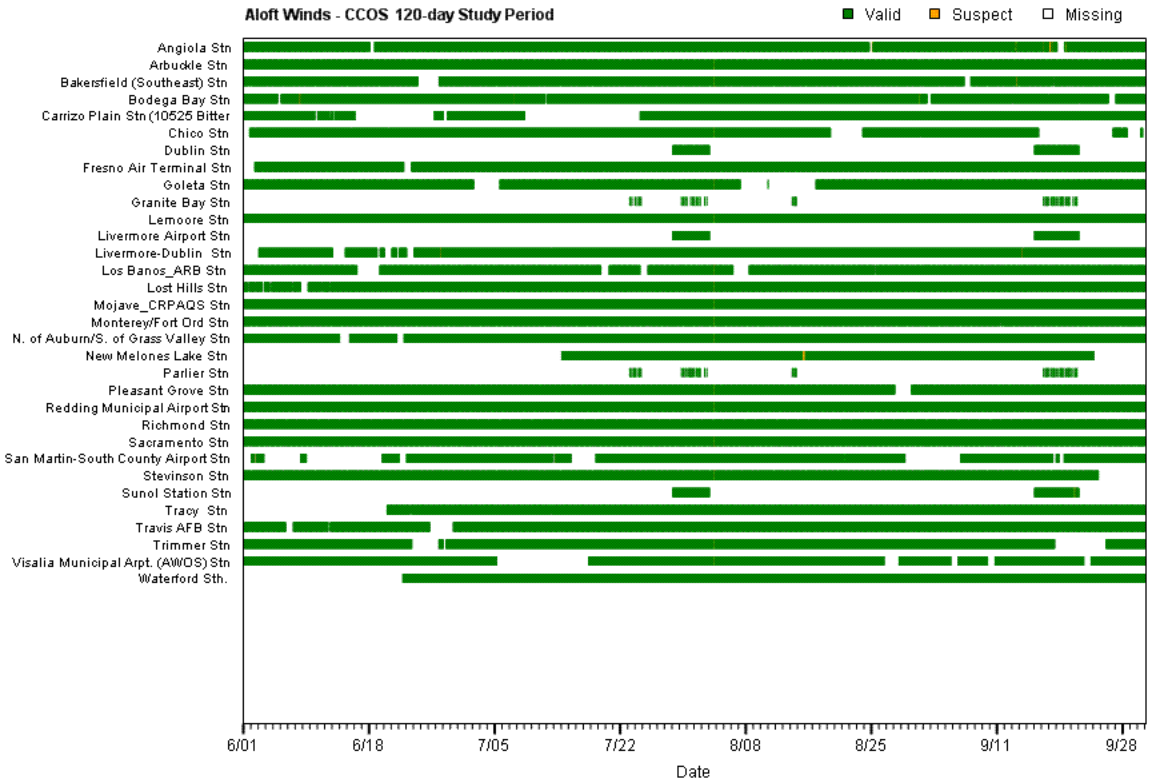
8/25
9/11
9/28
Date


Aloft Winds - CCOS 120-day Study Period
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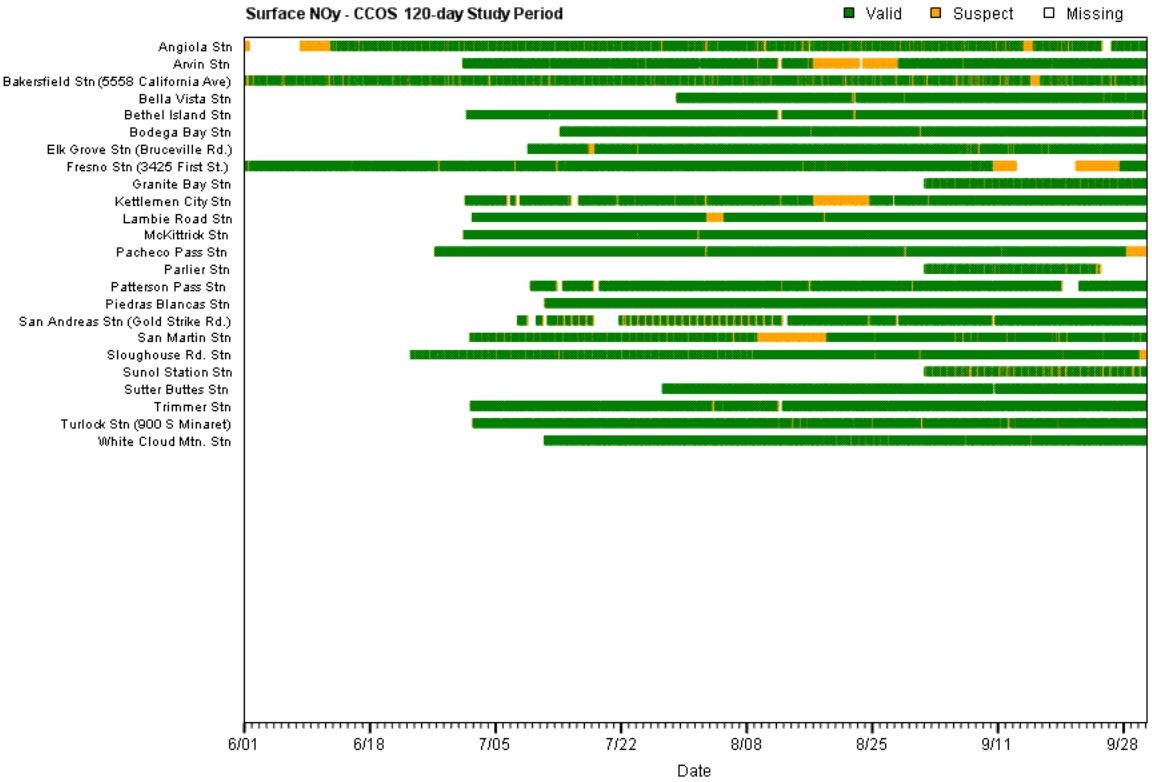
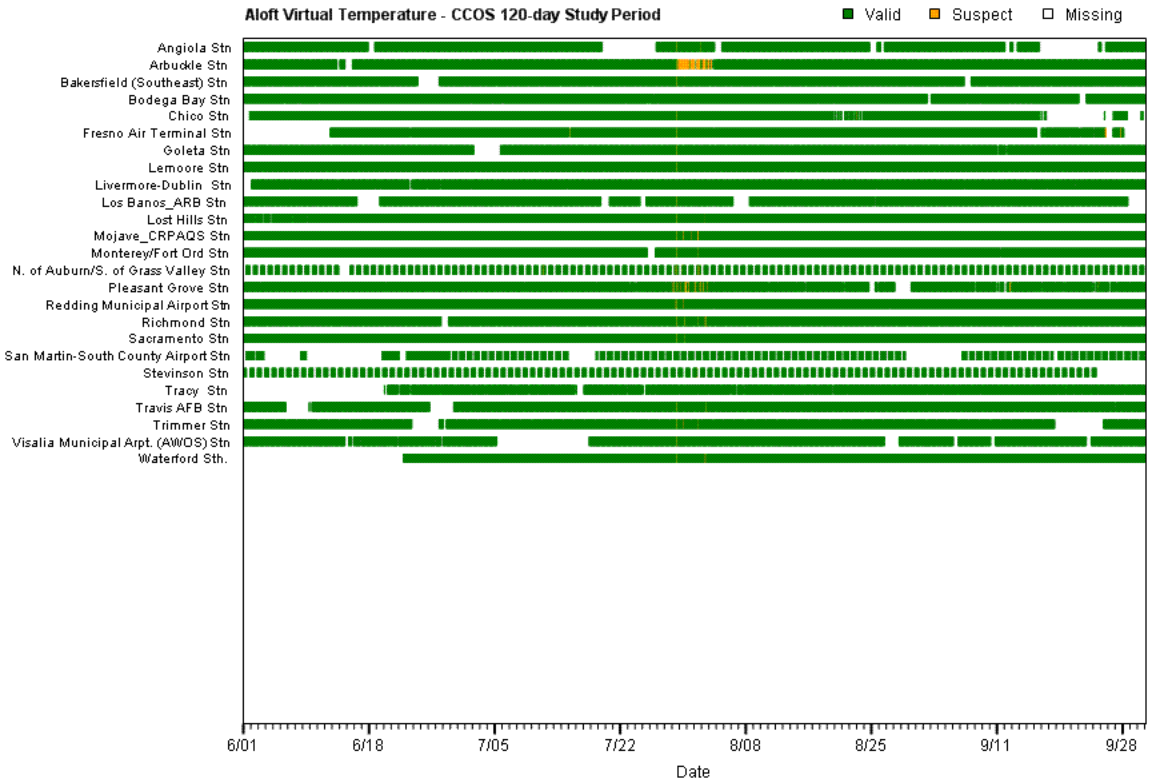
Angiola Stn
Arbuckle Stn
Bakersfield (Southeast) Stn
Bodega Bay Stn
Carrizo Plain Stn (10525 Bitter
Chico Stn
Dublin Stn
Fresno Air Terminal Stn
Goleta Stn
Granite Bay Stn
Lemoore Stn
Livermore Airport Stn
Livermore-Dublin Stn
Los Banos_ARB Stn
Lost Hills Stn
Mojave_CRPAQS Stn
Monterey/Fort Ord Stn
N. of Auburn/S. of Grass Valley Stn
New Melones Lake Stn
Parlier Stn
Pleasant Grove Stn
Redding Municipal Airport Stn
Richmond Stn
Sacramento Stn
San Martin-South County Airport Stn
Stevinson Stn
Sunol Station Stn
Tracy Stn
Travis AFB Stn
Trimmer Stn
Visalia Municipal Arpt. (AWOS) Stn
Waterford Sth.
6/01
6/18
7/05
7/22
8/08
8/25
9/11
9/28
Date


Surface NOy - CCOS 120-day Study Period
Valid
Suspect
Missing
Angiola Stn
Arvin Stn
Bakersfield Stn (5558 California Ave)
Bella Vista Stn
Bethel Island Stn
Bodega Bay Stn
Elk Grove Stn (Bruceville Rd.)
Fresno Stn (3425 First St.)
Granite Bay Stn
Kettlemen City Stn
Lambie Road Stn
McKittrick Stn
Pacheco Pass Stn
Parlier Stn
Patterson Pass Stn
Piedras Blancas Stn
San Andreas Stn (Gold Strike Rd.)
San Martin Stn
Sloughouse Rd. Stn
Sunol Station Stn
Sutter Buttes Stn
Trimmer Stn
Turlock Stn (900 S Minaret)
White Cloud Mtn. Stn
6/01
6/18
7/05
7/22
8/08
8/25
9/11
9/28
Date


Aloft Virtual Temperature - CCOS 120-day Study Period
Valid
Suspect
Missing
Angiola Stn
Arbuckle Stn
Bakersfield (Southeast) Stn
Bodega Bay Stn
Chico Stn
Fresno Air Terminal Stn
Goleta Stn
Lemoore Stn
Livermore-Dublin Stn
Los Banos_ARB Stn
Lost Hills Stn
Mojave_CRPAQS Stn
Monterey/Fort Ord Stn
N. of Auburn/S. of Grass Valley Stn
Pleasant Grove Stn
Redding Municipal Airport Stn
Richmond Stn
Sacramento Stn
San Martin-South County Airport Stn
Stevinson Stn
Tracy Stn
Travis AFB Stn
Trimmer Stn
Visalia Municipal Arpt. (AWOS) Stn
Waterford Sth.
6/01
6/18
7/05
7/22
8/08
8/25
9/11
9/28
Date

APPENDIX B

SUMMARY OF ELECTRONIC DATA VOLUME

An electronic data volume (EDV) is provided with this report that contains supporting data and analyses developed during this project. The EDV includes

- A listing of sites that reported surface meteorological data in the database (Surface_Meteorological_Sites.xls)
- A listing summarizing data in the database (Inventory_Existing.xls)
- A listing showing, by site and parameter, the number of points checked for each automated QC test and the number of points that failed that test (Gross_Outlier_Output.xls)
- A complete listing of suspect air quality records from aircraft measurements (CCOS_Aircraft_Suspect_Records.xls)
- Vertical concentration profile plots from flight segments identified as "spirals"
- Spatial plots of air quality concentrations from aircraft measurements
- Vertical O_3 concentration profiles from ozonesondes released from Granite Bay (GNBY) and Parlier (PLR)
- Final ozonesonde data updated with QC flags (ozonesondes-edited.csv)

The following schematic of the EDV's directory structure is provided as a guide to its contents. It contains 390 files in 11 directories.

```
CCOS_DV_EDV
|-- Aircraft_Data_Suspect
|    `-- CCOS_Aircraft_Suspect_Records.xls
|-- Aircraft_Spatial_Plots
|    |-- A10NO.png
|    |-- A10NOY.png
|    |-- A10O3.png
|    |-- A11NO.png
|    |-- A11NOY.png
|    |-- A11O3.png
|    |-- A7NO.png
|    |-- A7NOY.png
|    |-- A7O3.png
|    |-- A8NO.png
|    |-- A8NOY.png
|    |-- A8O3.png
```

```
|    |-- A8NOY.png
|    |-- A8O3.png
|    |-- A9NO.png
|    |-- A9NOY.png
|    |-- A9O3.png
|    |-- C5NO.png
|    |-- C5NOY.png
|    |-- C5O3.png
|    |-- C6NO.png
|    |-- C6NOY.png
|    |-- C6O3.png
|    |-- C7NO.png
|    |-- C7NOY.png
|    |-- C7O3.png
|    |-- C8NO.png
|    |-- C8NOY.png
|    |-- C8O3.png
|    |-- C9NO.png
|    |-- C9NOY.png
|    |-- C9O3.png
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|    |-- TVA1NO2.png
|    |-- TVA1NOX.png
|    |-- TVA1NOY.png
|    |-- TVA1O3.png
|    |-- TVA3NO.png
|    |-- TVA3NO2.png
|    |-- TVA3NOX.png
|    |-- TVA3NOY.png
|    |-- TVA3O3.png
|    |-- TVA4NO.png
|    |-- TVA4NO2.png
|    |-- TVA4NOX.png
|    |-- TVA4NOY.png
|    |-- TVA4O3.png
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|    |-- UD1721aNOY.png
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|    |-- UD1721bNO.png
|    |-- UD1721bNOY.png
|    |-- UD1721bO3.png
|    |-- UD1721cNO.png
|    |-- UD1721cNOY.png
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|    |-- UD1722aNO.png
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|    |-- UD1722bNO.png
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|    |-- UD1722cNOY.png
|    |-- UD1722cO3.png
|    |-- UD1821aNO.png
|    |-- UD1821aNOY.png
|    |-- UD1821aO3.png
|    |-- UD1821bNO.png
```

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|   |-- UD1821bNOY.png
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|   |-- UD1822aNOY.png
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|   |-- UD1822bNO.png
|   |-- UD1822bNOY.png
|   |-- UD1822bO3.png
|   |-- UD1822cNO.png
|   |-- UD1822cNOY.png
|   `-- UD1822cO3.png
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|       |-- PLR  20000802 1500 PST.gif
|       |-- PLR  20000814 0500 PST.gif
|       |-- PLR  20000814 1100 PST.gif
|       |-- PLR  20000814 1400 PST.gif
|       |-- PLR  20000814 1700 PST.gif
|       |-- PLR  20000917 0500 PST.gif
|       |-- PLR  20000917 1100 PST.gif
|       |-- PLR  20000917 1400 PST.gif
|       |-- PLR  20000917 1700 PST.gif
|       |-- PLR  20000917 2200 PST.gif
|       |-- PLR  20000918 0500 PST.gif
|       |-- PLR  20000918 1100 PST.gif
|       |-- PLR  20000918 1400 PST.gif
|       |-- PLR  20000918 1700 PST.gif
|       |-- PLR  20000918 2200 PST.gif
|       |-- PLR  20000919 0500 PST.gif
|       |-- PLR  20000919 1100 PST.gif
|       |-- PLR  20000919 1400 PST.gif
|       |-- PLR  20000919 1700 PST.gif
|       |-- PLR  20000919 2200 PST.gif
|       |-- PLR  20000920 0500 PST.gif
|       |-- PLR  20000920 1100 PST.gif
|       |-- PLR  20000920 1400 PST.gif
|       |-- PLR  20000920 1700 PST.gif
|       |-- PLR  20000920 2200 PST.gif
|       |-- PLR  20000921 0500 PST.gif
|       |-- PLR  20000921 1100 PST.gif
|       |-- PLR  20000921 1400 PST.gif
|       `-- PLR  20000921 1700 PST.gif
`-- QC_Gross_Outliers
    `-- Gross_Outlier_Output.xls
```

APPENDIX C

CCAQS/CCOS HOURLY DATA AUTOMATIC QUALITY CONTROL

This appendix describes the tables used to perform automated gross outlier checks against selected CCAQS/CCOS hourly data. Sonoma Technology, Inc. originally ran these checks against data extracted into our own proprietary database structure so that we could performance tune the data and apply additional visual assessment tools. We have modified the tables and the automated QC query script (AutoQC_CCOS.sql) to enable the California Air Resources Board to perform these checks directly against the CCOS database and obtain the same results.

The automated gross outlier checks require the following three support tables:

1. **QC_Checks Table** – Some of the fields contained in this table are
   - "Method_ID" of the Method the test will be run against
   - "IsCheck": 1 to run the test or 0 to not run it
   - "Type" of data like "SFMET" or "SFGAS"
   - Range Min and Max
   - Range hours of the day to perform the test. Null means all hours.
   - Range data heights to perform the test. Null means all heights.
   - Range Type with values like "Rural" or "Urban"
   - Rate of Change rate
   - Number of hours over which a value is considered stuck
   - Sticking value over which a sticking check will apply. Null means all values are checked for stickiness.
   - Sticking begin and end hour of the day to run the check. Null means all hours.
   - Method, Parameter, and Unit fields that make it easy to identify the record.

The QC_Checks table was originally a spreadsheet and the user could easily update the various check arguments. This spreadsheet was imported into SQL Server. If a primary check field is NULL like Min, Max, or Rate of change the test is not performed. If IsCheck is 0 then

all the tests for a record are not performed. Multiple records may be entered for a given Method to allow for different values to be applied to different hours of the day or heights.

2. **Buddy_Supports** – Some of the fields contained in this table are
   - Support_ID and one or more Buddy IDs (BuddyID)
   - Type like "SFGAS" or "SFVOC"
3. **Rural Urban** – Some of the fields contained in this table are
   - Support_ID
   - Original Designation like "Rural" or "Urbanized Area"
   - STI simplified Type like "Rural" or "Urban"

The QC_Checks table drives the automated process and can be easily modified to user requirements. The above three tables are available in the SQL Server 2000 database, "Auto_QC", which is included with and attachable to your SQL Server 2000 system.

In addition to the three support tables there are three results tables:

1. **QC_Errors** – One record for each data record and has Checked? And Failed? Field pairs indicating if a check was performed (1 or 0) and if it failed (1 or 0). Additional fields show the values used during validation.
2. **QC_Errors_Data_Summary** – Since there can be multiple QC_Checks performed for a single data record this table groups them. The query used to produce this table could easily be combined with the main query to create QC_Errors already summarized.
3. **QC_Reports** – Summarizes data by Support and Parameter providing counts of checks performed and errors encountered.

The SQL script that performs the checks, "AutoQC_CCOS.sql", is self contained and can be run in SQL Query Analyzer or placed in a stored procedure. It can be run as a job by either method. The query took two hours to run on our proprietary in-house database but would probably take much longer to run on the full database. As a test, we ran it on a small subset of four methods and it took about an hour. Additional indexes may need to be created to get acceptable run times.

The **Figure C-1** shows the QC tables and how they relate to CCOS tables.

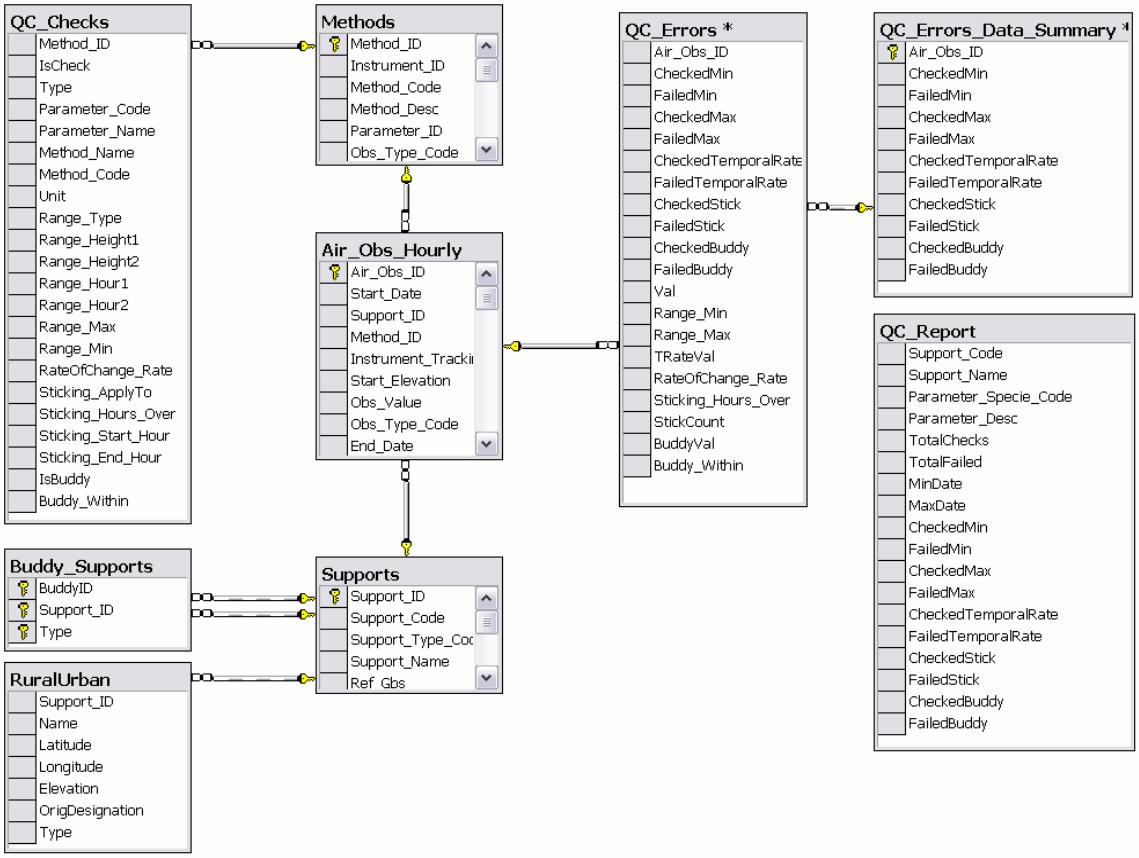

Figure C-1. Diagram showing the relationship among QC support tables, CCOS tables, and QC results tables.