Evaluation of the Implementation of the Coupled Ocean Atmosphere Response Experiment (COARE) Algorithms into AERMET for Marine Boundary Layer Environments

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Office of Air Quality Planning and Standards
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Preface

This document provides an evaluation of implementation of the Coupled Ocean-Atmosphere Response Experiment (COARE) algorithms from the AERCOARE program into AERMET for applications in marine boundary layer environments as part of the proposed updates to the 2023 revision of the *Guideline on Air Quality Models*. The purpose of the document is to provide results indicating that the inclusion of COARE into AERMET gives equivalent results to AERCOARE, and there were no coding errors in the implementation of COARE into AERMET. Included in this document are descriptions of the inputs, comparison of meteorological output from AERCOARE and AERMET, and comparison of AERMOD results from AERCOARE and AERMET.

Acknowledgements

This report was developed as part of the 2023 proposal of *The Guideline on Air Quality Models*, Appendix W with input from the meteorological data workgroup comprised of staff from EPA's Office of Air Quality Planning and Standards and Region 10. WRF a processing for the evaluations were processed by General Dynamics Information Technology.

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1.0 Introduction

In recent years, applications of AERMOD (U.S. EPA, 2023a) in marine boundary layer environments, i.e., overwater applications, have increased. Calculations of boundary layer parameters for the marine boundary layer present special challenges as the marine boundary layer can be very different from the boundary layer over land. For example, convective conditions can occur in the overnight hours in the marine boundary layer while typically over land, stable conditions occur at night. Also, surface roughness in the marine environment is a function of wave height and wind speed and less static with time than surface roughness over land.

While the Offshore and Coastal Dispersion Model (OCD) (DiCristofaro and Hanna, 1989) is the preferred model for overwater applications, there are applications where the use of AERMOD is applicable. These include applications that utilize features of AERMOD not included in OCD (e.g., NO_2 chemistry). Such use of AERMOD would require consultation with the Regional Office and appropriate reviewing authority to ensure that platform downwash and shoreline fumigation are adequately considered in the modeling demonstration.

For the reasons stated above, a standalone pre-processor to AERMOD, called AERCOARE (U.S. EPA, 2012a) was developed to use the Coupled Ocean Atmosphere Response Experiment (COARE) bulk-flux algorithms (Fairall et al., 2003) to bypass AERMET and calculate the boundary layer parameters for input to AERMOD for the marine boundary layer. AERCOARE can process either measurements from water-based sites such as buoys or prognostic data processed via the Mesoscale Model Interface program (MMMIF) (Ramboll, 2023). AERCOARE was developed in response of a need for overwater meteorology for an AERMOD application in an Arctic Ice Free Environment (U.S. EPA, 2011a) and that the boundary layer calculations in AERMET (U.S. EPA, 2023b) are more suited for land-based data.

To better facilitate the use of the COARE algorithms for AERMOD, EPA included the COARE algorithms into AERMET version 23132 (U.S. EPA, 2023b) as part of the 2023 proposed updates to the *Guideline on Air Quality Models* (U.S. EPA, 2023c), thus eliminating the need for a standalone pre-processor and ensures the algorithms are updated as part of routine AERMET updates.

This report details the evaluation process to determine if the COARE algorithms in AERCOARE were incorporated into AERMET (U.S. EPA, 2023b) correctly, i.e., no coding errors. Results between AERCOARE and AERMET with COARE processing should be equivalent or have very small differences (due to real type variables in AERCOARE vs. double precision type variables in AERMET) when both processors are input with the same data. The comparisons are made for both measured data processed in AERCOARE and AERMET and prognostic data processed in AERCOARE and AERMET. Both measured and prognostic data are used to fully check the incorporation of COARE into AERMET and no attempt is made in this document to compare the measured vs. prognostic data. For an evaluation of prognostic data configurations in AERMET with COARE see U.S. EPA (2023d). The comparisons presented in this report do not include the warm layer or cool skin options available for COARE. These options have been included in AERMET but have not been evaluated as the data necessary for these options are not available in the datasets used in this evaluation. Section 2 discusses the methodology of the case studies. There are four case studies used to evaluate the incorporation of COARE into AERMET: 1) Cameron, LA; 2) Carpinteria, CA, 3) Pismo Beach, CA, and 4) Ventura, CA. This report includes comparisons of meteorological data output from AERCOARE and AERMET and comparison of AERMOD results using AERCOARE and AERMET meteorology. Section 2.0 describes the methodology of the evaluations, Section 3.0 discusses the results of the evaluations, and Section 4.0 is the summary and conclusion of the evaluation.

2.0 Methodology

Following is the methodology of the evaluation of incorporating COARE into AERMET. Section 2.1 describes the study areas, Section 2.2 describes the AERCOARE and AERMET configurations, Section 2.3 describes the meteorological data evaluation and Section 2.4 describes the AERMOD evaluation.

2.1 Study Areas

Four case study areas were considered for evaluation (Figure 1) as noted in Section 1.0. Each study area is detailed below and more information about each can be found in U.S. EPA (2012b).

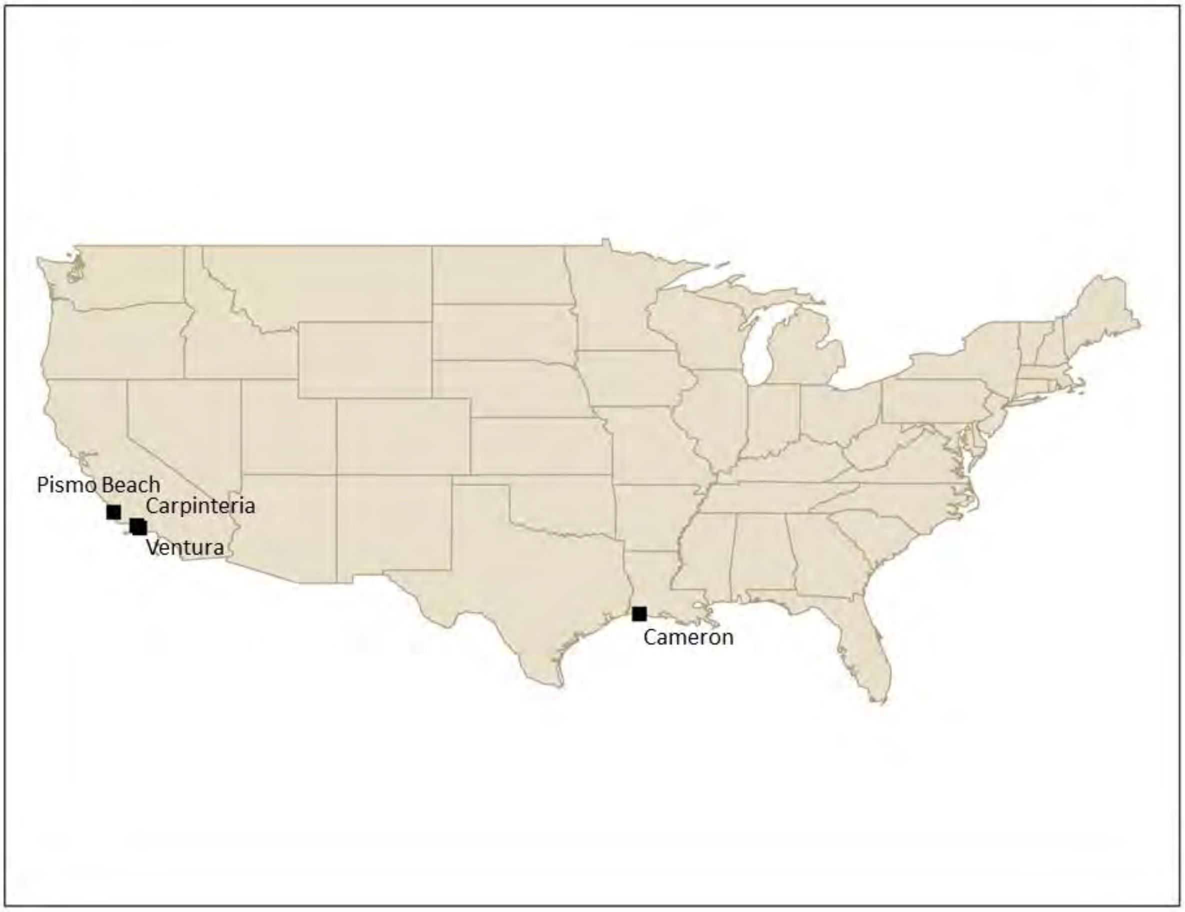


Figure 1. Study areas for COARE to AERMET testing.

2.1.1 Cameron, LA

The Cameron case study consisted of 26 tracer releases from field studies in July 1981 and February 1982. Tracer was released from both a boat and a low-profile platform at a height of 13 m. Receptors were located in flat terrain near the shoreline with transport distances ranging from 4 to 10 km (U.S. EPA, 2012b). **Error! Reference source not found.** shows the general study area. The meteorological data for Cameron is shown in Table 1. Note, for all hours, the station pressure was set to 1000 mb and wind direction was assumed to be 270° because AERMOD would be run in screening mode. The data set contains both very stable and fairly unstable conditions. There are several hours of stable lapse rates accompanied by unstable air-sea temperature differences. For example, on February 15, 1982, hour 1700, the air-sea temperature difference is -0.8 °C, while the virtual potential temperature lapse rate is 0.06 °C/m (extreme stability "G" in OCD). Over 10 m, this virtual potential temperature lapse rate would result in at least an air-sea temperature difference of +0.5 °C. The data was adjusted for the AERCOARE evaluations by adjusting the air-sea temperature difference to be at least as stable as indicated by the virtual potential temperature lapse rate. The sea temperature was adjusted so the air-sea temperature difference matched the measured potential temperature lapse rate (U.S. EPA, 2012b) and those hours are highlighted in Table 1.

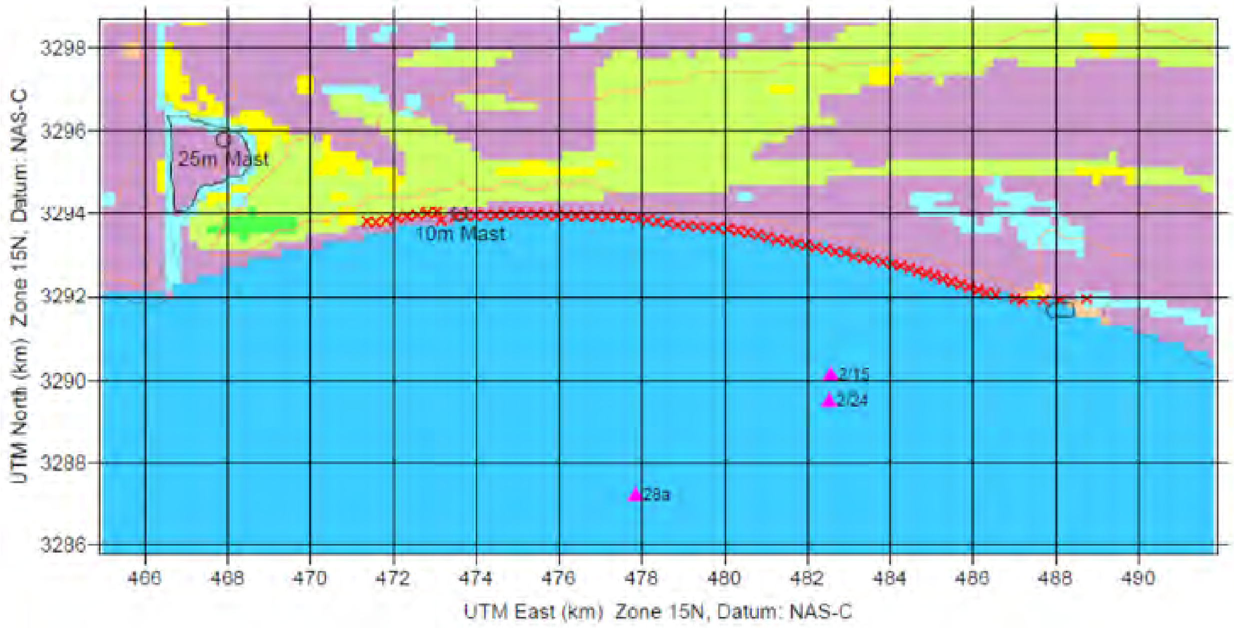


Figure 2. Cameron, LA study area

Table 1. Cameron measured meteorological data.

Date	Hour (LST)	Wind ht (m)	Wind speed (m/s)	Temperature/RH height (m)	RH (%)	Air temperature (°C)	Sea temperature (°C)	σ_θ (°)	Mixing height (m)
7/20/81	14	10	4.6	10	63	29.25	31.95	6.4	800
7/20/81	15	10	4.8	10	64	29.45	32.05	4.9	800
7/23/81	17	10	4.3	18	73	30.45	31.85	4.7	225
7/23/81	18	10	5.1	18	74	30.55	31.75	4.7	225
7/27/81	20	10	2.1	18	82	27.05	31.45	999	400
7/27/81	22	10	4.5	18	82	26.85	31.35	999	450
7/29/81	16	10	4.6	18	69	29.85	32.05	9.6	420
7/29/81	17	10	5	18	68	29.85	31.85	6.4	430
7/29/81	19	10	5	18	68	29.95	31.65	9.6	450
2/15/82	16	10	5.7	10	89	14.25	13.75	999	200
2/15/82	17	10	5.6	10	88	13.95	13.45	999	200
2/15/82	20	10	5.9	10	87	14.25	13.75	999	200
2/17/82	14	10	3.3	10	93	15.65	13.55	2.5	200
2/17/82	15	18	3.7	18	93	14.95	14.05	7.6	200
2/17/82	16	18	4.3	18	93	14.85	14.25	3.9	200
2/17/82	17	18	3.5	18	93	14.55	14.19	3.8	200
2/17/82	18	18	3.5	18	93	14.25	13.89	2.1	200
2/22/82	14	18	5.2	18	75	17.45	16.15	2.7	100
2/22/82	16	18	4.7	18	76	17.45	16.55	2.4	100
2/22/82	17	18	4.5	18	76	17.75	16.95	2.8	100
2/23/82	14	18	4.8	18	84	18.35	14.65	0.6	50
2/23/82	17	18	6.2	18	88	18.05	15.75	3.2	80
2/24/82	15	18	3.7	18	49	19.95	14.95	2.7	50
2/24/82	16	18	3.7	18	50	19.75	15.15	3.2	50
2/24/82	17	18	3.5	18	50	19.75	15.05	3.3	50
2/24/82	19	18	4.1	18	52	17.55	14.85	2.6	50

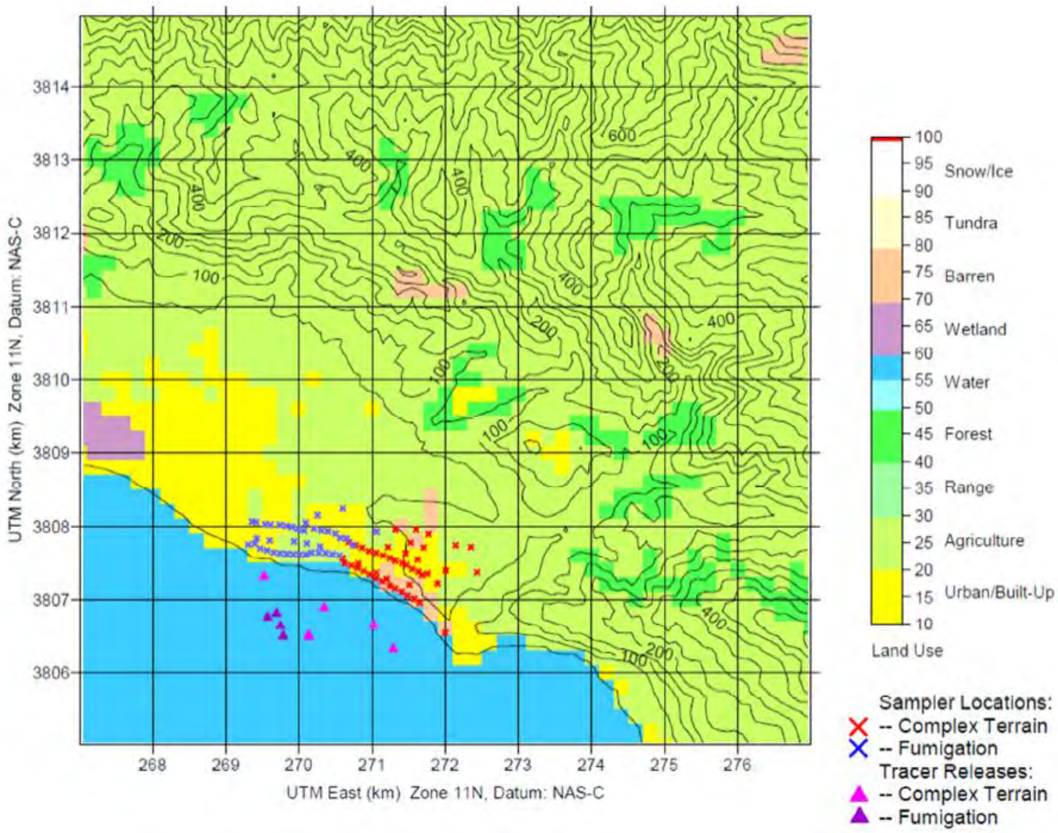
Table 2 shows the Cameron source and receptor data for AERMOD. Release heights for releases was 13.0 m. AERMOD was run in screening mode with westerly winds with the source location at (0,0). Receptor coordinates are (X,0) where X is the downwind distance of the peak observed concentration.

Table 2. Cameron source and receptor data.

Release number	Date	Hour (LST)	Building ht (m)	Building width (m)	Receptor distance (m)
1	7/20/81	14	0.0	0.0	7180
2	7/20/81	15	0.0	0.0	7400
3	7/23/81	17	0.0	0.0	8930
4	7/23/81	18	0.0	0.0	8710
5	7/27/81	20	0.0	0.0	7020
6	7/27/81	22	0.0	0.0	7859
7	7/29/81	16	0.0	0.0	7820
8	7/29/81	17	0.0	0.0	9780
9	7/29/81	19	0.0	0.0	9950
10	2/15/82	16	7.0	20.0	4834
11	2/15/82	17	7.0	20.0	5762
12	2/15/82	20	7.0	20.0	4526
13	2/17/82	14	0.0	0.0	7000
14	2/17/82	15	0.0	0.0	6985
15	2/17/82	16	0.0	0.0	7400
16	2/17/82	17	0.0	0.0	7260
17	2/17/82	18	0.0	0.0	6950
18	2/22/82	14	0.0	0.0	7095
19	2/22/82	16	0.0	0.0	7070
20	2/22/82	17	0.0	0.0	6955
21	2/23/82	14	0.0	0.0	7769
22	2/23/82	17	0.0	0.0	7245
23	2/24/82	15	7.0	20.0	5669
24	2/24/82	16	7.0	20.0	5669
25	2/24/82	17	7.0	20.0	6023
26	2/24/82	19	7.0	20.0	4786

2.1.2 Carpinteria, CA

The Carpinteria tracer study was conducted in September and October 1985. Studies were conducted to examine offshore impacts caused by both interaction with complex terrain and shoreline fumigation. The current analysis only evaluated the complex terrain data set as the AERCOARE-AERMOD approach currently cannot simulate shoreline fumigation.



shows the land use and terrain for the Carpinteria field study. The shoreline receptors are located on a 20 m to 30 m high bluff within 0.8 km to 1.5 km of the offshore tethersonde release. Two tracers were released with heights varying from 18 m to 61 m. The tethersonde was well above the anchor boat and downwash was not considered in the simulations.

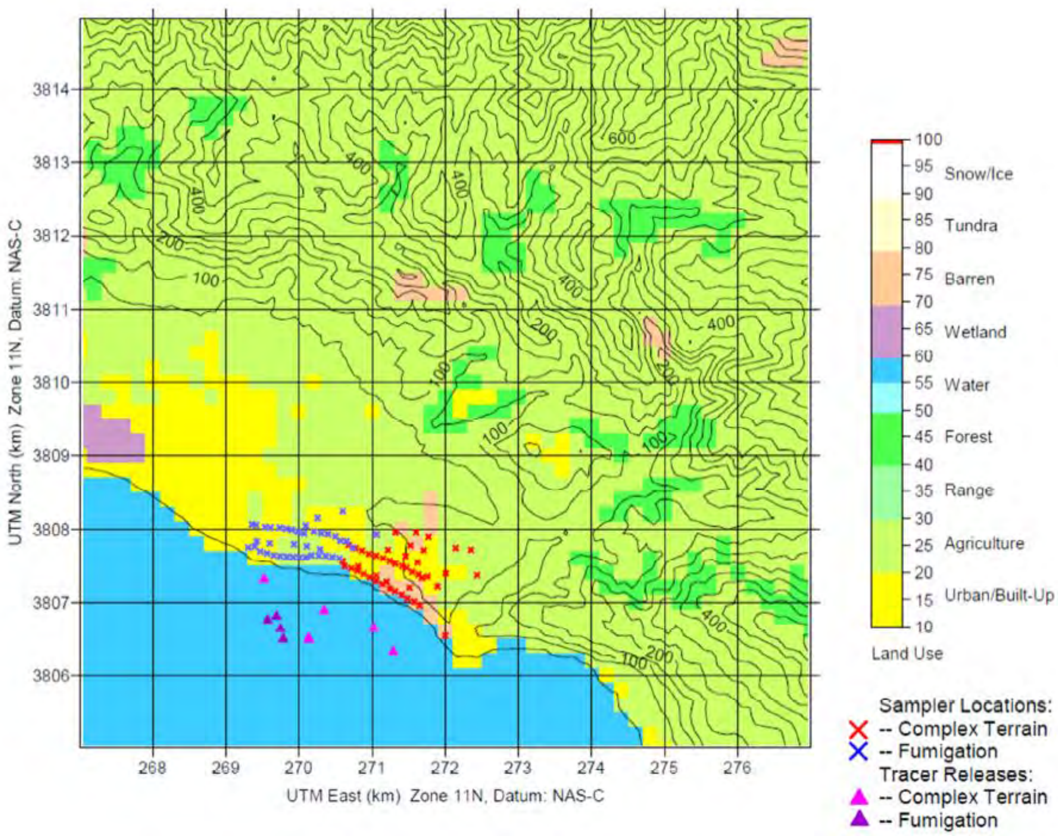


Figure 3. Carpinteria, CA study area.

Table 3 displays the meteorological data used in the current simulations and previous evaluations of OCD and CALPUFF. The winds were very light for most of the releases, especially considering the wind measurement heights were from 30 m to 49 m. Note that the air temperature and relative humidity measuring height was 9 m for all hours, station pressure was 1,000 mb for all hours, and the mixing height was 500 m for all hours. The combined influences of low wind speeds and the air-sea temperature differences in Table 3 result in cases with unstable to very stable stratifications. Unlike the Cameron data set, the virtual potential temperature lapse rates do not contradict the gradient inferred from the air temperature difference measurements. One suspect aspect of the data is the constant mixed layer height of 500 m for the entire data set. In cases where plumes are not trapped under a strong inversion, CALPUFF and OCD are less sensitive to the mixing height than AERMOD. Thus, uncertainty in the boundary layer height in this experiment may not have been important to the original investigators.

Table 4 lists the source release parameters used for the AERCOARE simulations of the Carpinteria data set. Unlike the other databases, actual wind directions, source locations and receptor sites were used in the analysis to consider the effects of terrain elevation on the model predictions. Receptor elevations and scale heights for AERMOD were calculated with AERMAP

(Version 11103) (EPA, 2011b) using 1/3 arc-second terrain data from the National Elevation Data (NED) set. The peak predicted concentration was compared to the peak measured concentration for each release.

Table 3. Carpinteria measured meteorological data.

Date	Hour (LST)	Wind ht (m)	Wind speed (m/s)	Wind direction (°)	RH (%)	Air temperature (°C)	Sea temperature (°C)	σ_θ (°)
9/19/85	9	30	1.3	259.7	78.8	16.3	17.4	26.8
9/19/85	10	30	1.3	235.4	79	16.8	17.6	28.4
9/19/85	11	30	2.6	214.1	80.1	17	17.7	24.4
9/19/85	12	30	3.1	252.9	80.1	17.1	17.8	32.9
9/22/85	9	30	1	220.8	70.6	17.4	16.9	32.1
9/22/85	10	30	1.2	251.1	81	17	16.7	17.4
9/22/85	11	30	2.4	253.8	92.1	16.4	15.4	8
9/22/85	11	30	2.4	230	92.1	16.4	15.4	8
9/22/85	12	30	2.8	248.4	91.1	16.3	15.2	17.4

9/22/85	12	30	2.8	237.7	91.1	16.3	15.2	17.4
9/25/85	10	24	1	163.8	60.3	21.2	18.4	41.7
9/25/85	11	46	1.6	163.8	69.9	21	18.7	9.9
9/25/85	12	46	1	165.6	90.3	20.9	18.8	26.1
9/25/85	13	46	1	175	90.4	21.4	18.7	18.4
9/26/85	12	49	3.8	262	83.5	18.7	19.4	10.9
9/26/85	13	49	4	262.2	81	18.8	19.8	11.8
9/28/85	10	24	5.4	155.8	85.1	18.1	18.7	8.9
9/28/85	10	24	5.4	155.8	85.1	18.1	18.7	8.9
9/28/85	11	24	3.2	174.7	84.1	18	18.8	10.9
9/28/85	11	24	3.2	177	84.1	18	18.8	10.9
9/28/85	13	24	1.5	234.5	82.5	18.3	18.9	10.9
9/28/85	13	24	1.5	229.5	82.5	18.3	18.9	10.9
9/28/85	14	24	2.1	215	81.7	18.5	18.8	11.8
9/28/85	14	24	2.1	215	81.7	18.5	18.8	11.8
9/29/85	11	30	3.4	243.7	86	18.2	18.5	18.4
9/29/85	12	30	3.1	238.9	87.8	18.1	18.5	5
9/29/85	12	30	3.1	232.7	87.8	18.1	18.5	5
10/1/85	9	61	2	215.5	92.1	16.5	17.4	19.2
10/3/85	10	61	1	164.6	89	26.3	24.2	12.8
10/3/85	11	61	1.8	215.5	95.9	24.8	21.4	32.9
10/4/85	12	76	1.7	216.9	70.3	21.6	18.3	14.7
10/4/85	9	76	2.6	231.2	71.9	21.7	18.4	11.8
10/4/85	10	76	1.7	186.4	76.4	21.3	18	13.7
10/5/85	11	91	1.3	171.3	66.8	20.9	20.2	28.4
10/5/85	11	91	1.5	208.2	64.8	21.3	20.6	19.2
10/5/85	12	91	1	195.2	62.7	21.5	20.8	28.4

Table 4. Carpinteria source parameters data.

Release number	Date	Hour (LST)	Release type	Release ht (m)	UTM East (m)	UTM North (m)
1	9/19/85	9	SF6	30.5	270,343	3,806,910
2	9/19/85	10	SF6	30.5	270,343	3,806,910
3	9/19/85	11	SF6	30.5	270,343	3,806,910
4	9/19/85	12	SF6	30.5	270,343	3,806,910
5	9/22/85	9	SF6	18.3	270,133	3,806,520
6	9/22/85	10	SF6	18.3	270,133	3,806,520
7	9/22/85	11	SF6	18.3	270,133	3,806,520
8	9/22/85	11	Freon	36.6	270,133	3,806,520
9	9/22/85	12	SF6	18.3	270,133	3,806,520

10	9/22/85	12	Freon	36.6	270,133	3,806,520
11	9/25/85	10	SF6	24.4	271,024	3,806,660
12	9/25/85	11	SF6	24.4	271,024	3,806,660
13	9/25/85	12	SF6	24.4	271,024	3,806,660
14	9/25/85	13	SF6	24.4	271,024	3,806,660
15	9/26/85	12	Freon	24.4	269,524	3,807,330
16	9/26/85	13	Freon	24.4	269,524	3,807,330
17	9/28/85	10	SF6	24.4	271,289	3,806,340
18	9/28/85	10	Freon	42.7	271,289	3,806,340
19	9/28/85	11	SF6	24.4	271,289	3,806,340
20	9/28/85	11	Freon	42.7	271,289	3,806,340
21	9/28/85	13	SF6	24.4	270,133	3,806,520
22	9/28/85	13	Freon	39.6	270,133	3,806,520
23	9/28/85	14	SF6	24.4	270,133	3,806,520
24	9/28/85	14	Freon	39.6	270,133	3,806,520
25	9/29/85	11	SF6	30.5	270,133	3,806,520
26	9/29/85	12	SF6	30.5	270,133	3,806,520
27	9/29/85	12	Freon	61	270,133	3,806,520

2.1.3 Pismo Beach, CA

The Pismo Beach experiment was conducted during December 1981 and June 1982. A depiction of land use, release point locations and receptor sites are shown in Figure 4 based on U.S. EPA (2012b). Tracer was released from a boat mast height of 13.1 m to 13.6 m above the water. Peak concentrations occurred near the shoreline at sampling distances from 6 km to 8 km away. The Pismo Beach evaluation database consists of 31 samples.

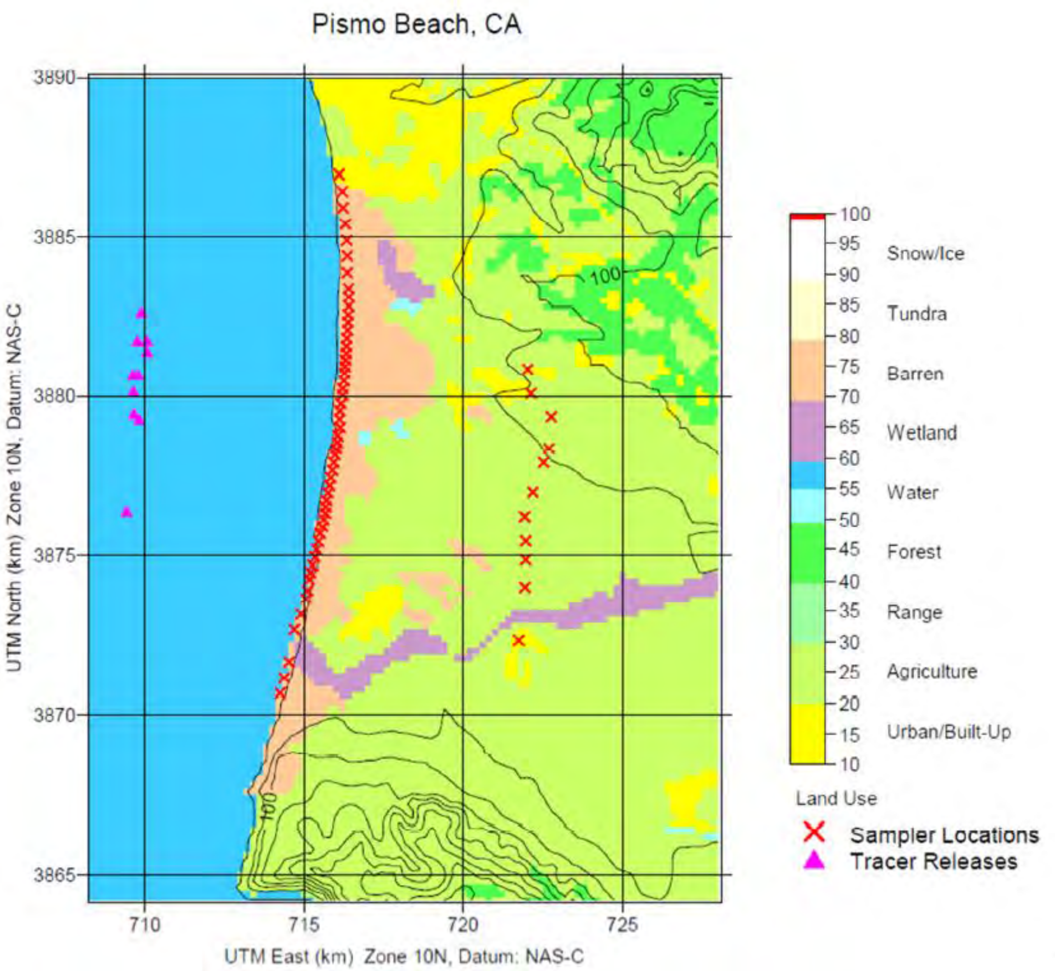


Figure 4. Pismo Beach, CA study area.

Table 5 lists the overwater meteorological data used in the current study. Note for all hours the station pressure was 1000 mb, wind measurement height was 20.5 m, air temperature/relative humidity measurement height was 7.0 m, and wind direction was assumed to be 270° because AERMOD was run in screening mode. Examination of the meteorological data in Table 5 reveals several inconsistencies between the air-sea temperature difference and the virtual potential temperature lapse rate. As with Cameron, the virtual potential temperature lapse rate sometimes indicates a stable boundary layer (positive) when the air-sea temperature difference is unstable (negative). Either there was a low mixed layer not reflected by the mixing height measurements in Table 5, or one of the measurements is not representative of the boundary layer profile. The air-sea temperature difference was adjusted to be at least as stable as indicated by the virtual potential temperature lapse rate to address this inconsistency in our evaluation. In these instances, the sea temperature was adjusted so the air-sea temperature difference matched the measured potential temperature lapse rate. The revised estimates are highlighted in gray in Table 5.

Table 5. Pismo Beach measured meteorological data.

Date	Hour (LST)	Wind speed (m/s)	RH (%)	Air temperature (°C)	Sea temperature (°C)	σ_θ (°)	Mixing height (m)
12/8/81	15	2.2	67	14.55	13.25	9.4	100
12/8/81	16	1.6	75	14.35	13.15	12.9	100
12/11/81	14	4.5	74	12.45	12.45	5.6	600
12/11/81	15	5.4	73	12.95	12.95	4.6	600
12/11/81	17	8.6	84	12.85	12.75	2.1	700
12/11/81	19	7.9	81	12.95	12.75	45	900
12/13/81	14	5.4	95	12.35	13.15	0.9	50
12/13/81	15	6.1	97	12.15	12.95	2.4	50
12/13/81	17	7.9	92	13.05	12.7	1.9	50
12/14/81	13	7.7	79	14.05	12.75	1.2	50
12/14/81	15	10.9	90	13.25	12.85	1.2	50
12/14/81	17	9.9	88	13.55	12.65	1.8	50
12/15/81	13	5.6	88	12.95	12.65	14.4	50
12/15/81	14	6.1	83	14.55	13.45	45	50
12/15/81	19	1.6	70	16.25	12.85	45	50
6/21/82	15	4.3	84	14.35	12.85	1.4	800
6/21/82	16	3.8	86	14.15	12.75	2.1	800
6/21/82	17	2.7	87	14.15	12.65	6.8	800
6/21/82	18	3	89	13.75	12.55	19.7	800
6/22/82	15	3.7	80	15.45	13.75	6.1	700
6/22/82	16	5.2	78	15.65	13.55	3.3	700
6/22/82	19	3.2	84	14.05	12.75	10.6	700
6/24/82	13	3.9	82	14.95	14.05	27.8	600
6/24/82	15	5.3	84	14.95	14.35	7.5	600
6/25/82	12	5.6	76	15.75	13.55	1.4	100
6/25/82	13	6.5	80	15.35	12.75	1.6	100
6/25/82	15	9.8	82	15.15	12.55	5.5	100
6/25/82	16	9.1	82	15.15	12.25	0.9	100
6/25/82	17	9.5	81	15.25	12.05	1.2	100
6/27/82	16	12.7	93	13.85	10.45	1.1	100
6/27/82	18	10.2	94	14.55	10.85	7.7	100

Table 6 shows the source-to-receptor relationships and the release characteristics assumed for the AERCOARE simulations. All simulations were performed with a unit emission rate and without plume rise. Building downwash from the release boat was considered using the dimensions with a constant building height of 7.0 m and building width of 20.0 m. As in the original OCD and CALPUFF evaluations, only peak concentration predictions and observations for each hour are compared in the current evaluation. To ensure that plume centerlines travelled over the receptor with the highest observed concentration, a constant westerly wind was assumed, and predictions were obtained at a single receptor located the correct distance east of the release point.

Table 6. Pismo Beach release heights and receptor distances.

Release number	Date	Hour (LST)	Release ht (m)	Receptor distance (m)
1	12/8/81	15	13.1	6730
2	12/8/81	16	13.1	6506
3	12/11/81	14	13.1	6422
4	12/11/81	15	13.1	6509
5	12/11/81	17	13.1	6619
6	12/11/81	19	13.1	7316
7	12/13/81	14	13.1	6516
8	12/13/81	15	13.1	6372
9	12/13/81	17	13.1	6870
10	12/14/81	13	13.1	6378
11	12/14/81	15	13.1	6378
12	12/14/81	17	13.1	6526
13	12/15/81	13	13.1	6944
14	12/15/81	14	13.1	6697
15	12/15/81	19	13.1	8312
16	6/21/82	15	13.6	6532
17	6/21/82	16	13.6	6589
18	6/21/82	17	13.6	6748
19	6/21/82	18	13.6	6532
20	6/22/82	15	13.6	6125
21	6/22/82	16	13.6	6214
22	6/22/82	19	13.6	6054
23	6/24/82	13	13.6	6244
24	6/24/82	15	13.6	6244
25	6/25/82	12	13.6	6406
26	6/25/82	13	13.6	6377
27	6/25/82	15	13.6	6406
28	6/25/82	16	13.6	6435
29	6/25/82	17	13.6	6455
30	6/27/82	16	13.6	6630
31	6/27/82	18	13.6	6579

2.1.4 Ventura, CA

The Ventura experiment was conducted during September 1980 and January 1981. Land use, release point locations and receptor sites are shown in Figure 5 based on the files from the CALPUFF evaluation archives. The tracer was released from a boat mast height of 8.1 m above the water. Peak concentrations occurred along the closet arc of receptors in Figure 5 at sampling distances from 7 km to 11 km away. The Ventura evaluation database consists of 17 samples.

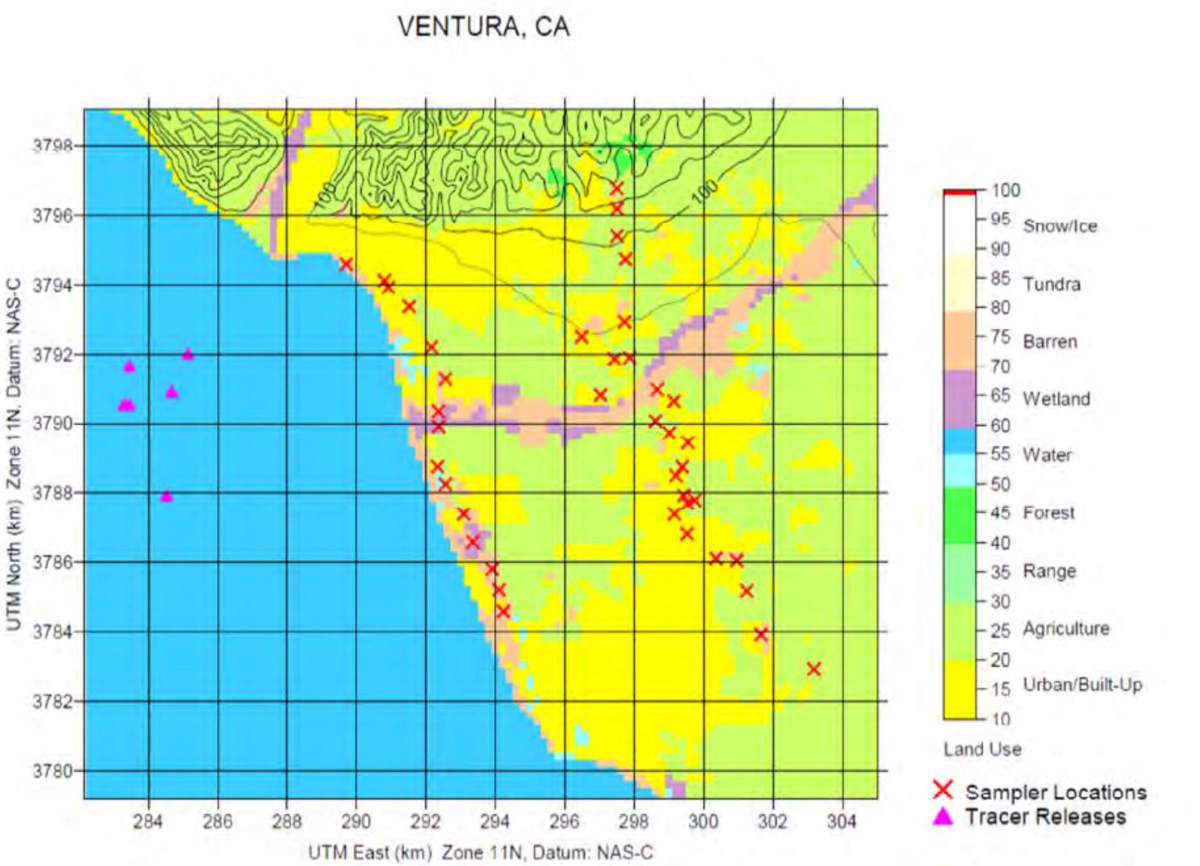


Figure 5. Ventura, CA study area.

The Ventura meteorological data used in the current analysis are shown in Table 7. Note for all hours the station pressure was 1000 mb, wind measurement height was 20.5 m, air temperature/relative humidity measurement height was 7.0 m, and wind direction was 270° because AERMOD was run in screening mode. The OCD and CALPUFF model evaluation data set stabilities ranged from moderately unstable to slightly stable. As with the Pismo Beach data, there are several hours of stable lapse rates accompanied by unstable air-sea temperature differences. For example, on September 29, 1980, hour 1400, the air-sea temperature difference is -0.8 °C, while the virtual potential temperature lapse rate is 0.03 °C/m. These contradictory data were resolved using the same methodology as in the Pismo Beach and Cameron datasets and the revised estimates are highlighted in gray in Table 7.

Table 7. Ventura measured meteorological data.

Date	Hour (LST)	Wind speed (m/s)	RH (%)	Air temperature (°C)	Sea temperature (°C)	σ_θ (°)	Mixing height (m)
9/24/80	16	4.1	72	15.15	17.25	8	400
9/24/80	18	6.2	78	14.85	16.85	6.5	400
9/24/80	19	6.9	77	14.85	16.95	6	400
9/27/80	14	6.3	80	14.85	16.75	4.7	400
9/27/80	19	6.1	80	15.85	16.85	3.6	400
9/28/80	18	3.1	80	16.85	16.85	4.4	250
9/29/80	14	3.3	76	15.55	15.44	5	100
9/29/80	16	5.1	76	16.15	16.04	3.9	100
9/29/80	18	5.2	76	16.05	15.94	5.2	50
1/6/81	16	4	60	17.15	15.55	21.5	50
1/6/81	17	5.1	58	17.45	15.75	13.1	50
1/6/81	18	4.9	60	17.25	15.45	9.4	50
1/9/81	15	4.7	87	14.45	15.35	3.4	100
1/9/81	16	4.6	85	14.85	15.35	4.8	100
1/9/81	18	4.9	87	15.05	15.35	3.1	100
1/13/81	15	5.8	65	16.95	15.55	11.6	50
1/13/81	17	4.2	84	15.85	15.45	8.5	50

Table 8 shows the source and receptor characteristics used in the Ventura tracer simulations. The boat releases assumed a release height of 8.1 m, building height of 7 m and a width (and length) of 20 m. Downwind receptor distances were varied to match the downwind distances of the measurement site with the highest observed concentration for each period.

Table 8. Ventura receptor distances.

Release number	Date	Hour (LST)	Receptor distance (m)
1	9/24/80	16	9291
2	9/24/80	18	9211
3	9/24/80	19	10799
4	9/27/80	14	9123
5	9/27/80	19	9123
6	9/28/80	18	9145
7	9/29/80	14	8085
8	9/29/80	16	7854
9	9/29/80	18	7854
10	1/6/81	16	7463
11	1/6/81	17	7416
12	1/6/81	18	7463
13	1/9/81	15	7956
14	1/9/81	16	7749
15	1/9/81	18	7704
16	1/13/81	15	7705
17	1/13/81	17	6914

2.2 AERCOARE and AERMET configurations

2.2.1 Measured data

For the case studies, AERCOARE and AERMET were run with the following the configurations and case study/configuration combinations are shown in Table 9 for measured data. An 'X' in the cell for a scenario and location indicates that scenario was run for the case location.

- Scenario 1:
  - Reset absolute value of Monin-Obukhov length to 5 m if absolute value of Monin-Obukhov length is less than 5 m. Retain original sign (+ or -) of Monin-Obukhov length
  - Use observed mixing height for convective mixing height and calculate mechanical mixing height without smoothing; Reset mechanical mixing height to 25 m if less than 25 m.

  - Use measured σ_θ (standard deviation of wind direction) to calculate σ_v in AERMOD runs

- Scenario 1a:
  - Reset absolute value of Monin-Obukhov length to 5 m if absolute value of Monin-Obukhov length is less than 5 m. Retain original sign (+ or -) of Monin-Obukhov length
  - Use observed mixing height for convective mixing height and calculate mechanical mixing height without smoothing; Reset mechanical mixing height to 1 m if less than 1 m.
  - Use measured σ_θ (standard deviation of wind direction) to calculate σ_v in AERMOD runs

- Scenario 1b:
  - Reset absolute value of Monin-Obukhov length to 5 m if absolute value of Monin-Obukhov length is less than 5 m. Retain original sign (+ or -) of Monin-Obukhov length
  - Use observed mixing height for convective mixing height and calculate mechanical mixing height without smoothing; Reset mechanical mixing height to 5 m if less than 5 m.
  - Use measured σ_θ (standard deviation of wind direction) to calculate σ_v in AERMOD runs

- Scenario 1c:
  - Reset absolute value of Monin-Obukhov length to 5 m if absolute value of Monin-Obukhov length is less than 5 m. Retain original sign (+ or -) of Monin-Obukhov length
  - Use observed mixing height for convective mixing height and calculate mechanical mixing height without smoothing; Reset mechanical mixing height to 15 m if less than 15 m.
  - Use measured σ_θ (standard deviation of wind direction) to calculate σ_v in AERMOD runs

- Scenario 2:
  - Reset absolute value of Monin-Obukhov length to 5 m if absolute value of Monin-Obukhov length is less than 5 m. Retain original sign (+ or -) of Monin-Obukhov length
  - Use observed mixing height for convective mixing height and calculate mechanical mixing height without smoothing; Reset mechanical mixing height to 25 m if less than 25 m.
  - Do not use measured σ_θ (standard deviation of wind direction) to calculate σ_v in AERMOD runs
- Scenario 3:
  - Reset absolute value of Monin-Obukhov length to 1 m if absolute value of Monin-Obukhov length is less than 1 m. Retain original sign (+ or -) of Monin-Obukhov length
  - Use observed mixing height for convective and mechanical mixing heights; Reset mechanical mixing height to 1 m if less than 1 m.
  - Use measured σ_θ (standard deviation of wind direction) to calculate σ_v in AERMOD runs;
- Scenario 4:
  - Reset absolute value of Monin-Obukhov length to 5 m if absolute value of Monin-Obukhov length is less than 5 m. Retain original sign (+ or -) of Monin-Obukhov length
  - Use observed mixing height for convective and mechanical mixing heights; Reset mechanical mixing height to 1 m if less than 1 m.
  - Use measured σ_θ (standard deviation of wind direction) to calculate σ_v in AERMOD runs

Table 9. AERCOARE and AERMET-COARE configurations for measured data.

Scenario	Cameron	Carpinteria	Pismo Beach	Ventura
1	X	X	X	X
1a		X	X	
1b		X	X	
1c		X	X	
2	X	X	X	X
3	X	X	X	X
4	X	X	X	X

2.2.2 Prognostic data

2.2.2.1 WRF simulations

WRF version 4.4.2 was applied over multiple near-shore locations in Louisiana and California. The time periods modeled for each location are indicated in Table 10 below. These simulations were conducted using nested domains of 12-km, 4-km, and 1.33-km and utilizing a 35-layer vertical resolution. These WRF domains encompass the entire dispersion modeling domain and are shown for each location in Figure 6 through Figure 9. The ERA-Interim 6-hourly reanalysis dataset was used for initialization. All WRF simulations utilized the physics options outlined below:

- Microphysics: Thompson
- Planetary Boundary Layer: UW

- Cumulus: Kain-Fritsch
- Radiation: RRTMG
- Land Surface Model: NOAH
- Surface Layer: Eta

An effort was made to select model options and domains similar to work conducted during the development of AERCOARE (U.S. EPA, 2015). That report outlines extensive model performance evaluation and is the basis for the options selected here.

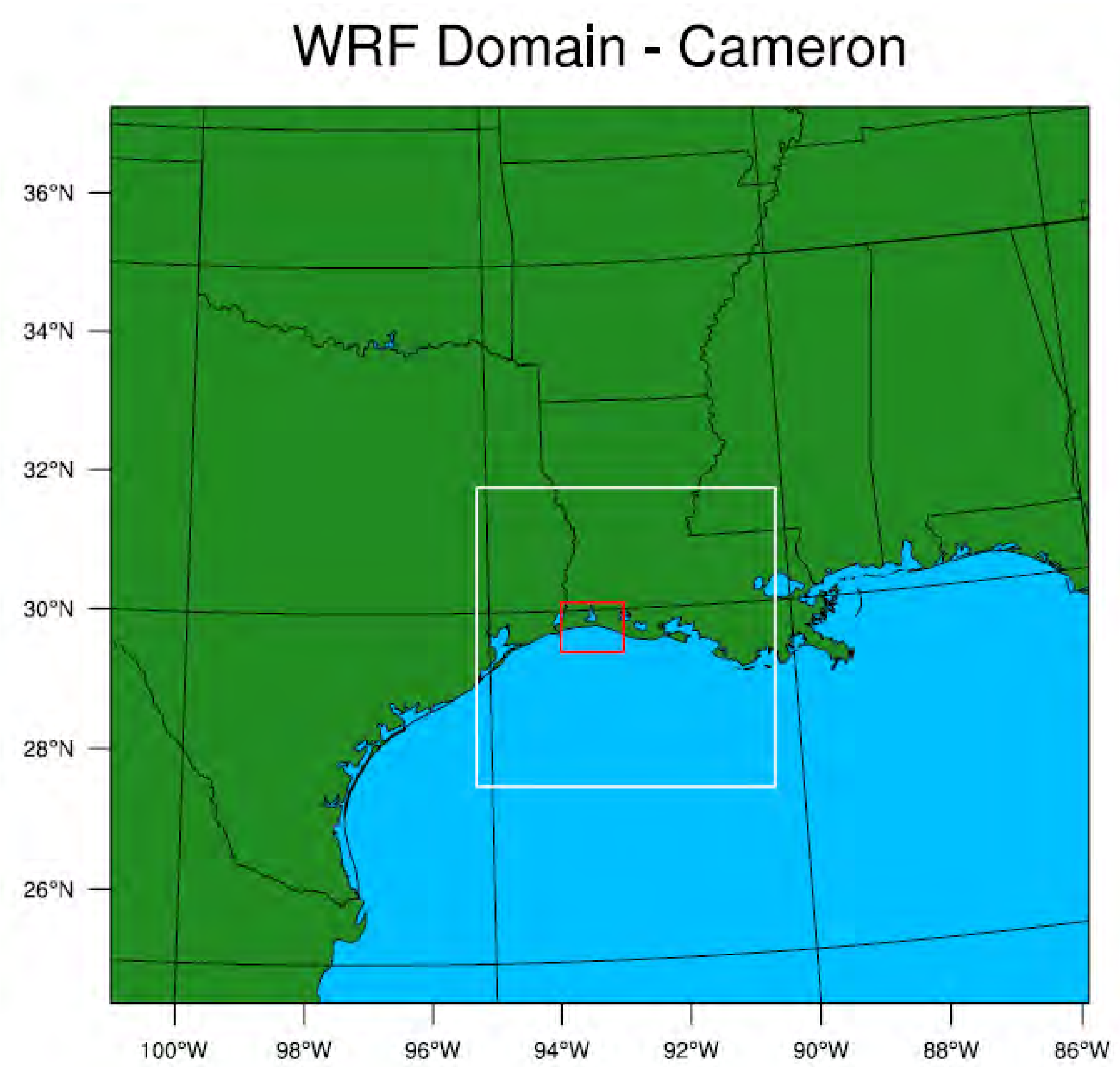


Figure 6. Cameron, LA WRF domains. The large outer box is the 12-km domain, the white box is the 4-km domain, and the red box is the 1.33 km domain.

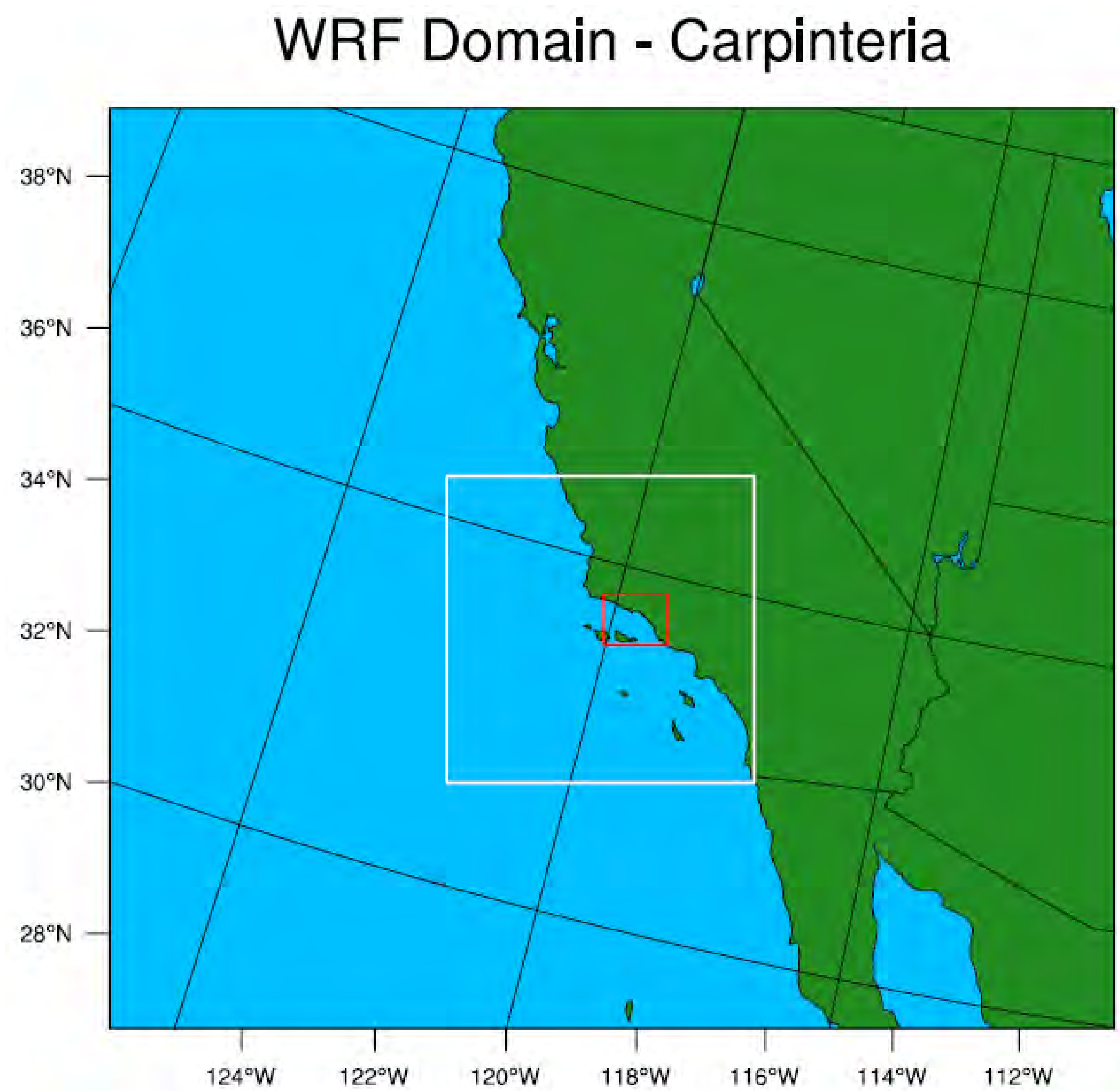


Figure 7. Carpinteria, CA WRF domains. The large outer box is the 12-km domain, the white box is the 4-km domain, and the red box is the 1.33 km domain.

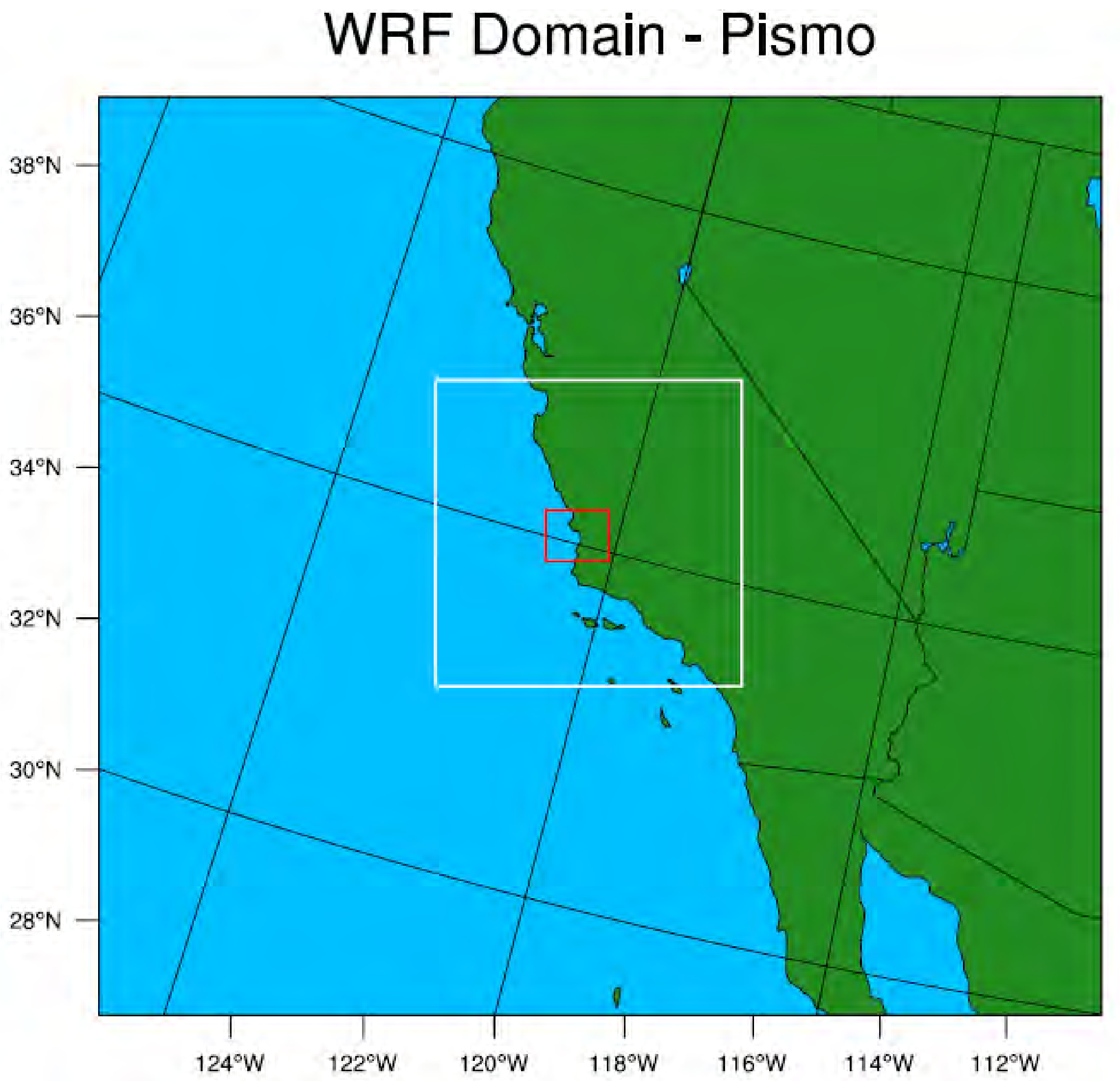


Figure 8. Pismo Beach, CA WRF domains. The large outer box is the 12-km domain, the white box is the 4-km domain, and the red box is the 1.33 km domain.

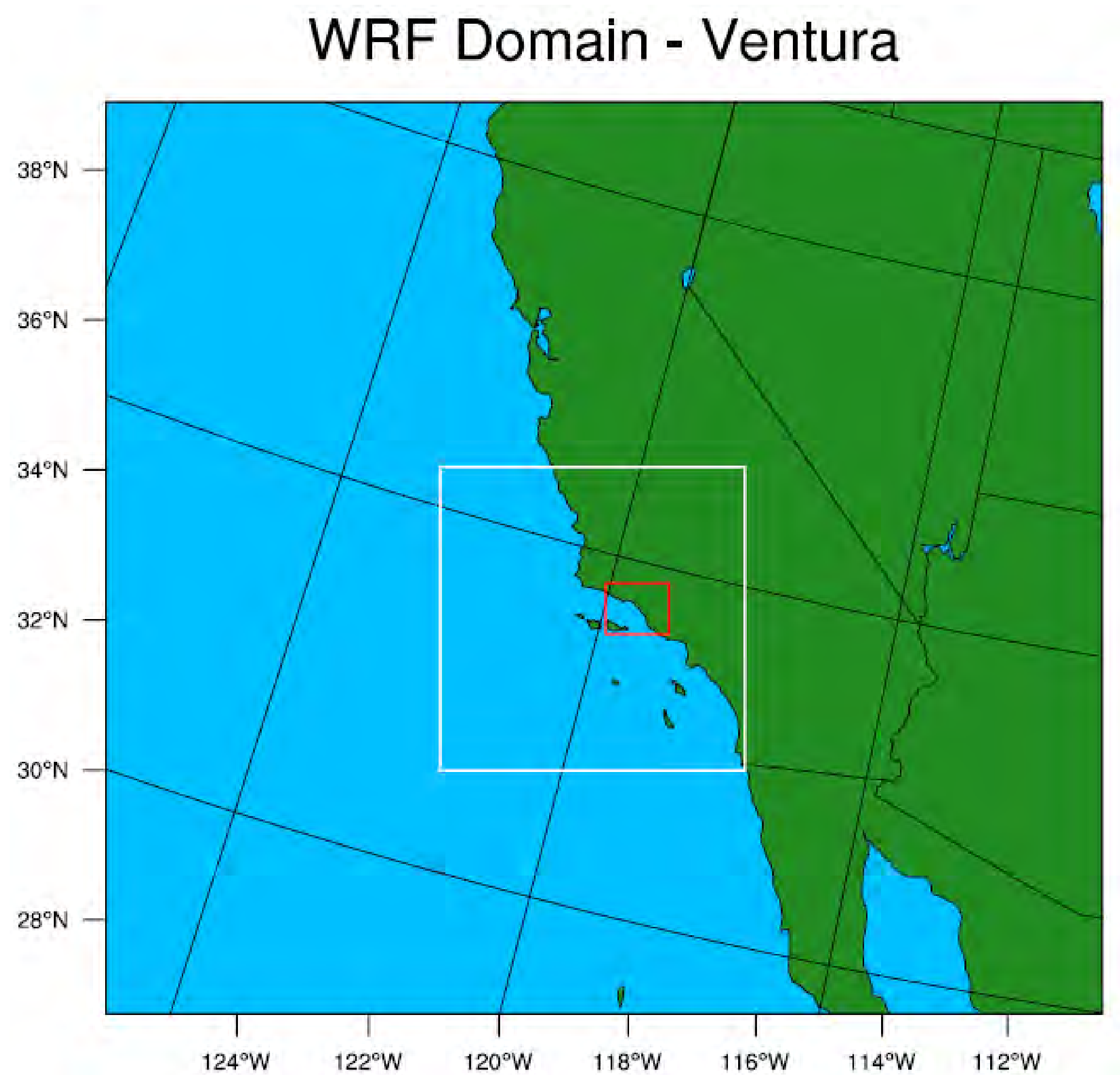


Figure 9. Ventura, CA WRF domains. The large outer box is the 12-km domain, the white box is the 4-km domain, and the red box is the 1.33 km domain.

Table 10. Time periods modeled for each location.

Location	Period
Cameron, LA	Period 1: 7/15/1981 – 7/31/1981 Period 2: 2/10/1982 – 2/25/1982
Carpinteria, CA	Period 1: 9/15/1985 – 9/30/1985
Pismo Beach, CA	Period 1: 12/5/1981 – 12/20/1981 Period 2: 6/15/1982 – 6/30/1982
Ventura, CA	Period 1: 9/15/1980 – 9/30/1980 Period 2: 1/1/1981 – 1/15/1981

2.2.2.2 MMIF output

Once WRF simulations were completed, the 1.3 km WRF output was processed in MMIF to generate data formatted for input to AERCOARE. Locations for extraction were based on the release point locations shown in Figure 2 through

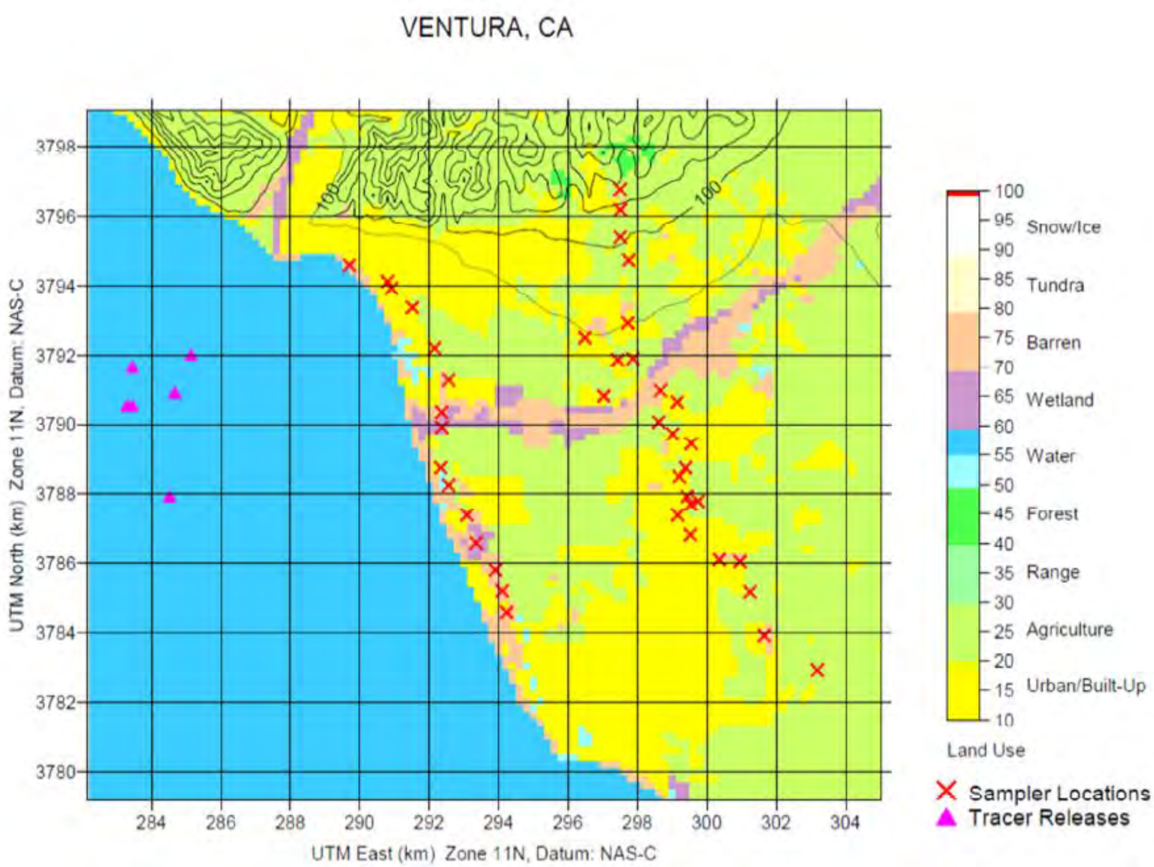


Figure 5. These same files were processed in AERCOARE and AERMET with the COARE processing. Winds were output for 10 m and temperature and relative humidity at 2 m. In addition to winds, temperature, and relative humidity, sea surface temperature, pressure, downward solar radiation, downward longwave radiation, precipitation, total sky cover, mixing height, vertical potential temperature gradient above the PBL, and depth of sea surface temperature measurement. See the MMIF user's guide (Ramboll, 2023) for AERCOARE formatted output.

2.2.2.3 <u>AERCOARE and AERMET-COARE configurations</u>

The prognostic data used for comparisons do not contain turbulence data so Scenarios 1, 1a-1c are analogous to the scenarios in Section 2.2.1 except without turbulence. Scenarios 2 and 3 are analogous to Scenarios 3 and 4 respectively in Section 2.2.1 except without turbulence. The following scenarios were run for the prognostic data and are shown in Table 11. An 'X' in the cell for a scenario and location indicates that scenario was run for the case location.

- Scenario 1:
    - Reset absolute value of Monin-Obukhov length to 5 m if absolute value of Monin-Obukhov length is less than 5 m. Retain original sign (+ or -) of Monin-Obukhov length
    - Use observed mixing height for convective mixing height and calculate mechanical mixing height without smoothing; Reset mechanical mixing height to 25 m if less than 25 m.
- Scenario 1a:
    - Reset absolute value of Monin-Obukhov length to 5 m if absolute value of Monin-Obukhov length is less than 5 m. Retain original sign (+ or -) of Monin-Obukhov length
    - Use observed mixing height for convective mixing height and calculate mechanical mixing height without smoothing; Reset mechanical mixing height to 1 m if less than 1 m.
- Scenario 1b:
    - Reset absolute value of Monin-Obukhov length to 5 m if absolute value of Monin-Obukhov length is less than 5 m. Retain original sign (+ or -) of Monin-Obukhov length

- Use observed mixing height for convective mixing height and calculate mechanical mixing height without smoothing; Reset mechanical mixing height to 5 m if less than 5 m.

- Scenario 1c:
  - Reset absolute value of Monin-Obukhov length to 5 m if absolute value of Monin-Obukhov length is less than 5 m. Retain original sign (+ or -) of Monin-Obukhov length
  - Use observed mixing height for convective mixing height and calculate mechanical mixing height without smoothing; Reset mechanical mixing height to 15 m if less than 15 m.
- Scenario 2:
  - Reset absolute value of Monin-Obukhov length to 1 m if absolute value of Monin-Obukhov length is less than 1 m. Retain original sign (+ or -) of Monin-Obukhov length
  - Use observed mixing height for convective and mechanical mixing heights; Reset mechanical mixing height to 1 m if less than 1 m.
- Scenario 3:
  - Reset absolute value of Monin-Obukhov length to 5 m if absolute value of Monin-Obukhov length is less than 5 m. Retain original sign (+ or -) of Monin-Obukhov length
  - Use observed mixing height for convective and mechanical mixing heights; Reset mechanical mixing height to 1 m if less than 1 m.

Table 11. AERCOARE and AERMET-COARE configurations for prognostic data.

Scenario	**Cameron**	**Carpinteria**	**Pismo Beach**	**Ventura**
1	X	X	X	X
1a		X	X	

1b		X	X	
1c		X	X	
2	X	X	X	X
3	X	X	X	X

To ensure a fair comparison between AERCOARE and AERMET so that differences were due to possible coding errors in AERMET, AERCOARE was modified with the following changes:

- The mechanical mixing height equation, $2300u*^{3/2}$ was changed to $2400u*^{3/2}$. Prior to 2013, both AERCOARE and AERMET used the same equation with the 2300 coefficient. With AERMET 13350, the coefficient was changed to 2400 to match the original formula in Venkatram (1980). AERCOARE, created in 2012, has not been updated since 2012 and does not include the change. The coefficient in AERCOARE was changed to match AERMET.
- The output formats for the surface and profile file output from AERCOARE to AERMOD were modified to match those of AERMET.

For the comparisons using prognostic data, both AERCOARE and AERMET were run with a wind speed threshold of 0.3 m/s. This is because AERCOARE does not reset winds below $2^{1/2}$ x σ_{vmin} where σ_{vmin}=0.2 m/s to $2^{1/2}$ x σ_{vmin} as AERMET does. This threshold does not follow the recommendation in the *Guidance on the Use of the Mesoscale Model Interface Program (MMIF) for AERMOD Applications* (U.S. EPA, 2023e) which states that the threshold speed input to AERMET should be 0 m/s. To allow a fair comparison between AERCOARE and AERMET to ensure the code in AERMET was implemented properly, the threshold was set to 0.3 m/s in both programs.

2.3 Meteorological data evaluation

The meteorological data evaluation or comparison between AERCOARE and AERMET generally follows the methodology used for comparing AERMET 22112 and AERMET 21112 in Appendix F of the AERMET User's Guide (U.S. EPA, 2023b). Hourly comparisons were made for all surface variables and profile variables with a tolerance to account for rounding differences since AERMET 22112 uses double precision vs. real for variable while AERCOARE uses real variables.

Table *12* lists the variables and tolerances.

Table 12. Meteorological variables for comparisons with tolerances.

Variable	Tolerance
Sensible heat flux	0.2 W/m^2
Surface friction velocity	0.002 m/s
Convective velocity scale	0.002 m/s
Θ lapse rate above mixing height	0.002 K/m
Convective mixing height	1 m
Mechanical Mixing height	1 m
Monin-Obukhov length	0.2 m
Surface roughness	0 m
Bowen ratio	0
Albedo	0
Reference wind speed	0 m/s
Reference wind direction	0°
Reference wind height	0 m
Reference temperature	0.2 K
Reference temperature height	0 m
Precipitation code	0
Precipitation	0 mm/hr
Relative humidity	1 %
Station pressure	2 mb
Cloud cover	0 tenths
Wind flag	Character: character strings compared
Profile height	0 m
Profile top indicator	Not checked
Profile wind speed	0 m/s
Profile wind direction	0°
Profile temperature	0°C
Profile σ_θ	0°
Profile σ_w	0 m/s

2.4 AERMOD evaluation

Except for Carpinteria, all AERMOD runs were run in screening mode, i.e., the receptor was assumed to be on the plume centerline and the AERMOD SCREEN model option used. For those screening mode cases using measured data, the wind direction was set to 270°, or westerly winds. Carpinteria AERMOD runs reflected actual source-receptor distances and orientation.

All AERMOD runs were with version 22112. AERMOD output based on AERCOARE and AERMET with COARE were compared in time and space. Ratios of concentrations were calculated for each hour and receptor. Additionally, test statistics called Robust Highest Concentrations (RHC) (U.S. EPA, 1992) were calculated and compared as well for each study area. The RHC is calculated as:

$$RHC = \mathrm{X}(N) + [\bar{\mathrm{X}} - \mathrm{X}(N)] \times \ln\left[\frac{3N-1}{2}\right] \qquad (1)$$

Where X(N) is the Nth largest value, X is the average of N-1 values, and N is the number of values exceeding the threshold value, in this case 10.

3.0 Results

3.1 Meteorological data comparisons

3.1.1 Measured data

- Cameron (all scenarios)
  - 13 hours where Bowen ratio from AERCOARE was -1.0 and Bowen ratio from AERMET was 0.01. this is due to AERMET setting any Bowen ratio to 0.01 regardless of sign. Note Bowen ratio is not used by AERMOD.
  - Two hours where Bowen ratio differed by 0.01 between AERCOARE and AERMET.
- Carpinteria (all cases)
  - 13 hours where Bowen ratio from AERCOARE was -1.0 and Bowen ratio from AERMET was 0.01. this is due to AERMET setting any Bowen ratio to 0.01 regardless of sign. Note Bowen ratio is not used by AERMOD.
- Pismo Beach (all cases)
  - 25 hours where Bowen ratio from AERCOARE was -1.0 and Bowen ratio from AERMET was 0.01. this is due to AERMET setting any Bowen ratio to 0.01 regardless of sign. Note Bowen ratio is not used by AERMOD.
  - Two hours where Bowen ratio differed by 0.01 between AERCOARE and AERMET.

    - 1 hour where Monin-Obukhov length differed by 4 m.
- Ventura (all cases)
    - 9 hours where Bowen ratio from AERCOARE was -1.0 and Bowen ratio from AERMET was 0.01. this is due to AERMET setting any Bowen ratio to 0.01 regardless of sign. Note Bowen ratio is not used by AERMOD.

3.1.2 Prognostic data

Prognostic data evaluation covered all grid cells that were processed for each study area. Multiple grid cells may have covered the same dates so reported totals are across all grid cell and date combinations.

- Cameron (all cases)
    - A total of 1,656 hours evaluated for each case. Values reported below are for each case, not cumulative across all cases.
    - 1 hour of missing albedo, Bowen ratio, surface roughness, u*, w*, surface heat flux, Monin-Obukhov length, mixing heights, and potential temperature lapse rate for AECOARE and non-missing for AERMET for July 31, 1981 hour 9. This is a calm hour and AERCOARE skips processing while AERMET continues processing. Will not impact AERMOD results since hour is calm.
    - 334 hours where Bowen ratio from AERCOARE was -1.0 and Bowen ratio from AERMET was 0.01. this is due to AERMET setting any Bowen ratio to 0.01 regardless of sign. Note Bowen ratio is not used by AERMOD.
    - 14 hours where Bowen ratio differed by 0.01 between AERCOARE and AERMET.
    - 30 hours where Monin-Obukhov length differed with a range of -28.6 m to -0.2 m. Only 6 hours differed more than 1 m.
    - 1 hour in profile where winds for AERCOARE were calm and winds were set to missing for AERMET. These were hours below the threshold of 0.3 m/s and AERMET sets the wind to missing for the profile. AERCOARE sets these hours to calm. Will not impact AERMOD results since hour is calm or missing and both are treated the same in AERMOD.

- 481 hours where potential temperature lapse rate is 0.01 for AERCOARE and less than 0.01 for AERMET. AERCOARE values reset to 0.01 if below 0.005 or greater than 0.1. AERMET values are based on the input lapse rate value from MMIF and not reset.
- 9 hours where potential temperature lapse rate is 0.01 for AERCOARE and 0 for AERMET.

- Carpinteria (all cases)
  - A total of 1,224 hours evaluated for each case. Values reported below are for each case, not cumulative across all cases.
  - 37 hours of missing albedo, Bowen ratio, surface roughness, u*, w*, surface heat flux, Monin-Obukhov length, mixing heights, and potential temperature lapse rate for AECOARE and non-missing for AERMET. These are calm hours and AERCOARE skips processing while AERMET continues processing. Will not impact AERMOD results since hour is calm.
  - 544 hours where Bowen ratio from AERCOARE was -1.0 and Bowen ratio from AERMET was 0.01. this is due to AERMET setting any Bowen ratio to 0.01 regardless of sign. Note Bowen ratio is not used by AERMOD.
  - 2 hours where Bowen ratio differed by 0.01 between AERCOARE and AERMET.
  - 49 hours where Monin-Obukhov length differed with a range of -17.7 m to -0.2 m. 19 hours differed more than 1 m.
  - 37 hours in profile where winds for AERCOARE were calm and winds were set to missing for AERMET. These were hours below the threshold of 0.3 m/s and AERMET sets the wind to missing for the profile. AERCOARE sets these hours to calm. Will not impact AERMOD results since hour is calm or missing and both are treated the same in AERMOD.
  - 58 hours where potential temperature lapse rate is 0.01 for AERCOARE and less than 0.01 for AERMET. AERCOARE values reset to 0.01 if below 0.005 or greater than 0.1. AERMET values are based on the input lapse rate value from MMIF and not reset.

- Pismo Beach (all cases)
  - A total of 2,856 hours evaluated for each case. Values reported below are for each case, not cumulative across all cases.
  - 3 hours of missing albedo, Bowen ratio, surface roughness, u*, w*, surface heat flux, Monin-Obukhov length, mixing heights, and potential temperature lapse rate for AECOARE and non-missing for AERMET. These are calm hours and AERCOARE skips processing while AERMET continues processing. Will not impact AERMOD results since hour is calm.
  - 523 hours where Bowen ratio from AERCOARE was -1.0 and Bowen ratio from AERMET was 0.01. This is due to AERMET setting any Bowen ratio to 0.01 regardless of sign. Note Bowen ratio is not used by AERMOD.
  - 7 hours where Bowen ratio from AERCOAR was 1.0 and Bowen ratio from AERMET is 0.01. This is due to AERMET setting any Bowen ratio to 0.01 regardless of sign. Note Bowen ratio is not used by AERMOD.
  - 38 hours where Bowen ratio differed by 0.01 between AERCOARE and AERMET.
  - 40 hours where Monin-Obukhov length differed with a range of -2.4 m to -0.2 m. 7 hours differed more than 1 m.
  - 3 hours in profile where winds for AERCOARE were calm and winds were set to missing for AERMET. These were hours below the threshold of 0.3 m/s and AERMET sets the wind to missing for the profile. AERCOARE sets these hours to calm. Will not impact AERMOD results since hour is calm or missing and both are treated the same in AERMOD.
  - 276 hours where potential temperature lapse rate is 0.01 for AERCOARE and less than 0.01 for AERMET. AERCOARE values reset to 0.01 if below 0.005 or greater than 0.1. AERMET values are based on the input lapse rate value from MMIF and not reset.
  - 1 hour of wind direction of 0 in AERCOARE and 360 in AERMET. Wind speed for the hour was 4.92 m/s.
- Ventura (all cases)
  - A total of 1,200 hours evaluated for each case. Values reported below are for each case, not cumulative across all cases.

- 5 hours of missing albedo, Bowen ratio, surface roughness, u*, w*, surface heat flux, Monin-Obukhov length, mixing heights, and potential temperature lapse rate for AECOARE and non-missing for AERMET. These are calm hours and AERCOARE skips processing while AERMET continues processing. Will not impact AERMOD results since hour is calm.
- 807 hours where Bowen ratio from AERCOARE was -1.0 and Bowen ratio from AERMET was 0.01. this is due to AERMET setting any Bowen ratio to 0.01 regardless of sign. Note Bowen ratio is not used by AERMOD.
- 8 hours where Bowen ratio differed by 0.01 between AERCOARE and AERMET.
- 51 hours where Monin-Obukhov length differed with a range of -8.6 m to -0.2 m. 13 hours differed more than 1 m.
- 4 hours in profile where winds for AERCOARE were calm and winds were set to missing for AERMET. These were hours below the threshold of 0.3 m/s and AERMET sets the wind to missing for the profile. AERCOARE sets these hours to calm. Will not impact AERMOD results since hour is calm or missing and both are treated the same in AERMOD.
- 10 hours where potential temperature lapse rate is 0.01 for AERCOARE and less than 0.01 for AERMET. AERCOARE values reset to 0.01 if below 0.005 or greater than 0.1. AERMET values are based on the input lapse rate value from MMIF and not reset.
- 2 hours where potential temperature lapse rate is non-missing for AERCOARE and missing for AERMET. These are two of the calm hours.

3.2 AERMOD results

3.2.1 Measured data

Table 13 lists the range of ratios of AERMOD results paired in time and space for each scenario. Ratios are AERMOD using AERMET/AERMOD using AERCOARE. Table 14 lists the Robust Highest Concentration (RHC) ratio (AERMET/AERCOARE) for each scenario. Differences for Carpinteria are due to slight differences in air temperatures (approximately 0.1 degrees) and differences for Pismo Beach are due to slight differences in Monin-Obukhov length. RHC values are based on N=10.

Table 13. Minimum and maximum AERMOD concentration ratios (AERMET/AERCORE) for measured meteorological data.

Scenario	Cameron	Carpinteria	Pismo Beach	Ventura Beach
1	1	0.996-1.0001	0.999-1.0001	1
1a	NA	0.9953-1.00008	0.999-1.0001	NA
1b	NA	0.9953-1.002	0.999-1.0001	NA
1c	NA	0.9953-1.00007	0.999-1.0001	NA
2	1	0.996-1.0001	1.0-1.0008	1
3	1	0.9975-1.00004	0.9999-1.0001	1
4	1	0.9982-1.00003	0.9999-1.0001	1

Table 14. AERMOD Robust Highest Concentration ratios (AERMET/AERCORE) for measured meteorological data.

Scenario	Cameron	Carpinteria	Pismo Beach	Ventura Beach
1	1	1.00005	1	1
1a	NA	1.00004	1	NA
1b	NA	1.00007	1	NA
1c	NA	1.00006	1	NA
2	1	1.00005	0.999	1
3	1	1.00001	1	1
4	1	1	1	1

3.2.2 Prognostic data

Table 15 and

Table *16* are analogous to Table 13 and Table 14 respectively for prognostic data.

Table 15. Minimum and maximum AERMOD concentration ratios (AERMET/AERCORE) for prognostic meteorological data.

Scenario	Cameron	Carpinteria	Pismo Beach	Ventura Beach
1	1.00-1.0002	0.9999-1.000009	1.0-1.00003	1.0-1.00003
1a	NA	0.9999-1.000009	1.0-1.00003	NA
1b	NA	0.9999-1.000009	1.0-1.00003	NA
1c	NA	0.9999-1.000009	1.0-1.00003	NA
2	1.00-1.0002	0.9999-1.000009	1.0-1.00003	1.0-1.00002

3	1.00-1.0002	0.9999-1.000009	1.0-1.00003	1.0-1.00002

Table 16. AERMOD Robust Highest Concentration ratios (AERMET/AERCORE) for prognostic meteorological data.

Scenario	Cameron	Carpinteria	Pismo Beach	Ventura Beach
2	1.00004	1	1	1
1a	NA	1	1	NA
1b	NA	1	1	NA
1c	NA	1	1	NA
2	1.00002	1	1	1

3	1.00002	1	1	1

4.0 Summary and Conclusions

COARE algorithms were incorporated into AERMET version 23132 to allow processing of measured or prognostic meteorological data to calculate representative boundary layer parameters for the marine boundary layer environment. Four case studies were used to assess the accuracy of the code incorporation into AERMET by comparing meteorological outputs from AERCOARE and AERMET as well as AERMOD outputs from both AERCOARE and AERMET. The results of the evaluations of meteorological data and AERMOD concentrations indicated that there were no coding errors when the COARE algorithms were incorporated into AERMET for the default configuration of COARE (no warm layer or cool skin options selected). Differences were due to the transition from real variables in AERCOARE to double precision in AERMET.

Given the equivalency between AERCOARE and AERMET with COARE, the original conclusions of the AERCOARE-AERMOD approach in U.S. EPA (2012b) are still valid with the AERMET-COARE approach:

- The AERCOARE-AERMOD modeling approach was not biased towards underestimates at the high-end of the concentration frequency distribution.
- The AERCOARE-AERMOD approach performed better using the observed $\sigma\Theta$ measurements.
- AERCOARE-MOD predictions were sensitive to the mixing height. An estimate of the mechanical mixing height based on the friction velocity, as in AERMET, was a better alternative than using the observed mixing height from the field studies.
- The AERCOARE-AERMOD approach was sensitive to assumptions during low wind speed conditions and restricting the Monin-Obukhov length such that the absolute value of L > 5 seemed to improve performance by limiting the occurrence of extremely unstable or stable conditions.

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