Application of CALMET / CALPUFF and MESOPUFF II to Compare Regulatory Design Concentrations for a Typical Long-Range Transport Analysis

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1. INTRODUCTION

The U.S. Environmental Protection Agency (EPA) has proposed to adopt the CALPUFF modeling system (Scire et al., 2000a,b) in Appendix A of the Guideline on Air Quality Models (Appendix W of 40 CFR Part 51) and recommend CALPUFF for Class I impact assessments and other long range transport applications or near field applications involving complex flows on a case-by-case basis (EPA, 2000). CALPUFF is also recommended by both the Federal Land Managers Air Quality Workgroup (FLAG, 2000) and the Interagency Workgroup on Air Quality Modeling (IWAQM, 1998) for Class I impact analyses. MESOPUFF II (Scire and Insley, 1993) is the current model identified as a refined modeling technique for long-range transport applications. As an "Appendix B" model, it is approved for use on a case-by-case basis, and applied following the guidance established by EPA (EPA, 1992).

The purpose of this report is to characterize similarities and differences between MESOPUFF II and CALPUFF when simulating regulatory design concentrations for long-range (50 km and greater) transport applications. This type of comparison is known as a consequence analysis. Its objective is to provide users of a newer modeling technique with a simple comparisons of results obtained with an established modeling technique for similar types of applications. Although representative, the results of the comparison are by no means conclusive for all potential applications.

The application chosen for this comparison is an analysis of SO_2 concentrations in a Federal Class I area located more than 50 km from a hypothetical point source. The Class I area chosen is the Shenandoah National Park. The point source is placed approximately 90 km SSE of the park.

There is substantial terrain in this domain, with peak elevations of 1000 meters (MSL) in the vicinity of the Shenandoah National Park. Hence, there is the potential for significant terrain effects, both on the meteorological fields and also in terms of plume-terrain interaction effects. Because the MESOPUFF II modeling system does not include terrain effects, we have used the CALMET model to prepare the gridded meteorological fields for driving both CALPUFF and MESOPUFF II. This allows us to isolate differences between MESOPUFF II and CALPUFF from effects introduced by the substantial differences between the MESOPAC meteorological processor and the CALMET meteorological model. It also allows us to make use of the National Center for Atmospheric Research / Penn State University (NCAR/PSU) Mesoscale Model, Version 4 (MM4) meteorological fields in both simulations. Note that CALMET offers a MESOPAC output data file option, which averages winds across CALMET layers to produce the 2-layer system of MESOPAC.

The meteorological and dispersion modeling simulations are conducted for nearly a one-year period (January 6 to December 29, 1990). This period is selected based on the availability of the EPA MM4 dataset. Meteorological observations are used to determine the wind field in areas where the observations are representative. Hourly meteorological data produced by MM4 on a coarse-grid (80-km resolution) are used by CALMET to help define the initial estimate of the wind fields. Fine scale terrain effects (~4 km resolution) are determined by the diagnostic wind module in CALMET. Spatial variability occurs in the wind fields over short distances due to the forcing of the terrain.

MESOPUFF II is applied as prescribed by EPA for modeling SO_2 as a “relatively inert pollutant”. Neither chemical transformation nor deposition is active. Terrain effects are not treated in the model, so MESOPUFF II results in this complex terrain setting are most appropriate for puffs that have become mixed in the vertical, or that are already “on the ground”. CALPUFF is applied both with and without chemical transformation and deposition, and when applied without these processes, it is run both with and without terrain adjustments. This allows us to characterize the results obtained when CALPUFF is applied both in its recommended mode, and also in modes more similar to MESOPUFF II.

Section 2 provides a general description of the study area and the source configuration, including descriptions of the site characteristics and the data bases (meteorological, geophysical, and aerometric) used in the analysis. Section 3 includes an overview of the CALMET, MESOPUFF, and CALPUFF models. Modeling results for Shenandoah National Park are described in Section 4.

2. SITE CHARACTERIZATION AND METEOROLOGICAL DATA

2.1 Source Description

A single isolated point source that emits SO_2. is used for this analysis. Its characteristics are summarized in Table 2-1.

Table 2-1. Hypothetical Point Source Characteristics

UTM-17 X (km)	UTM-17 Y (km)	Stack Height (m)	Base Elevation (m MSL)	Stack Diameter (m)	Exit Velocity (m/s)	Exit Temperature (K)	SO_2 Emission Rate (g/s)
750.0	4150.0	100.0	100.0	8.0	26.0	430.0	6000.0

2.2 Geophysical Data

Gridded terrain elevations for the modeling domain are obtained from 3 arc-second digital elevation model (DEM) files produced by the United States Geological Survey (USGS). Data are provided in files covering 1 degree by 1 degree block of latitude and longitude. The 1-degree DEMs are produced by the Defense Mapping Agency using cartographic and photographic sources. USGS 1:250,000 scale topographic maps are the primary source of 1-degree DEMs.

One degree DEM data consists of an array of 1201 by 1201 elevations referenced on the geographic (latitude/longitude) coordinate system of the World Geodetic System 1972 Datum. Elevations are in meters relative to mean sea level, and the spacing of the elevations along each profile is 3 arc-seconds, which corresponds to a spacing of approximately 90 meters.

The modeling domain chosen for this analysis covers an area of 312 km by 240 km over most of the northern portions of central and eastern Virginia, including the entire length of the Shenandoah National Park. Topographical features in the area influence the wind flow, including peak elevations of over 1300 meters, which are significantly above the base elevation of the hypothetical source.

A resolution of 4 km in the horizontal is used to represent the variations of the terrain elevations in the area. USGS elevation records located within each grid cell in the domain are averaged to produce a mean elevation at each grid point. The 4 km resolution produces a workable number of grid cells (78 x 60), but allows adequate representation of the important terrain features associated with the Class I area and the surrounding SW-NE oriented ridges. Figure 2-1 shows the terrain contours and the hypothetical source location for the modeling domain.

USGS land use data in the vicinity of the facility have been used to produce a gridded field of dominant land use categories. The land use data are obtained in Composite Theme Grid format (CTG) from the USGS, with a resolution of 200 m and are processed to produce a 4 km resolution gridded field of fractional land use categories.

The 38 USGS land use categories are mapped into 14 CALMET land use categories for CALPUFF modeling, and 12 MESOPUFF categories for MESOPUFF II modeling. Surface properties such as albedo, Bowen ratio, roughness length, and leaf area index are computed proportionally to the fractional land use for the CALPUFF modeling. The USGS land use categories are described in Table 2-2. Table 2-3 displays the 14 CALMET land use categories and their associated geophysical parameters. The mapping of the USGS categories to the corresponding MESOPUFF categories is indicated in Table 2-4. Figure 2-2 shows the terrain, dominant CALMET land use categories, and the hypothetical source location for the modeling domain.

2.3 Meteorological Data

The wind fields in the modeling domain are complex and highly variable. Depending on the location, some of the observational data will be representative of a small area. The local terrain has a strong influence on the local flow. Therefore, much of the structure in the wind fields is determined by CALMET using its diagnostic wind field module, rather than being driven by observations.

One of the sources of meteorological data used is output from the NCAR/PSU Mesoscale Model Version 4 (MM4). It is used to define the CALMET initial guess wind field. This data set consists of hourly values of wind speed, wind direction, temperature, and pressure on an 80 km grid that covers the continental United States, southern Canada, and northern Mexico. It was prepared by the U.S. EPA for use in modeling studies to supplement observational data in data sparse areas and to improve the time resolution of upper air data. The EPA MM4 dataset is available for most of the year 1990. This is the period selected for these simulations.

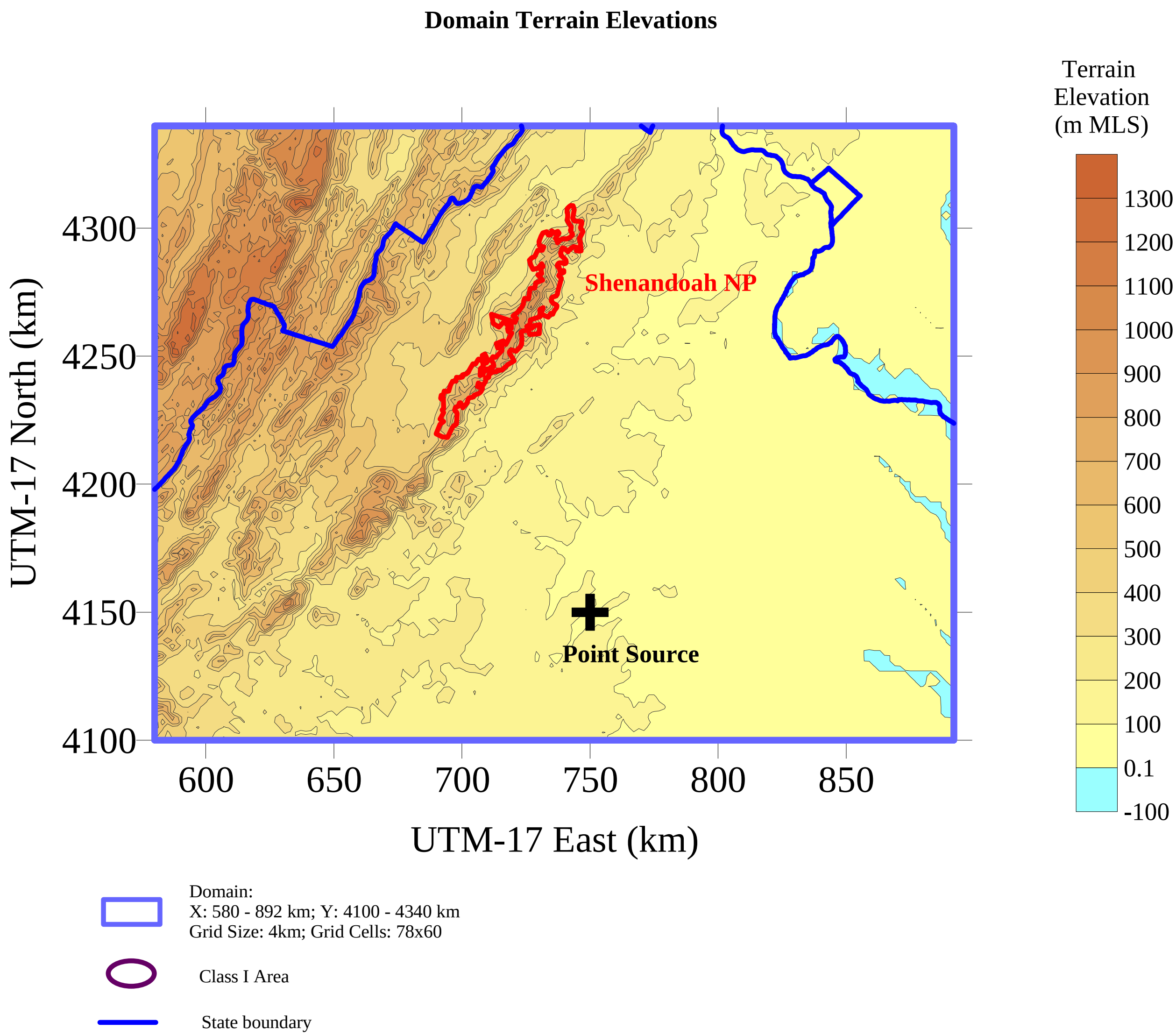

Figure 2-1. Terrain contours (m MSL) plotted with 4 km resolution for the 78 x 60 computational domain. The Class I area and the hypothetical facility site are also shown.

Table 2-2. U.S. Geological Survey Land Use and Land Cover Classification System

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

Table 2-3. Default CALMET Land Use Categories and Associated Geophysical Parameters Based on the U.S. Geological Survey Land Use Classification System (14-Category System)

Land Use Type	Description	Surface Roughness (m)	Albedo	Bowen Ratio	Soil Heat Flux Parameter	Anthropogenic Heat Flux (W/m^2)	Leaf Area Index
10	Urban or Built-up Land	1.0	0.18	1.5	.25	0.0	0.2
20	Agricultural Land – Unirrigated	0.25	0.15	1.0	.15	0.0	3.0
-20*	Agricultural Land - Irrigated	0.25	0.15	0.5	.15	0.0	3.0
30	Rangeland	0.05	0.25	1.0	.15	0.0	0.5
40	Forest Land	1.0	0.10	1.0	.15	0.0	7.0
50	Water	0.001	0.10	0.0	1.0	0.0	0.0
54	Small Water Body	0.001	0.10	0.0	1.0	0.0	0.0
55	Large Water Body	0.001	0.10	0.0	1.0	0.0	0.0
60	Wetland	1.0	0.10	0.5	.25	0.0	2.0
61	Forested Wetland	1.0	0.1	0.5	0.25	0.0	2.0
62	Nonforested Wetland	0.2	0.1	0.1	0.25	0.0	1.0
70	Barren Land	0.05	0.30	1.0	.15	0.0	0.05
80	Tundra	.20	0.30	0.5	.15	0.0	0.0
90	Perennial Snow or Ice	.05	0.70	0.5	.15	0.0	0.0

* Negative values indicate "irrigated" land use

Table 2-4. MESOPUFF II Land Use and Land Cover Classification System

MESOPUFF II		Mapped USGS Level II	
1	Cropland & Pasture	21	Cropland and Pasture
2	Crop, Woodland, & Grazing Land	23	Confined Feeding Operations
		24	Other Agricultural Land
3	Irrigated Crops	-21	Irrigated Cropland and Pasture
4	Grazed Forest & Woodlands	22	Orchards, Groves, Vineyards, Nurseries, and Ornamental Horticultural Areas
5	Ungrazed Forest & Woodland	41	Deciduous Forest Land
		42	Evergreen Forest Land
		43	Mixed Forest Land
6	Semi-arid Grazing	71	Dry Salt Flats
		72	Beaches
		73	Sandy Areas Other than Beaches
		74	Bare Exposed Rock
		75	Strip Mines, Quarries, and Gravel Pits
		77	Mixed Barren Land
		81	Shrub and Brush Tundra
		82	Herbaceous Tundra
		83	Bare Ground
		84	Wet Tundra
		85	Mixed Tundra
		91	Perennial Snowfields
		92	Glaciers
7	Open Woodland Grazed	31	Herbaceous Rangeland
		32	Shrub and Brush Rangeland
		33	Mixed Rangeland
8	Desert Shrubland	76	Transitional Areas
9	Swamp	62	Non-forested Wetland
10	Marshland	61	Forested Wetland
11	Metropolitan City	11	Residential
		12	Commercial and Services
		13	Industrial
		14	Transportation, Communications and Utilities
		15	Industrial and Commercial Complexes
		16	Mixed Urban or Built-up Land
		17	Other Urban or Built-up Land
12	Lake or Ocean	51	Streams and Canals
		52	Lakes
		53	Reservoirs
		54	Bays and Estuaries
		55	Oceans and Seas

Dominant Land Use Categories in Modeling Domain

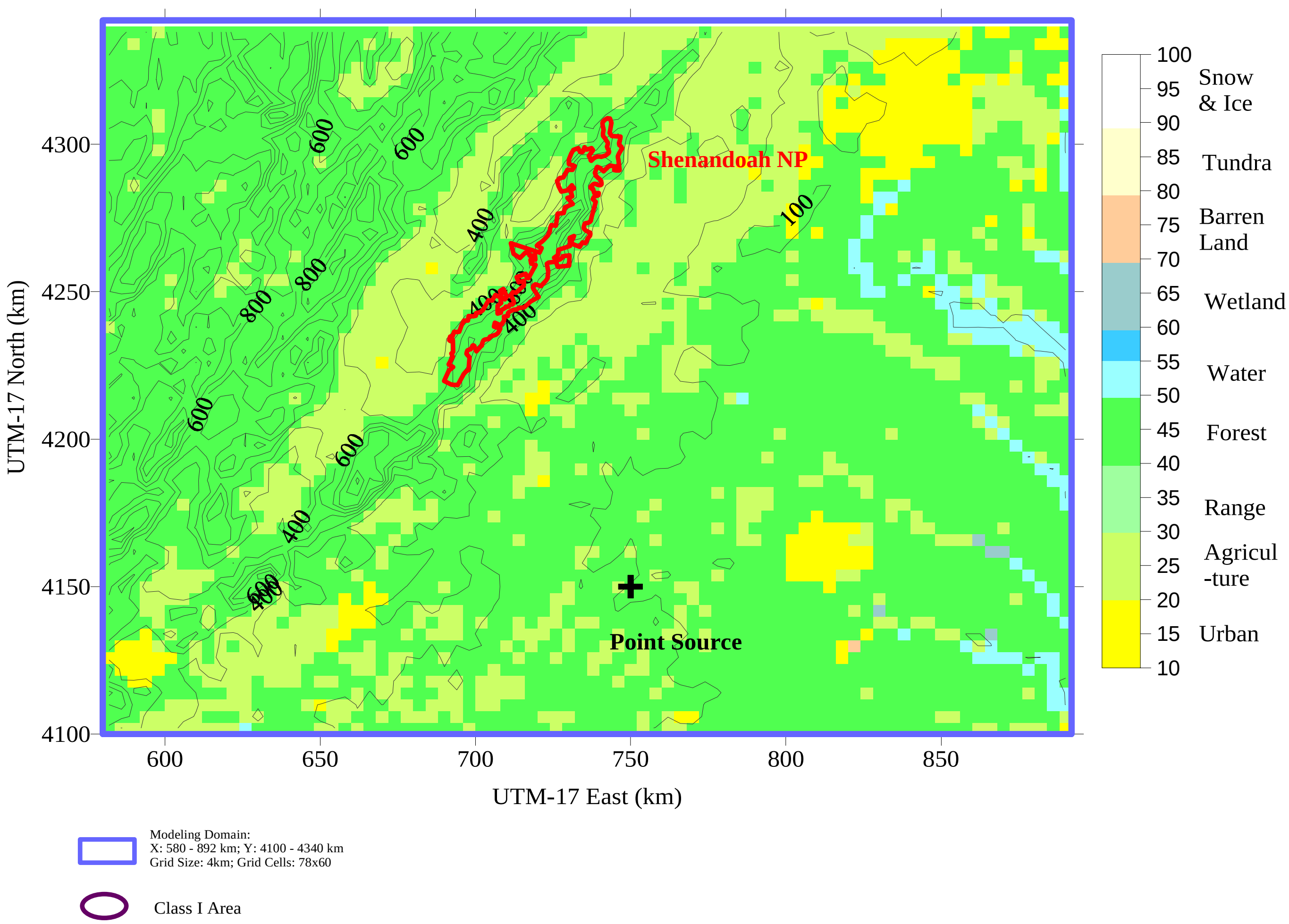

Figure 2-2. Dominant land use categories for 4 km resolution on the 78 x 60 computational domain. The Class I areas and the hypothetical facility are also shown.

In addition to the optional MM4 data, CALMET requires hourly surface observations of wind speed, wind direction, temperature, cloud cover, ceiling height, surface pressure, relative humidity, and precipitation type (e.g., snow, rain, etc.). These variables are routinely measured at National Weather Service (NWS) surface stations. The upper air data required include twice-daily observations of vertical profiles of wind speed, wind direction, temperature, and pressure. In addition, hourly precipitation measurements are required for wet deposition calculations in CALPUFF.

Table 2-5 is a list of the observational and modeled meteorological data available for the analysis. There are seven surface meteorological stations within or near the modeling domain (Table 2-6): Lynchburg, VA, Richmond, VA, Roanoke, VA, Quantico, VA, Raleigh-Durham, NC, Greensboro, NC, and Elkin, WV. The available upper air site on the southern side of the domain is the Greensboro, NC station. The upper air site on the northeastern side of the domain is the Sterling, VA station (Table 2-7). A total of 81 hourly precipitation stations are used in the modeling (Table 2-8). These data were available from NCDC in TD3240 format. Figure 2-3 shows the locations and spatial coverage of all of these stations.

3.4 Air Quality Monitoring Data

CALPUFF uses hourly ozone concentration measurements in the chemical transformation rates. Here, the ambient ozone measurements are used in determining SO_2 loss rates due to chemical transformation to sulfate. Ambient ozone monitoring data for 1990 from the U.S. EPA AIRS and CASTNET networks are used to develop the hourly ozone monitoring data file (OZONE.DAT) for the modeling analysis. The AIRS data covers the time period from April through October while the CASTNET dataset includes data for all 12 months. A total of 58 ozone monitoring stations, listed in Table 2-9, are used in the modeling (see Figure 2-4).

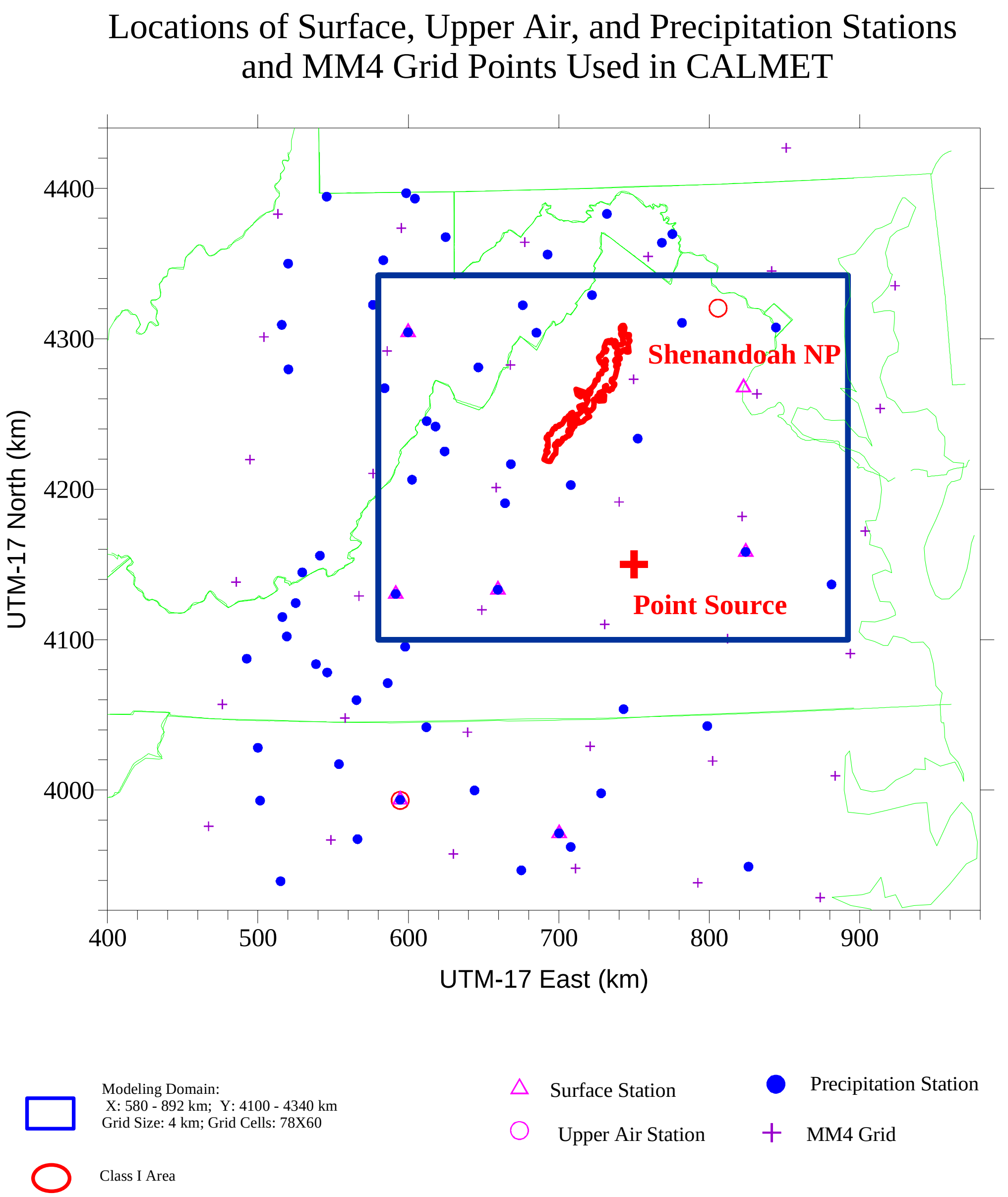

Figure 2-3. Locations of meteorological observation sites and MM4 grid points used in the CALMET modeling.

Ozone Stations Used in CALPUFF

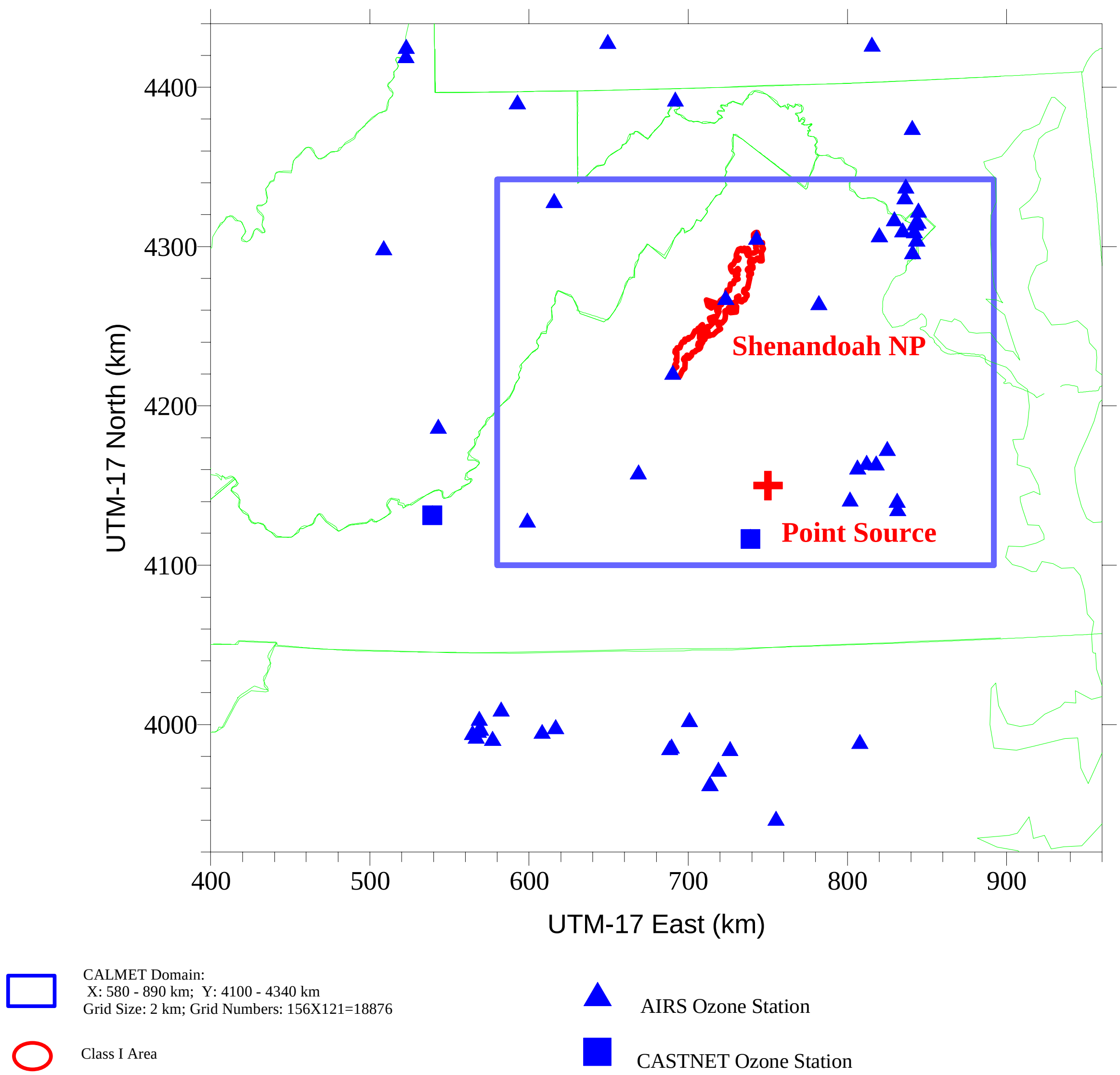

Figure 2-4. Locations of ozone monitoring stations.

Table 2-5. Meteorological Data Sources and Parameters Available

Type of Dataset	Frequency	Source	Parameters
Surface obs.	Hourly	NWS	Wind speed, wind direction, temperature, ceiling height, cloud cover, relative humidity, surface pressure, precipitation type
Upper Air	Twice-daily	NWS	Soundings of wind speed, wind direction, temperature, and pressure
Precipitation	Hourly	NWS	Hourly precipitation amounts
Modeled Profiles (MM4)	Hourly	US EPA CD-ROM	Hourly, gridded fields of winds, temperature, pressure, and humidity on an 80-km grid for the year 1990.

Table 2-6. NWS Hourly Surface Stations

#	Station Name	UTM-17 X (km)	UTM-17 Y (km)	Latitude (deg)	Longitude (deg)	WBAN#	Elevation (m)
1	Lynchburg Municipal Arp	659.466	4133.166	37.3333	79.2000	13733	94
2	Richmond R E Byrd Int'l	824.09	4158.306	37.5167	77.3333	13740	16.4
3	Roanoke Woodrum Arpt	591.562	4130.299	37.3167	79.9667	13741	114.9
4	Quantico Mcas	822.691	4267.578	38.5000	77.3000	13773	1.3
5	Raleigh-Durham	700.141	3971.229	35.8667	78.7833	13722	41.6
6	Greensboro-High Pt-Wins	594.539	3993.501	36.0833	79.9500	13723	89.7
7	Elkins-Randolph, WV	599.748	4304.251	38.8833	79.85	13729	194.8

Table 2-7. Upper Air Stations

#	Station Name	UTM-17 X (km)	UTM-17 Y (km)	Latitude (deg)	Longitude (deg)	WBAN#	Elevation (m)
1	Greensboro, NC	594.543	3993.131	36.0800	79.9500	13723	277
2	Sterling (Wash Dulles), VA	805.804	4320.279	38.9800	77.4700	93734	85

Table 2-8. Hourly NWS Precipitation Stations

#	Station Name	UTM-17 X (km)	UTM-17 Y (km)	Latitude (deg)	Longitude (deg)	Station ID	Elevation (m)
1	ALTAVISTA, VA	651.071	4107.114	37.1	79.3	166	155.4
2	BREMO BLUFF, VA	738.044	4175.757	37.7	78.3	993	68.6
3	CAMP PICKETT, VA	771.301	4102.718	37.0333	77.95	1322	100.6
4	CHATHAM, VA	642.713	4075.526	36.8167	79.4	1614	195.1
5	COVINGTON FILTER PLT, VA	588.039	4183.891	37.8	80	2044	374.9
6	CULPEPER RIVRSIDE CG, VA	766.541	4248.847	38.35	77.95	2159	79.2
7	DALE ENTERPRISE, VA	680.347	4257.562	38.45	78.9333	2208	426.7
8	FREDERICKSBURG 2, VA	809.002	4244.805	38.3	77.4667	3200	36.6
9	GALAX WATER PLANT, VA	507.449	4055.848	36.65	80.9167	3272	719.3
10	GATHRIGHT DAM, VA	592.254	4200.581	37.95	79.95	3310	539.5
11	HOT SPRINGS, VA	602.434	4206.252	38	79.8333	4128	681.5
12	HURLEY, VA	538.608	4083.664	36.9	80.5667	4180	301.8
13	INDIAN VALLEY, VA	743.012	4053.735	36.6	78.2833	4246	823
14	JOHN FLANNAGAN LAKE, VA	659.466	4133.166	37.3333	79.2	4410	445
15	JOHN H KERR DAM, VA	612.14	4245.222	38.35	79.7167	4414	76.2
16	LYNCHBURG MUNI AP, VA	664.234	4190.609	37.85	79.1333	5120	286.5
17	MILLGAP 2 NNW, VA	618.022	4241.606	38.3167	79.65	5595	767.8
18	MONTEBELLO FISH NURS, VA	707.948	4202.704	37.95	78.6333	5690	807.1
19	MUSTOE 1 SW, VA	586.258	4071.07	36.7833	80.0333	5880	725.3
20	NORFOLK INTL ARPT, VA	752.434	4233.581	38.2167	78.1167	6139	7.3
21	NORTH GARDEN, VA	519.263	4102.086	37.0667	80.7833	6178	209
22	PAINTER 2 W, VA	824.09	4158.306	37.5167	77.3333	6475	9.1
23	PHILPOTT DAM 2, VA	591.562	4130.299	37.3167	79.9667	6692	342.3
24	PIEDMONT RESEARCH ST, VA	597.879	4095.235	37	79.9	6712	158.5
25	PULASKI, VA	525.122	4124.289	37.2667	80.7167	6955	563.9
26	RICHMOND BYRD AP, VA	722.012	4328.952	39.0833	78.4333	7201	50
27	ROANOKE WOODRUM AP, VA	668.099	4216.59	38.0833	79.0833	7285	350.2
28	ROCKY MOUNT, VA	781.859	4310.495	38.9	77.75	7338	375.5
29	STAFFORDSVILLE 3 ENE, VA	856.072	4100.305	36.9833	77	8022	594.4
30	STAR TANNERY, VA	844.273	4307.406	38.85	77.0333	8046	289.6
31	STAUNTON SEWAGE PLAN, VA	516.274	4115.023	37.1833	80.8167	8062	423.4
32	THE PLAINS 2 NNE, VA	881.194	4136.626	37.3	76.7	8396	161.5
33	TROUT DALE 3 SSE, VA	624.103	4225.049	38.1667	79.5833	8547	859.5
34	WAKEFIELD 2, VA	546.062	4078.154	36.85	80.4833	8800	27.4
35	WALLOPS FLIGHT FAC, VA	565.522	4059.793	36.6833	80.2667	8849	10
36	WASHINGTN DC NATL AP, VA	492.578	4087.277	36.9333	81.0833	8906	3
37	WHITE GATE, VA	675.029	3946.652	35.65	79.0667	9060	563.9
38	WILLIAMSBURG 2 N, VA	643.971	3999.722	36.1333	79.4	9151	21.3
39	WILLIAMSVILLE 2 S, VA	553.873	4017.189	36.3	80.4	9159	499.9
40	WILLIS, VA	523.912	4028.147	36.4	80.7333	9169	883.9
41	WISE 2 E, VA	611.926	4041.781	36.5167	79.75	9215	776.9

Table 2-8. Hourly NWS Precipitation Stations (Cont'd)

#	Station Name	UTM-17 X (km)	UTM-17 Y (km)	Latitude (deg)	Longitude (deg)	Station ID	Elevation (m)
42	WOOLWINE 4 S, VA	728.063	3997.811	36.1	78.4667	9272	463.3
43	WYTHEVILLE 1 S, VA	594.539	3993.501	36.0833	79.95	9301	746.8
44	B EVERETT JORDAN DAM, NC	826.033	3949.054	35.6333	77.4	750	94.5
45	BURLINGTON 3 NNE, NC	566.222	3967.359	35.85	80.2667	1241	195.1
46	DALTON, NC	515.096	3939.397	35.6	80.8333	2230	307.8
47	DOBSON, NC	501.501	3992.991	36.0833	80.9833	2388	381
48	EDEN, NC	700.141	3971.229	35.8667	78.7833	2631	190.5
49	FRANKLINTON, NC	707.883	3962.158	35.7833	78.7	3232	114.3
50	GRNSBR,HGH PT,W-S AP, NC	798.64	4042.527	36.4833	77.6667	3630	273.4
51	GREENVILLE, NC	500	4028.114	36.4	81	3638	9.8
52	LEXINGTON, NC	775.976	3954.764	35.7	77.95	4970	231.6
53	MOORESVILLE 2 WNW, NC	543.491	3998.645	36.1333	80.5167	5814	265.2
54	N WILKESBORO 11 SE, NC	609.971	4296.987	38.8167	79.7333	6261	320
55	RALEIGH DURHAM AP, NC	567.848	4315.011	38.9833	80.2167	7069	126.7
56	RALEIGH STATE UNIV, NC	732.166	4375.537	39.5	78.3	7079	121.9
57	ROANOKE RAPIDS, NC	637.015	4323.31	39.05	79.4167	7319	64
58	ROARING GAP 1 NW, NC	556.075	4346.362	39.2667	80.35	7324	859.2
59	WILSON 3 SW, NC	604.337	4393.109	39.6833	79.7833	9476	33.5
60	YADKINVILLE 6 E, NC	599.748	4304.251	38.8833	79.85	9675	262.1
61	BEMIS, WV	646.453	4280.925	38.6667	79.3167	664	785.7
62	BUCKHANNON, WV	547.538	4331.509	39.1333	80.45	1220	443.5
63	CACAPON STATE PARK, WV	520.301	4279.606	38.6667	80.7667	1323	289.6
64	CANAAN VALLEY, WV	515.891	4309.187	38.9333	80.8167	1393	990.3
65	CLARKSBURG 1, WV	731.944	4382.937	39.5667	78.3	1677	301.8
66	COOPERS ROCK ST FOR, WV	576.438	4322.488	39.05	80.1167	1900	694.6
67	ELKINS RNDLPH CO AP, WV	545.725	4394.388	39.7	80.4667	2718	593.8
68	FRANKLIN 2 NE, WV	768.449	4363.743	39.3833	77.8833	3215	579.1
69	FREEMANSBURG 5 NE, WV	598.572	4396.733	39.7167	79.85	3238	310.9
70	GASSAWAY, WV	529.484	4144.643	37.45	80.6667	3361	256
71	GLENVILLE 1 ENE, WV	502.892	4299.924	38.85	80.9667	3544	219.5
72	GREAT CACAPON, WV	580.246	4230.046	38.2167	80.0833	3669	825.1
73	HALL 1 WSW, WV	685.089	4303.936	38.8667	78.8667	3820	512.1
74	HUNDRED, WV	676	4322.234	39.0333	78.9667	4369	304.8
75	KEARNEYSVILLE, WV	692.492	4355.938	39.3333	78.7667	4763	167.6
76	LAKE LYNN, WV	775.43	4369.545	39.4333	77.8	5002	274.3
77	LINDSIDE, WV	624.764	4367.51	39.45	79.55	5284	609.6
78	LOCKNEY, WV	583.335	4352.155	39.3167	80.0333	5341	219.5
79	MARLINTON, WV	541.224	4155.786	37.55	80.5333	5672	655.3
80	MATHIAS, WV	584.237	4267.078	38.55	80.0333	5739	495.3
81	MOOREFIELD 2 SSE, WV	520.121	4349.886	39.3	80.7667	6163	253

Table 2-9. Ozone Stations

#	Station Name	UTM-17 (km)	UTM-17 (km)	Latitude (deg)	Longitude (deg)	Station ID
1	NOT IN A CITY	508.682	4297.71	38.83	-80.9	540218001
2	MOUNDSVILLE	522.695	4418.24	39.916	-80.734	540511002
3	SHADYSIDE	522.775	4424.067	39.968	-80.733	390133002
4	BLACKSBURG	539.199	4131.493	37.331	-80.558	511218001
5	NOT IN A CITY	542.908	4185.689	37.819	-80.512	540250001
6	WINSTON-SALEM	564.521	3993.537	36.086	-80.283	370670019
7	WINSTON-SALEM	566.792	3991.304	36.066	-80.258	370670023
8	WINSTON-SALEM	568.039	3994.858	36.098	-80.244	370670018
9	NOT IN A CITY	568.63	4002.38	36.166	-80.237	370670007
10	WINSTON-SALEM	569.601	3996.288	36.111	-80.227	370670022
11	NOT IN A CITY	577.111	3989.726	36.051	-80.144	370671008
12	NOT IN A CITY	582.393	4008.138	36.216	-80.083	370670006
13	MORGANTOWN	592.588	4389.229	39.65	-79.921	540610003
14	VINTON	598.912	4126.931	37.286	-79.884	511611004
15	GREENSBORO	608.237	3994.153	36.088	-79.798	370811011
16	NOT IN A CITY	616.604	3997.065	36.113	-79.704	370810011
17	NOT IN A CITY	615.699	4327.377	39.09	-79.662	540938001
18	NOT IN A CITY	649.426	4427.164	39.983	-79.25	421118001
19	NOT IN A CITY	668.679	4157.12	37.548	-79.091	510090006
20	DURHAM	688.322	3983.917	35.983	-78.911	370630010
21	DURHAM	689.425	3985.02	35.993	-78.899	370630008
22	NOT IN A CITY	690.211	4219.575	38.106	-78.831	510150004
23	NOT IN A CITY	700.724	4001.674	36.141	-78.769	370770001
24	CUMBERLAND	691.954	4391.064	39.65	-78.763	240010006
25	RALEIGH	713.474	3961.49	35.776	-78.638	371830011
26	RALEIGH	713.729	3961.434	35.776	-78.636	371830010
27	RALEIGH	718.932	3970.504	35.856	-78.576	371830014
28	WAKE FOREST	726.253	3983.425	35.971	-78.491	371832001
29	NOT IN A CITY	723.522	4266.637	38.522	-78.436	511130003
30	NOT IN A CITY	723.52	4266.699	38.522	-78.436	511138001
31	NOT IN A CITY	739.026	4116.582	37.167	-78.308	511478001
32	NOT IN A CITY	742.898	4304.449	38.857	-78.201	511870002
33	NOT IN A CITY	755.045	3939.672	35.57	-78.186	371010099
34	NOT IN A CITY	781.98	4263.264	38.475	-77.768	510610002
35	NOT IN A CITY	801.711	4139.929	37.359	-77.594	510410004
36	NOT IN A CITY	807.741	3987.906	35.989	-77.587	370650099
37	RICHMOND	806.364	4160.165	37.539	-77.533	517600022
38	RICHMOND	812.034	4163.001	37.563	-77.468	517600021
39	NOT IN A CITY	817.992	4162.703	37.558	-77.4	510870014

Table 2-9. Ozone Stations (Cont'd)

#	Station Name	UTM-17 (km)	UTM-17 (km)	Latitude (deg)	Longitude (deg)	Station ID
40	NOT IN A CITY	825.058	4171.808	37.638	-77.316	510850001
41	FAIRFAX	820.108	4305.805	38.845	-77.312	516000005
42	NOT IN A CITY	815.472	4425.504	39.923	-77.309	420018001
43	NOT IN A CITY	831.271	4139.165	37.342	-77.261	510360002
44	HOPEWELL	831.557	4133.865	37.294	-77.26	516700007
45	MC LEAN	829.518	4315.891	38.932	-77.199	510595001
46	SEVEN CORNERS	834.663	4309.002	38.868	-77.143	510591004
47	ROCKVILLE	836.097	4329.67	39.053	-77.116	240311008
48	ROCKVILLE	836.625	4336.489	39.114	-77.107	240313001
49	NOT IN A CITY	840.951	4295.305	38.743	-77.077	510590018
50	ALEXANDRIA	842.01	4308.358	38.859	-77.059	515100009
51	WASHINGTON, D. C.	842.424	4313.289	38.904	-77.052	110010017
52	WASHINGTON, D. C.	842.88	4313.34	38.904	-77.046	110010023
53	NOT IN A CITY	843.532	4303.234	38.813	-77.044	510130020
54	NOT IN A CITY	840.666	4373.343	39.444	-77.042	240130001
55	WASHINGTON, D. C.	844.349	4314.486	38.914	-77.029	110010019
56	WASHINGTON, D. C.	844.582	4321.354	38.975	-77.023	110010025
57	Horton, CASTNET	539.132	4131.369	37.33	-80.557	VPI120
58	Prince Edward, CASTNET	739.14	4116.458	37.166	-78.307	PED108

3. AIR QUALITY MODELING METHODOLOGY

3.1 Meteorological Modeling Options

CALMET is run twice, producing the "CALMET.DAT" file for use with CALPUFF, and also producing the "PACOUT.DAT" file used with MESOPUFF II. The same configuration is used in both, but each uses the appropriate "GEO.DAT" file. That for CALPUFF has the 14-class CALMET land use scheme while that for MESOPUFF II has the 12-class MESOPUFF land use scheme.

The horizontal grid is uniform, and resolves terrain and land use with a resolution of 4 km. In the vertical, a stretched grid resolves the mixed layer with a fine resolution and uses a somewhat coarser resolution aloft. Ten vertical levels are centered at: 10, 30, 60, 120, 230, 450, 800, 1250, 1850, and 2600 meters. The full three-dimensional gridded field of winds and temperatures from CALMET are used directly in CALPUFF. For MESOPUFF II, the output format is equivalent to the MESOPAC.output The horizontal grid is the same, but the vertical structure is captured in two layers. CALMET winds are averaged within the surface boundary layer, and above, and the resulting fields are written in the MESOPAC format.

Initial Guess Field

The EPA MM4 data base is used to define the initial guess field for the CALMET simulations. Hourly MM4 data are available for the period January 6 through December 29, 1990. The MM4 dataset has a horizontal resolution of 80 km at hourly intervals. In the vertical, 20 levels of data are provided.

Step 1 Field: Terrain Effects

In developing the Step 1 wind field, CALMET adjusts the initial guess field to reflect kinematic effects of the terrain, slope flows and blocking effects. Slope flows are a function of the local slope and altitude of the nearest crest. The crest is defined as the highest peak within a radius TERRAD around each grid point. The value of TERRAD selected (12 km) was determined based on an analysis of the scale of the terrain. The Step 1 field produces a flow field consistent with the fine-scale CALMET terrain resolution (4km).

Step 2 Field: Objective Analysis

In Step 2, observations are incorporated into the Step 1 wind field to produce a final wind field. Each observation site influences the final wind field within a radius of influence (parameters RMAX1 at the surface and RMAX2 aloft). Observations and Step 1 field are weighted by means of parameters R1 at the surface and R2 aloft: at a distance R1 from an observation site, the Step 1 wind field and the surface observations are weighted equally. In complex terrain, channeling (blocking effects) and slope flows contribute significantly to the wind field. Therefore, relatively small values of R1 and R2 were selected (1 km and 2 km, respectively) to produce a large weight of the Step 1 field.

RMAX1 and RMAX2 are set to large values (100 km). However, the large RMAX values become irrelevant as the small R1 and R2 values limit the influence of the surface observations.

3.2 CALPUFF Dispersion Modeling Options

The CALPUFF simulations are conducted using the following model options:

- Gaussian near-field distribution
- Transitional plume rise
- Stack tip downwash
- PG dispersion coefficients (rural areas), McElroy-Pooler coefficients (urban areas)
- Transition of σ_y to time-dependent (Heffter) growth rates
- Partial plume path adjustment for terrain
- Wet deposition, dry deposition, and chemical transformation algorithms

A second simulation is done without deposition and chemical transformation, and without the terrain adjustment. This configuration, although not recommended for most CALPUFF applications, is similar to the MESOPUFF II configuration and therefore provides a useful comparison for this analysis.

The CALPUFF modeling domain includes a buffer zone south and east of the source area and north and west beyond the borders of the Class I area. This minimizes edge effects and allows pollutants involved in flow reversals to be brought back into the Class I area.

The partial plume path adjustment option is used in CALPUFF for this analysis (MCTADJ=3). The CALMET wind field incorporates the effect of the terrain on the plume trajectories. The plume path coefficient is used to characterize the local effect on ground-level concentrations. The default plume path coefficients (PPC) are listed below:

Stability Class	A	B	C	D	E	F
PPC	0.5	0.5	0.5	0.5	0.35	0.35

Deposition and chemical transformation effects are modeled using the default dry deposition model, the scavenging coefficient wet removal module, and the default chemical transformation mechanism. Two species are modeled with CALPUFF for this analysis: SO_2 and SO_4. SO_2 is emitted and the chemical mechanism computes transformation rates of SO_2 to SO_4. Hourly measured ozone concentrations are provided in an external OZONE.DAT file for use with the chemical transformation module. These ozone concentrations, along with radiation intensity, are used as surrogates for the OH concentration during the day when the gas phase free radical chemistry is active.

Discrete receptors are placed within Shenandoah National Park at a spacing of approximately 1 km, as depicted in Figure 3-1.

3.2 MESOPUFF II Dispersion Modeling Options

The MESOPUFF II simulations are conducted using the following model options:

- Gaussian near-field distribution
- 8 puffs/hour release rate
- Variable sampling rate
- Minimum age before sampling = 300 s
- Default dispersion parameters (similar to PG coefficients)
- NO wet or dry deposition, and NO chemical transformations

Discrete receptors are placed within Shenandoah National Park at a spacing of approximately 1 km. These locations are identical to those used in CALPUFF, but are translated to the MESOPUFF grid coordinate system.

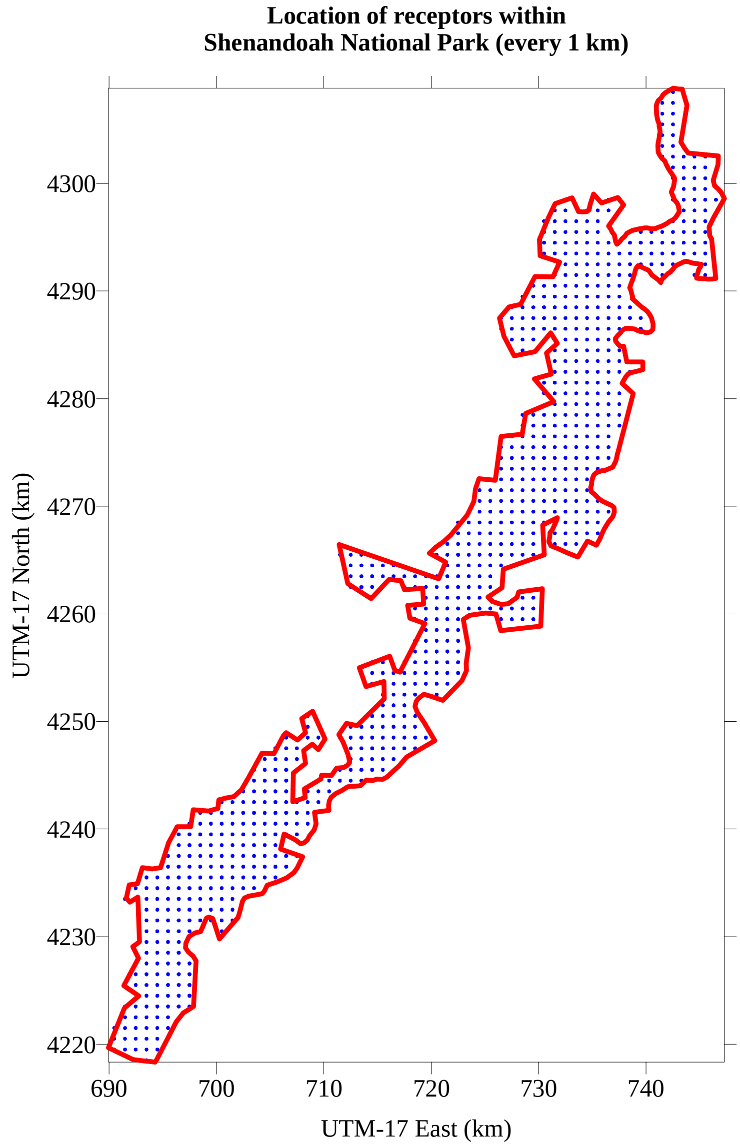

Figure 3-1. Location of discrete receptors within Shenandoah National Park. The spacing is every 1 kilometer.

4. RESULTS

Results of the CALMET/CALPUFF and the CALMET/MESOPUFF II (with the MESOPAC output option in CALMET) simulations of the impact of a hypothetical source of SO_2 on concentrations in the Shenandoah National Park Class I area are presented in Table 4-1. SO_2 concentrations are listed for averaging times of 1 hour, 3 hours, 24 hours, and annual (nearly a full year). Both the peak concentration and the highest second-highest concentrations are listed for each averaging time.

When the CALPUFF simulation is made without chemical transformation and without a terrain adjustment, its results are very similar to the MESOPUFF II results. This illustrates the degree of similarity in the approaches of the two models. Wind fields provided each are from the same source (CALMET), but they are not the same due to the way the two systems represent the vertical structure of the atmosphere. Nonetheless, the concentrations of regulatory significance are similar.

Significantly different results are obtained when CALPUFF is applied with the preferred modeling options, including chemical transformation, deposition, and terrain adjustment. The larger concentrations for this simulation appear to result from peak impact episodes in which the vertical distribution of SO_2 is not well-mixed, and remains aloft at the travel distance to the Class I area. For this situation, the high terrain of this application will promote an adjustment that leads to the larger ground-level concentrations.

Table 4-1. Highest and Highest Second-Highest SO_2 Concentrations Simulated in the Shenandoah National Park.

Averaging Period	Type of Peak	MESOPUFF II (μg/m³)	CALPUFF (no terrain, no transformation, no removal) (μg/m³)	CALPUFF (μg/m³)
1 hour	H	120.2	119.5	264.2
	HSH	91.9	90.9	228.5
3 hours	H	69.2	72.0	188.6
	HSH	63.9	57.5	109.4
24 hours	H	21.8	18.5	47.8
	HSH	20.8	17.4	41.9
Annual	H	0.48	0.60	0.76

5. REFERENCES

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U.S. Environmental Protection Agency (EPA), 1992. A modeling protocol for applying MESOPUFF II to long range transport problems. EPA-454/R-92-021, U.S. Environmental Protection Agency, Research Triangle Park, NC.

U.S. Environmental Protection Agency (EPA), 1998: Interagency Workgroup on Air Quality Modeling (IWAQM), Phase 2 Report: Summary Report and Recommendation for Modeling Long Range Transport and Impacts on Regional Visibility. EPA-454/R-98-019.

U.S. Environmental Protection Agency (EPA), 2000: Federal Register Notice of Proposed Rulemaking (65 FR 21506), April 21, 2000.

APPENDIX A

CALMET INPUT CONTROL FILE

```
CALMET/CALPUFF Consequence Example, 78 x 60 grid cells @ 4 km grid
Class I Area: Shenandoah National Park           --- ZIMAX=2695m
January 6, 1990 - January 31, 1990
--------------- Run title (3 lines) -----------------------------------------

                    CALMET MODEL CONTROL FILE
                    --------------------------

-------------------------------------------------------------------------------

INPUT GROUP: 0 -- Input and Output File Names


Subgroup (a)
------------
Default Name  Type          File Name
------------  ----          ---------
GEO.DAT       input    ! GEODAT=..\GEO.DAT       !
SURF.DAT      input    ! SRFDAT=..\SURF.DAT      !
CLOUD.DAT     input    * CLDDAT=            *
PRECIP.DAT    input    ! PRCDAT=..\PRECIP.DAT    !
MM4.DAT       input    ! MM4DAT=..\MM4.DAT     !
WT.DAT        input    * WTDAT=             *

CALMET.LST    output   ! METLST=jan.LST     !
CALMET.DAT    output   ! METDAT=jan.DAT    !
PACOUT.DAT    output   * PACDAT=            *

All file names will be converted to lower case if LCFILES = T
Otherwise, if LCFILES = F, file names will be converted to UPPER CASE
         T = lower case      ! LCFILES = T !
         F = UPPER CASE

NUMBER OF UPPER AIR & OVERWATER STATIONS:

    Number of upper air stations (NUSTA)  No default     ! NUSTA =  2  !
    Number of overwater met stations
                                 (NOWSTA) No default     ! NOWSTA =  0  !

                       !END!
--------------------------------------------------------------------------------
Subgroup (b)
---------------------------------
Upper air files (one per station)
---------------------------------
Default Name  Type       File Name
------------  ----       ---------
UP1.DAT       input     1  ! UPDAT=..\UPGSO.DAT!    !END!
UP2.DAT       input     2  ! UPDAT=..\UPIAD.DAT!    !END!
--------------------------------------------------------------------------------
Subgroup (c)
-----------------------------------------
Overwater station files (one per station)
-----------------------------------------
Default Name  Type       File Name
```

```
------------  ----       ---------
--------------------------------------------------------------------------------
Subgroup (d)
----------------
Other file names
----------------

Default Name  Type       File Name
------------  ----       ---------
DIAG.DAT      input      * DIADAT=                  *
PROG.DAT      input      * PRGDAT=                  *

TEST.PRT      output     * TSTPRT=                  *
TEST.OUT      output     * TSTOUT=                  *
TEST.KIN      output     * TSTKIN=                  *
TEST.FRD      output     * TSTFRD=                  *
TEST.SLP      output     * TSTSLP=                  *

--------------------------------------------------------------------------------
NOTES: (1) File/path names can be up to 70 characters in length
       (2) Subgroups (a) and (d) must have ONE 'END' (surround by
           delimiters) at the end of the group
       (3) Subgroups (b) and (c) must have an 'END' (surround by
           delimiters) at the end of EACH LINE

                         !END!


-------------------------------------------------------------------------------

INPUT GROUP: 1 -- General run control parameters
--------------

     Starting date:   Year (IBYR) -- No default       ! IBYR=  1990  !
                     Month (IBMO) -- No default       ! IBMO=  1  !
                       Day (IBDY) -- No default       ! IBDY=  6  !
                      Hour (IBHR) -- No default       ! IBHR=  0  !

     Base time zone        (IBTZ) -- No default       ! IBTZ=  5  !
        PST = 08, MST = 07
        CST = 06, EST = 05

     Length of run (hours) (IRLG) -- No default       ! IRLG=  624  !

     Run type            (IRTYPE) -- Default: 1       ! IRTYPE=  1  !

        0 = Computes wind fields only
        1 = Computes wind fields and micrometeorological variables
            (u*, w*, L, zi, etc.)
        (IRTYPE must be 1 to run CALPUFF or CALGRID)

     Compute special data fields required
     by CALGRID (i.e., 3-D fields of W wind
     components and temperature)
     in additional to regular            Default: T    ! LCALGRD = T !
     fields ? (LCALGRD)
     (LCALGRD must be T to run CALGRID)

      Flag to stop run after
      SETUP phase (ITEST)             Default: 2       ! ITEST=  2   !
      (Used to allow checking
      of the model inputs, files, etc.)
      ITEST = 1 - STOPS program after SETUP phase
      ITEST = 2 - Continues with execution of
                  COMPUTATIONAL phase after SETUP
```

```
!END!

--------------------------------------------------------------------------------

INPUT GROUP: 2 -- Grid control parameters
--------------

     HORIZONTAL GRID DEFINITION:

            No. X grid cells (NX)      No default     ! NX =   78  !
            No. Y grid cells (NY)      No default     ! NY =   60  !

     GRID SPACING (DGRIDKM)            No default     ! DGRIDKM = 4. !
                                       Units: km

     REFERENCE COORDINATES
     of SOUTHWEST corner of grid cell (1,1)

        X coordinate (XORIGKM)         No default     ! XORIGKM = 580.000 !
        Y coordinate (YORIGKM)         No default     ! YORIGKM = 4100.000 !
                                       Units: km
        Latitude  (XLAT0)              No default     ! XLAT0 = 37.044 !
        Longitude (XLON0)              No default     ! XLON0 = 80.100 !

     UTM ZONE (IUTMZN)                 Default: 0     ! IUTMZN =  17  !

     LAMBERT CONFORMAL PARAMETERS

     Rotate input winds from true north to
     map north using a Lambert conformal
     projection? (LLCONF)              Default: F     ! LLCONF = F !

     Latitude of 1st standard parallel   Default: 30.   ! XLAT1 = 30.000 !
     Latitude of 2nd standard parallel   Default: 60.   ! XLAT2 = 60.000 !
     (XLAT1 and XLAT2; + in NH, - in SH)

        Longitude (RLON0)                Default = 90.  ! RLON0 = 90.000 !
        (used only if LLCONF = T)
        (Positive = W. Hemisphere;
         Negative = E. Hemisphere)
        Origin Latitude (RLAT0)          Default = 40.  ! RLAT0 = 40.000 !
        (used only if IPROG > 2)
        (Positive = N. Hemisphere;
         Negative = S. Hemisphere)

     Vertical grid definition:

        No. of vertical layers (NZ)    No default     ! NZ =  10  !

        Cell face heights in arbitrary
        vertical grid (ZFACE(NZ+1))    No defaults
                                       Units: m
        ! ZFACE = 0.,20.,40.,80.,160.,300.,600.,1000.,1500.,2200.,3000. !

!END!


--------------------------------------------------------------------------------

INPUT GROUP: 3 -- Output Options
--------------


    DISK OUTPUT OPTION

       Save met. fields in an unformatted
```

```
   output file ?              (LSAVE)  Default: T     ! LSAVE = T !
   (F = Do not save, T = Save)

   Type of unformatted output file:
   (IFORMO)                            Default: 1    ! IFORMO =  1  !

        1 = CALPUFF/CALGRID type file (CALMET.DAT)
        2 = MESOPUFF-II type file     (PACOUT.DAT)


LINE PRINTER OUTPUT OPTIONS:

   Print met. fields ?  (LPRINT)       Default: F     ! LPRINT = F !
   (F = Do not print, T = Print)
   (NOTE: parameters below control which
          met. variables are printed)

   Print interval
   (IPRINF) in hours                   Default: 1     ! IPRINF =  1  !
   (Meteorological fields are printed
    every  1  hours)


   Specify which layers of U, V wind component
   to print (IUVOUT(NZ)) -- NOTE: NZ values must be entered
   (0=Do not print, 1=Print)
   (used only if LPRINT=T)        Defaults: NZ*0
   ! IUVOUT =  0 ,  0 ,  0 ,  0 ,  0 ,  0 ,  0 ,  0 ,  0 ,  0  !
   -----------------------


   Specify which levels of the W wind component to print
   (NOTE: W defined at TOP cell face --  10  values)
   (IWOUT(NZ)) -- NOTE: NZ values must be entered
   (0=Do not print, 1=Print)
   (used only if LPRINT=T & LCALGRD=T)
   -----------------------------------
                                        Defaults: NZ*0
    ! IWOUT =  0 ,  0 ,  0 ,  0 ,  0 ,  0 ,  0 ,  0 ,  0 ,  0  !


   Specify which levels of the 3-D temperature field to print
   (ITOUT(NZ)) -- NOTE: NZ values must be entered
   (0=Do not print, 1=Print)
   (used only if LPRINT=T & LCALGRD=T)
   -----------------------------------
                                        Defaults: NZ*0
    ! ITOUT =  0 ,  0 ,  0 ,  0 ,  0 ,  0 ,  0 ,  0 ,  0 ,  0  !

   Specify which meteorological fields
   to print
   (used only if LPRINT=T)             Defaults: 0 (all variables)
   -----------------------


     Variable            Print ?
                     (0 = do not print,
                      1 = print)
     --------        ------------------

  !  STABILITY  =           0           ! - PGT stability class
  !  USTAR      =           0           ! - Friction velocity
  !  MONIN      =           0           ! - Monin-Obukhov length
  !  MIXHT      =           0           ! - Mixing height
  !  WSTAR      =           0           ! - Convective velocity scale
  !  PRECIP     =           0           ! - Precipitation rate
```

```
! SENSHEAT   =          0           ! - Sensible heat flux
! CONVZI     =          0           ! - Convective mixing ht.


 Testing and debug print options for micrometeorological module

    Print input meteorological data and
    internal variables (LDB)         Default: F       ! LDB = F !
    (F = Do not print, T = print)
    (NOTE: this option produces large amounts of output)

    First time step for which debug data
    are printed (NN1)                Default: 1       ! NN1 =  1  !

    Last time step for which debug data
    are printed (NN2)                Default: 1       ! NN2 =  24  !


 Testing and debug print options for wind field module
 (all of the following print options control output to
  wind field module's output files: TEST.PRT, TEST.OUT,
  TEST.KIN, TEST.FRD, and TEST.SLP)

    Control variable for writing the test/debug
    wind fields to disk files (IOUTD)
    (0=Do not write, 1=write)        Default: 0       ! IOUTD =  0  !

    Number of levels, starting at the surface,
    to print (NZPRN2)                Default: 1       ! NZPRN2 =  0  !

    Print the INTERPOLATED wind components ?
    (IPR0) (0=no, 1=yes)             Default: 0       !  IPR0 =  0  !

    Print the TERRAIN ADJUSTED surface wind
    components ?
    (IPR1) (0=no, 1=yes)             Default: 0       !  IPR1 =  0  !

    Print the SMOOTHED wind components and
    the INITIAL DIVERGENCE fields ?
    (IPR2) (0=no, 1=yes)             Default: 0       !  IPR2 =  0  !

    Print the FINAL wind speed and direction
    fields ?
    (IPR3) (0=no, 1=yes)             Default: 0       !  IPR3 =  0  !

    Print the FINAL DIVERGENCE fields ?
    (IPR4) (0=no, 1=yes)             Default: 0       !  IPR4 =  0  !

    Print the winds after KINEMATIC effects
    are added ?
    (IPR5) (0=no, 1=yes)             Default: 0       !  IPR5 =  0  !

    Print the winds after the FROUDE NUMBER
    adjustment is made ?
    (IPR6) (0=no, 1=yes)             Default: 0       !  IPR6 =  0  !

    Print the winds after SLOPE FLOWS
    are added ?
    (IPR7) (0=no, 1=yes)             Default: 0       !  IPR7 =  0  !

    Print the FINAL wind field components ?
    (IPR8) (0=no, 1=yes)             Default: 0       !  IPR8 =  0  !

!END!
```

```
--------------------------------------------------------------------------------

INPUT GROUP: 4 -- Meteorological data options
--------------


    NUMBER OF SURFACE & PRECIP. METEOROLOGICAL STATIONS

       Number of surface stations   (NSSTA)  No default     ! NSSTA =  7  !
       Number of precipitation stations
                                    (NPSTA)  No default     ! NPSTA =  59  !

    CLOUD DATA OPTIONS
       Griddid cloud fields:
                                   (ICLOUD)  Default: 0     ! ICLOUD =  0  !
       ICLOUD = 0 - Gridded clouds not used
       ICLOUD = 1 - Gridded CLOUD.DAT generated as OUTPUT
       ICLOUD = 2 - Gridded CLOUD.DAT read as INPUT

    FILE FORMATS

       Surface meteorological data file format
                                   (IFORMS)  Default: 2     ! IFORMS =  2  !
       (1 = unformatted (e.g., SMERGE output))
       (2 = formatted   (free-formatted user input))

       Precipitation data file format
                                   (IFORMP)  Default: 2     ! IFORMP =  2  !
       (1 = unformatted (e.g., PMERGE output))
       (2 = formatted   (free-formatted user input))

       Cloud data file format
                                   (IFORMC)  Default: 2     ! IFORMC =  2  !
       (1 = unformatted - CALMET unformatted output)
       (2 = formatted   - free-formatted CALMET output or user input)

!END!


--------------------------------------------------------------------------------

INPUT GROUP: 5 -- Wind Field Options and Parameters
--------------


    WIND FIELD MODEL OPTIONS
       Model selection variable (IWFCOD)     Default: 1      ! IWFCOD =  1  !
          0 = Objective analysis only
          1 = Diagnostic wind module

       Compute Froude number adjustment
       effects ? (IFRADJ)                    Default: 1      ! IFRADJ =  1  !
       (0 = NO, 1 = YES)

       Compute kinematic effects ? (IKINE)   Default: 0      ! IKINE  =  0  !
       (0 = NO, 1 = YES)

       Use O'Brien procedure for adjustment
       of the vertical velocity ? (IOBR)     Default: 0      ! IOBR =  0  !
       (0 = NO, 1 = YES)

       Compute slope flow effects ? (ISLOPE) Default: 1      ! ISLOPE  =  1  !
       (0 = NO, 1 = YES)

       Extrapolate surface wind observations
       to upper layers ? (IEXTRP)            Default: -4     ! IEXTRP = -4  !
```

```
(1 = no extrapolation is done,
 2 = power law extrapolation used,
 3 = user input multiplicative factors
     for layers 2 - NZ used (see FEXTRP array)
 4 = similarity theory used
 -1, -2, -3, -4 = same as above except layer 1 data
     at upper air stations are ignored

Extrapolate surface winds even
if calm? (ICALM)                     Default: 0      ! ICALM  =  0  !
(0 = NO, 1 = YES)

Layer-dependent biases modifying the weights of
surface and upper air stations (BIAS(NZ))
  -1<=BIAS<=1
Negative BIAS reduces the weight of upper air stations
  (e.g. BIAS=-0.1 reduces the weight of upper air stations
by 10%; BIAS= -1, reduces their weight by 100 %)
Positive BIAS reduces the weight of surface stations
  (e.g. BIAS= 0.2 reduces the weight of surface stations
by 20%; BIAS=1 reduces their weight by 100%)
Zero BIAS leaves weights unchanged (1/R**2 interpolation)
Default: NZ*0
                       ! BIAS =  0 ,  0 ,  0 ,  0 ,  0 ,  0 ,  0 ,  0 ,  0 ,  0  !

Minimum distance from nearest upper air station
to surface station for which extrapolation
of surface winds at surface station will be allowed
(RMIN2: Set to -1 for IEXTRP = 4 or other situations
 where all surface stations should be extrapolated)
                                      Default: 4.    ! RMIN2 = -1.0 !

Use gridded prognostic wind field model
output fields as input to the diagnostic
wind field model (IPROG)             Default: 0      ! IPROG =  4  !
(0 = No, [IWFCOD = 0 or 1]
 1 = Yes, use CSUMM prog. winds as Step 1 field, [IWFCOD = 0]
 2 = Yes, use CSUMM prog. winds as initial guess field [IWFCOD = 1]
 3 = Yes, use winds from MM4.DAT file as Step 1 field [IWFCOD = 0]
 4 = Yes, use winds from MM4.DAT file as initial guess field [IWFCOD = 1]
 5 = Yes, use winds from MM4.DAT file as observations [IWFCOD = 1]
 13 = Yes, use winds from MM5.DAT file as Step 1 field [IWFCOD = 0]
 14 = Yes, use winds from MM5.DAT file as initial guess field [IWFCOD = 1]
 15 = Yes, use winds from MM5.DAT file as observations [IWFCOD = 1]

RADIUS OF INFLUENCE PARAMETERS

Use varying radius of influence      Default: F      ! LVARY =  F!
(if no stations are found within RMAX1,RMAX2,
 or RMAX3, then the closest station will be used)

Maximum radius of influence over land
in the surface layer (RMAX1)         No default      ! RMAX1 = 100. !
                                     Units: km
Maximum radius of influence over land
aloft (RMAX2)                        No default      ! RMAX2 = 100. !
                                     Units: km
Maximum radius of influence over water
(RMAX3)                              No default      ! RMAX3 = 100. !
                                     Units: km


OTHER WIND FIELD INPUT PARAMETERS

Minimum radius of influence used in
the wind field interpolation (RMIN)  Default: 0.1    ! RMIN = 0.1 !
```

```
                                      Units: km
      Radius of influence of terrain
      features (TERRAD)               No default      ! TERRAD = 12. !

                                      Units: km
      Relative weighting of the first
      guess field and observations in the
      SURFACE layer (R1)              No default      ! R1 = 1. !
      (R1 is the distance from an     Units: km
      observational station at which the
      observation and first guess field are
      equally weighted)

      Relative weighting of the first
      guess field and observations in the
      layers ALOFT (R2)               No default      ! R2 = 2. !
      (R2 is applied in the upper layers   Units: km
      in the same manner as R1 is used in
      the surface layer).

      Relative weighting parameter of the
      prognostic wind field data (RPROG)   No default      ! RPROG = 0. !
      (Used only if IPROG = 1)        Units: km
      ------------------------

      Maximum acceptable divergence in the
      divergence minimization procedure
      (DIVLIM)                        Default: 5.E-6  ! DIVLIM= 5.0E-06 !

      Maximum number of iterations in the
      divergence min. procedure (NITER)    Default: 50     ! NITER =  50  !

      Number of passes in the smoothing
      procedure (NSMTH(NZ))
      NOTE: NZ values must be entered
           Default: 2,(mxnz-1)*4 ! NSMTH =
2 ,  4 ,  4 ,  4 ,  4 ,  4 ,  4 ,  4 ,  4 ,  4  !

      Maximum number of stations used in
      each layer for the interpolation of
      data to a grid point (NINTR2(NZ))
      NOTE: NZ values must be entered      Default: 99.    ! NINTR2 =
99 ,  99 ,  99 ,  99 ,  99 ,  99 ,  99 ,  99 ,  99 ,  99  !

      Critical Froude number (CRITFN)      Default: 1.0    ! CRITFN = 1. !

      Empirical factor controlling the
      influence of kinematic effects
      (ALPHA)                         Default: 0.1    ! ALPHA = 0.1 !

      Multiplicative scaling factor for
      extrapolation of surface observations
      to upper layers (FEXTR2(NZ))    Default: NZ*0.0
      ! FEXTR2 = 0., 0., 0., 0., 0., 0., 0., 0., 0. !
      (Used only if IEXTRP = 3 or -3)


   BARRIER INFORMATION

      Number of barriers to interpolation
      of the wind fields (NBAR)       Default: 0      ! NBAR =  0  !

      THE FOLLOWING 4 VARIABLES ARE INCLUDED
      ONLY IF NBAR > 0
      NOTE: NBAR values must be entered    No defaults
            for each variable         Units: km
```

```
      X coordinate of BEGINNING
      of each barrier (XBBAR(NBAR))      ! XBBAR = 0. !
      Y coordinate of BEGINNING
      of each barrier (YBBAR(NBAR))      ! YBBAR = 0. !

      X coordinate of ENDING
      of each barrier (XEBAR(NBAR))      ! XEBAR = 0. !
      Y coordinate of ENDING
      of each barrier (YEBAR(NBAR))      ! YEBAR = 0. !


DIAGNOSTIC MODULE DATA INPUT OPTIONS

   Surface temperature (IDIOPT1)         Default: 0      ! IDIOPT1 =  0  !
      0 = Compute internally from
          hourly surface observations
      1 = Read preprocessed values from
          a data file (DIAG.DAT)

      Surface met. station to use for
      the surface temperature (ISURFT)   No default     ! ISURFT =  1  !
      (Must be a value from 1 to NSSTA)
      (Used only if IDIOPT1 = 0)
      --------------------------

   Domain-averaged temperature lapse
   rate (IDIOPT2)                        Default: 0     ! IDIOPT2 =  0  !
      0 = Compute internally from
          twice-daily upper air observations
      1 = Read hourly preprocessed values
          from a data file (DIAG.DAT)

      Upper air station to use for
      the domain-scale lapse rate (IUPT) No default     ! IUPT   =  1  !
      (Must be a value from 1 to NUSTA)
      (Used only if IDIOPT2 = 0)
      --------------------------

      Depth through which the domain-scale
      lapse rate is computed (ZUPT)      Default: 200.  ! ZUPT = 200. !
      (Used only if IDIOPT2 = 0)         Units: meters
      --------------------------

   Domain-averaged wind components
   (IDIOPT3)                             Default: 0     ! IDIOPT3 =  0  !
      0 = Compute internally from
          twice-daily upper air observations
      1 = Read hourly preprocessed values
          a data file (DIAG.DAT)

      Upper air station to use for
      the domain-scale winds (IUPWND)    Default: -1    ! IUPWND = -1  !
      (Must be a value from -1 to NUSTA)
      (Used only if IDIOPT3 = 0)
      --------------------------

      Bottom and top of layer through
      which the domain-scale winds
      are computed
      (ZUPWND(1), ZUPWND(2))        Defaults: 1., 1000. ! ZUPWND= 1., 1000. !
      (Used only if IDIOPT3 = 0)    Units: meters
      --------------------------

   Observed surface wind components
   for wind field module (IDIOPT4)  Default: 0     ! IDIOPT4 =  0  !
```

```
          0 = Read WS, WD from a surface
              data file (SURF.DAT)
          1 = Read hourly preprocessed U, V from
              a data file (DIAG.DAT)

       Observed upper air wind components
       for wind field module (IDIOPT5)  Default: 0     ! IDIOPT5 =  0  !
          0 = Read WS, WD from an upper
              air data file (UP1.DAT, UP2.DAT, etc.)
          1 = Read hourly preprocessed U, V from
              a data file (DIAG.DAT)

       LAKE BREEZE INFORMATION

          Use Lake Breeze Module  (LLBREZE)
                                           Default: F      ! LLBREZE = F !

           Number of lake breeze regions (NBOX)            ! NBOX =  0  !

        X Grid line 1 defining the region of interest
                                                        ! XG1 = 0. !
        X Grid line 2 defining the region of interest
                                                        ! XG2 = 0. !
        Y Grid line 1 defining the region of interest
                                                        ! YG1 = 0. !
        Y Grid line 2 defining the region of interest
                                                        ! YG2 = 0. !

         X Point defining the coastline (Straight line)
                   (XBCST)  (KM)   Default: none    ! XBCST = 0. !

         Y Point defining the coastline (Straight line)
                   (YBCST)  (KM)   Default: none    ! YBCST = 0. !

         X Point defining the coastline (Straight line)
                   (XECST)  (KM)   Default: none    ! XECST = 0. !

         Y Point defining the coastline (Straight line)
                   (YECST)  (KM)   Default: none    ! YECST = 0. !


       Number of stations in the region     Default: none ! NLB = *1 !*
       (Surface stations + upper air stations)

       Station ID's  in the region   (METBXID(NLB))
       (Surface stations first, then upper air stations)
         ! METBXID = *0 !*

!END!


-------------------------------------------------------------------------------

INPUT GROUP: 6 -- Mixing Height, Temperature and Precipitation Parameters
--------------

    EMPIRICAL MIXING HEIGHT CONSTANTS

       Neutral, mechanical equation
       (CONSTB)                              Default: 1.41   ! CONSTB = 1.41 !
       Convective mixing ht. equation
       (CONSTE)                              Default: 0.15   ! CONSTE = 0.15 !
       Stable mixing ht. equation
       (CONSTN)                              Default: 2400.  ! CONSTN = 2400.!
       Overwater mixing ht. equation
       (CONSTW)                              Default: 0.16   ! CONSTW = 0.16 !
```

```
   Absolute value of Coriolis
   parameter (FCORIOL)                  Default: 1.E-4  ! FCORIOL = 1.0E-04!
                                        Units: (1/s)

SPATIAL AVERAGING OF MIXING HEIGHTS

   Conduct spatial averaging
   (IAVEZI)  (0=no, 1=yes)              Default: 1      ! IAVEZI =  1  !

   Max. search radius in averaging
   process (MNMDAV)                     Default: 1      ! MNMDAV =  5  !
                                        Units: Grid
                                               cells
   Half-angle of upwind looking cone
   for averaging (HAFANG)               Default: 30.    ! HAFANG = 30. !
                                        Units: deg.
   Layer of winds used in upwind
   averaging (ILEVZI)                   Default: 1      ! ILEVZI =  1  !
   (must be between 1 and NZ)

OTHER MIXING HEIGHT VARIABLES

   Minimum potential temperature lapse
   rate in the stable layer above the
   current convective mixing ht.        Default: 0.001  ! DPTMIN = 0.001 !
   (DPTMIN)                             Units: deg. K/m
   Depth of layer above current conv.
   mixing height through which lapse    Default: 200.   ! DZZI = 200. !
   rate is computed (DZZI)              Units: meters

   Minimum overland mixing height       Default:  50.   ! ZIMIN = 50. !
   (ZIMIN)                              Units: meters
   Maximum overland mixing height       Default: 3000.  ! ZIMAX = 2695. !
   (ZIMAX)                              Units: meters
   Minimum overwater mixing height      Default:   50.  ! ZIMINW = 50. !
   (ZIMINW) -- (Not used if observed    Units: meters
   overwater mixing hts. are used)
   Maximum overwater mixing height      Default: 3000.  ! ZIMAXW = 2695. !
   (ZIMAXW) -- (Not used if observed    Units: meters
   overwater mixing hts. are used)


TEMPERATURE PARAMETERS

   Interpolation type
   (1 = 1/R ; 2 = 1/R**2)               Default:1         ! IRAD =  1  !

   Radius of influence for temperature
   interpolation (TRADKM)               Default: 500.     ! TRADKM = 500. !
                                        Units: km

   Maximum Number of stations to include
   in temperature interpolation (NUMTS)  Default: 5        ! NUMTS = 5  !

   Conduct spatial averaging of temp-
   eratures (IAVET)  (0=no, 1=yes)        Default: 1     ! IAVET =  1  !
   (will use mixing ht MNMDAV,HAFANG
    so make sure they are correct)

   Default temperature gradient        Default: -.0098 ! TGDEFB = -0.0098 !
   below the mixing height over
   water (K/m) (TGDEFB)

   Default temperature gradient        Default: -.0045 ! TGDEFA = -0.0045 !
   above the mixing height over
   water (K/m) (TGDEFA)
```

```
       Beginning (JWAT1) and ending (JWAT2)
       land use categories for temperature                    ! JWAT1 =  100  !
       interpolation over water -- Make                       ! JWAT2 =  100 !
       bigger than largest land use to disable

   PRECIP INTERPOLATION PARAMETERS

       Method of interpolation (NFLAGP)      Default = 2    ! NFLAGP =  2  !
        (1=1/R,2=1/R**2,3=EXP/R**2)
       Radius of Influence (km) (SIGMAP)     Default = 100.0  ! SIGMAP = 100. !
        (0.0 => use half dist. btwn
         nearest stns w & w/out
         precip when NFLAGP = 3)
       Minimum Precip. Rate Cutoff (mm/hr)   Default = 0.01  ! CUTP = 0.01 !
        (values < CUTP = 0.0 mm/hr)
!END!


-------------------------------------------------------------------------------

INPUT GROUP: 7 -- Surface meteorological station parameters
--------------

     SURFACE STATION VARIABLES
     (One record per station --  7  records in all)


             1     2
         Name   ID            X coord.   Y coord.   Time   Anem.
                                (km)       (km)      zone   Ht.(m)
       ----------------------------------------------------------
! SS1  ='RICH'   13740       824.090     4158.306    5    10  !
! SS2  ='RALE'   13722       700.141     3971.229    5    10  !
! SS3  ='QUAN'   13773       822.691     4267.578    5    10  !
! SS4  ='ROAN'   13741       591.562     4130.299    5    10  !
! SS5  ='LYNC'   13733       659.466     4133.166    5    10  !
! SS6  ='GREE'   13723       594.539     3993.501    5    10  !
! SS7  ='ELKI'   13729       599.748     4304.251    5    10  !
-------------------
      1
        Four character string for station name
        (MUST START IN COLUMN 9)

      2
        Five digit integer for station ID

!END!


-------------------------------------------------------------------------------

INPUT GROUP: 8 -- Upper air meteorological station parameters
--------------

     UPPER AIR STATION VARIABLES
     (One record per station --  2  records in all)

             1     2
         Name    ID      X coord.   Y coord.  Time zone
                           (km)       (km)
        -----------------------------------------------
! US1  ='GSO'   13723    594.543   3993.131    5  !
! US2  ='STE'   93734    805.804   4320.279    5  !
-------------------
      1
```

```
        Four character string for station name
        (MUST START IN COLUMN 9)

      2
        Five digit integer for station ID

!END!


-------------------------------------------------------------------------------

INPUT GROUP: 9 -- Precipitation station parameters
--------------

     PRECIPITATION STATION VARIABLES
     (One record per station --  59  records in all)
     (NOT INCLUDED IF NPSTA = 0)

            1          2
         Name   Station    X coord.  Y coord.
                  Code       (km)      (km)
         -----------------------------------

! PS1  ='0001'   466163    520.121   4349.886      !
! PS2  ='0002'   465739    584.237   4267.078      !
! PS3  ='0003'   465672    541.224   4155.786      !
! PS4  ='0004'   465341    583.335   4352.155      !
! PS5  ='0005'   465284    624.764   4367.510      !
! PS6  ='0006'   465002    775.430   4369.545      !
! PS7  ='0007'   464763    692.492   4355.938      !
! PS8  ='0008'   464369    676.000   4322.234      !
! PS9  ='0009'   463820    685.089   4303.936      !
! PS10 ='0010'   463361    529.484   4144.643      !
! PS11 ='0011'   463238    598.572   4396.733      !
! PS12 ='0012'   463215    768.449   4363.743      !
! PS13 ='0013'   462718    545.725   4394.388      !
! PS14 ='0014'   461900    576.438   4322.488      !
! PS15 ='0015'   461677    731.944   4382.937      !
! PS16 ='0016'   461393    515.891   4309.187      !
! PS17 ='0017'   461323    520.301   4279.606      !
! PS18 ='0018'   460664    646.453   4280.925      !
! PS19 ='0019'   319675    599.748   4304.251      !
! PS20 ='0020'   319476    604.337   4393.109      !
! PS21 ='0021'   313638    500.000   4028.114      !
! PS22 ='0022'   313630    798.640   4042.527      !
! PS23 ='0023'   313232    707.883   3962.158      !
! PS24 ='0024'   312631    700.141   3971.229      !
! PS25 ='0025'   312388    501.501   3992.991      !
! PS26 ='0026'   312230    515.096   3939.397      !
! PS27 ='0027'   311241    566.222   3967.359      !
! PS28 ='0028'   310750    826.033   3949.054      !
! PS29 ='0029'   449301    594.539   3993.501      !
! PS30 ='0030'   449272    728.063   3997.811      !
! PS31 ='0031'   449215    611.926   4041.781      !
! PS32 ='0032'   449159    553.873   4017.189      !
! PS33 ='0033'   449151    643.971   3999.722      !
! PS34 ='0034'   449060    675.029   3946.652      !
! PS35 ='0035'   448906    492.578   4087.277      !
! PS36 ='0036'   448849    565.522   4059.793      !
! PS37 ='0037'   448800    546.062   4078.154      !
! PS38 ='0038'   448547    624.103   4225.049      !
! PS39 ='0039'   448396    881.194   4136.626      !
! PS40 ='0040'   448062    516.274   4115.023      !
! PS41 ='0041'   448046    844.273   4307.406      !
! PS42 ='0042'   447338    781.859   4310.495      !
! PS43 ='0043'   447285    668.099   4216.590      !
```

```
! PS44 ='0044'   447201    722.012   4328.952      !
! PS45 ='0045'   446955    525.122   4124.289      !
! PS46 ='0046'   446712    597.879   4095.235      !
! PS47 ='0047'   446692    591.562   4130.299      !
! PS48 ='0048'   446475    824.090   4158.306      !
! PS49 ='0049'   446178    519.263   4102.086      !
! PS50 ='0050'   446139    752.434   4233.581      !
! PS51 ='0051'   445880    586.258   4071.070      !
! PS52 ='0052'   445690    707.948   4202.704      !
! PS53 ='0053'   445595    618.022   4241.606      !
! PS54 ='0054'   445120    664.234   4190.609      !
! PS55 ='0055'   444414    612.140   4245.222      !
! PS56 ='0056'   444410    659.466   4133.166      !
! PS57 ='0057'   444246    743.012   4053.735      !
! PS58 ='0058'   444180    538.608   4083.664      !
! PS59 ='0059'   444128    602.434   4206.252      !

-------------------
      1
        Four character string for station name
        (MUST START IN COLUMN 9)

      2
        Six digit station code composed of state
        code (first 2 digits) and station ID (last
        4 digits)

!END!
```

APPENDIX B

MESOPUFF II INPUT CONTROL FILE

```
MESOPUFF II Consequence Run
   90  006    0 8592    1    0  790    1    0
    1    8    8    T   2.    F 300.
    1   78    1   60    1   78    1   60    1
    T    F    F    F    T
    T    F   12    F    0    0    F    F    F    F    F    F    0    0
000000
 42.5 12.5 100.   8. 26.0 430.    6000.0
    28.125    29.625
    28.375    29.625
    27.625    29.875
    27.875    29.875
    28.125    29.875
    28.375    29.875
    28.625    29.875
    27.625    30.125
    27.875    30.125
    28.125    30.125
    28.375    30.125
    28.625    30.125
    27.625    30.375
    27.875    30.375
    28.125    30.375
    28.375    30.375
    28.625    30.375
    28.875    30.375
    27.875    30.625
    28.125    30.625
    28.375    30.625
    28.625    30.625
    28.875    30.625
    27.875    30.875
    28.125    30.875
    28.375    30.875
    28.625    30.875
    28.875    30.875
    29.125    30.875
    29.375    30.875
    28.375    31.125
    28.625    31.125
    28.875    31.125
    29.125    31.125
    29.375    31.125
    27.875    31.375
    28.125    31.375
    28.375    31.375
    28.625    31.375
    28.875    31.375
    29.125    31.375
    29.375    31.375
    28.125    31.625
    28.375    31.625
    28.625    31.625
    28.875    31.625
    29.125    31.625
    29.375    31.625
    28.125    31.875
    28.375    31.875
    28.625    31.875
    28.875    31.875
```

29.125	31.875
29.375	31.875
28.125	32.125
28.375	32.125
28.625	32.125
28.875	32.125
29.125	32.125
28.375	32.375
28.625	32.375
28.875	32.375
29.125	32.375
28.375	32.625
28.625	32.625
28.875	32.625
29.125	32.625
29.375	32.625
30.125	32.625
28.375	32.875
28.625	32.875
28.875	32.875
29.125	32.875
29.375	32.875
29.625	32.875
29.875	32.875
30.125	32.875
30.375	32.875
28.375	33.125
28.625	33.125
28.875	33.125
29.125	33.125
29.375	33.125
29.625	33.125
29.875	33.125
30.125	33.125
30.375	33.125
27.875	33.375
28.125	33.375
28.375	33.375
28.625	33.375
28.875	33.375
29.125	33.375
29.375	33.375
29.625	33.375
29.875	33.375
30.125	33.375
30.375	33.375
28.125	33.625
28.375	33.625
28.625	33.625
28.875	33.625
29.125	33.625
29.375	33.625
29.625	33.625
29.875	33.625
30.125	33.625
30.375	33.625
30.625	33.625
30.875	33.625
28.375	33.875
28.625	33.875
28.875	33.875
29.125	33.875
29.375	33.875
29.625	33.875
29.875	33.875
30.125	33.875

*************** REMAINING RECEPTOR REMOVED FOR THIS LISTING ********************

APPENDIX C

CALPUFF INPUT CONTROL FILE

```
CALMET/CALPUFF Consequence Example, 78 x 60 grid cells @ 4 km grid
Class I Area: Shenandoah National Park      ----- Transformation & Removal
January 6, 1990 - December 29, 1990
---------------- Run title (3 lines) ----------------------------------------

                    CALPUFF MODEL CONTROL FILE
                    --------------------------

-------------------------------------------------------------------------------

INPUT GROUP: 0 -- Input and Output File Names

--------------
Default Name  Type          File Name
------------  ----          ---------
CALMET.DAT    input    * METDAT =             *
    or
ISCMET.DAT    input    * ISCDAT =             *
    or
PLMMET.DAT    input    * PLMDAT =             *
    or
PROFILE.DAT   input    * PRFDAT =             *
SURFACE.DAT   input    * SFCDAT =             *
RESTARTB.DAT  input    * RSTARTB=  *
--------------------------------------------------------------------------------
CALPUFF.LST   output   ! PUFLST =calpuff3.LST  !
CONC.DAT      output   ! CONDAT =calpuff3.CON     !
DFLX.DAT      output   ! DFDAT  =calpuff3.DRY     !
WFLX.DAT      output   ! WFDAT  =calpuff3.WET     !

VISB.DAT      output   ! VISDAT =calpuff.VIS     !
RESTARTE.DAT  output   ! RSTARTE=calpuff.DAT     !
--------------------------------------------------------------------------------
Emission Files
--------------
PTEMARB.DAT   input    * PTDAT  =             *
VOLEMARB.DAT  input    * VOLDAT =             *
BAEMARB.DAT   input    * ARDAT  =             *
LNEMARB.DAT   input    * LNDAT  =             *
--------------------------------------------------------------------------------
Other Files
-----------
OZONE.DAT     input    ! OZDAT  =OZONE.DAT    !
VD.DAT        input    * VDDAT  =             *
CHEM.DAT      input    * CHEMDAT=             *
H2O2.DAT      input    * H2O2DAT=             *
HILL.DAT      input    * HILDAT=             *
HILLRCT.DAT   input    * RCTDAT=             *
COASTLN.DAT   input    * CSTDAT=             *
FLUXBDY.DAT   input    * BDYDAT=             *
BCON.DAT      input    * BCNDAT=             *
DEBUG.DAT     output   * DEBUG =             *
MASSFLX.DAT   output   * FLXDAT=             *
MASSBAL.DAT   output   * BALDAT=             *
FOG.DAT       output   * FOGDAT=             *
--------------------------------------------------------------------------------
All file names will be converted to lower case if LCFILES = T
Otherwise, if LCFILES = F, file names will be converted to UPPER CASE
         T = lower case      ! LCFILES = F !
         F = UPPER CASE
```

```
NOTE: (1) file/path names can be up to 70 characters in length


Provision for multiple input files
----------------------------------

     Number of CALMET.DAT files for run (NMETDAT)
                                     Default: 1       ! NMETDAT =   12   !

     Number of PTEMARB.DAT files for run (NPTDAT)
                                     Default: 0       ! NPTDAT =  0  !

     Number of BAEMARB.DAT files for run (NARDAT)
                                     Default: 0       ! NARDAT =  0  !

     Number of VOLEMARB.DAT files for run (NVOLDAT)
                                     Default: 0       ! NVOLDAT =  0  !

!END!

-------------
Subgroup (0a)
-------------

  The following CALMET.DAT filenames are processed in sequence if NMETDAT>1

Default Name  Type          File Name

 none         input    ! METDAT=..\calmet\cal\JAN.DAT     !  !END!
 none         input    ! METDAT=..\calmet\cal\FEB.DAT     !  !END!
 none         input    ! METDAT=..\calmet\cal\MAR.DAT     !  !END!
 none         input    ! METDAT=..\calmet\cal\APR.DAT     !  !END!
 none         input    ! METDAT=..\calmet\cal\MAY.DAT     !  !END!
 none         input    ! METDAT=..\calmet\cal\JUN.DAT     !  !END!
 none         input    ! METDAT=..\calmet\cal\JUL.DAT     !  !END!
 none         input    ! METDAT=..\calmet\cal\AUG.DAT     !  !END!
 none         input    ! METDAT=..\calmet\cal\SEP.DAT     !  !END!
 none         input    ! METDAT=..\calmet\cal\OCT.DAT     !  !END!
 none         input    ! METDAT=..\calmet\cal\NOV.DAT     !  !END!
 none         input    ! METDAT=..\calmet\cal\DEC.DAT     !  !END!


--------------------------------------------------------------------------------

INPUT GROUP: 1 -- General run control parameters
--------------

    Option to run all periods found
    in the met. file     (METRUN)   Default: 0       ! METRUN =   0  !

         METRUN = 0 - Run period explicitly defined below
         METRUN = 1 - Run all periods in met. file

     Starting date:   Year (IBYR) -- No default       ! IBYR =  1990  !
     (used only if   Month (IBMO) -- No default       ! IBMO =  1  !
      METRUN = 0)      Day (IBDY) -- No default       ! IBDY =  6  !
                      Hour (IBHR) -- No default       ! IBHR =  0  !

     Base time zone        (XBTZ) -- No default       ! XBTZ = 5.0  !
        PST = 8., MST = 7.
        CST = 6., EST = 5.

     Length of run (hours) (IRLG) -- No default       ! IRLG =  8592  !

     Number of chemical species (NSPEC)
                                     Default: 5       ! NSPEC =  2   !

     Number of chemical species
     to be emitted  (NSE)            Default: 3       ! NSE =  1   !

     Flag to stop run after
```

```
     SETUP phase (ITEST)             Default: 2       ! ITEST =  2   !
     (Used to allow checking
     of the model inputs, files, etc.)
           ITEST = 1 - STOPS program after SETUP phase
           ITEST = 2 - Continues with execution of program
                       after SETUP

     Restart Configuration:

        Control flag (MRESTART)      Default: 0       ! MRESTART =  0   !

           0 = Do not read or write a restart file
           1 = Read a restart file at the beginning of
               the run
           2 = Write a restart file during run
           3 = Read a restart file at beginning of run
               and write a restart file during run

        Number of periods in Restart
        output cycle (NRESPD)        Default: 0       ! NRESPD =  720   !

           0 = File written only at last period
          >0 = File updated every NRESPD periods

     Meteorological Data Format (METFM)
                                     Default: 1       ! METFM =  1   !

           METFM = 1 - CALMET binary file (CALMET.MET)
           METFM = 2 - ISC ASCII file (ISCMET.MET)
           METFM = 3 - AUSPLUME ASCII file (PLMMET.MET)
           METFM = 4 - CTDM plus tower file (PROFILE.DAT) and
                       surface parameters file (SURFACE.DAT)

     PG sigma-y is adjusted by the factor (AVET/PGTIME)**0.2
     Averaging Time (minutes) (AVET)
                                     Default: 60.0    ! AVET = 60. !
     PG Averaging Time (minutes) (PGTIME)
                                     Default: 60.0    ! PGTIME = 60. !


!END!


-------------------------------------------------------------------------------

INPUT GROUP: 2 -- Technical options
--------------


     Vertical distribution used in the
     near field (MGAUSS)                   Default: 1     ! MGAUSS =  1   !
        0 = uniform
        1 = Gaussian

     Terrain adjustment method
     (MCTADJ)                              Default: 3     ! MCTADJ =  3   !
        0 = no adjustment
        1 = ISC-type of terrain adjustment
        2 = simple, CALPUFF-type of terrain
            adjustment
        3 = partial plume path adjustment

     Subgrid-scale complex terrain
     flag (MCTSG)                          Default: 0     ! MCTSG =  0   !
        0 = not modeled
        1 = modeled

     Near-field puffs modeled as
     elongated 0 (MSLUG)                   Default: 0     ! MSLUG =  0   !
        0 = no
        1 = yes (slug model used)
```

```
Transitional plume rise modeled ?
(MTRANS)                           Default: 1     ! MTRANS =  1   !
   0 = no  (i.e., final rise only)
   1 = yes (i.e., transitional rise computed)

Stack tip downwash? (MTIP)         Default: 1     ! MTIP =  1  !
   0 = no  (i.e., no stack tip downwash)
   1 = yes (i.e., use stack tip downwash)

Vertical wind shear modeled above
stack top? (MSHEAR)                Default: 0     ! MSHEAR =  0  !
   0 = no  (i.e., vertical wind shear not modeled)
   1 = yes (i.e., vertical wind shear modeled)

Puff splitting allowed? (MSPLIT)   Default: 0     ! MSPLIT =  0  !
   0 = no (i.e., puffs not split)
   1 = yes (i.e., puffs are split)

Chemical mechanism flag (MCHEM)    Default: 1     ! MCHEM =  1   !
   0 = chemical transformation not
       modeled
   1 = transformation rates computed
       internally (MESOPUFF II scheme)
   2 = user-specified transformation
       rates used
   3 = transformation rates computed
       internally (RIVAD/ARM3 scheme)
   4 = secondary organic aerosol formation
       computed (MESOPUFF II scheme for OH)

Aqueous phase transformation flag (MAQCHEM)
(Used only if MCHEM = 1, or 3)     Default: 0     ! MAQCHEM =  0   !
   0 = aqueous phase transformation
       not modeled
   1 = transformation rates adjusted
       for aqueous phase reactions

Wet removal modeled ? (MWET)       Default: 1     ! MWET =  1   !
   0 = no
   1 = yes

Dry deposition modeled ? (MDRY)    Default: 1     ! MDRY =  1   !
   0 = no
   1 = yes
   (dry deposition method specified
    for each species in Input Group 3)

Method used to compute dispersion
coefficients (MDISP)               Default: 3     ! MDISP =  3   !

   1 = dispersion coefficients computed from measured values
       of turbulence, sigma v, sigma w
   2 = dispersion coefficients from internally calculated
       sigma v, sigma w using micrometeorological variables
       (u*, w*, L, etc.)
   3 = PG dispersion coefficients for RURAL areas (computed using
       the ISCST multi-segment approximation) and MP coefficients in
       urban areas
   4 = same as 3 except PG coefficients computed using
       the MESOPUFF II eqns.
   5 = CTDM sigmas used for stable and neutral conditions.
       For unstable conditions, sigmas are computed as in
       MDISP = 3, described above.  MDISP = 5 assumes that
       measured values are read

Sigma-v/sigma-theta, sigma-w measurements used? (MTURBVW)
(Used only if MDISP = 1 or 5)      Default: 3     ! MTURBVW =  3  !
   1 = use sigma-v or sigma-theta measurements
       from PROFILE.DAT to compute sigma-y
       (valid for METFM = 1, 2, 3, 4)
```

```
   2 = use sigma-w measurements
       from PROFILE.DAT to compute sigma-z
       (valid for METFM = 1, 2, 3, 4)
   3 = use both sigma-(v/theta) and sigma-w
       from PROFILE.DAT to compute sigma-y and sigma-z
       (valid for METFM = 1, 2, 3, 4)
   4 = use sigma-theta measurements
       from PLMMET.DAT to compute sigma-y
       (valid only if METFM = 3)

Back-up method used to compute dispersion
when measured turbulence data are
missing (MDISP2)                      Default: 3     ! MDISP2 =  3  !
(used only if MDISP = 1 or 5)
   2 = dispersion coefficients from internally calculated
       sigma v, sigma w using micrometeorological variables
       (u*, w*, L, etc.)
   3 = PG dispersion coefficients for RURAL areas (computed using
       the ISCST multi-segment approximation) and MP coefficients in
       urban areas
   4 = same as 3 except PG coefficients computed using
       the MESOPUFF II eqns.

PG sigma-y,z adj. for roughness?      Default: 0     ! MROUGH =  0  !
(MROUGH)
   0 = no
   1 = yes

Partial plume penetration of          Default: 1     ! MPARTL =  1  !
elevated inversion?
(MPARTL)
   0 = no
   1 = yes

Strength of temperature inversion     Default: 0     ! MTINV =  0  !
provided in PROFILE.DAT extended records?
(MTINV)
   0 = no (computed from measured/default gradients)
   1 = yes

PDF used for dispersion under convective conditions?
                                      Default: 0     ! MPDF =  0  !
(MPDF)
   0 = no
   1 = yes

Sub-Grid TIBL module used for shore line?
                                      Default: 0     ! MSGTIBL = 0  !
(MSGTIBL)
   0 = no
   1 = yes

Boundary conditions (concentration) modeled?
                                      Default: 0     ! MBCON = 0  !
(MBCON)
   0 = no
   1 = yes


Analyses of fogging and icing impacts due to emissions from
arrays of mechanically-forced cooling towers can be performed
using CALPUFF in conjunction with a cooling tower emissions
processor (CTEMISS) and its associated postprocessors.  Hourly
emissions of water vapor and temperature from each cooling tower
cell are computed for the current cell configuration and ambient
conditions by CTEMISS. CALPUFF models the dispersion of these
emissions and provides cloud information in a specialized format
for further analysis. Output to FOG.DAT is provided in either
'plume mode' or 'receptor mode' format.

Configure for FOG Model output?
```

```
                                           Default: 0     ! MFOG =  0   !
     (MFOG)
        0 = no
        1 = yes  - report results in PLUME Mode format
        2 = yes  - report results in RECEPTOR Mode format


     Test options specified to see if
     they conform to regulatory
     values? (MREG)                        Default: 1     ! MREG =  0   !

        0 = NO checks are made
        1 = Technical options must conform to USEPA values
                       METFM    1
                       AVET     60. (min)
                       MGAUSS   1
                       MCTADJ   3
                       MTRANS   1
                       MTIP     1
                       MCHEM    1 (if modeling SOx, NOx)
                       MWET     1
                       MDRY     1
                       MDISP    3
                       MROUGH   0
                       MPARTL   1
                       SYTDEP   550. (m)
                       MHFTSZ   0

!END!


-------------------------------------------------------------------------------

INPUT GROUP: 3a, 3b -- Species list
-------------------

------------
Subgroup (3a)
------------

  The following species are modeled:

! CSPEC =          SO2 !         !END!
! CSPEC =          SO4 !         !END!
* CSPEC =          NOX *         *END*
* CSPEC =         HNO3 *         *END*
* CSPEC =          NO3 *         *END*

                                                         Dry                 OUTPUT GROUP
    SPECIES          MODELED          EMITTED       DEPOSITED                  NUMBER
     NAME         (0=NO, 1=YES)    (0=NO, 1=YES)    (0=NO,                   (0=NONE,
   (Limit: 12                                        1=COMPUTED-GAS          1=1st CGRUP,
    Characters                                       2=COMPUTED-PARTICLE    2=2nd CGRUP,
    in length)                                       3=USER-SPECIFIED)      3= etc.)

!          SO2  =         1,               1,           1,                 0   !
!          SO4  =         1,               0,           2,                 0   !
*          NOX  =         1,               1,           1,                 0   *
*         HNO3  =         1,               0,           1,                 0   *
*          NO3  =         1,               0,           2,                 0   *

!END!

-------------
Subgroup (3b)
-------------
  The following names are used for Species-Groups in which results
  for certain species are combined (added) prior to output.  The
  CGRUP name will be used as the species name in output files.
  Use this feature to model specific particle-size distributions
```

```
  by treating each size-range as a separate species.
  Order must be consistent with 3(a) above.


-------------------------------------------------------------------------------


INPUT GROUP: 4 -- Grid control parameters
--------------


METEOROLOGICAL grid:

            No. X grid cells (NX)      No default     ! NX =  78   !
            No. Y grid cells (NY)      No default     ! NY =  60   !
         No. vertical layers (NZ)      No default     ! NZ =  10   !

           Grid spacing (DGRIDKM)      No default     ! DGRIDKM = 4. !
                                       Units: km

                Cell face heights
                    (ZFACE(nz+1))      No defaults
                                       Units: m
   ! ZFACE = 0., 20., 40., 80., 160., 300., 600., 1000., 1500., 2200.,
              3000. !

            Reference Coordinates
           of SOUTHWEST corner of
                 grid cell(1, 1):

            X coordinate (XORIGKM)     No default     ! XORIGKM = 580. !
            Y coordinate (YORIGKM)     No default     ! YORIGKM = 4100. !
                                      Units: km

                 UTM zone (IUTMZN)     No default     ! IUTMZN =  17   !

   Reference coordinates of CENTER
        of the domain (used in the
    calculation of solar elevation
                            angles)


Computational grid:

     The computational grid is identical to or a subset of the MET. grid.
     The lower left (LL) corner of the computational grid is at grid point
     (IBCOMP, JBCOMP) of the MET. grid.  The upper right (UR) corner of the
     computational grid is at grid point (IECOMP, JECOMP) of the MET. grid.
     The grid spacing of the computational grid is the same as the MET. grid.

        X index of LL corner (IBCOMP)      No default     ! IBCOMP =  1   !
                  (1 <= IBCOMP <= NX)

        Y index of LL corner (JBCOMP)      No default     ! JBCOMP =  1   !
                  (1 <= JBCOMP <= NY)


        X index of UR corner (IECOMP)      No default     ! IECOMP =  78   !
                  (1 <= IECOMP <= NX)

        Y index of UR corner (JECOMP)      No default     ! JECOMP =  60   !
                  (1 <= JECOMP <= NY)


SAMPLING GRID (GRIDDED RECEPTORS):

     The lower left (LL) corner of the sampling grid is at grid point
     (IBSAMP, JBSAMP) of the MET. grid.  The upper right (UR) corner of the
```

```
     sampling grid is at grid point (IESAMP, JESAMP) of the MET. grid.
     The sampling grid must be identical to or a subset of the computational
     grid.  It may be a nested grid inside the computational grid.
     The grid spacing of the sampling grid is DGRIDKM/MESHDN.

        Logical flag indicating if gridded
        receptors are used (LSAMP)         Default: T     ! LSAMP = F !
        (T=yes, F=no)

        X index of LL corner (IBSAMP)      No default     ! IBSAMP =  0   !
         (IBCOMP <= IBSAMP <= IECOMP)

        Y index of LL corner (JBSAMP)      No default     ! JBSAMP =  0   !
         (JBCOMP <= JBSAMP <= JECOMP)


        X index of UR corner (IESAMP)      No default     ! IESAMP =  0   !
         (IBCOMP <= IESAMP <= IECOMP)

        Y index of UR corner (JESAMP)      No default     ! JESAMP =  0   !
         (JBCOMP <= JESAMP <= JECOMP)


       Nesting factor of the sampling
        grid (MESHDN)                      Default: 1     ! MESHDN =  1  !
        (MESHDN is an integer >= 1)

!END!


-------------------------------------------------------------------------------


INPUT GROUP: 5 -- Output Options
--------------
                                            *                           *
     FILE                       DEFAULT VALUE             VALUE THIS RUN
     ----                       -------------             --------------

   Concentrations (ICON)              1                   !  ICON =  1   !
   Dry Fluxes (IDRY)                  1                   !  IDRY =  0   !
   Wet Fluxes (IWET)                  1                   !  IWET =  0   !
   Relative Humidity (IVIS)           1                   !  IVIS =  0   !
    (relative humidity file is
     required for visibility
     analysis)
   Use data compression option in output file?
   (LCOMPRS)                           Default: T         ! LCOMPRS = T !

   *
    0 = Do not create file, 1 = create file


    DIAGNOSTIC MASS FLUX OUTPUT OPTIONS:

       Mass flux across specified boundaries
       for selected species reported hourly?
       (IMFLX)                         Default: 0         ! IMFLX =  0  !
         0 = no
         1 = yes (FLUXBDY.DAT and MASSFLX.DAT filenames
                  are specified in Input Group 0)

       Mass balance for each species
       reported hourly?
       (IMBAL)                         Default: 0         ! IMBAL =  0  !
         0 = no
         1 = yes (MASSBAL.DAT filename is
              specified in Input Group 0)


    LINE PRINTER OUTPUT OPTIONS:
```

```
       Print concentrations (ICPRT)    Default: 0         ! ICPRT =  0   !
       Print dry fluxes (IDPRT)        Default: 0         ! IDPRT =  0   !
       Print wet fluxes (IWPRT)        Default: 0         ! IWPRT =  0   !
       (0 = Do not print, 1 = Print)

       Concentration print interval
       (ICFRQ) in hours                Default: 1         ! ICFRQ =  1   !
       Dry flux print interval
       (IDFRQ) in hours                Default: 1         ! IDFRQ =  1   !
       Wet flux print interval
       (IWFRQ) in hours                Default: 1         ! IWFRQ =  1   !

       Units for Line Printer Output
       (IPRTU)                         Default: 1         ! IPRTU =  1   !
                       for            for
                  Concentration    Deposition
           1 =       g/m**3         g/m**2/s
           2 =      mg/m**3        mg/m**2/s
           3 =      ug/m**3        ug/m**2/s
           4 =      ng/m**3        ng/m**2/s
           5 =     Odour Units

       Messages tracking progress of run
       written to the screen ?
       (IMESG)                         Default: 2         ! IMESG =  2   !
         0 = no
         1 = yes (advection step, puff ID)
         2 = yes (YYYYJJJHH, # old puffs, # emitted puffs)


     SPECIES (or GROUP for combined species) LIST FOR OUTPUT OPTIONS

                 ---- CONCENTRATIONS ----   ------ DRY FLUXES ------   ------ WET FLUXES ------
-- MASS FLUX --
   SPECIES
   /GROUP        PRINTED?  SAVED ON DISK?   PRINTED?  SAVED ON DISK?   PRINTED?  SAVED ON DISK?
SAVED ON DISK?
   -------       ------------------------   ------------------------   ------------------------
---------------
!         SO2 =     0,          1,          0,          1,          0,          1,
0   !
!         SO4 =     0,          1,          0,          0,          0,          0,
0   !
*         NOX =     0,          1,          0,          1,          0,          1,
0   *
*        HNO3 =     0,          1,          0,          1,          0,          1,
0   *
*         NO3 =     0,          1,          0,          1,          0,          1,
0   *

     OPTIONS FOR PRINTING "DEBUG" QUANTITIES (much output)

       Logical for debug output
       (LDEBUG)                                 Default: F     ! LDEBUG = F !

       First puff to track
       (IPFDEB)                                 Default: 1     ! IPFDEB =  1  !

       Number of puffs to track
       (NPFDEB)                                 Default: 1     ! NPFDEB =  1  !

       Met. period to start output
       (NN1)                                    Default: 1     ! NN1 =  1   !

       Met. period to end output
       (NN2)                                    Default: 10    ! NN2 =  10  !

!END!
```

```
-------------------------------------------------------------------------------

INPUT GROUP: 6a, 6b, & 6c -- Subgrid scale complex terrain inputs
-------------------------

---------------
Subgroup (6a)
---------------
       Number of terrain features (NHILL)       Default: 0     ! NHILL =  0   !

       Number of special complex terrain
       receptors  (NCTREC)                      Default: 0     ! NCTREC =  0   !

       Terrain and CTSG Receptor data for
       CTSG hills input in CTDM format ?
       (MHILL)                                  No Default     ! MHILL =  0   !
       1 = Hill and Receptor data created
           by CTDM processors & read from
           HILL.DAT and HILLRCT.DAT files
       2 = Hill data created by OPTHILL &
           input below in Subgroup (6b);
           Receptor data in Subgroup (6c)

       Factor to convert horizontal dimensions  Default: 1.0   ! XHILL2M = 1. !
       to meters (MHILL=1)

       Factor to convert vertical dimensions    Default: 1.0   ! ZHILL2M = 1. !
       to meters (MHILL=1)

       X-origin of CTDM system relative to      No Default     ! XCTDMKM = 0.0E00 !
       CALPUFF coordinate system, in Kilometers (MHILL=1)

       Y-origin of CTDM system relative to      No Default     ! YCTDMKM = 0.0E00 !
       CALPUFF coordinate system, in Kilometers (MHILL=1)

! END !

---------------
Subgroup (6b)
---------------

                      1 **
     HILL information


HILL           XC        YC       THETAH  ZGRID  RELIEF    EXPO 1    EXPO 2   SCALE 1    SCALE 2
AMAX1     AMAX2
 NO.          (km)      (km)      (deg.)   (m)     (m)      (m)       (m)       (m)        (m)
(m)       (m)
----          ----      ----      ------  -----  ------    ------    ------   -------    -------
-----     -----

---------------
Subgroup (6c)
---------------

    COMPLEX TERRAIN RECEPTOR INFORMATION

                      XRCT         YRCT        ZRCT          XHH
                      (km)         (km)         (m)
                     ------        -----      ------         ----


-------------------
1
     Description of Complex Terrain Variables:
          XC, YC  = Coordinates of center of hill
          THETAH  = Orientation of major axis of hill (clockwise from
                    North)
          ZGRID   = Height of the  0  of the grid above mean sea
```

```
                    level
          RELIEF  = Height of the crest of the hill above the grid elevation
          EXPO 1  = Hill-shape exponent for the major axis
          EXPO 2  = Hill-shape exponent for the major axis
          SCALE 1 = Horizontal length scale along the major axis
          SCALE 2 = Horizontal length scale along the minor axis
          AMAX    = Maximum allowed axis length for the major axis
          BMAX    = Maximum allowed axis length for the major axis

          XRCT, YRCT = Coordinates of the complex terrain receptors
          ZRCT    = Height of the ground (MSL) at the complex terrain
                    Receptor
          XHH     = Hill number associated with each complex terrain receptor
                    (NOTE: MUST BE ENTERED AS A REAL NUMBER)

   **
     NOTE: DATA for each hill and CTSG receptor are treated as a separate
           input subgroup and therefore must end with an input group terminator.

-------------------------------------------------------------------------------


INPUT GROUP: 7 -- Chemical parameters for dry deposition of gases
--------------

      SPECIES     DIFFUSIVITY      ALPHA STAR      REACTIVITY    MESOPHYLL RESISTANCE     HENRY'S
LAW COEFFICIENT
       NAME        (cm**2/s)                                            (s/cm)
(dimensionless)
      -------     -----------      ----------      ----------    --------------------     -------
----------------

!          SO2 =     0.1509,         1000.,           8.,                0.,
0.04 !
*          NOX =     0.1656,            1.,           8.,                5.,
3.5 *
*         HNO3 =     0.1628,            1.,          18.,                0.,
0.00000008 *

!END!


-------------------------------------------------------------------------------


INPUT GROUP: 8 -- Size parameters for dry deposition of particles
--------------

     For SINGLE SPECIES, the mean and standard deviation are used to
     compute a deposition velocity for NINT (see group 9) size-ranges,
     and these are then averaged to obtain a mean deposition velocity.

     For GROUPED SPECIES, the size distribution should be explicitly
     specified (by the 'species' in the group), and the standard deviation
     for each should be entered as 0.  The model will then use the
     deposition velocity for the stated mean diameter.

      SPECIES      GEOMETRIC MASS MEAN        GEOMETRIC STANDARD
       NAME             DIAMETER                   DEVIATION
                        (microns)                  (microns)
      -------      -------------------        ------------------
!          SO4 =         0.48,                      2.   !
*          NO3 =         0.48,                      2.   *

!END!


-------------------------------------------------------------------------------


INPUT GROUP: 9 -- Miscellaneous dry deposition parameters
```

```
--------------

     Reference cuticle resistance (s/cm)
     (RCUTR)                          Default: 30    !  RCUTR = 30.0 !
     Reference ground resistance  (s/cm)
     (RGR)                            Default: 10    !    RGR = 10.0 !
     Reference pollutant reactivity
     (REACTR)                         Default: 8     ! REACTR = 8.0 !

     Number of particle-size intervals used to
     evaluate effective particle deposition velocity
     (NINT)                           Default: 9     !   NINT =  9  !

     Vegetation state in unirrigated areas
     (IVEG)                           Default: 1     !   IVEG =  1   !
        IVEG=1 for active and unstressed vegetation
        IVEG=2 for active and stressed vegetation
        IVEG=3 for inactive vegetation

!END!


-------------------------------------------------------------------------------


INPUT GROUP: 10 -- Wet Deposition Parameters
---------------


                      Scavenging Coefficient -- Units: (sec)**(-1)

       Pollutant      Liquid Precip.       Frozen Precip.
       ---------      --------------       --------------
!          SO2 =         3.0E-05,             0.0E00 !
!          SO4 =         1.0E-04,            3.0E-05 !
*         HNO3 =         6.0E-05,             0.0E00 *
*          NO3 =         1.0E-04,            3.0E-05 *

!END!


-------------------------------------------------------------------------------


INPUT GROUP: 11 -- Chemistry Parameters
---------------

     Ozone data input option (MOZ)     Default: 1            ! MOZ =  1   !
     (Used only if MCHEM = 1, 3, or 4)
        0 = use a monthly background ozone value
        1 = read hourly ozone concentrations from
            the OZONE.DAT data file

     Monthly ozone concentrations
     (Used only if MCHEM = 1, 3, or 4 and
      MOZ = 0 or MOZ = 1 and all hourly O3 data missing)
     (BCKO3) in ppb                   Default: 12*80.
     !  BCKO3 = 24., 29., 32., 44., 43., 43., 38., 36., 37., 28., 32., 20. !

     Monthly ammonia concentrations
     (Used only if MCHEM = 1, or 3)
     (BCKNH3) in ppb                  Default: 12*10.
     !  BCKNH3 = 12*0.50 !

     Nighttime SO2 loss rate (RNITE1)
     in percent/hour                  Default: 0.2          ! RNITE1 = .2 !

     Nighttime NOx loss rate (RNITE2)
     in percent/hour                  Default: 2.0          ! RNITE2 = 2.0 !

     Nighttime HNO3 formation rate (RNITE3)
```

```
     in percent/hour                  Default: 2.0         ! RNITE3 = 2.0 !

     H2O2 data input option (MH2O2)    Default: 1           ! MH2O2 =  1   !
     (Used only if MAQCHEM = 1)
        0 = use a monthly background H2O2 value
        1 = read hourly H2O2 concentrations from
            the H2O2.DAT data file

     Monthly H2O2 concentrations
     (Used only if MQACHEM = 1 and
      MH2O2 = 0 or MH2O2 = 1 and all hourly H2O2 data missing)
     (BCKH2O2) in ppb                 Default: 12*1.
     !  BCKH2O2 = 12*1.00 !


 --- Data for SECONDARY ORGANIC AEROSOL (SOA) Option
     (used only if MCHEM = 4)

     The SOA module uses monthly values of:
          Fine particulate concentration in ug/m^3 (BCKPMF)
          Organic fraction of fine particulate     (OFRAC)
          VOC / NOX ratio (after reaction)         (VCNX)
     to characterize the air mass when computing
     the formation of SOA from VOC emissions.
     Typical values for several distinct air mass types are:

        Month    1    2    3    4    5    6    7    8    9   10   11   12
                Jan  Feb  Mar  Apr  May  Jun  Jul  Aug  Sep  Oct  Nov  Dec

     Clean Continental
        BCKPMF   1.   1.   1.   1.   1.   1.   1.   1.   1.   1.   1.   1.
        OFRAC  .15  .15  .20  .20  .20  .20  .20  .20  .20  .20  .20  .15
        VCNX    50.  50.  50.  50.  50.  50.  50.  50.  50.  50.  50.  50.

     Clean Marine (surface)
        BCKPMF  .5   .5   .5   .5   .5   .5   .5   .5   .5   .5   .5   .5
        OFRAC  .25  .25  .30  .30  .30  .30  .30  .30  .30  .30  .30  .25
        VCNX    50.  50.  50.  50.  50.  50.  50.  50.  50.  50.  50.  50.

     Urban - low biogenic (controls present)
        BCKPMF  30.  30.  30.  30.  30.  30.  30.  30.  30.  30.  30.  30.
        OFRAC  .20  .20  .25  .25  .25  .25  .25  .25  .20  .20  .20  .20
        VCNX     4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.

     Urban - high biogenic (controls present)
        BCKPMF  60.  60.  60.  60.  60.  60.  60.  60.  60.  60.  60.  60.
        OFRAC  .25  .25  .30  .30  .30  .55  .55  .55  .35  .35  .35  .25
        VCNX    15.  15.  15.  15.  15.  15.  15.  15.  15.  15.  15.  15.

     Regional Plume
        BCKPMF  20.  20.  20.  20.  20.  20.  20.  20.  20.  20.  20.  20.
        OFRAC  .20  .20  .25  .35  .25  .40  .40  .40  .30  .30  .30  .20
        VCNX    15.  15.  15.  15.  15.  15.  15.  15.  15.  15.  15.  15.

     Urban - no controls present
        BCKPMF 100. 100. 100. 100. 100. 100. 100. 100. 100. 100. 100. 100.
        OFRAC  .30  .30  .35  .35  .35  .55  .55  .55  .35  .35  .35  .30
        VCNX     2.   2.   2.   2.   2.   2.   2.   2.   2.   2.   2.   2.

     Default: Clean Continental
     !  BCKPMF = 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00 !
     !  OFRAC  = 0.15, 0.15, 0.20, 0.20, 0.20, 0.20, 0.20, 0.20, 0.20, 0.20, 0.20, 0.15 !
     !  VCNX   = 50.00, 50.00, 50.00, 50.00, 50.00, 50.00, 50.00, 50.00, 50.00, 50.00, 50.00,
50.00 !


!END!


-------------------------------------------------------------------------------
```

```
INPUT GROUP: 12 -- Misc. Dispersion and Computational Parameters
---------------

     Horizontal size of puff (m) beyond which
     time-dependent dispersion equations (Heffter)
     are used to determine sigma-y and
     sigma-z (SYTDEP)                           Default: 550.   ! SYTDEP = 5.5E02 !

     Switch for using Heffter equation for sigma z
     as above (0 = Not use Heffter; 1 = use Heffter
     (MHFTSZ)                                   Default: 0      ! MHFTSZ =  0   !

     Stability class used to determine plume
     growth rates for puffs above the boundary
     layer (JSUP)                               Default: 5      ! JSUP =  5   !

     Vertical dispersion constant for stable
     conditions (k1 in Eqn. 2.7-3)  (CONK1)     Default: 0.01   ! CONK1 = .01 !

     Vertical dispersion constant for neutral/
     unstable conditions (k2 in Eqn. 2.7-4)
     (CONK2)                                    Default: 0.1    ! CONK2 = .1 !

     Factor for determining Transition-point from
     Schulman-Scire to Huber-Snyder Building Downwash
     scheme (SS used for Hs < Hb + TBD * HL)
     (TBD)                                      Default: 0.5    ! TBD = .5 !
        TBD < 0   ==> always use Huber-Snyder
        TBD = 1.5 ==> always use Schulman-Scire
        TBD = 0.5 ==> ISC Transition-point

     Range of land use categories for which
     urban dispersion is assumed
     (IURB1, IURB2)                             Default: 10     ! IURB1 =  10  !
                                                         19     ! IURB2 =  19  !

     Site characterization parameters for single-point Met data files ---------
     (needed for METFM = 2,3,4)

        Land use category for modeling domain
        (ILANDUIN)                              Default: 20     ! ILANDUIN =  20  !

        Roughness length (m) for modeling domain
        (Z0IN)                                  Default: 0.25   ! Z0IN = .25 !

        Leaf area index for modeling domain
        (XLAIIN)                                Default: 3.0    ! XLAIIN = 3.0 !

        Elevation above sea level (m)
        (ELEVIN)                                Default: 0.0    ! ELEVIN = .0 !

        Latitude (degrees) for met location
        (XLATIN)                                Default: -999.  ! XLATIN = -999.0 !

        Longitude (degrees) for met location
        (XLONIN)                                Default: -999.  ! XLONIN = -999.0 !

     Specialized information for interpreting single-point Met data files -----

        Anemometer height (m) (Used only if METFM = 2,3)
        (ANEMHT)                                Default: 10.    ! ANEMHT = 10.0 !

        Form of lateral turbulance data in PROFILE.DAT file
        (Used only if METFM = 4 or MTURBVW = 1 or 3)
        (ISIGMAV)                               Default: 1      ! ISIGMAV =  1  !
            0 = read sigma-theta
            1 = read sigma-v

        Choice of mixing heights (Used only if METFM = 4)
        (IMIXCTDM)                              Default: 0      ! IMIXCTDM =  0  !
```

```
       0 = read PREDICTED mixing heights
       1 = read OBSERVED mixing heights

Maximum length of a slug (met. grid units)
(XMXLEN)                                  Default: 1.0    ! XMXLEN = 1.0 !

Maximum travel distance of a puff/slug (in
grid units) during one sampling step
(XSAMLEN)                                 Default: 1.0    ! XSAMLEN = 1.0 !

Maximum Number of slugs/puffs release from
one source during one time step
(MXNEW)                                   Default: 99     ! MXNEW =  99   !

Maximum Number of sampling steps for
one puff/slug during one time step
(MXSAM)                                   Default: 99     ! MXSAM =  99   !

Number of iterations used when computing
the transport wind for a sampling step
that includes gradual rise (for CALMET
and PROFILE winds)
(NCOUNT)                                  Default: 2      ! NCOUNT =  2   !

Minimum sigma y for a new puff/slug (m)
(SYMIN)                                   Default: 1.0    ! SYMIN = .01  !

Minimum sigma z for a new puff/slug (m)
(SZMIN)                                   Default: 1.0    ! SZMIN = .01  !

Default minimum turbulence velocities
sigma-v and sigma-w for each
stability class (m/s)
(SVMIN(6) and SWMIN(6))     Default SVMIN : .50,  .50,  .50,  .50,  .50,  .50
                            Default SWMIN : .20,  .12,  .08,  .06,  .03,  .016

                          Stability Class :  A     B     C     D     E     F
                                            ---   ---   ---   ---   ---   ---
                                ! SVMIN = 0.500, 0.500, 0.500, 0.500, 0.500, 0.500!
                                ! SWMIN = 0.200, 0.120, 0.080, 0.060, 0.030, 0.016!

Divergence criterion for dw/dz across puff
used to initiate adjustment for horizontal
convergence (1/s)
Partial adjustment starts at CDIV(1), and
full adjustment is reached at CDIV(2)
(CDIV(2))                                 Default: 0.0,0.0  ! CDIV = .0, .0 !

Minimum wind speed (m/s) allowed for
non-calm conditions. Also used as minimum
speed returned when using power-law
extrapolation toward surface
(WSCALM)                                  Default: 0.5    ! WSCALM = .5 !

Maximum mixing height (m)
(XMAXZI)                                  Default: 3000.  ! XMAXZI = 3000.0 !

Minimum mixing height (m)
(XMINZI)                                  Default: 50.    ! XMINZI = 50.0 !

Default wind speed classes --
5 upper bounds (m/s) are entered;
the 6th class has no upper limit
(WSCAT(5))                      Default   :
                                ISC RURAL : 1.54, 3.09, 5.14, 8.23, 10.8 (10.8+)

                         Wind Speed Class :  1     2     3     4     5
                                            ---   ---   ---   ---   ---
                                  ! WSCAT = 1.54, 3.09, 5.14, 8.23, 10.80 !

Default wind speed profile power-law
```

```
exponents for stabilities 1-6
(PLX0(6))                        Default   : ISC RURAL values
                                 ISC RURAL : .07, .07, .10, .15, .35, .55
                                 ISC URBAN : .15, .15, .20, .25, .30, .30

                           Stability Class :  A     B     C     D     E     F
                                             ---   ---   ---   ---   ---   ---
                                    ! PLX0 = 0.07, 0.07, 0.10, 0.15, 0.35, 0.55 !

Default potential temperature gradient
for stable classes E, F (degK/m)
(PTG0(2))                        Default: 0.020, 0.035
                                    ! PTG0 = 0.020,   0.035 !

Default plume path coefficients for
each stability class (used when option
for partial plume height terrain adjustment
is selected -- MCTADJ=3)
(PPC(6))                   Stability Class :  A     B     C     D     E     F
                              Default  PPC : .50,  .50,  .50,  .50,  .35,  .35
                                             ---   ---   ---   ---   ---   ---
                                    !  PPC = 0.50, 0.50, 0.50, 0.50, 0.35, 0.35 !

Slug-to-puff transition criterion factor
equal to sigma-y/length of slug
(SL2PF)                                Default: 10.        ! SL2PF = 10.0 !

Puff-splitting control variables ------------------------

  VERTICAL SPLIT
  --------------

  Number of puffs that result every time a puff
  is split - nsplit=2 means that 1 puff splits
  into 2
  (NSPLIT)                             Default:   3        ! NSPLIT =  3  !

  Time(s) of a day when split puffs are eligible to
  be split once again; this is typically set once
  per day, around sunset before nocturnal shear develops.
  24 values: 0 is midnight (00:00) and 23 is 11 PM (23:00)
  0=do not re-split    1=eligible for re-split
  (IRESPLIT(24))                       Default:  Hour 17 = 1
  !  IRESPLIT = 0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0 !

  Split is allowed only if last hour's mixing
  height (m) exceeds a minimum value
  (ZISPLIT)                            Default: 100.       ! ZISPLIT = 100.0 !

  Split is allowed only if ratio of last hour's
  mixing ht to the maximum mixing ht experienced
  by the puff is less than a maximum value (this
  postpones a split until a nocturnal layer develops)
  (ROLDMAX)                            Default: 0.25       ! ROLDMAX = 0.25 !


  HORIZONTAL SPLIT
  ----------------

  Number of puffs that result every time a puff
  is split - nsplith=5 means that 1 puff splits
  into 5
  (NSPLITH)                            Default:   5        ! NSPLITH =  5  !

  Minimum sigma-y (Grid Cells Units) of puff
  before it may be split
  (SYSPLITH)                           Default:  1.0       ! SYSPLITH = 1.0 !

  Minimum puff elongation rate (SYSPLITH/hr) due to
  wind shear, before it may be split
  (SHSPLITH)                           Default:  2.        ! SHSPLITH = 2.0 !
```

```
       Minimum concentration (g/m^3) of each
       species in puff before it may be split
       Enter array of NSPEC values; if a single value is
       entered, it will be used for ALL species
       (CNSPLITH)                        Default:  1.0E-07   ! CNSPLITH = 1.0E-07 !

     Integration control variables ------------------------

       Fractional convergence criterion for numerical SLUG
       sampling integration
       (EPSSLUG)                         Default:   1.0e-04  ! EPSSLUG = 1.0E-04 !

       Fractional convergence criterion for numerical AREA
       source integration
       (EPSAREA)                         Default:   1.0e-06  ! EPSAREA = 1.0E-06 !

       Trajectory step-length (m) used for numerical rise
       integration
       (DSRISE)                          Default:   1.0      ! DSRISE = 1.0 !

!END!


-------------------------------------------------------------------------------


INPUT GROUPS: 13a, 13b, 13c, 13d -- Point source parameters
--------------------------------

---------------
Subgroup (13a)
---------------

     Number of point sources with
     parameters provided below      (NPT1)  No default  !  NPT1 =  1  !

     Units used for point source
     emissions below                (IPTU)  Default: 1  !  IPTU =   1  !
           1 =        g/s
           2 =       kg/hr
           3 =       lb/hr
           4 =     tons/yr
           5 =     Odour Unit * m**3/s  (vol. flux of odour compound)
           6 =     Odour Unit * m**3/min
           7 =     metric tons/yr

     Number of source-species
     combinations with variable
     emissions scaling factors
     provided below in (13d)        (NSPT1) Default: 0  !  NSPT1 =  0  !

     Number of point sources with
     variable emission parameters
     provided in external file      (NPT2)  No default  !  NPT2 =  0  !

     (If NPT2 > 0, these point
     source emissions are read from
     the file: PTEMARB.DAT)

!END!

---------------
Subgroup (13b)
---------------
                                      a
          POINT SOURCE: CONSTANT DATA
          -----------------------------
                                                                              b          c
  Source       X UTM      Y UTM     Stack   Base     Stack    Exit  Exit    Bldg.  Emission
   No.     Coordinate Coordinate Height Elevation Diameter  Vel.  Temp.   Dwash   Rates
```

```
             (km)      (km)       (m)      (m)       (m)  (m/s) (deg. K)
  ------   ---------- ---------- ------  ------   -------- ----- -------- ----- --------
   1 ! SRCNAM =  STACK1 !
   1 ! X =    750.,    4150.,    100.,    100.,     8.0,     26.,  430.,   0.0,   6.0E03, 0.0  !
   1 ! FMFAC  =      1.0 !   !END!

--------

    a
     Data for each source are treated as a separate input subgroup
     and therefore must end with an input group terminator.

     SRCNAM  is a 12-character name for a source
             (No default)
     X       is an array holding the source data listed by the column headings
             (No default)
     SIGYZI  is an array holding the initial sigma-y and sigma-z (m)
             (Default: 0.,0.)
     FMFAC   is a vertical momentum flux factor (0. or 1.0) used to represent
             the effect of rain-caps or other physical configurations that
             reduce momentum rise associated with the actual exit velocity.
             (Default: 1.0  -- full momentum used)

    b
     0. = No building downwash modeled, 1. = downwash modeled
     NOTE: must be entered as a REAL number (i.e., with decimal point)

    c
     An emission rate must be entered for every pollutant modeled.
     Enter emission rate of zero for secondary pollutants that are
     modeled, but not emitted.  Units are specified by IPTU
     (e.g. 1 for g/s).

---------------
Subgroup (13c)
---------------

           BUILDING DIMENSION DATA FOR SOURCES SUBJECT TO DOWNWASH
           ------------------------------------------------------
Source                                                                a
 No.       Effective building width and height (in meters) every 10 degrees
------     ---------------------------------------------------------------


--------

    a
     Each pair of width and height values is treated as a separate input
     subgroup and therefore must end with an input group terminator.

---------------
Subgroup (13d)
---------------
                                                a
          POINT SOURCE: VARIABLE EMISSIONS DATA
          ---------------------------------------

     Use this subgroup to describe temporal variations in the emission
     rates given in 13b.  Factors entered multiply the rates in 13b.
     Skip sources here that have constant emissions.  For more elaborate
     variation in source parameters, use PTEMARB.DAT and NPT2 > 0.

     IVARY determines the type of variation, and is source-specific:
     (IVARY)                                Default: 0
           0 =       Constant
           1 =       Diurnal cycle (24 scaling factors: hours 1-24)
           2 =       Monthly cycle (12 scaling factors: months 1-12)
           3 =       Hour & Season (4 groups of 24 hourly scaling factors,
                                    where first group is DEC-JAN-FEB)
           4 =       Speed & Stab. (6 groups of 6 scaling factors, where
                                    first group is Stability Class A,
```

```
                                    and the speed classes have upper
                                    bounds (m/s) defined in Group 12
           5 =       Temperature   (12 scaling factors, where temperature
                                    classes have upper bounds (C) of:
                                    0, 5, 10, 15, 20, 25, 30, 35, 40,
                                    45, 50, 50+)



--------
    a
     Data for each species are treated as a separate input subgroup
     and therefore must end with an input group terminator.


-------------------------------------------------------------------------------


INPUT GROUPS: 14a, 14b, 14c, 14d -- Area source parameters
--------------------------------

---------------
Subgroup (14a)
---------------

     Number of polygon area sources with
     parameters specified below (NAR1)       No default  !  NAR1 =  0   !

     Units used for area source
     emissions below            (IARU)       Default: 1  !  IARU =   1  !
           1 =        g/m**2/s
           2 =       kg/m**2/hr
           3 =       lb/m**2/hr
           4 =     tons/m**2/yr
           5 =     Odour Unit * m/s  (vol. flux/m**2 of odour compound)
           6 =     Odour Unit * m/min
           7 =     metric tons/m**2/yr

     Number of source-species
     combinations with variable
     emissions scaling factors
     provided below in (14d)        (NSAR1) Default: 0  !  NSAR1 =  0  !

     Number of buoyant polygon area sources
     with variable location and emission
     parameters (NAR2)                      No default  !  NAR2 =  0   !
     (If NAR2 > 0, ALL parameter data for
     these sources are read from the file: BAEMARB.DAT)

!END!

---------------
Subgroup (14b)
---------------
                                     a
          AREA SOURCE: CONSTANT DATA
          ----------------------------
                                                         b
Source           Effect.    Base      Initial    Emission
 No.             Height   Elevation   Sigma z     Rates
                   (m)       (m)        (m)
-------          ------    ------     --------   ---------


--------
    a
     Data for each source are treated as a separate input subgroup
     and therefore must end with an input group terminator.
    b
     An emission rate must be entered for every pollutant modeled.
     Enter emission rate of zero for secondary pollutants that are
```

```
     modeled, but not emitted.  Units are specified by IARU
     (e.g. 1 for g/m**2/s).

---------------
Subgroup (14c)
---------------

           COORDINATES (UTM-km) FOR EACH VERTEX(4) OF EACH POLYGON
           --------------------------------------------------------
Source                                                             a
 No.       Ordered list of X followed by list of Y, grouped by source
------     ------------------------------------------------------------


--------
    a
     Data for each source are treated as a separate input subgroup
     and therefore must end with an input group terminator.


---------------
Subgroup (14d)
---------------
                                               a
          AREA SOURCE: VARIABLE EMISSIONS DATA
          --------------------------------------

     Use this subgroup to describe temporal variations in the emission
     rates given in 14b.  Factors entered multiply the rates in 14b.
     Skip sources here that have constant emissions.  For more elaborate
     variation in source parameters, use BAEMARB.DAT and NAR2 > 0.

     IVARY determines the type of variation, and is source-specific:
     (IVARY)                               Default: 0
           0 =       Constant
           1 =       Diurnal cycle (24 scaling factors: hours 1-24)
           2 =       Monthly cycle (12 scaling factors: months 1-12)
           3 =       Hour & Season (4 groups of 24 hourly scaling factors,
                                    where first group is DEC-JAN-FEB)
           4 =       Speed & Stab. (6 groups of 6 scaling factors, where
                                    first group is Stability Class A,
                                    and the speed classes have upper
                                    bounds (m/s) defined in Group 12
           5 =       Temperature   (12 scaling factors, where temperature
                                    classes have upper bounds (C) of:
                                    0, 5, 10, 15, 20, 25, 30, 35, 40,
                                    45, 50, 50+)



--------
    a
     Data for each species are treated as a separate input subgroup
     and therefore must end with an input group terminator.


-------------------------------------------------------------------------------

INPUT GROUPS: 15a, 15b, 15c -- Line source parameters
---------------------------

---------------
Subgroup (15a)
---------------

     Number of buoyant line sources
     with variable location and emission
     parameters (NLN2)                              No default  !  NLN2 =  0   !

     (If NLN2 > 0, ALL parameter data for
      these sources are read from the file: LNEMARB.DAT)
```

```
     Number of buoyant line sources (NLINES)        No default   ! NLINES =  0  !

     Units used for line source
     emissions below               (ILNU)          Default: 1  !  ILNU =   1  !
           1 =       g/s
           2 =      kg/hr
           3 =      lb/hr
           4 =    tons/yr
           5 =    Odour Unit * m**3/s  (vol. flux of odour compound)
           6 =    Odour Unit * m**3/min
           7 =    metric tons/yr

     Number of source-species
     combinations with variable
     emissions scaling factors
     provided below in (15c)       (NSLN1) Default: 0  !  NSLN1 =  0  !

     Maximum number of segments used to model
     each line (MXNSEG)                            Default: 7   ! MXNSEG =  7  !

     The following variables are required only if NLINES > 0.  They are
     used in the buoyant line source plume rise calculations.

        Number of distances at which               Default: 6   ! NLRISE =  6  !
        transitional rise is computed

        Average building length (XL)               No default   ! XL = .0 !
                                                   (in meters)

        Average building height (HBL)              No default   ! HBL = .0 !
                                                   (in meters)

        Average building width (WBL)               No default   ! WBL = .0 !
                                                   (in meters)

        Average line source width (WML)            No default   ! WML = .0 !
                                                   (in meters)

        Average separation between buildings (DXL)  No default   ! DXL = .0 !
                                                   (in meters)

        Average buoyancy parameter (FPRIMEL)       No default   ! FPRIMEL = .0 !
                                                   (in m**4/s**3)

!END!

---------------
Subgroup (15b)
---------------

          BUOYANT LINE SOURCE: CONSTANT DATA
          ----------------------------------
                                                                                     a
Source     Beg. X      Beg. Y      End. X    End. Y     Release    Base        Emission
 No.     Coordinate  Coordinate  Coordinate Coordinate  Height    Elevation      Rates
            (km)        (km)        (km)       (km)       (m)       (m)
------   ----------  ----------  ---------  ----------  -------   ---------    ---------

--------

    a
     Data for each source are treated as a separate input subgroup
     and therefore must end with an input group terminator.

    b
     An emission rate must be entered for every pollutant modeled.
     Enter emission rate of zero for secondary pollutants that are
     modeled, but not emitted.  Units are specified by ILNTU
     (e.g. 1 for g/s).
```

```
---------------
Subgroup (15c)
---------------
                                                       a
          BUOYANT LINE SOURCE: VARIABLE EMISSIONS DATA
          ----------------------------------------------

     Use this subgroup to describe temporal variations in the emission
     rates given in 15b.  Factors entered multiply the rates in 15b.
     Skip sources here that have constant emissions.

     IVARY determines the type of variation, and is source-specific:
     (IVARY)                                Default: 0
           0 =       Constant
           1 =       Diurnal cycle (24 scaling factors: hours 1-24)
           2 =       Monthly cycle (12 scaling factors: months 1-12)
           3 =       Hour & Season (4 groups of 24 hourly scaling factors,
                                    where first group is DEC-JAN-FEB)
           4 =       Speed & Stab. (6 groups of 6 scaling factors, where
                                    first group is Stability Class A,
                                    and the speed classes have upper
                                    bounds (m/s) defined in Group 12
           5 =       Temperature   (12 scaling factors, where temperature
                                    classes have upper bounds (C) of:
                                    0, 5, 10, 15, 20, 25, 30, 35, 40,
                                    45, 50, 50+)



--------
    a
     Data for each species are treated as a separate input subgroup
     and therefore must end with an input group terminator.


--------------------------------------------------------------------------------


INPUT GROUPS: 16a, 16b, 16c -- Volume source parameters
---------------------------

---------------
Subgroup (16a)
---------------

     Number of volume sources with
     parameters provided in 16b,c (NVL1)     No default  !  NVL1 =  0   !

     Units used for volume source
     emissions below in 16b       (IVLU)     Default: 1  !  IVLU =   1  !
           1 =        g/s
           2 =       kg/hr
           3 =       lb/hr
           4 =     tons/yr
           5 =     Odour Unit * m**3/s  (vol. flux of odour compound)
           6 =     Odour Unit * m**3/min
           7 =     metric tons/yr

     Number of source-species
     combinations with variable
     emissions scaling factors
     provided below in (16c)      (NSVL1)    Default: 0  !  NSVL1 =  0  !

     Number of volume sources with
     variable location and emission
     parameters                   (NVL2)     No default  !  NVL2 =   0   !

     (If NVL2 > 0, ALL parameter data for
      these sources are read from the VOLEMARB.DAT file(s) )

!END!
```

```
---------------
Subgroup (16b)
---------------
                                        a
           VOLUME SOURCE: CONSTANT DATA
           ------------------------------
                                                                                b
       X UTM      Y UTM      Effect.    Base     Initial    Initial    Emission
     Coordinate  Coordinate   Height   Elevation  Sigma y    Sigma z     Rates
       (km)       (km)         (m)       (m)        (m)       (m)
     ----------  ----------   ------    ------    --------   --------   --------


--------
    a
     Data for each source are treated as a separate input subgroup
     and therefore must end with an input group terminator.

    b
     An emission rate must be entered for every pollutant modeled.
     Enter emission rate of zero for secondary pollutants that are
     modeled, but not emitted.  Units are specified by IVLU
     (e.g. 1 for g/s).

---------------
Subgroup (16c)
---------------
                                                 a
          VOLUME SOURCE: VARIABLE EMISSIONS DATA
          ---------------------------------------

     Use this subgroup to describe temporal variations in the emission
     rates given in 16b.  Factors entered multiply the rates in 16b.
     Skip sources here that have constant emissions.  For more elaborate
     variation in source parameters, use VOLEMARB.DAT and NVL2 > 0.

     IVARY determines the type of variation, and is source-specific:
     (IVARY)                         Default: 0
           0 =       Constant
           1 =       Diurnal cycle (24 scaling factors: hours 1-24)
           2 =       Monthly cycle (12 scaling factors: months 1-12)
           3 =       Hour & Season (4 groups of 24 hourly scaling factors,
                                    where first group is DEC-JAN-FEB)
           4 =       Speed & Stab. (6 groups of 6 scaling factors, where
                                    first group is Stability Class A,
                                    and the speed classes have upper
                                    bounds (m/s) defined in Group 12
           5 =       Temperature   (12 scaling factors, where temperature
                                    classes have upper bounds (C) of:
                                    0, 5, 10, 15, 20, 25, 30, 35, 40,
                                    45, 50, 50+)



--------
    a
     Data for each species are treated as a separate input subgroup
     and therefore must end with an input group terminator.


-------------------------------------------------------------------------------

INPUT GROUPS: 17a & 17b -- Non-gridded (discrete) receptor information
----------------------

---------------
Subgroup (17a)
---------------

     Number of non-gridded receptors (NREC)  No default  !  NREC =  790   !
```

```
!END!

---------------
Subgroup (17b)
---------------
                                                  a
           NON-GRIDDED (DISCRETE) RECEPTOR DATA
           ------------------------------------

                  X UTM       Y UTM        Ground       Height   b
Receptor       Coordinate  Coordinate   Elevation   Above Ground
  No.             (km)        (km)         (m)          (m)
--------       ----------  ----------   ---------   ------------
  1238 ! X =     692.500,   4218.500,     505.000,       0.000!   !END!
  1239 ! X =     693.500,   4218.500,     550.000,       0.000!   !END!
  1240 ! X =     690.500,   4219.500,     461.000,       0.000!   !END!
  1241 ! X =     691.500,   4219.500,     631.000,       0.000!   !END!
  1242 ! X =     692.500,   4219.500,     543.000,       0.000!   !END!
  1243 ! X =     693.500,   4219.500,     575.000,       0.000!   !END!
  1244 ! X =     694.500,   4219.500,     670.000,       0.000!   !END!
  1245 ! X =     690.500,   4220.500,     500.000,       0.000!   !END!
  1246 ! X =     691.500,   4220.500,     591.000,       0.000!   !END!
  1247 ! X =     692.500,   4220.500,     675.000,       0.000!   !END!
  1248 ! X =     693.500,   4220.500,     647.000,       0.000!   !END!
  1249 ! X =     694.500,   4220.500,     687.000,       0.000!   !END!
  1250 ! X =     690.500,   4221.500,     495.000,       0.000!   !END!
  1251 ! X =     691.500,   4221.500,     705.000,       0.000!   !END!
  1252 ! X =     692.500,   4221.500,     771.000,       0.000!   !END!
  1253 ! X =     693.500,   4221.500,     653.000,       0.000!   !END!
  1254 ! X =     694.500,   4221.500,     653.000,       0.000!   !END!
  1255 ! X =     695.500,   4221.500,     465.000,       0.000!   !END!
  1256 ! X =     691.500,   4222.500,     559.000,       0.000!   !END!
  1257 ! X =     692.500,   4222.500,     715.000,       0.000!   !END!
  1258 ! X =     693.500,   4222.500,     735.000,       0.000!   !END!
  1259 ! X =     694.500,   4222.500,     763.000,       0.000!   !END!
  1260 ! X =     695.500,   4222.500,     626.000,       0.000!   !END!
  1261 ! X =     691.500,   4223.500,     487.000,       0.000!   !END!
  1262 ! X =     692.500,   4223.500,     570.000,       0.000!   !END!
  1263 ! X =     693.500,   4223.500,     642.000,       0.000!   !END!
  1264 ! X =     694.500,   4223.500,     878.000,       0.000!   !END!
  1265 ! X =     695.500,   4223.500,     762.000,       0.000!   !END!
  1266 ! X =     696.500,   4223.500,     453.000,       0.000!   !END!
  1267 ! X =     697.500,   4223.500,     305.000,       0.000!   !END!
  1268 ! X =     693.500,   4224.500,     651.000,       0.000!   !END!
  1269 ! X =     694.500,   4224.500,     797.000,       0.000!   !END!
  1270 ! X =     695.500,   4224.500,     785.000,       0.000!   !END!
  1271 ! X =     696.500,   4224.500,     516.000,       0.000!   !END!
  1272 ! X =     697.500,   4224.500,     454.000,       0.000!   !END!
  1273 ! X =     691.500,   4225.500,     456.000,       0.000!   !END!
  1274 ! X =     692.500,   4225.500,     639.000,       0.000!   !END!
  1275 ! X =     693.500,   4225.500,     688.000,       0.000!   !END!
  1276 ! X =     694.500,   4225.500,     789.000,       0.000!   !END!
  1277 ! X =     695.500,   4225.500,     786.000,       0.000!   !END!
  1278 ! X =     696.500,   4225.500,     657.000,       0.000!   !END!
  1279 ! X =     697.500,   4225.500,     514.000,       0.000!   !END!


*****************   REMAINING RECEPTORS REMOVED FOR THIS LISTING    ***************


-------------
    a
     Data for each receptor are treated as a separate input subgroup
     and therefore must end with an input group terminator.

    b
     Receptor height above ground is optional.  If no value is entered,
     the receptor is placed on the ground.
```