TRC

Assessment of Air Quality Impacts of Emissions from the Alcoa Aluminum Plant in Husavik, Iceland.

March 2010

Útdráttur á íslensku

Alcoa fékk TRC til setja upp loftdreifingarlíkan vegna fyrirhugaðs álvers Alcoa á Bakka norðan Húsavíkur. Sömu aðilar gerðu samskonar útreikninga fyrir álver Alcoa Fjarðaáls á Reyðarfirði í tengslum við mat á umhverfisáhrifum en fyrirtækið hét þá Earth Tech. Líkanið reiknar áhrif á loftgæði vegna útblásturs svifryks (PM_{10}), brennisteinsdíoxíðs (SO_2), loftkennds flúoríðs (HF), vokvetniskolefna (PAH) og benzo(a)pyrene (BaP). Í skýrslunni er metinn styrkur PM_{10}, SO_2, HF, allra PAH og BaP og borinn saman við viðeigandi loftgæðastaðla úr íslenskum reglugerðum, norskum viðmiðunarreglum og tilskipunum Evrópusambandsins.

Aðferðafræðin sem notuð er við þessa athugun byggir á viðamiklu veðurfræði- og dreifingar-líkani sem er það fullkomnasta sem notað er í loftdreifingarreikningum. Líkanaðferðin er byggð á veðurfræðilega spálíkaninu CALMET (Scire et al., 2000a) og tímaháða dreifingar-líkaninu CALPUFF (Scire o.fl., 2000b). Umhverfisstofnun Bandaríkjanna (U.S. EPA) mælir með notkun CALPUFF við mat á loftgæðum og flutningi efna í lofti um langan veg og, eftir því sem við á, við staðbundin vandamál þar sem streymi er flókið, s.s. breytileika veðurs vegna þátta eins og nálægðar flókins landslags eða vatns, svælingar (strandsvælingar eða brot hitahvarfa), lítils vindhraða eða annarra þátta þar sem æstæðir líkanreikningar eiga ekki við (U.S. EPA, Federal Register, April 15, 2003).

Við athugun Umhverfisstofnunar Bandaríkjanna vegna vals á líkönum hefur CALPUFF líkanið farið í gegnum ítarlegar úttektir og prófanir. Líkanið hefur einnig farið í gegnum opið athugasemdaferli samkvæmt bandarískum lögum um loftgæði. Prófanir á CALPUFF líkaninu við reikninga nálægt upptökum eru t.d. mat á brennisteinsdíoxíði fyrir tvo skorsteina á orkuveri í dal með flóknu landslagi og mælingar á sporefni fyrir háan skorstein á orkuveri á flatlendi (Strimaitis et al., 1998), mat á útblæstri umhverfis álver í Kanada (Morrison et al., 2003), orkuver í Texas (Robe et al., 2002), og við umfangsmikið mat á samanlögðum áhrifum frá mörgum upptökum í mismunandi fjarlægðum (Scire et al., 2003). Á meðal annarra prófa á CALPUFF eru Bennett et al. (2002), Levy et al. (2002) and Zhou et al. (2003). Reiknirit CALPUFF líkansins fyrir langar uppsprettur byggir á BLP dreifingarlíkani, sem hefur verið prófað við álver í Arkansas og Tennessee (Scire and Schulman, 1981). CALPUFF líkanið er notað um allan heim og eru notendur þess í yfir eitt hundrað löndum. Líkanið hefur verið ritrýnt og prófað við margs konar aðstæður um allan heim.

CALMET/CALPUFF líkönin voru valin af Alcoa vegna eftirfarandi ástæðna:

- Flókið landslag nærri álverinu sem leiðir til þess að vindur getur verið breyti-legur frá einum stað til annars.
- Nálægð við hafið leiðir til breytileika í veðurþáttum og mikilvægi hafgolu.
- Hitauppstreymi frá álverinu veldur staðbundnum breytingum á dreifingar-aðstæðum nálægt álverinu.
- Hugsanlegt mikilvægi logns og hægviðristímabila á svæðinu.
- Hugsanlegt mikilvægi stöðnunar loftmassa, hringstreymis loftmassa og svælingar.

CALMET líkanið notar fáanleg veðurgögn og upplýsingar um landslag til að framkalla vindhraðasvið sem er breytilegt í rúmi í samræmi við landslag og stöðuleika lofts á svæðinu. Í þessu tilfelli er reiknað þrívítt vindsvið með upplausn 1 km til líkja sem best eftir stað-bundnum landslagsáhrifum.

Samanburður á reiknuðum styrk vegna fyrirhugaðs álvers og gildandi loftgæðastöðlum leiðir í ljós að álver Alcoa á Bakka fullnægir öllum kröfum varðandi loftgæði, hvort sem er með eða án vothreinsunar.

Assessment of Air Quality Impacts of Emissions from the Alcoa Aluminum Plant in Húsavík, Iceland

March 2010

Prepared For:

Alcoa, Inc.
Pittsburgh, PA

Submitted By:
TRC
650 Suffolk Street
Lowell, Massachusetts 01854
(978) 656-3627

Table of Contents

APPENDICES

Page

LIST OF FIGURES

LIST OF FIGURES

LIST OF FIGURES

LIST OF FIGURES

LIST OF TABLES

1. INTRODUCTION

TRC has been retained by Alcoa to conduct refined air quality dispersion modeling of the proposed Alcoa aluminum reduction facility at an industrial site in Húsavík, located approximately 2-3 km north of Húsavík town (66.0476N; 17.3436W; X= 393.850 km; Y=7327.204 km in UTM-28, datum WGS-84) in Iceland. The modeling analysis evaluates the air quality impacts due to emissions of particulate matter (PM_{10}), sulfur dioxide (SO_2), hydrogen fluoride (HF), Polycyclic Aromatic Hydrocarbons (PAHs) and benzo(a)pyrene (BaP). This study estimates the concentration of PM_{10}, SO_2, HF, PAHs and BaP and compares these concentrations with the corresponding ambient standards or air quality guidelines from the Icelandic regulation, European Union directive or Norwegian guidelines.

The techniques used for this study involve the use of a comprehensive meteorological and dispersion modeling system representing the current state-of-the science in regulatory air quality modeling. The modeling approach is based on the CALMET diagnostic meteorological model (Scire et al., 2000a) and the CALPUFF non-steady-state dispersion model (Scire et al., 2000b). The U.S. Environmental Protection Agency (U.S. EPA) has adopted the CALPUFF modeling system as a *Guideline Model* for Class I impact ambient air quality assessments and other long range transport applications or, on a case-by-case basis, near-field applications involving complex flows, such as spatial changes in meteorological fields due to factors such as the presence of complex terrain or water bodies, plume fumigation (coastal fumigation or inversion break-up conditions), light wind speed or calm wind impacts, or other factors for which a steady-state straight-line modeling approach is not appropriate (U.S. EPA, Federal Register, April 15, 2003).

CALPUFF was designed to be a regulatory modeling tool that would treat multiple effects within a single modeling framework. It is consistent with Guideline plume modeling techniques where and when those techniques are valid (i.e., under steady-state conditions), but CALPUFF offers the advantage of accounting for non-steady-state effects when they exist. CALPUFF was developed to be suitable for use in the near-field (e.g., at the property fence line) at distances of tens of meters out to distances of several hundred kilometers. It includes near-field effects, such as transitional plume rise, building downwash effects, stack-tip downwash, momentum and buoyant plume rise, as well as far-field effects such as wet and dry deposition, chemical transformation, long range dispersion, and other factors (see Section 4). The model explicitly includes the buoyant line source algorithms in the Buoyant Line and Point Source (BLP) model (Schulman and Scire, 1980). BLP is accepted by the U.S. EPA as a *Guideline model* for buoyant line source emissions.

The CALPUFF model has been extensively evaluated and tested as part of the U.S. EPA Guideline model review process. The model has been subjected to extensive public review and comment through a public process mandated by the Clean Air Act. Evaluations of the CALPUFF model in near-field applications include an SO_2 evaluation for a pair of power plant stacks in a river valley with complex terrain and a tracer evaluation of a tall power plant stack in flat terrain (Strimaitis et al., 1998), near-field evaluation of smelter emissions in Canada (Morrison et al., 2003), a smelter-power plant facility in Texas (Robe et al., 2002), and an extensive evaluation of cumulative impacts from many sources at various distances (Scire et al., 2003). Other CALPUFF evaluation studies include Bennett et al. (2002), Levy et al. (2002) and Zhou et al. (2003). The algorithms in CALPUFF for line source dispersion are based on the BLP dispersion model which have been evaluated at aluminum plants in Arkansas and Tennessee (Scire and Schulman, 1981). The CALPUFF model was used in the comprehensive impact assessment of the Alcoa facility in Reydarfjordur in eastern Iceland. The CALPUFF modeling system is used extensively throughout the world with users in 101 countries. It has undergone extensive peer review and testing through numerous applications throughout the United States and internationally.

The CALMET/CALPUFF modeling system for the proposed Alcoa facility was selected for the following reasons:

- the presence of complex terrain in the immediate vicinity of the facility, and its importance in producing spatially varying wind fields;

- the presence of a body of water near the facility introducing spatial inhomogeneities in the meteorological fields and the importance of sea breeze circulations;

- the significant anthropogenic heat fluxes associated with the aluminum reduction facility producing local spatial variability in the dispersion characteristics;

- the potential importance of light wind speed and calm wind effects at this site; and

- the potential importance of plume recirculation, and plume fumigation.

The CALMET meteorological model uses available sources of meteorological and geophysical information to produce a spatially-varying wind field that is consistent with the local terrain features and atmospheric stability conditions at the site. In this application, a full three-dimensional wind field with a grid spacing of 1.0 km is used to provide appropriate resolution of terrain effects.

In Section 2, descriptions of the source configuration and emissions data are provided. The modeling domain, the geophysical data and the meteorological data used in the analysis are described in Section 3. Section 4 contains a description of the MM5 modeling. Section 5 includes an overview of the CALMET and CALPUFF models, and the importance of evaluating non-steady-state effects in this application and describes the CALMET/CALPUFF model configuration. In Section 6, the MM5 and CALMET outputs are analyzed and compared to observations, while in Section 7, the meteorological conditions for the year modeled are compared to other years. Finally, Section 8 presents the modeling results of predicted pollutant concentrations. A comparison of the predicted concentrations due to the proposed facility against the relevant air quality standards is provided.

2. SOURCE DESCRIPTION

2.1 Source Data

The proposed Alcoa aluminum plant is to be located at a site, approximately 2-3 km north of the Húsavík town in Iceland. The proposed plant will have an annual production capacity of 346,000 metric tons of aluminum per year (TPY). Two source configuration scenarios are examined in this study. First, a base case scenario, where the plant will consist of two potrooms associated with one tall anode cooling stack for fume treatment with a height of 78 meters and a cast house with two casting furnaces. Second, a sea water wet scrubber scenario, where the plant will consist of two potrooms, four sea water scrubber towers, and a cast house with two casting furnaces.

The cast house furnaces will use electric heating. The smelting operation will use 2.4% sulfur coke in the base case scenario and 3.0% sulfur coke in the wet scrubber scenario. The summary is:

Base Case Scenario: Single tall stack venting anode cooling and scrubber emissions, 2.4% S coke

Wet Scrubber Scenario: Sea water scrubbers, four 40-m scrubber stacks, 3.0% S coke

Figures 2-1 and 2-2 show a plot plan of the facility for each of the two scenarios. The emission sources and buildings important for building downwash are indicated on each figure. The point sources information for the base case scenario are listed in Table 2-1 and the line sources information in Table 2-2. The point sources information for the sea water scrubber scenario are listed in Table 2-3, and the information for the line sources is listed in Table 2-4. The source information tables include emission rates for SO_2, PM_{10}, HF, BaP and PAHs. The proposed facility will be based on technology in use at the existing Alcoa facility in Deschambault, Quebec, Canada. The line source parameters used to compute the average buoyancy parameter (F’) were provided by Alcoa from measurements made at the Deschambault facility. The average temperature differences between the rooftop emissions and the ambient air for the calculation of the line source F’ was computed using a full year of measurements made during the year 2001 at the Deschambault facility (see Appendix A). The annual average temperature difference was computed to be 19.2º Celsius (C). This temperature difference is applied at Húsavík facility. The average potroom exit temperature is used in the calculation of the buoyancy parameter is 23º Celsius (296.15 Kelvin), which produces a value for the line source buoyancy parameter (F’) of 1813 m^4/s^3.

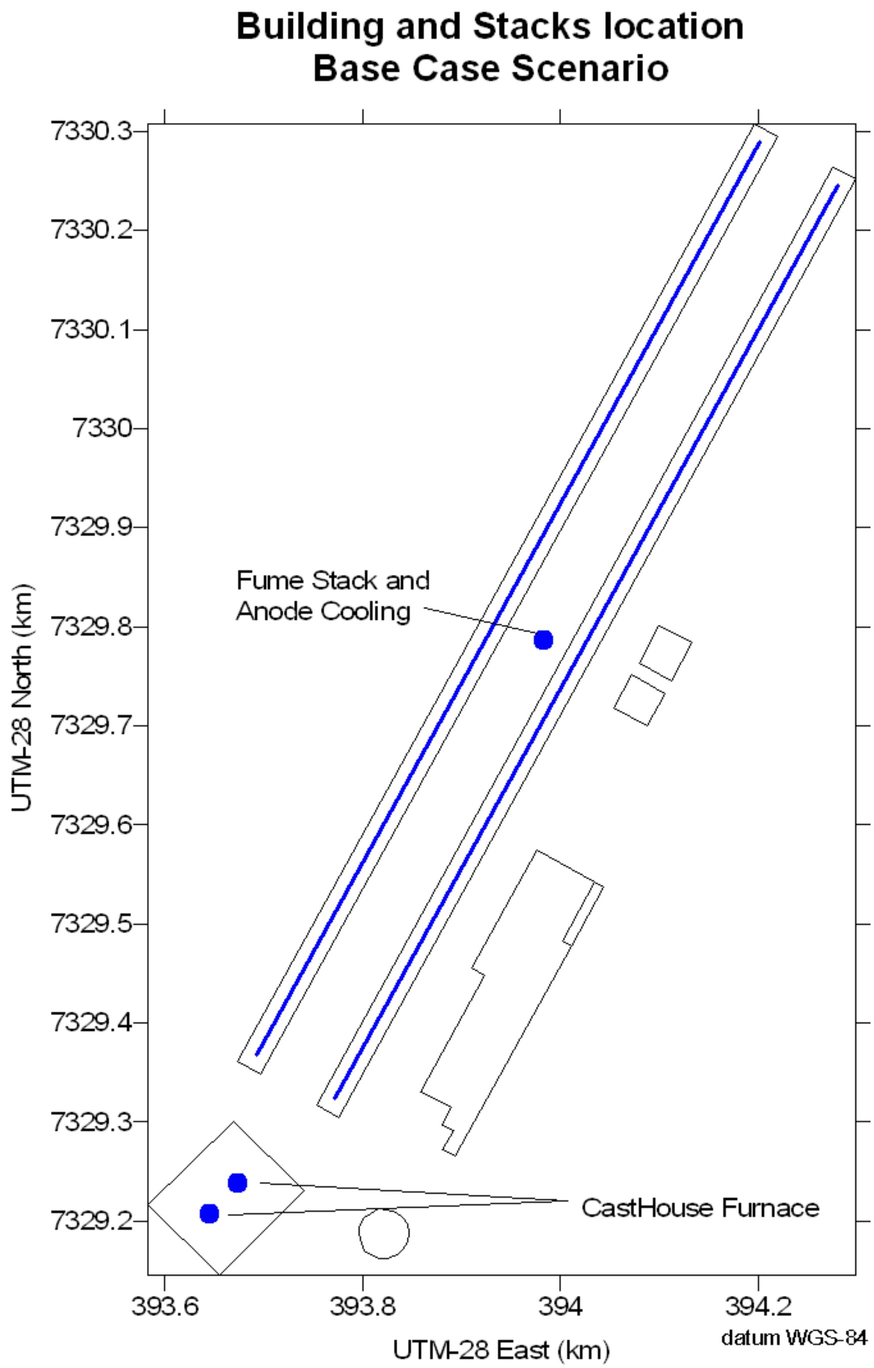


Figure 2-1. Plan of the Alcoa facility showing building locations and the emission sources for the base case scenario.

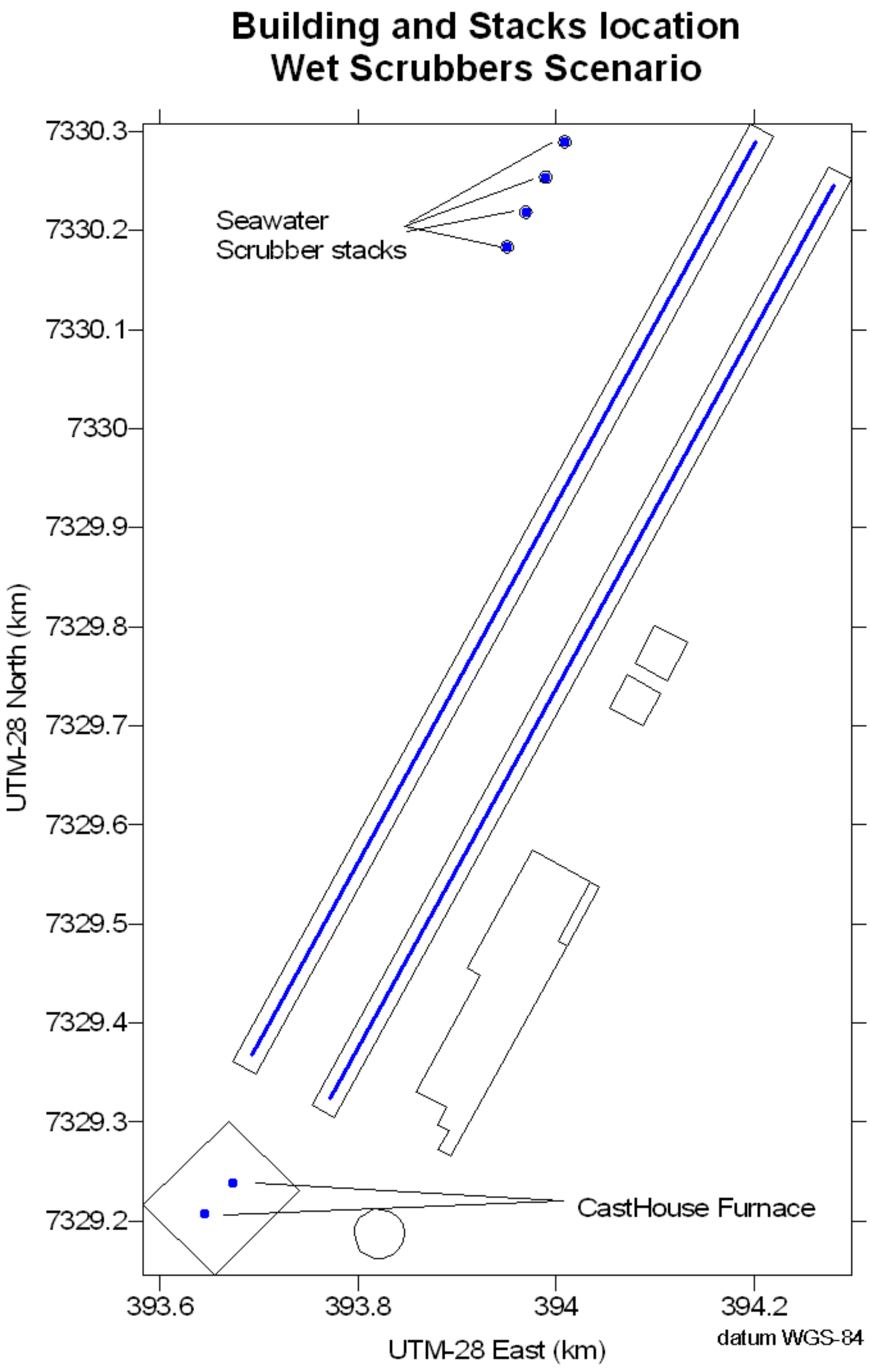


Figure 2-2. Plan of the Alcoa facility showing building locations and the emission sources for the sea water scrubber scenario.

Table 2-1. Point Source Parameters and Emission Rates for the Base Case Scenario.

Source Description	UTM-28 X-Coord. (km)	UTM-28 Y-Coord. (km)	Stack Height (m)	Base Elev. (m)	Stack Diameter (m)	Exit Veloc. (m/s)	Exit Temp (K)	HF Emission Rate (g/s)	SO_2 Emission Rate (g/s)	PM_{10} Emission Rate (g/s)	PAH Emission Rate (g/s)	BaP Emission Rate (g/s)
Fume Stack and Anode Cooling	393.9825	7329.787	78	20.0	9.45	19.0	362.15	0.94	194.7	2.70	1.41E-03	2.81E-05
Furnace 1	393.6454	7329.208	29.5	20.0	0.8	12.0	553.15	0	0	0.05		0
Furnace 2	393.6735	7329.238	29.5	20.0	0.8	12.0	553.15	0	0	0.05		0

Table 2-2. Line Source (Potroom) Emissions Data for the Base Case Scenario.

Source Description	Line No.	UTM-28 Coord. Beg. X (km)	UTM-28 Coord. Beg. Y (km)	UTM-28 Coord. End X (km)	UTM-28 Coord. End Y (km)	Release Height (m)	Base Elevation (m)	HF Emission Rate (g/s)	SO_2 Emission Rate (g/s)	PM_{10} Emission Rate (g/s)	PAH Emission Rate (g/s)	BaP Emission Rate (g/s)
LINE 1	1	393.693	7329.368	394.201	7330.288	22.5	20.0	0.94	1.99	0.29	2.14E-03	2.14E-05
LINE 2	2	393.772	7329.324	394.279	7330.244	22.5	20.0	0.94	1.99	0.29	2.14E-03	2.14E-05

Potroom dimensions:

Building length = 1081.2m

Building height = 22.5m

Building width = 25.8m

Line source width = 2.9m

Average separation between building = 64.36m

Exit velocity = 1m/s

Total vent length = 984m

Average buoyancy parameter = 1813 m^4/s^3; ΔT = 19.2º C, average exit temperature = 23º C

Table 2-3. Point Source Parameters and Emission Rates for the Sea Water Wet Scrubber Scenario.

Source Description	UTM-28 X-Coord. (km)	UTM-28 Y-Coord. (km)	Stack Height (m)	Base Elev. (m)	Stack Diameter (m)	Exit Veloc. (m/s)	Exit Temp. (K)	HF Emission Rate (g/s)	SO_2 Emission Rate (g/s)	PM_{10} Emission Rate (g/s)	PAH Emission Rate (g/s)	BaP Emission Rate (g/s)
Furnace 1	393.6454	7329.208	29.5	20.0	0.8	12.0	553.15	0	0	0.05	0	0
Furnace 2	393.6735	7329.238	29.5	20.0	0.8	12.0	553.15	0	0	0.05	0	0
Sea water Scrubber 1	394.009	7330.289	40.0	20.0	4.93	14.0	288.15	0.024	1.2	0.38	2.24E-04	4.48E-06
Sea water Scrubber 2	393.989	7330.254	40.0	20.0	4.93	14.0	288.15	0.024	1.2	0.38	2.24E-04	4.48E-06
Sea water Scrubber 3	393.969	7330.219	40.0	20.0	4.93	14.0	288.15	0.024	1.2	0.38	2.24E-04	4.48E-06
Sea water Scrubber 4	393.950	7330.183	40.0	20.0	4.93	14.0	288.15	0.024	1.2	0.38	2.24E-04	4.48E-06

Table 2-4. Line Source (Potroom) Emissions Data the Sea Water Wet Scrubber Scenario.

Source Description	Line No.	UTM-28 Coord. Beg. X (km)	UTM-28 Coord. Beg. Y (km)	UTM-28 Coord. End X (km)	UTM-28 Coord. End Y (km)	Release Height (m)	Base Elevation (m)	HF Emission Rate (g/s)	SO_2 Emission Rate (g/s)	PM_{10} Emission Rate (g/s)	PAH Emission Rate (g/s)	BaP Emission Rate (g/s)
LINE 1	1	393.693	7329.368	394.201	7330.288	22.5	20.0	0.94	2.48	0.29	2.14E-03	2.14E-05
LINE 2	2	393.772	7329.324	394.279	7330.244	22.5	20.0	0.94	2.48	0.29	2.14E-03	2.14E-05

Potroom dimensions: Building length = 1081.2m; Building height = 22.5m; Building width = 25.8m

Line source width = 2.9m; Total vent length = 984m

Average separation between building = 64.36m; Exit velocity = 1m/s

Average buoyancy parameter = 1813 m^4/s^3; ΔT = 19.2º C, average exit temperature = 23º C

2.2 Building Downwash Analysis

Because some of the stacks are short and relatively close to buildings or other structures, some building downwash effects will occur. Building downwash will also be a factor for the rooftop vent (line source) emissions. A complete building downwash analysis was conducted to develop wind-direction-specific effective building dimensions for use in the modeling analysis. Results of this analysis are shown in Appendix B.

The building downwash analysis was produced using the Environmental Protection Agency's Building Profile Input Program (BPIP, dated 04112). The program incorporates Good Engineering Practice (GEP) guidance and building downwash guidance to produce the building heights and projected building widths that affect the dispersion of pollutants from the source in question. It has been determined that a building's wake has a direct effect on the dispersion of a pollutant. For every wind direction, this area of influence extends five times L (5L) directly downwind from the trailing edge of the structure, where L is the lesser of the building's height or direction specific projected building width. The area of influence extends 0.5L in the crosswind direction and 2L in the upwind direction. A building's wake effect height is determined by adding 1.5L to the building's height. The building with the largest wake effect height, whose area of influence encompasses a stack, is the dominant influential building for that stack. Wakes from two structures, that are closer than the greater of either structure's L, are considered "sufficiently close" to one another that their wakes effectively act as one. If the projected widths of the structures do not overlap, then the structures are combined and the gap between the two structures is treated as if the gap had been filled with a structure equal in height to the lower structure.

The buildings and emission sources are shown in Figure 2-1 for the base case scenario and in Figure 2-2 for the sea water scrubber scenario. A description of the eight structures tall enough to be included in the building downwash analysis is summarized in Table 2-5.

Table 2-5. Building Dimensions

	Building Length (m)	Building Width (m)	Building Height Above Ground (m)	Base Elevation (m)	Height Above Sea Level (m)
2 potrooms	1081.2	25.8	22.5	14	36.5
Cast House	120	100	22	12	34
Building 345	37.5	37.5	23	17	40
Building 346	43	37.5	17.5	17	34.5
Building 442	67.5	9.375	34	17	51
Anode Plant	More than 4 sides building (see Figure 2-1)		12.3	17	29.3
Silo	Diameter: 25m		55	14	69
4 Sea Water Scrubber Towers	Radius: 6.2m		25	12	37

3. GEOPHYSICAL AND METEOROLOGICAL DATA

3.1 Modeling Domain and Terrain

The CALMET modeling domain consists of 56 x 51 grid cells centered on the Alcoa facility with a grid size of 1.0 km. The southwest corner of the domain has a UTM Coordinate of 369.5 km East, 7299.5 km North in UTM Zone 28, datum WGS-84 (WGS-84 Reference Ellipsoid and Geoid, Global coverage). The size of the domain is 56 km x 51 km.

Gridded terrain elevations are derived from digitized terrain data in the vicinity of the facility. In this data set, elevations are in meters relative to mean sea level, and the spacing of the elevations along each profile is approximately 15 meters (m). Further away from the facility and to cover the entire domain, data from the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) Global Digital Elevation Model (GDEM) developed jointly by the Ministry of Economy, Trade, and Industry (METI) of Japan and the United States National Aeronautics and Space Administration (NASA) were used. The spatial resolution is 15 meters (m) in the horizontal plane. Figure 3-1 shows a contour plot of terrain elevations within the CALMET modeling domain.

3.2 Land Use

The USGS Global Land Use data in the vicinity of the facility has been used to produce a gridded field of dominant land use categories. The land use data were obtained from the USGS FTP site, with a resolution of 0.9 km.

Land use data were processed to produce a 1.0 km resolution gridded field of fractional land use categories. The 38 USGS land use categories were mapped into 14 CALMET land use categories. Surface properties such as albedo, Bowen ratio, roughness length, and leaf area index were computed proportionally to the fractional land use. The USGS land use categories are described in Table 3-1. Table 3-2 displays the 14 CALMET land use categories and their associated geophysical parameters. These land use categories and associated parameter values were used for the summer months (mid-May to mid-October). The summer period was defined using the Satellite images available for everyday (http://www.natice.noaa.gov/ims/archive/index.html) of the modeled year 2003. Theses images show that on May 15, it is the end of the snow coverage in the North of Iceland while on October 11, the snow covers again North of Iceland. So, the summer period is defined from May 16 to October 10 for the year 2003. During the other months of the year, all land use categories, except ocean water, forest and urban areas are set with ice/perennial snow for all surface properties. Figure 3-2 shows the dominant land use category for each CALMET grid cell in the modeling domain for the summer month.

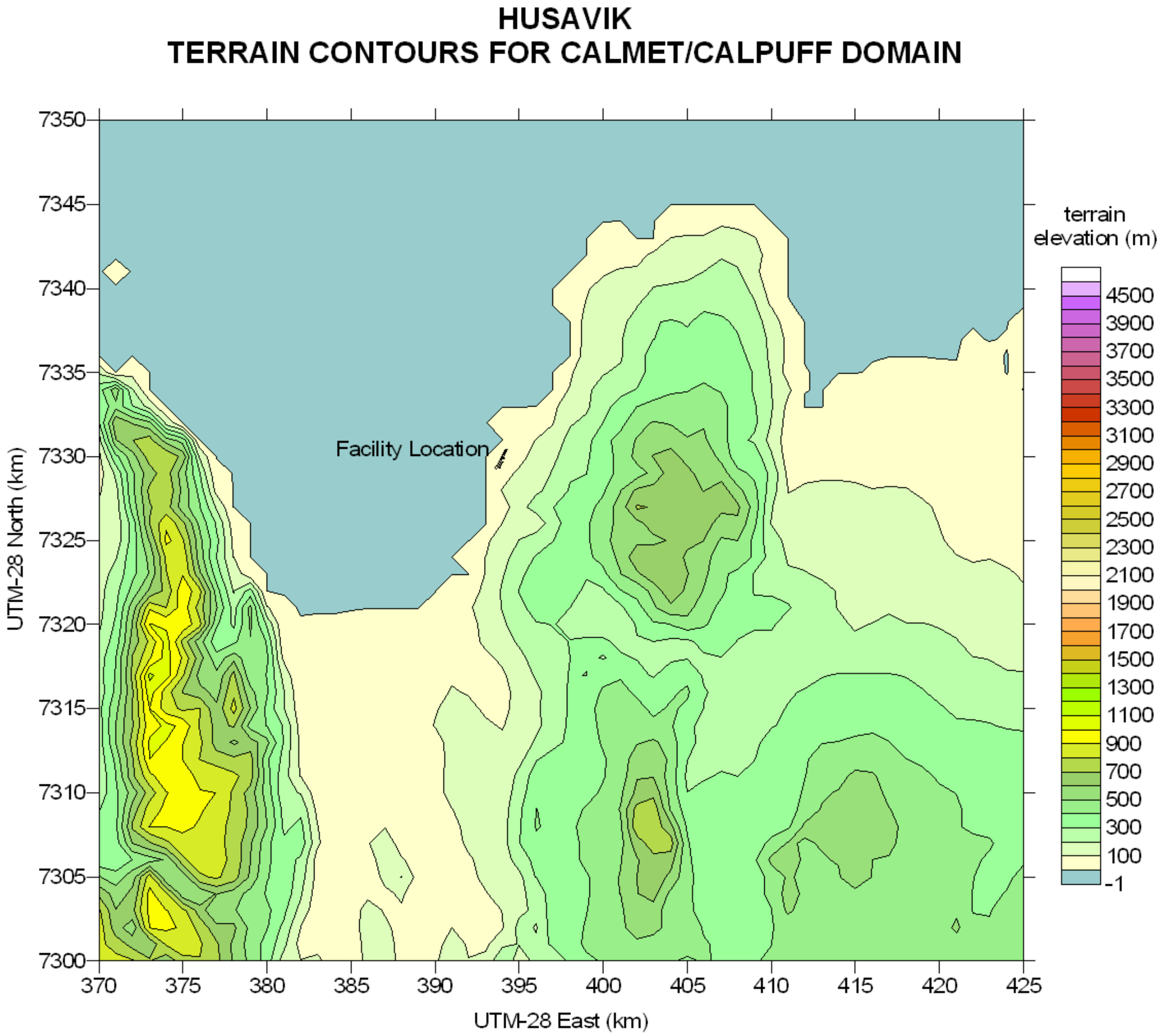


Figure 3-1. Terrain elevations for the CALMET/CALPUFF computational domain. The facility location has been added.

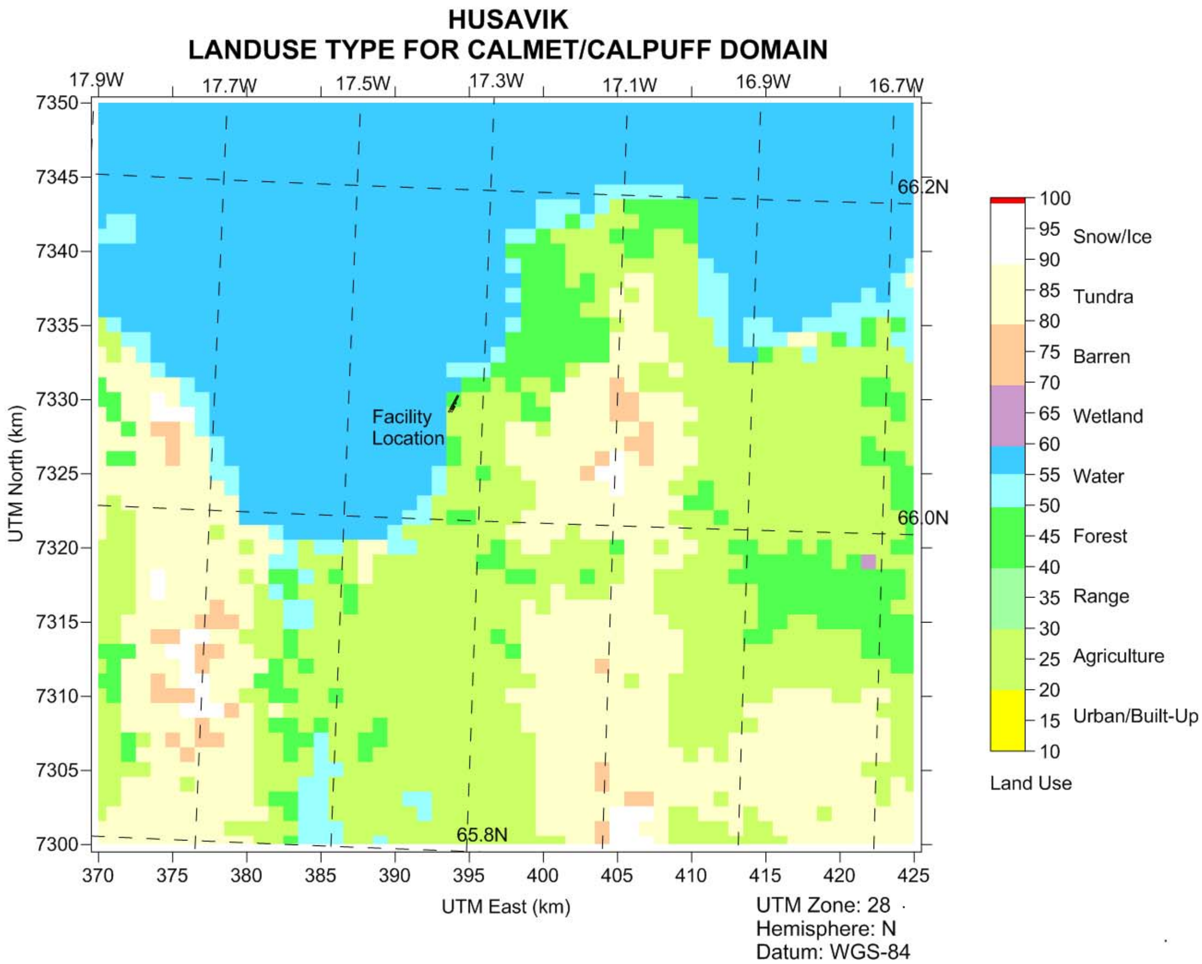


Figure 3-2. Dominant land use categories for the 1.0 kilometer grid resolution for the CALMET/CALPUFF computational domain. The Alcoa facility location has been added in black.

Table 3-1. 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 3-2. 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

3.3 Meteorological Data Base

3.3.1 Meteorological Stations

The CALMET diagnostic model requires hourly surface observations of wind speed, wind direction, temperature, cloud cover, ceiling height, surface pressure and relative humidity. It also requires an hourly precipitation rate when wet deposition is modeled. In Iceland, these variables are routinely measured by various organizations, including the Icelandic Meteorological Office, Public Roads Administration, National Power Company and Marine Authority. CALMET allows observational data to be supplemented by three dimensional gridded data sets from a prognostic numerical model such as MM5. Table 3-3 lists the types of observational and modeled data available for the modeling including available parameters.

In this study, the CALMET simulations use three dimensional gridded data from the Fifth Generation Penn State/NCAR Mesoscale Model Version 3 (MM5) along with available surface observations. The MM5 data set consists of hourly values of wind speed, wind direction, temperature, and pressure on a grid with a horizontal grid cell size of 1 km and 24 vertical half-sigma levels. The MM5 simulations were conducted by TRC specifically for this application (see Section 4).

Table 3-4 lists the surface stations and precipitation stations included in the CALMET simulations and Figures 3-3 and 3-4 show plots of the surface stations along with the MM5 grid points used in the CALMET computational domain. The surface stations include 9 stations from the Icelandic Meteorological Office, Public Roads Administration, National Power Company and Marine Authority. These data were provided to TRC by the Icelandic Meteorological Office.

Five of the meteorological stations are located closed to the project facility within a 5 km radius and are important data for the CALMET/CALPUFF modeling.

Meteorological conditions during the modeled time period (January to December 2003) are compared with meteorological conditions of other years in Section 7.

3.3.2 Sea Data

As the domain includes both land and water, CALMET requires overwater information such as the air /water temperature difference for the overwater boundary layer model. This information is provided to CALMET on an hourly basis from the 3-D MM5 dataset. In CALMET, the air-sea temperature difference data are used with a profile technique to compute the micrometeorological parameters in the marine boundary layer.

Table 3-3. Meteorological Data Sources and Parameters Available

Type of Dataset	Frequency	Source	Parameters
Surface	Hourly	Various sources	- Wind speed, wind direction, - air temperature, - ceiling height, cloud cover, - relative humidity, - surface pressure, - precipitation rate
Modeled Profiles	Hourly	Produced by MM5	- Gridded fields of winds, - temperature, - pressure, - relative humidity, - computed ceiling height and cloud cover

Table 3-4. Summary of Surface Meteorological Stations Near or Within the CALMET Modeling Domain

Station Name	Source	Station Identifier	Parameters Available	Latitude (º N)	Longitude (º W)	UTM East (km)	UTM North (km)
Akureyri	WMO	40630	W,T,Prc,Rh,P,Cld	65.6830	-18.0830	633.996	7287.687
Grimsstaoir	WMO	40730	W,T,Prc,Rh,P,Cld	65.6330	-16.1170	448.578	7279.461
Raufarhofn	WMO	40770	W,T,Prc,Rh,P,Cld	66.4500	-15.9500	457.645	7370.392
Húsavíkurhofn	HH	3691	W,T,P	66.0333	-17.3500	393.499	7325.584
Bakkahofdi	IMO	3692	W,T	66.0768	-17.3609	393.186	7330.505
Gvendarbas	IMO	3693	W,T	66.0233	-17.3800	392.098	7324.522
Húsavíkurfjall	IMO	3694	T	66.0533	-17.3200	394.941	7327.762
Húsavík	IMO	3696	W,T,P	66.0418	-17.3281	394.533	7326.550
Manarbakki	IMO	479	W,T,Prc,Cld	66.2000	-17.1000	405.449	7343.789

W=wind speed + wind direction; T=air temperature; Rh= relative humidity; P=pressure; Cld= Cloud cover or/and ceiling height; Prc=hourly precipitation rate.

WMO = World Meteorological Organization; HH = Húsavík Harbour; IMO = Icelandic Meteorological Office

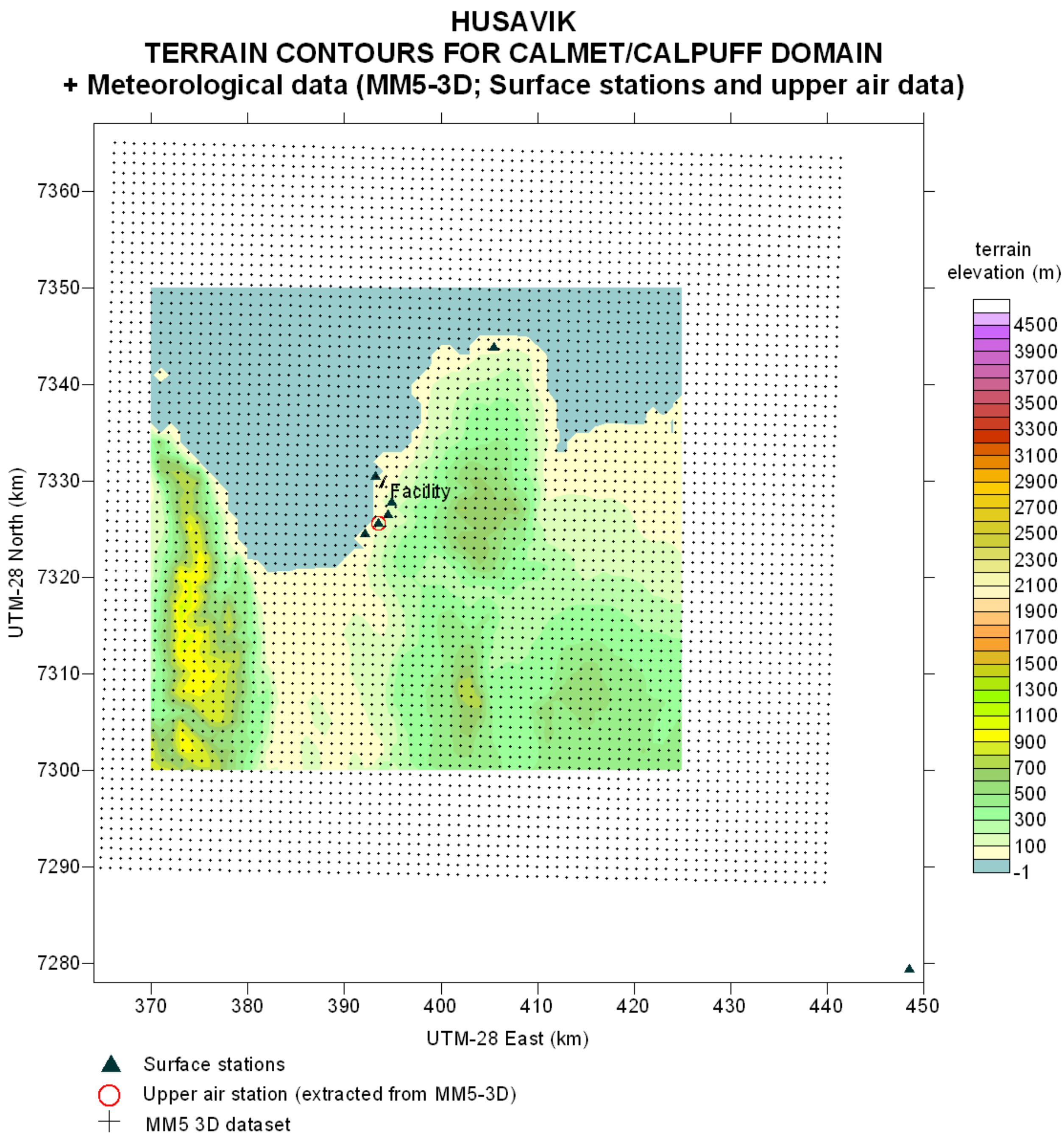


Figure 3-3. Locations of meteorological observations sites used in the CALMET modeling. The black crosses are the MM5 grid points and the black line is the industrial site. The meteorological stations are represented by dark green triangles and the red circle the MM5 grid point extracted for upper air station. Two surface meteorological stations are missing on this plot, being located far out of the CALMET/CALPUFF domain.

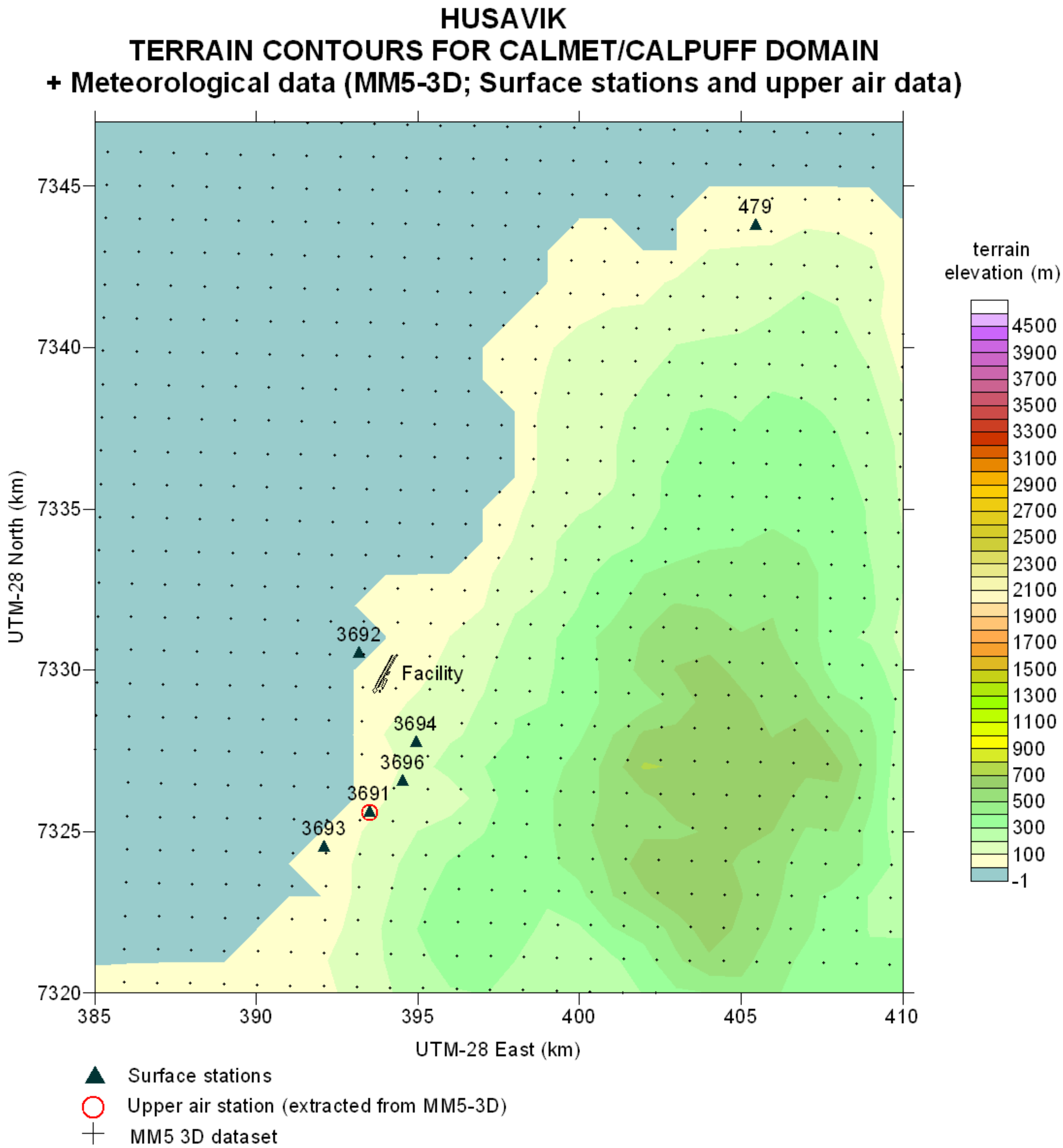


Figure 3-4. Zoom in of the location of meteorological observations sites used in the CALMET modeling. The black crosses are the MM5 grid points and the black line is the industrial site. The meteorological stations are represented by dark green triangles and the red circle the MM5 grid point extracted for upper air station.

4. MM5 SIMULATIONS

4.1 MM5 Description

The Fifth Generation Penn State/NCAR Mesoscale Model (MM5) is a three-dimensional numerical weather prediction model maintained at the National Center for Atmospheric Research (NCAR). MM5 can be run with multiple nested grids. It contains non-hydrostatic dynamics, a variety of physics options and the capability to perform Four Dimensional Data Assimilation (FDDA). MM5 is capable of simulating a variety of meteorological phenomena such as tropical cyclones, severe convective storms, sea-land breezes, and terrain forced flows such as mountain valley wind systems.

MM5 was used in this analysis to develop high-resolution three-dimensional meteorological fields through FDDA simulations to serve as an initial guess field for the CALMET Diagnostic Meteorological Model. The FDDA simulations involved running MM5 for the one-year period used in this study (January to December 2003) and then nudging the model solutions (i.e. predictions) toward a gridded analysis at regular intervals. This gridded analysis places a constraint on the model predictions so that the resulting meteorological fields are consistent with observational data for a given time interval and at the same time are dynamically balanced. This gridded analysis is developed using surface and upper air observations over the MM5 modeling domain and consists of both a full three dimensional meteorological analysis and a surface analysis. The result of the MM5 simulations with FDDA is a high resolution three dimensional gridded data set of meteorological fields (i.e. wind, temperature, pressure etc).

Figure 4-1 shows an example of the MM5 model's multi-nested horizontal grid configuration. A staggered grid cell configuration known as the Arakawa-Lamb B staggered grid is used by MM5. In this grid configuration scalars such as temperature or moisture variables are defined at the center of a grid cell known as the cross points. The vector quantities (e.g., u and v wind components) are defined at the corners of each grid cell known as the dot points.

Typically, meteorological analysis is performed on constant pressure levels instead of height. MM5 uses a terrain following vertical coordinate where the model vertical levels are defined by a dimensionless quantity σ. The σ coordinate is defined as:

$$\sigma = \frac{(P - P_t)}{(P_s - P_t)}$$

Where P = Pressure
P_t = Constant top pressure
P_s = Surface pressure

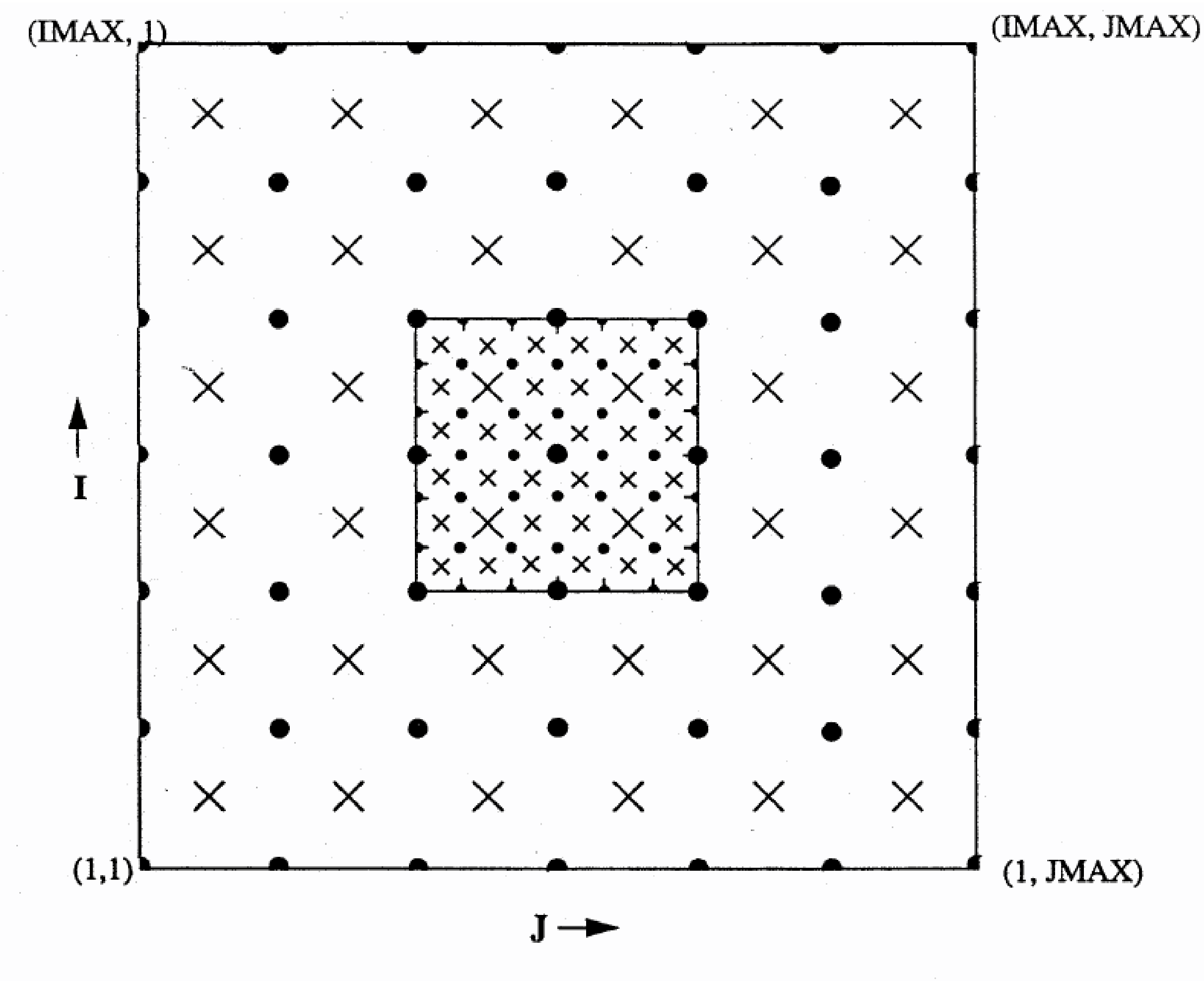


Figure 4-1. MM5 horizontal grid (Arakawa B-grid) showing the staggering of the dot (.) and cross (X) grid points. The smaller inner box is a representative mesh staggering for a 3:1 coarse-grid distance to fine-grid distance ratio (from Dudhia et al., 2000).

The σ coordinate has a value of zero at the top of the model and a value of 1 at the surface. Figure 4-2 shows a schematic of the σ layer vertical structure used by MM5.

The MM5 modeling system uses several preprocessor programs to prepare input data for the model simulations. Figure 4-3 shows a flow chart of the MM5 modeling system showing how the various support programs interface with MM5. The terrain preprocessor is used to interpolate gridded terrain elevations and land use data onto the MM5 modeling grid. The REGRID preprocessor interpolates meteorological analysis data sets from some native grid to the MM5 grids while the RAWINS preprocessor improves the REGRID derived analysis by performing an objective analysis using surface and upper air observations. The RAWINS preprocessor will provide three dimensional meteorological fields used for initial and lateral boundary conditions, provide three dimensional fields for analysis nudging, and surface fields used for surface nudging during the FDDA process.

The INTERPF program takes the various analysis fields generated by REGRID and RAWINS and prepares the data for input to the MM5 Model. INTERPF performs vertical interpolation of the analysis fields to the model σ levels and generates the boundary condition files used by MM5.

4.2 MM5 Configuration

MM5 data to drive the CALMET model was obtained from simulations that are described below. Initial simulations were carried out to test the sensitivity of model output to the domain grid sizes. Two main types of simulations were performed that involved the exclusion and inclusion of Greenland in the modeling domain. Prior studies have shown the presence of a dominant wintertime surface low-pressure system between Greenland and Iceland – the so-called 'Icelandic Low'. The wintertime area of this Icelandic low is a preferred spot for creation of meso-cyclones of which many do not travel far. Thus it is essential to have a proper reproduction of the system in the model runs. In order to minimize any boundary effects and to let the model generate its own 'Icelandic Low', we expanded the initial domain (without Greenland) to include the whole of Greenland and also parts of Northern Canada.

The MM5 modeling in this study includes four domains in total. Geographical locations of the domains are presented in Figure 4-4. The center of the coarse domain (Domain 1) was located at 64.214^{o}N, 16.375^{o}W. Since the MM5 modeling is over a region close to the North Pole, the Polar Stereographic (PS) map projection was used in the model coordinates. The standard latitude of the projection was 60^{o}N. This domain covers almost the entire North Atlantic Ocean and includes besides

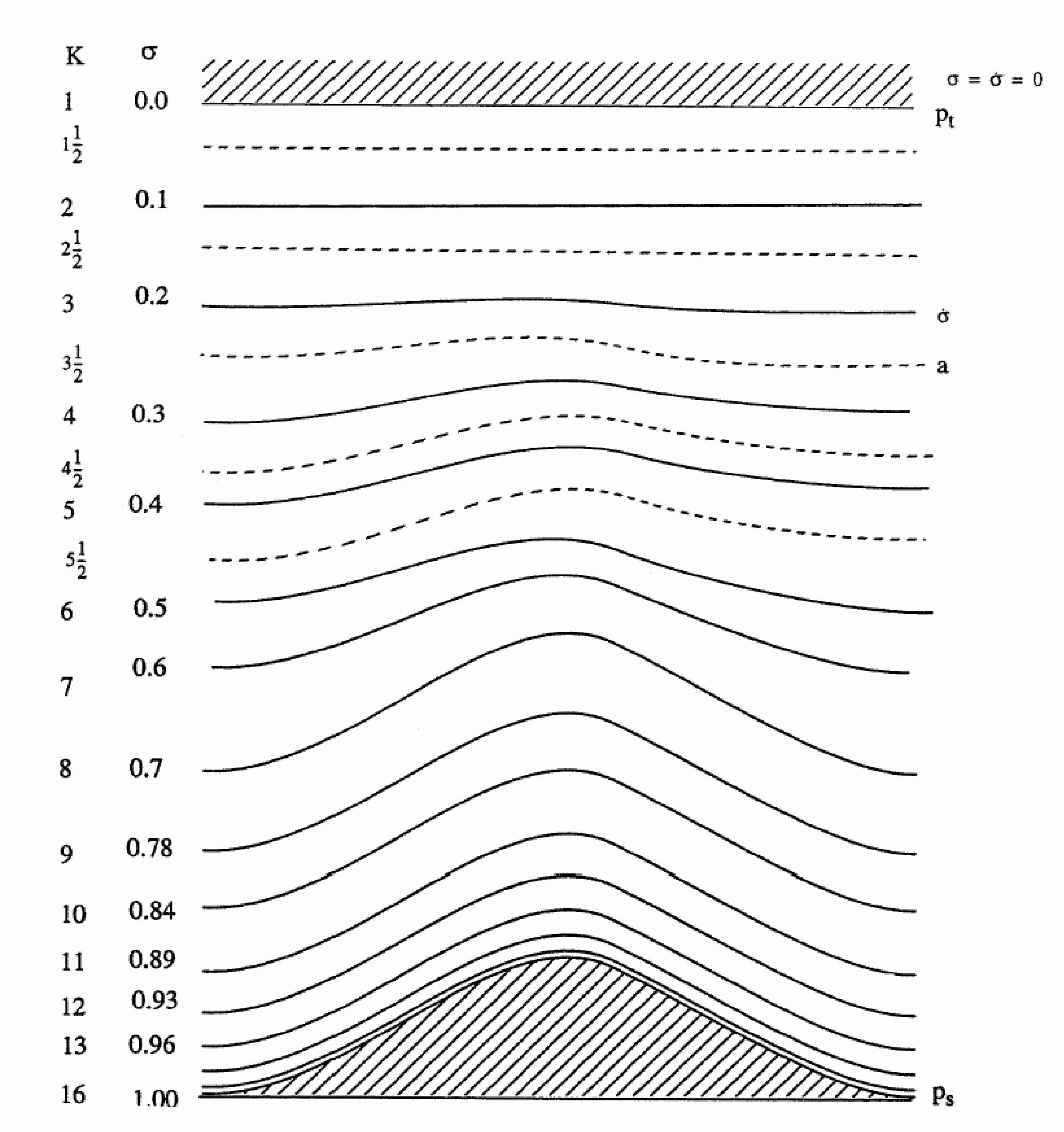


Figure 4-2. Schematic representation of the vertical structure used in MM5. The example is for 15 vertical layers. Dashed lines denote half-sigma levels, solid lines denote full-sigma levels (from Dudhia et al., 2000).

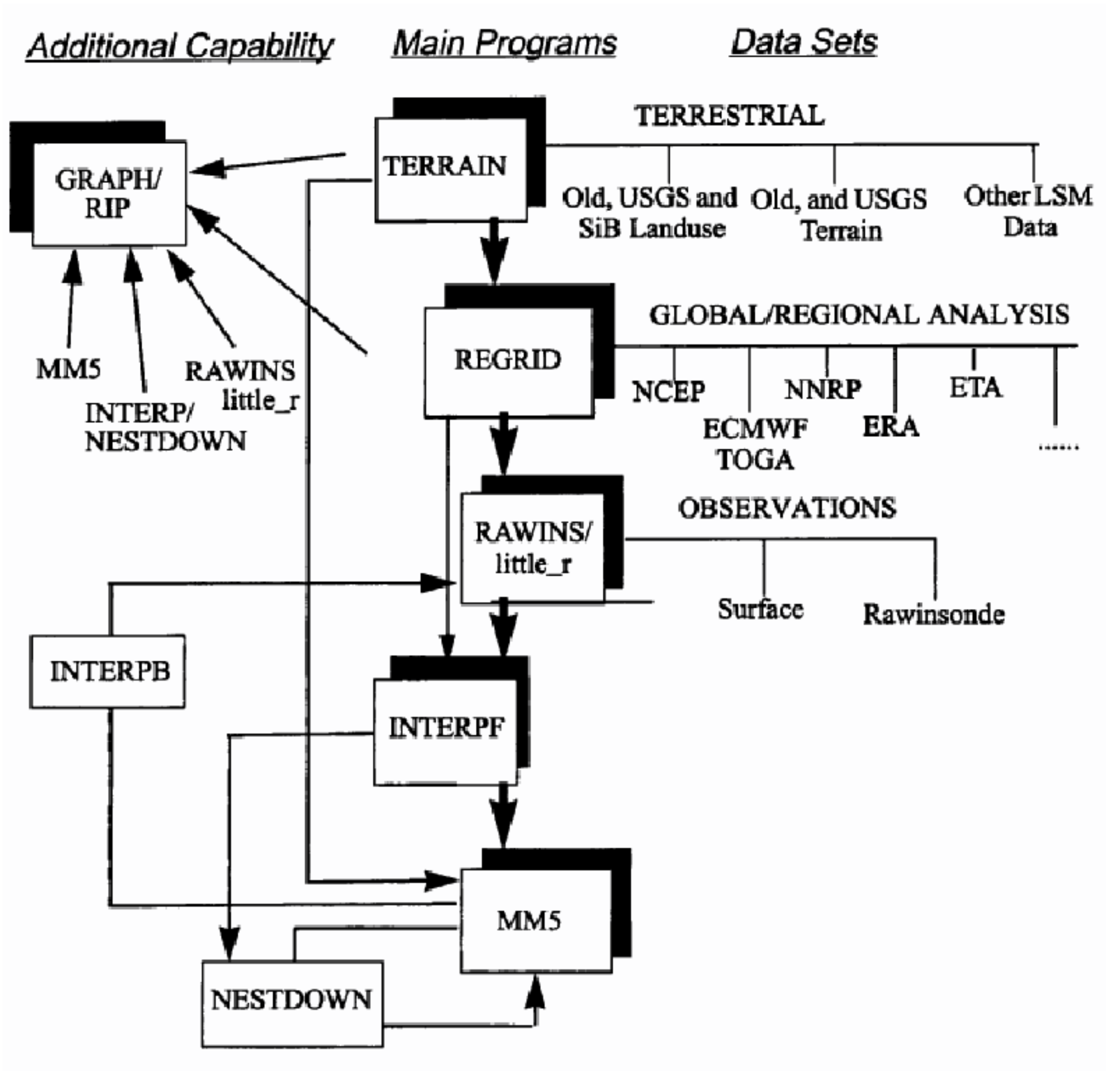


Figure 4-3. Flow chart of MM5 modeling system (Dudhia et al., 2000).

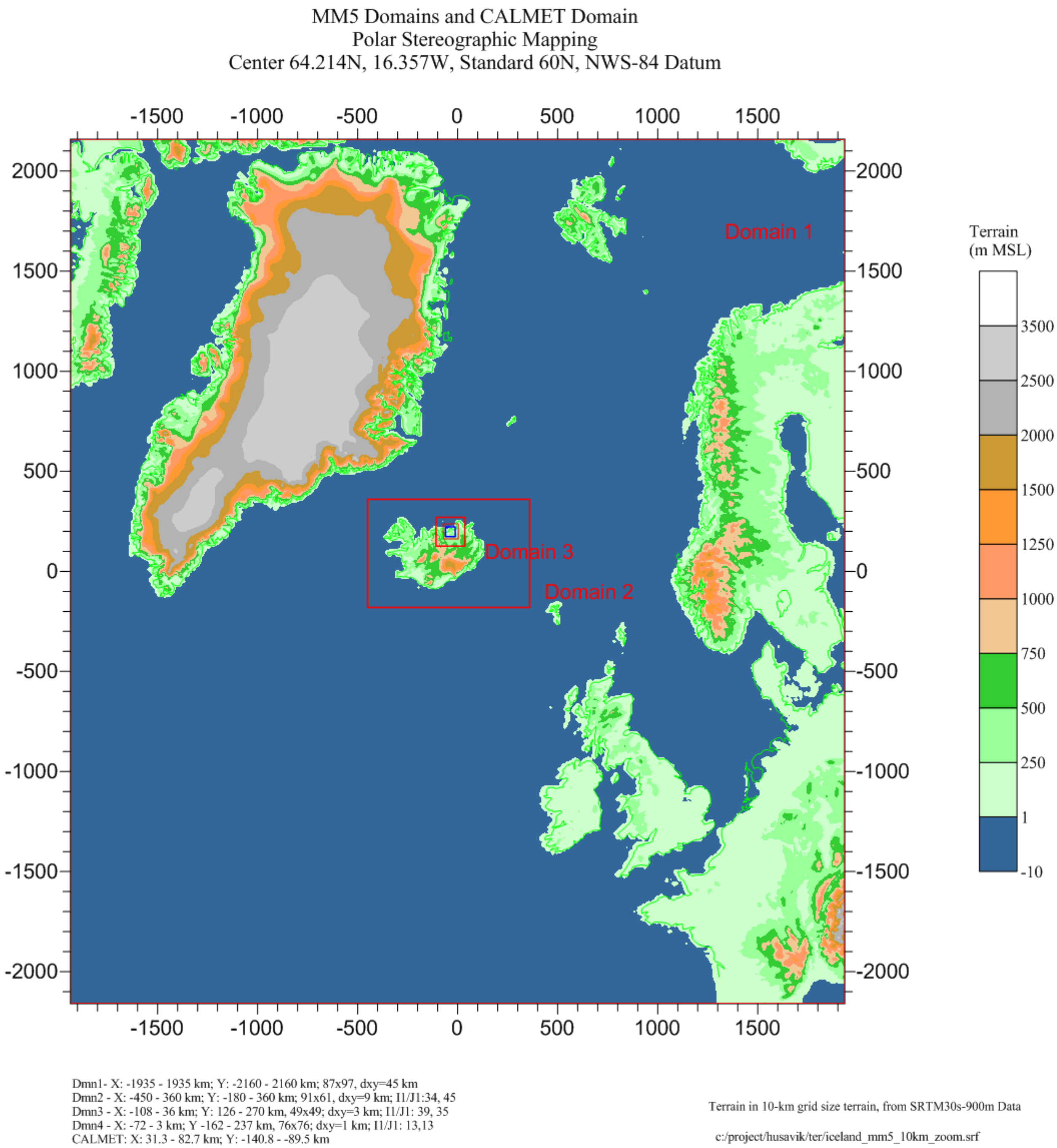


Figure 4-4. Plot of MM5 modeling domains with terrain elevations.

Iceland, the whole of Greenland, Norway, United Kingdom and parts of Western Europe and northern parts of Canada with a total area of about $14x10^6$ km^2. The grid spacing was 45 km. The second-nesting domain (Domain 2) covers all of Iceland with a grid size of 9 km. The third and the fourth nesting domains (Domains 3 and 4) were selected based on the needs of CALMET modeling and were more or less centered on the location of the facility (Figure 4-5). The grid spacing of these domains were 3 km and 1 km, respectively. Table 4-1 lists the details of configurations for the four domains. In the vertical direction, there were 25 sigma levels (24 half sigma levels) from the surface to 100 hPa, located at the sigma values of 1.00, 0.996, 0.992, 0.983, 0.973, 0.961, 0.948, 0.933, 0.916, 0.897, 0.875, 0.851, 0.823, 0.792, 0.756, 0.716, 0.670, 0.618, 0.559, 0.493, 0.418, 0.333, 0.236, 0.128, 0.0. More details of vertical levels are presented in Table 4-2.

The terrain elevation and land use category were from the 5-min, 2-min, 30-sec (~9 km, ~4 km, ~0.9 km, 0.9 km, respectively) global data set for Domains 1 through 4. The terrain elevations of all domains are shown in Figure 4-4.

The MM5 model was run in the non-hydrostatic mode. One-Way nesting was used between Domains 2 to 4. Extensive research has been done in mesoscale modeling in the polar regions with the development of the polar version of MM5 – the Polar MM5 (Bromwich et al., 2001; Cassano et al., 2001). Our model settings were based on the options recommended from the work of the Polar MM5 research team. The mixed phase explicit moisture scheme that represents microphysics parameterizations (Reisner et. al., 1998) was used in all domains. The Grell cumulus parameterization scheme (Grell et. al., 1994) was used for convections in Domains 1, 2, while explicit convection was carried out for Domain 3 and Domain 4. The Grell scheme uses the updraft and downdraft fluxes and the compensating flow to determine the heating and moisture vertical profiles. The planetary boundary layer module is from the NCEP Eta Model. Turbulent fluxes in the atmosphere and the turbulent fluxes between the atmosphere and the surface are parameterized using the 1.5 order turbulence closure parameterization. The region of our modeling experiences long periods of darkness and light. For this we used a sophisticated radiation scheme based on the NCAR community climate model (CCM2) (Hack et. al. 1993). The scheme accounts for the long wave and short wave interactions with cloud and clear air. The cloud cover is predicted as a simple function of the grid box relative humidity, with the cloud liquid water path determined from the grid box temperature. The five-layer soil model was used to predict soil temperatures at about 1, 2, 4, 8, and 16 cm. The vertical resolved soil temperature profile allows rapid response to surface temperature changes. The SOILFAC parameter in the MM5 deck was increased to 1.5 in order to reduce the time step in the soil model calculations. With larger time step, instability in numerical calculations significantly deteriorates the integration results. Physics options employed in the MM5 simulations are shown in Table 4-3.

MM5 was initialized using the large-scale analysis data from NCEP at NCAR. The NCEP Final Analysis (FNL) (http://dss.ucar.edu/datasets/ds083.2) data archived at NCAR exists every 6 hours at a spatial resolution of 1^o x 1^o at 21 standard pressure levels under 100 hPa: the surface, 1000, 975, 950, 925, 900, 850, 800, 750, 700, 650, 600, 550, 500, 450, 400, 350, 300, 250, 200, 150, and 100 hPa. The data include two-dimensional variables of snow cover, sea surface temperature, and sea level pressure, and three-dimensional variables of temperature, geopotential height, U and V components, and relative humidity. Sea surface temperature (SST) data was also available from "Real Time Global" SST (RTG SST) analysis from NOAA (0.5^ox0.5^o resolution). However, model calculations from the FNL SST data were the most encouraging according to a study done modeling Eastern Iceland previously. MM5 now has an option to vary the lower boundary condition with respect to time. Hence we employed this option to provide a realistic representation of the time variation of the lower boundary condition. For the FNL dataset, the temporal resolution of the data being 6 hours, the lower boundary conditions were updated every 6 hours. Moreover, the SST data was interpolated to the four domain grids prior to the start of the simulation. This assures that the spatial lower boundary condition comes from the original FNL dataset. Alternatively, MM5 interpolates the lower boundary on the fly. In this case, the lower boundary values for Domains 2 through 4 come from those integrated in Domain 1 and may not be the original FNL values.

Four dimensional data assimilation (FDDA) was used to force the model integration to the fields from the FNL data. Only three-dimensional FDDA was carried out since the surface observations were with a time resolution of 6 hours. In the FDDA, only Domain 1 (D1) was nudged toward the observations while the model integrated Domains 2, 3 and 4. Winds, temperature and moisture were nudged to the observed values every 6 hours. Further details about the runtime options and the nudging coefficients are given in Table 4-4.

The model was run in single processor mode. Each MM5 simulation was 3-day long with 12 hours of overlap between simulations. The first 12 hours of each run were discarded as an initialization spin-up period, and the final 2 days of each run were appended to other runs to form a complete and continuous full year dataset. A spin-up time of 12 hours is enough to let the MM5 reach the dynamical balance in its domains. The 2-day simulation length can reduce the divergence between forecasts and analyses. MM5 output covers the period from 2002123112 to 2004010111, so that any conversion between local and UTC times can be properly processed.

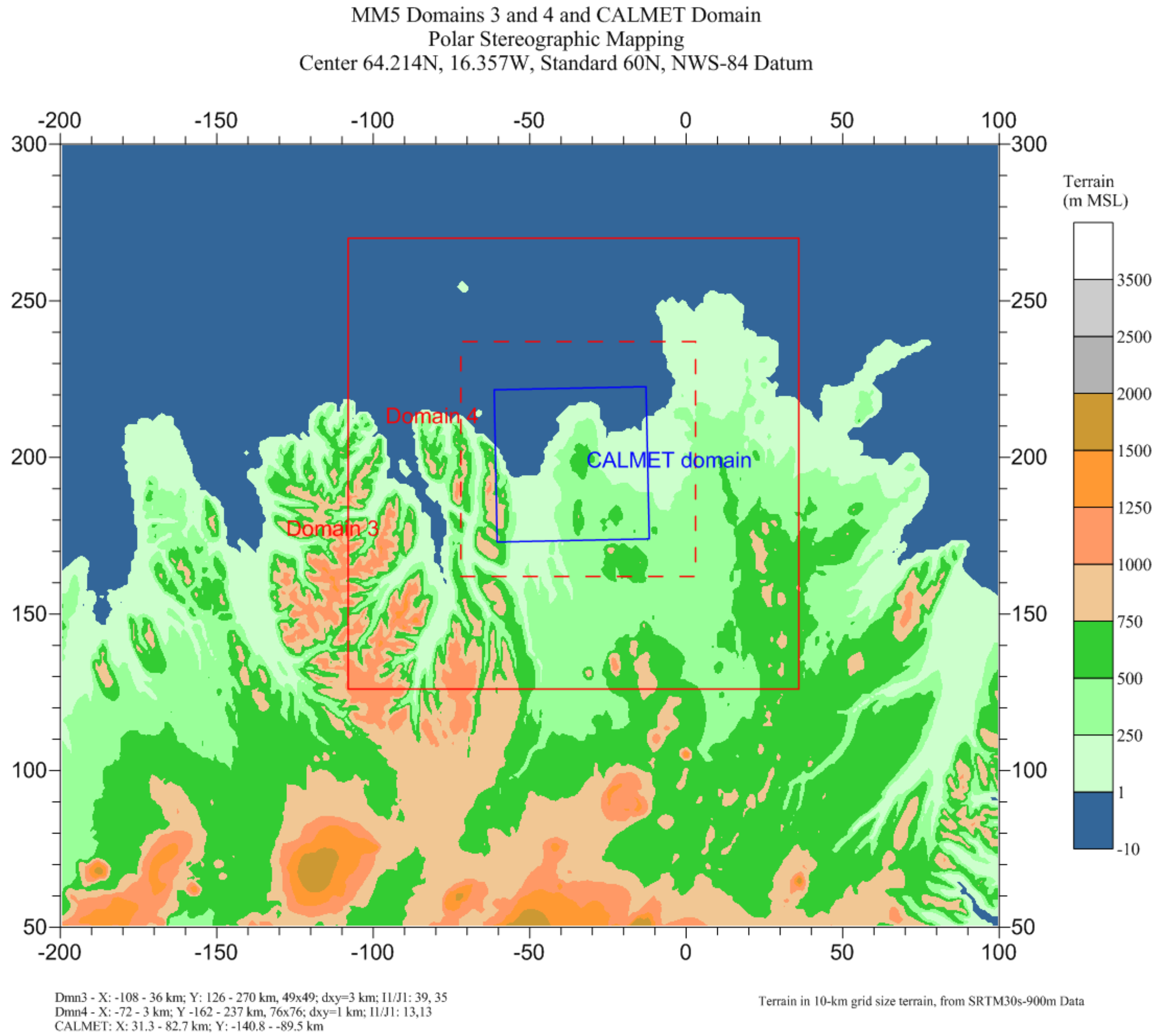


Figure 4-5. MM5 Domain 3 and MM5 Domain 4 along with the CALMET domain.

Table 4-1. Configuration of MM5 domains

Domain #	Dimensions (kmxkm)	Map Projection	Grid size (km)	Vertical Levels	Grid Numbers	Mother Domain	Mother Domain (i, j)	Terrain Resolution (km)
Domain 1	3870x4320	PS	45	24	87x97			9
Domain 2	810x540	PS	9	24	91x61	1	34,45	4
Domain 3	144x144	PS	3	24	49x49	2	39,35	0.9
Domain 4	75x75	PS	1	24	76x76	3	13,13	0.9

Table 4-2. Vertical Wind Levels in the MM5 Modeling

Level No.	½ sigma lev	Ref P (mb)	Height (m)
1	0.998	1008.18	14.51
2	0.994	1004.54	43.59
3	0.988	998.63	91.03
4	0.978	989.98	160.78
5	0.967	979.97	242.17
6	0.955	968.60	335.49
7	0.941	955.86	441.07
8	0.925	941.30	563.16
9	0.907	924.94	702.36
10	0.886	906.26	863.36
11	0.863	885.33	1047.24
12	0.837	861.67	1259.42
13	0.807	834.37	1510.20
14	0.774	803.89	1798.24
15	0.736	769.76	2131.37
16	0.693	730.63	2528.39
17	0.644	686.04	3002.29
18	0.589	635.54	3569.97
19	0.526	578.66	4254.28
20	0.456	514.51	5093.85
21	0.376	441.71	6153.72
22	0.285	359.35	7533.06
23	0.183	266.08	9430.51
24	0.064	158.24	12399.89

Table 4-3. Physics Options Used in the MM5 Modeling

Domain #	Explicit Moisture Schemes (IMPHYS)	Cumulus Schemes (ICUPA)	PBL Scheme (IBLTYP)	Radiation Cooling of Atmosphere (FRAD)	Shallow Convection (ISHALLO)	Multi Layer Soil Model (ISOIL)
Domain 1	Reisner 1	Grell	ETA-Yamada-Mellor	CCM2	None	5-Layer
Domain 2	Reisner 1	Grell	ETA-Yamada-Mellor	CCM2	None	5-Layer
Domain 3	Reisner 1	None	ETA-Yamada-Mellor	CCM2	None	5-Layer
Domain 4	Reisner 1	None	ETA-Yamada-Mellor	CCM2	None	5-Layer

Table 4-4. Runtime Options Used in the MM5 modeling

3D Data	SST Data	Time-varying SST	Update Frequency of SST	Space-varying SST	Runtime
FNL	FNL	Yes	24 hours	Yes	3.5 days with 12 hours overlap

FDDA	Domains Nudged	Fields Nudged	Frequency of Nudging	Nudging Coefficients		
				Wind	Temperature	Moisture
3D (analysis)	D1	Winds, temperature, moisture	6 hours	2.5E-04	2.5E-04	1.0E-05

5. AIR QUALITY MODELING METHODOLOGY

5.1 Model Selection

Principal factors in the selection of a modeling approach included the complex terrain of the region, the importance of light wind and calm wind conditions and flow reversals, the need to handle both buoyant line and point sources, the importance of building downwash effects, the importance of spatial inhomogeneities in the meteorological fields due to terrain features and a nearby water body and significant anthropogenic heat fluxes. The complex terrain considerations include the need to incorporate terrain channeling effects on the flow field, diurnally varying slope flows (downslope at night, upslope during the day), and representing the strong spatial variability of the wind fields over relative short distances. The ability to treat plume interactions and plume impingement on terrain above stack height are also important.

The CALMET/CALPUFF modeling system (Scire et al., 2000a,b) was used in the modeling of the Húsavík facility. CALPUFF, and its meteorological model CALMET, were designed to handle the complexities posed by the seashore location and the other issues listed above. CALMET is a diagnostic meteorological model that produces three-dimensional wind and temperature fields and two-dimensional fields such as mixing heights and stability class. It contains slope flow effects, terrain channeling, and kinematic effects of terrain. CALPUFF is a non-steady-state Gaussian puff model. It includes algorithms for building downwash effects of both point sources and buoyant line sources. A complete summary of the capabilities and features of CALMET and CALPUFF is provided in Sections 5.1.1 and 5.1.2. CALMET Version 6.326 and CALPUFF Version 6.262 were used for the current analysis.

5.1.1 Major Features of CALMET

The CALMET meteorological model consists of a diagnostic wind field module and micrometeorological modules for overwater and overland boundary layers. When using large domains, the user has the option to adjust input winds to a Lambert Conformal Projection coordinate system to account for the curvature of the Earth. The diagnostic wind field module uses a two step approach in the computation of the wind fields (Douglas and Kessler, 1988). In the first step, an initial-guess wind field is adjusted for kinematic effects of terrain, slope flows, and terrain blocking effects to produce a Step 1 wind field. The second step consists of an objective analysis procedure to introduce observational data into the Step 1 wind field to produce a final wind field.

The major features and options of the meteorological model are summarized in Table 5-1. The techniques used in the CALMET model are briefly described below.

Step 1 Wind Field:

Kinematic Effects of Terrain: The approach of Liu and Yocke (1980) is used to evaluate kinematic terrain effects. The domain-scale winds are used to compute a terrain-forced vertical velocity, subject to an exponential, stability-dependent decay function. The kinematic effects of terrain on the horizontal wind components are evaluated by applying a divergence-minimization scheme to the initial guess wind field. The divergence minimization scheme is applied iteratively until the three-dimensional divergence is less than a threshold value.

Slope Flows: The slope flow algorithm in CALMET has recently been upgraded (Scire and Robe, 1997). It is based on the shooting flow algorithm of Mahrt (1982). This scheme includes both advective-gravity and equilibrium flow regimes. At night, the slope flow model parameterizes the flow down the sides of the valley walls into the floor of the valley, and during the day, upslope flows are parameterized. The magnitude of the slope flow depends on the local surface sensible heat flux and local terrain gradients. The slope flow wind components are added to the wind field adjusted for kinematic effects.

Blocking Effects: The thermodynamic blocking effects of terrain on the wind flow are parameterized in terms of the local Froude number (Allwine and Whiteman, 1985). If the Froude number at a particular grid point is less than a critical value and the wind has an uphill component, the wind direction is adjusted to be tangent to the terrain.

Step 2 Wind Field:

The wind field resulting from the adjustments described above of the initial-guess wind is the Step 1 wind field. The second step of the procedure involves the introduction of observational data into the Step 1 wind field through an objective analysis procedure. An inverse-distance squared interpolation scheme is used which weighs observational data heavily in the vicinity of the observational station, while the Step 1 wind field dominates the interpolated wind field in regions with no observational data. The resulting wind field is subject to smoothing, an optional adjustment of vertical velocities based on the O'Brien (1970) method, and divergence minimization to produce a final Step 2 wind field.

Table 5-1. Major Features of the CALMET Meteorological Model

- **Boundary Layer Modules of CALMET**
  - Overland Boundary Layer - Energy Balance Method
  - Overwater Boundary Layer - Profile Method
  - Produces Gridded Fields of:
    - Surface Friction Velocity
    - Convective Velocity Scale
    - Monin-Obukhov Length
    - Mixing Height
    - PGT Stability Class
    - Air Temperature (3-D)
    - Precipitation Rate

- **Diagnostic Wind Field Module of CALMET**
  - Slope Flows
  - Kinematic Terrain Effects
  - Terrain Blocking Effects
  - Divergence Minimization
  - Produces Gridded Fields of U, V, W Wind Components
  - Inputs Include Domain-Scale Winds, Observations, and (optionally) Coarse-Grid Prognostic Model Winds
  - Lambert Conformal Projection Capability

CALMET Boundary Layer Models:

The CALMET model contains two boundary layer models for application to overland and overwater grid cells.

Overland Boundary Layer Model: Over land surfaces, the energy balance method of Holtslag and van Ulden (1983) is used to compute hourly gridded fields of the sensible heat flux, surface friction velocity, Monin-Obukhov length, and convective velocity scale. Mixing heights are determined from the computed hourly surface heat fluxes and observed temperature soundings using a modified Carson (1973) method based on Maul (1980). Gridded fields of PGT stability class and optional hourly precipitation rates are also determined by the model.

Overwater Boundary Layer Model: The aerodynamic and thermal properties of water surfaces suggest that a different method is best suited for calculating the boundary layer parameters in the marine environment. A profile technique, using air-sea temperature differences, is used in CALMET to compute the micrometeorological parameters in the marine boundary layer.

An upwind-looking spatial averaging scheme is optionally applied to the mixing heights and 3-dimensional temperature fields in order to account for important advective effects.

5.1.2 Major Features of CALPUFF

By its puff-based formulation and through the use of three-dimensional meteorological data developed by the CALMET meteorological model, CALPUFF can simulate the effects of time- and space-varying meteorological conditions on pollutant transport from point and line sources in complex terrain. The major features and options of the CALPUFF model are summarized in Table 5-2. Some of the technical algorithms are briefly described below.

Complex Terrain: The effects of complex terrain on puff transport are derived from the CALMET winds. In addition, puff-terrain interactions at gridded and discrete receptor locations are simulated using one of two algorithms that modify the puff-height (either that of ISCST3 or a general "plume path coefficient" adjustment), or an algorithm that simulates enhanced vertical dispersion derived from the weakly-stratified flow and dispersion module of the Complex Terrain Dispersion Model (CTDMPLUS) (Perry et al., 1989). The puff-height adjustment algorithms rely on the receptor elevation (relative to the elevation at the source) and the height of the puff above the surface. The enhanced dispersion adjustment relies on the slope of the gridded terrain in the direction of transport during the time step.

Table 5-2. Major Features of the CALPUFF Model

- **Source types**
  - Point sources (constant or variable emissions)
  - Line sources (constant or variable emissions)
  - Volume sources (constant or variable emissions)
  - Area sources (constant or variable emissions)

- **Non-steady-state emissions and meteorological conditions**
  - Gridded 3-D fields of meteorological variables (winds, temperature)
  - Spatially-variable fields of mixing height, friction velocity, convective velocity scale, Monin-Obukhov length, precipitation rate
  - Vertically and horizontally-varying turbulence and dispersion rates
  - Time-dependent source and emissions data for point, area, and volume sources
  - Temporal or wind-dependent scaling factors for emission rates, for all source types

- **Interface to the Emissions Production Model (EPM)**
  - Time-varying heat flux and emissions from controlled burns and wildfires

- **Efficient sampling functions**
  - Integrated puff formulation
  - Elongated puff (slug) formulation

- **Dispersion coefficient (σ_y, σ_z) options**
  - Direct measurements of σ_v and σ_w
  - Estimated values of σ_v and σ_w based on similarity theory
  - Pasquill-Gifford (PG) dispersion coefficients (rural areas)
  - McElroy-Pooler (MP) dispersion coefficients (urban areas)
  - CTDM dispersion coefficients (neutral/stable)

- **Vertical wind shear**
  - Puff splitting
  - Differential advection and dispersion

- **Plume rise**
  - Buoyant and momentum rise
  - Stack tip effects
  - Building downwash effects
  - Partial penetration
  - Vertical wind shear

- **Building downwash**
  - PRIME building downwash
  - Huber-Snyder method
  - Schulman-Scire method

- **Complex terrain**
  - Steering effects in CALMET wind field
  - Optional puff height adjustment: ISC3 or "plume path coefficient"
  - Optional enhanced vertical dispersion (neutral/weakly stable flow in CTDMPLUS)

Table 5-2. Major Features of the CALPUFF Model (Cont'd)

- **Subgrid scale complex terrain (CTSG option)**
  - Dividing streamline, H_d, as in CTDMPLUS:
    - Above H_d, material flows over the hill and experiences altered diffusion rates
    - Below H_d, material deflects around the hill, splits, and wraps around the hill

- **Dry Deposition**
  - Gases and particulate matter
  - Three options:
    - Full treatment of space and time variations of deposition with a resistance model
    - User-specified diurnal cycles for each pollutant
    - No dry deposition

- **Overwater and coastal interaction effects**
  - Overwater boundary layer parameters
  - Abrupt change in meteorological conditions, plume dispersion at coastal boundary
  - Plume fumigation

- **Chemical transformation options**
  - Pseudo-first-order chemical mechanism for SO_2, $SO_4^=$, NO_x, HNO_3, and NO_3^- (MESOPUFF II method)
  - Pseudo-first-order chemical mechanism for SO_2, $SO_4^=$, NO, NO_2 HNO_3, and NO_3^- (RIVAD/ARM3 method)
  - User-specified diurnal cycles of transformation rates
  - No chemical conversion

- **Wet Removal**
  - Scavenging coefficient approach
  - Removal rate a function of precipitation intensity and precipitation type

- **Graphical User Interface**
  - Point-and-click model setup and data input
  - Enhanced error checking of model inputs
  - On-line Help files

- **Interface Utilities**
  - Scan ISCST3 and AUSPLUME meteorological data files for problems
  - Translate ISCST3 and AUSPLUME input files to CALPUFF input format

Subgrid Scale Complex Terrain (CTSG): An optional module in CALPUFF, CTSG treats terrain features that are not resolved by the gridded terrain field, and is based on the Complex Terrain Dispersion Model (CTDMPLUS) (Perry et al., 1989). Plume impingement on subgrid-scale hills is evaluated at the CTSG subgroup of receptors using a dividing streamline height (H_d) to determine which pollutant material is deflected around the sides of a hill (below H_d) and which material is advected over the hill (above H_d). The local flow (near the feature) used to define H_d is taken from the gridded CALMET fields. As in CTDMPLUS, each feature is modeled in isolation with its own set of receptors.

Puff Sampling Functions: A set of accurate and computationally efficient puff sampling routines are included in CALPUFF which solve many of the computational difficulties encountered when applying a puff model to near-field releases. For near-field applications during rapidly-varying meteorological conditions, an elongated puff (slug) sampling function may be used. An integrated puff approach may be used during less demanding conditions. Both techniques reproduce continuous plume results under the appropriate steady state conditions.

Building Downwash: The PRIME building downwash model as well as the Huber-Snyder and Schulman-Scire downwash models are incorporated into CALPUFF. An option is provided to use either model for all stacks, or make the choice on a stack-by-stack and wind sector-by-wind sector basis. The algorithms have been implemented in such a way as to allow the use of wind direction specific building dimensions. For long buildings such as aluminum smelters, the use of the Schulman-Scire/Huber-Snyder methods are recommended.

Dispersion Coefficients: Several options are provided in CALPUFF for the computation of dispersion coefficients, including the use of turbulence measurements (σ_v and σ_w), the use of similarity theory to estimate σ_v and σ_w from modeled surface heat and momentum fluxes, or the use of Pasquill-Gifford (PG) or McElroy-Pooler (MP) dispersion coefficients, or dispersion equations based on the Complex Terrain Dispersion Model (CTDM). Options are provided to apply an averaging time correction or surface roughness length adjustments to the PG coefficients.

Overwater and Coastal Interaction Effects: Because the CALMET meteorological model contains both overwater and overland boundary layer algorithms, the effects of water bodies on plume transport, dispersion, and deposition can be simulated with CALPUFF. The puff formulation of CALPUFF is designed to handle spatial changes in meteorological and dispersion conditions, including the abrupt changes which occur at the coastline of a major body of water.

Dry Deposition: A full resistance model is provided in CALPUFF for the computation of dry deposition rates of gases and particulate matter as a function of geophysical parameters, meteorological conditions, and pollutant species. Options are provided to allow user-specified, diurnally varying deposition velocities to be used for one or more pollutants instead of the resistance model (e.g., for sensitivity testing) or to by-pass the dry deposition model completely. For particles, source-specific mass distributions may be provided for use in the resistance model.

Wind Shear Effects: CALPUFF contains an optional puff splitting algorithm that allows vertical wind shear effects across individual puffs to be simulated. Differential rates of dispersion and transport among the "new" puffs generated from the original, well-mixed puff can substantially increase the effective rate of horizontal spread of the material.

Wet Deposition: An empirical scavenging coefficient approach is used in CALPUFF to compute the depletion and wet deposition fluxes due to precipitation scavenging. The scavenging coefficients are specified as a function of the pollutant and precipitation type (i.e., frozen vs. liquid precipitation).

Chemical Transformation: CALPUFF includes options for parameterizing chemical transformation effects using the five species scheme (SO_2, $SO_4^{=}$, NO_x, HNO_3, and NO_3^{-}) employed in the MESOPUFF II model, the six species RIVAD scheme (SO_2, $SO_4^{=}$, NO, NO_2, HNO_3, and NO_3^{-}), or a set of user-specified, diurnally-varying transformation rates.

5.2 Modeling Domain Configuration

The CALMET computational domain consists of a uniform horizontal grid with a grid cell size of 1.0 km. It extends out to approximately 20 to 30 km from the facility and consists of 56 x 51 grid cells (56 km x 51 km domain). The southwest corner of the domain has a UTM coordinate of 369.5 km East, 7299.5 km North in UTM Zone 28, datum WGS-84. In the vertical, a stretched grid is used with fine resolution in the lower layers in order to resolve the mixed layer and a somewhat coarser resolution aloft. Ten vertical layers are used that are centered at 10, 30, 60, 120, 240, 460, 800, 1250, 1850, and 2600 meters. This horizontal and vertical grid structure was chosen to provide a detailed fine-scale representation of terrain effects. There are significant topographical features in the area that affect the wind flow and offer the potential for plume-terrain interaction. Peak terrain heights are over 600 meters in the area surrounding the proposed Alcoa facility. The base elevation of the plant is approximately 20 meters MSL and the majority of the emission points have heights between 22.5 and 78.0 meters. Therefore, complex terrain effects, in terms of both low-level wind flow channeling as well as terrain-plume interaction effects, are potentially important.

5.3 Meteorological Modeling Options

Initial Guess Field

Gridded MM5 meteorological fields produced by TRC were used to define the initial guess fields for the CALMET simulations. The MM5 simulations were made for the period January to December 2003, the same period selected for the CALMET/CALPUFF runs. The MM5 data were produced at a horizontal resolution of 1 km and at 25 vertical sigma levels (24 half-sigma levels where the winds are defined).

Step 1 Field: Terrain Effects

In developing the Step 1 wind field, CALMET adjusts the initial guess field to reflect 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. A value of TERRAD of 8 km is considered most appropriate for the Húsavík computational domain and was determined based on an analysis of the width size of Húsavík domain (see Figure 3-2). The Step 1 field produces a flow field consistent with the CALMET terrain resolution scale (1.0 km).

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 the 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 (2 km) of R1 and R2 were selected because the three meteorological stations in the vicinity of the Alcoa facility project are located very close to each other (at a distance of less than 5 km), and each of these stations should have an important weight. Since the initial guess field is driven by the MM5 winds and terrain effects are expected to be important, RMAX1 and RMAX2 were set to 10 km in order to give greater weight to the surface station and RMIN=0.1 km.

5.4 Dispersion Modeling Options

The CALPUFF simulations were conducted for the period January to December 2003 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

-Building downwash effects – (ISCST3 techniques)

-Wet and dry deposition were applied

-Chemical transformation was not considered.

The configuration of the sources is such that building downwash effects will influence dispersion. Wind direction building dimensions were derived from the application of the BPIP building downwash program. The Gaussian vertical distribution option is selected in CALPUFF to provide a better representation of near-field concentrations.

The CALPUFF computational grid consists of a sub-domain within the meteorological grid (i.e., 56 x 51 km with a 1.0 km resolution or 56 x 51 grid cells). The entire domain is used as computational domain. Two important computational parameters in CALPUFF are XMXLEN (maximum length of an emitted puff, in grid units) and XSAMLEN (maximum travel distance of a puff, in grid units, during one time step). Both of these variables were set to 1.0 grid units in the CALPUFF simulations in order to allow the wind channeling effects to be accounted for in the puff trajectory calculations. The first parameter ensures that the length of an emitted puff does not become so large that it cannot respond to changes in the wind field on the scale of the meteorological grid (1.0 km resolution). The model automatically increases the frequency of puff releases to ensure the length of a single puff is not larger than the grid size. The second parameter decreases the internal time step to ensure the travel distance during one time step does not exceed the grid size.

Deposition effects were modeled using the default dry deposition model and the scavenging coefficient wet removal module. Deposition fluxes are derived from the total (wet + dry) deposition fluxes of the species produced by the CALPUFF model. The SO_2 default values are used for SO_2 and for PM_{10}, which is mostly sub 2.5 microns, the default value of SO_4 or NO_3 can be used both for dry and wet deposition parameters, and these parameters were estimated for HF, PAH and BaP.

HNO_3 and HF have similar solubility and reactivity parameters. Therefore, the default HNO_3 chemical parameters are used for the HF dry deposition parameters.

5.5 Receptor Grid

CALPUFF was run using a UTM-based Cartesian receptor grid around the Alcoa facility. The receptor grid consists of three nested grids of discrete receptors with the highest resolution (100 meters) confined to the immediate vicinity of the Alcoa site. The fine resolution 100 meter spaced discrete receptor grid extend 2-3 km around and including the facility. Beyond this area, a receptor spacing of 200 meters was used out to 10 km of the facility and then 400m- spaced receptors extended up to 20km away from the facility (see Figure 5-1). This resulted in a total of 17,585 discrete receptors.. Receptor elevations were obtained from the 15 m resolution terrain elevation data from digitized data for the 100m-spaced receptors and from the ASTER GDEM data set (also 15m resolution data) for the 200m and 400m-spaced receptors.

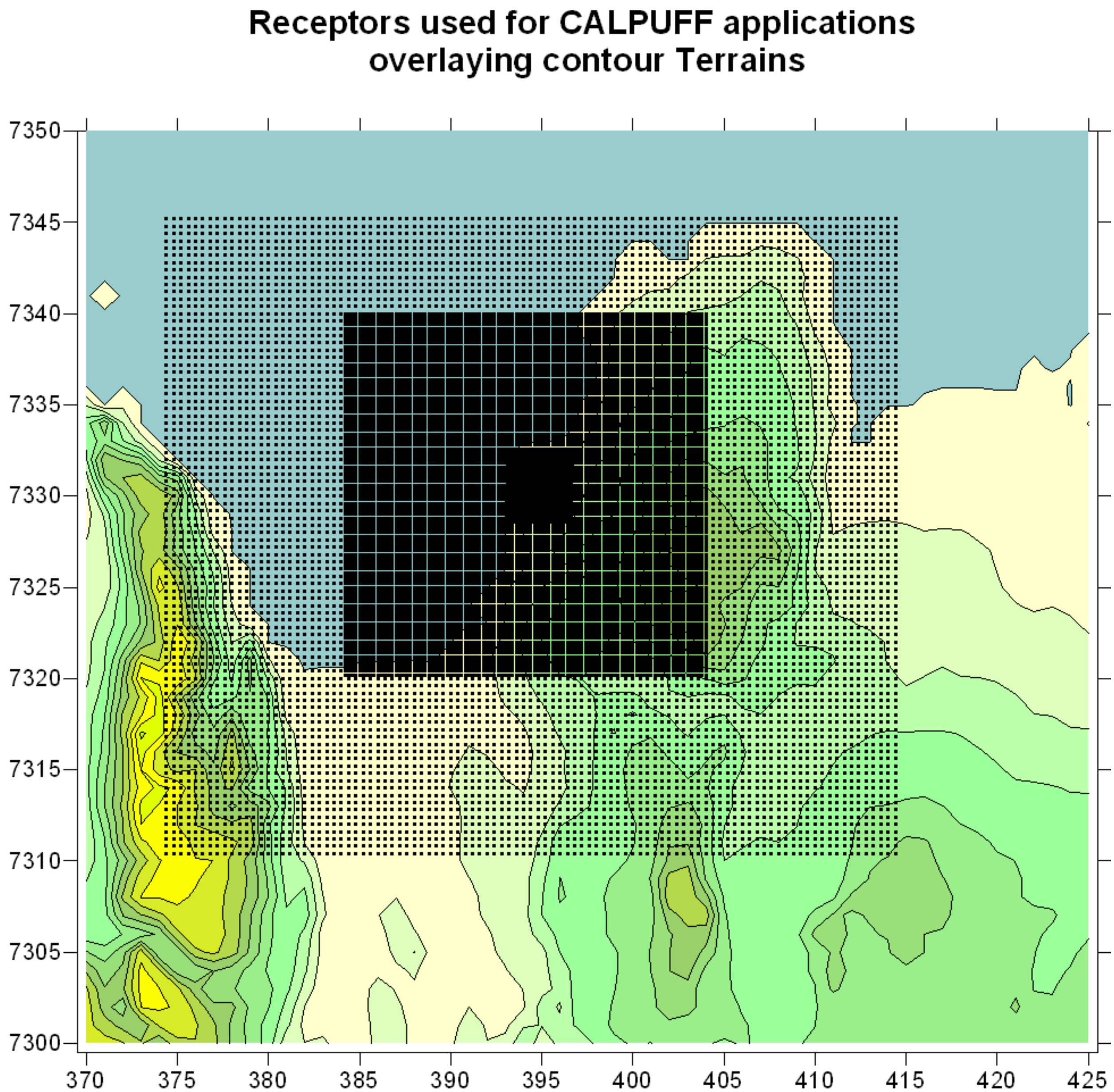


Figure 5-1. Plot of CALPUFF domain and CALPUFF discrete receptors. Receptors closed to the facility are 100-meter spaced up to 2-3 km. From 2-3 km to 10 km, receptors are 200-meter spaced and from 10 km to approximately 20 km, receptors are 400-meter spaced.

6. MM5 AND CALMET OUTPUT ANALYSIS

Annual wind roses are plotted at three meteorological stations for observations, MM5 run output, and CALMET predictions. Figure 6-1 shows plots for Bakkahofdi (3692), the closest station to the facility used in the CALMET runs and Húsavík (3696), situated less than 5km south of the facility. Figure 6-2 shows plots for Manarbakki (479), which is located much more north, approximately 15km north. Location of the three stations are shown on Figure 3-5 of section 3. At the two meteorological stations of Figure 6-1, the predicted MM5 winds reproduce the observed winds coming from the south very well, while the northerlies wind are shifted slightly east. These small differences in wind direction observed in MM5 are corrected in the CALMET runs where the observations have been included. Indeed, a very strong correlation exists between observations and CALMET predictions as one would expect with a diagnostic model. Because the CALMET wind fields are used to drive CALPUFF, the process of introducing the observed winds into the MM5 fields ensures an accurate representation of the observed flow in the areas around where the measurements are made. Overall though, good agreement exists between the predicted winds from CALMET and observed winds. A strong influence of terrain on the winds may be observed in both CALMET and Observed winds.

At Figure 6-2, the observations covered only 24% of the total hours of the year, CALMET wind rose show a combination of the observations and MM5 data.

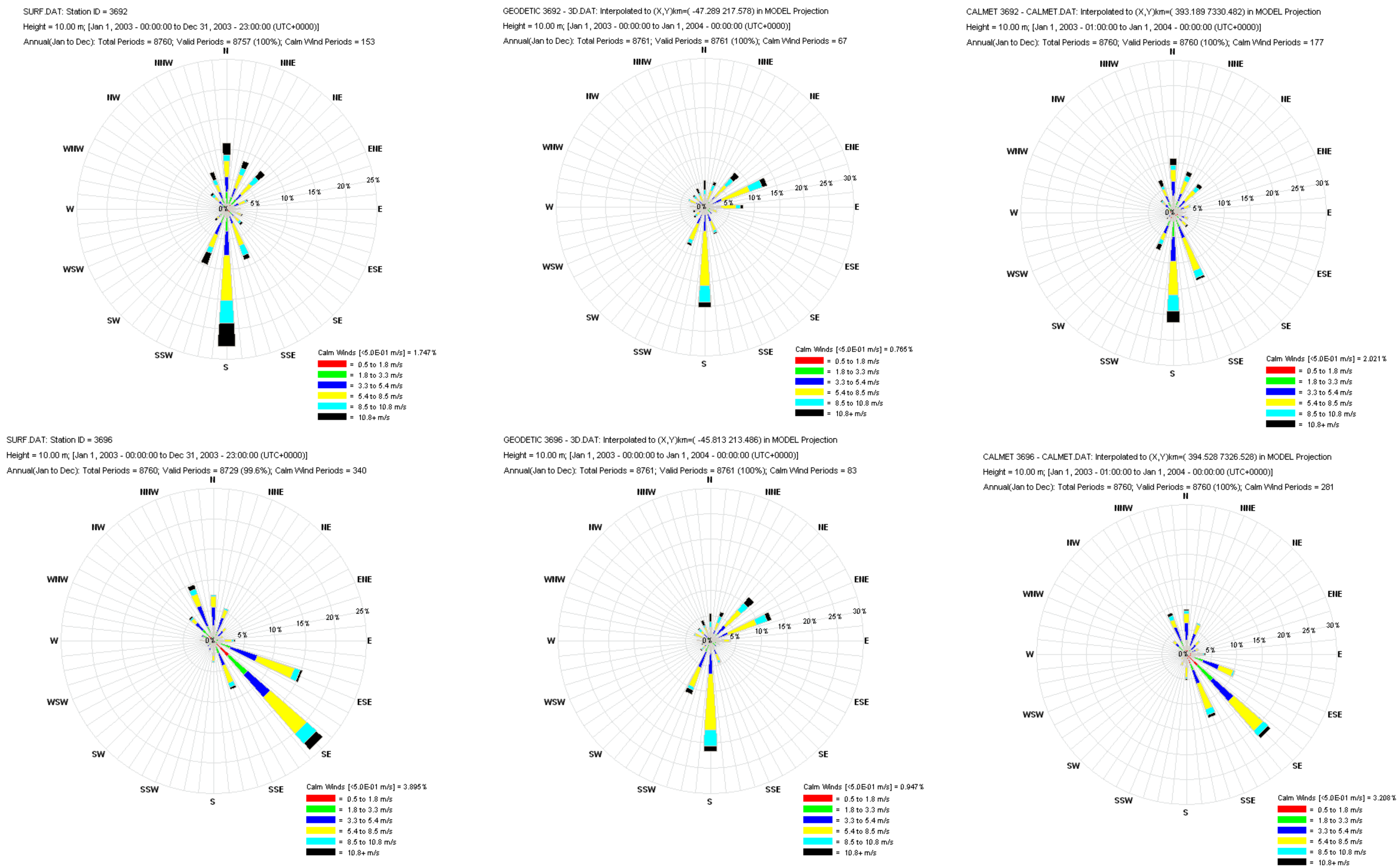


Figure 6-1. Annual average wind roses plotted at meteorological stations Bakkahofdi (top) and Húsavík (bottom). From left to right, plots are for observations, MM5, and CALMET.

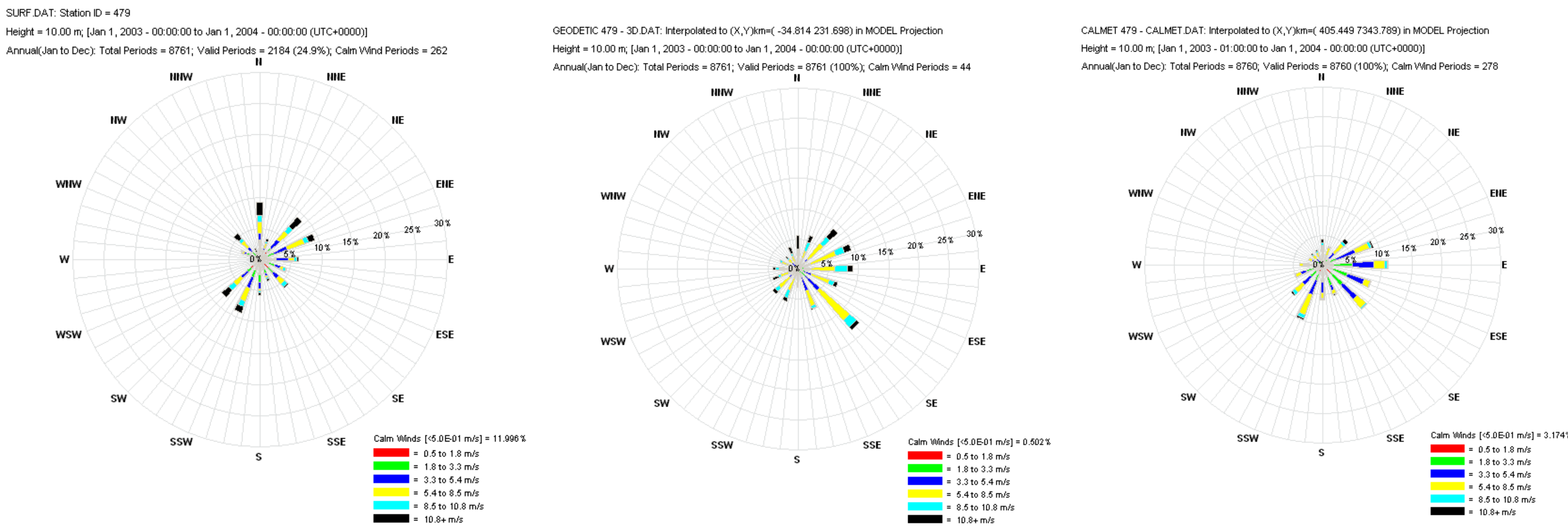


Figure 6-2. Annual average wind roses plotted at meteorological stations Manarbakki. From left to right, plots are for observations, MM5, and CALMET.

7. MODELED PERIOD VERSUS CLIMATOLOGY

For the closest meteorological station (Figure 7-1), Bakkahofdi (Station 3692), to the proposed location of the aluminum plant, four full years of data were provided to us, from January 2003 to December 2006. This period will define the climatology period with which the year modeled will be compared and analyzed. Year 1 is January to December 2003 (year modeled), Year 2 is January to December 2004, Year 3 is January to December 2005 and Year 4 is January to December 2006. Recorded data for January to October 2009 were also provided for this station but only one and a half month have valid wind data. The second closest station (Figure 7-1) to the facility is Húsavík (Station 3696). This station also has data recorded for the period 2003-2006. The wind measurements at this station are also used to analyzed the modeled period versus climatology. Measurements from a third station, Hedinshofdi (Station 3695) were received for a 10-month period of 2009. No data were available at this station for the year modeled (2003), so it was not used in the CALMET runs. The facility is located between Stations 3692 and 3695. So, Station 3695 is also used to evaluate year variability when it is compared to the two other stations.

At Bakkahofdi, the annual average wind rose has two dominant wind directions: notherlies and southerlies (Figure 7-2). At Húsavík station (Figure 7-3), the annual average wind rose has also two dominant wind direction but slightly different, northwesterlies and southeasterlies. The difference between the wind rose at these two stations can be explain by their location. Bakkahofdi is located right on the shore, which can explain the stronger winds, while Húsavík station seems to be located south west of a little hill which explain the change in wind direction from north to northwest and south to southeast when it is compared to the Bakkahofdi station. All four years display a similar wind rose at both stations with not much variability. Figure 7-4 displays the wind rose for the station Hedinshofdi (Station 3695) located northeast of the proposed site of the facility (Figure 7-1). This wind rose covers a 10-month period (January to October) of 2009. The wind rose at this station has similar features as the wind rose observed at Bakkahofdi with northerlies and southerlies dominating the wind rose components. The southerlies being from the south-southeast an intermediate between the south of Bakkahofdi station and the southeast of Húsavík station. The location of Station 3695 much closer to the terrain can explain the dominant south wind changing from true south to south southeast between Stations 3692 and 3695.

In summer (June to September), the night wind rose (0h-6h) is represented primarily by light winds coming from the south (Appendix C). During the day (12h-18h), the winds are mainly from the north and much stronger (Appendix C). All four years show the same features. Húsavík station, situated slightly south of the facility (less than 5 km away), displays similar features as in Bakkahofdi station, except that at night the wind has a very strong component from the south east rather than the south. Hedinshofdi station display also similar features but with a night wind much more variable and lighter.

The wind velocity is then plotted as a function of wind direction (every 10 degrees) for two periods at Bakkahofdi station (Station 3692): summer (April-September) and winter (October-March), plotted respectively on Figure 7-5 and Figure 7-6. For both periods, similar to the annual wind roses, two wind directions dominate, northerly and southerly. The average wind speed in the summer is approximately 6 m/s. Northerlies and southerlies happen with a similar frequency in summer, while southerlies are more frequent during the winter. Indeed, in winter, 2003 has a high frequency of wind from 180 degrees while the other year display a higher frequency for 170 degrees. On average, winter winds from the north are the strongest. Winter wind speeds show also the largest variability from year to year. Southerlies winds tend to be weaker during the summer than in winter by approximately 2 m/s and northerlies by 4 to 6 m/s. During summer months of 2003 (year modeled), northwesterly winds tend to be slightly weaker than in the other years, while the southerlies in winter are much more frequent in 2003 than in any other years. In addition, wind velocity as function of wind direction is added on the same plot for Station 3695 for 2009. In summer month, it shows similar features as the four years of Station 3692, except the highest frequency of southerlies wind is rather from 140 degree rather than 180. But as explain earlier, this can be explain by the location of this station closer to the terrain. In winter, Station 3695 shows also similar wind speed and direction, may be slightly lower in intensity due to its location more inland. Two similar plot displays the features for Húsavík station in summer and winter, on Figures 7-7 and 7-8, respectively. The wind speed at Húsavík station is usually lower than at Bakkahofdi station and Hedinshofdi station and from slightly different direction as it was shown on the wind rose. But the year to year variability is rather small.

Table 7-1 shows the number of calm periods per year for each year of the period 2003-2006 at Bakkahofdi (Station 3692) and Húsavík (Station 3696) and for 2009 at Hedinshofdi (Station 3695). A calm event is defined as the number of consecutive hours with calm winds (i.e. wind speeds less than 1 m/s). The year 2003 is very similar to the three other years in term of calm wind events at the two stations covering the period 2003-2006. However, calm events at Hedinshofdi station for 2009 seem to be more frequent than at Station 3692 but quite the same as in Station 3696, located also more inland. Table 7-2 gives information on the number of days with occurrences of substantial wind intensity events, characterized by winds stronger than 5 m/s for a period between 9h and 24h. The four years at Station 3692 and Station 3696 give the same indication that more days are recorded as substantial wind intensity event at the shoreline station than at the more inland station. For

2009, Station 3695 gives a number of event in between the number of events at Station 3692 and Station 3696.

As one would expect, a small amount of annual variability exists between the four years analyzed but in general the four years are quite similar in term of wind direction and intensity, number and length of calm events and number of substantial wind intensity event. The wind observations recorded at the on-site station Hedinshofdi for 2009 (January to October), displays in general similar features in wind speed and directions as for the four other years analyzed at the two stations in the vicinity. Small discrepancies can be explained by the location of each of these stations.

Figure 7-1. Location of surface stations in relation to facility, terrain contours and shoreline. Stations 3692, 3696 and 3695 are used for the climatology analysis. These three stations are the closest stations to the facility with wind data information. Station 3694 does not have any wind measurements.

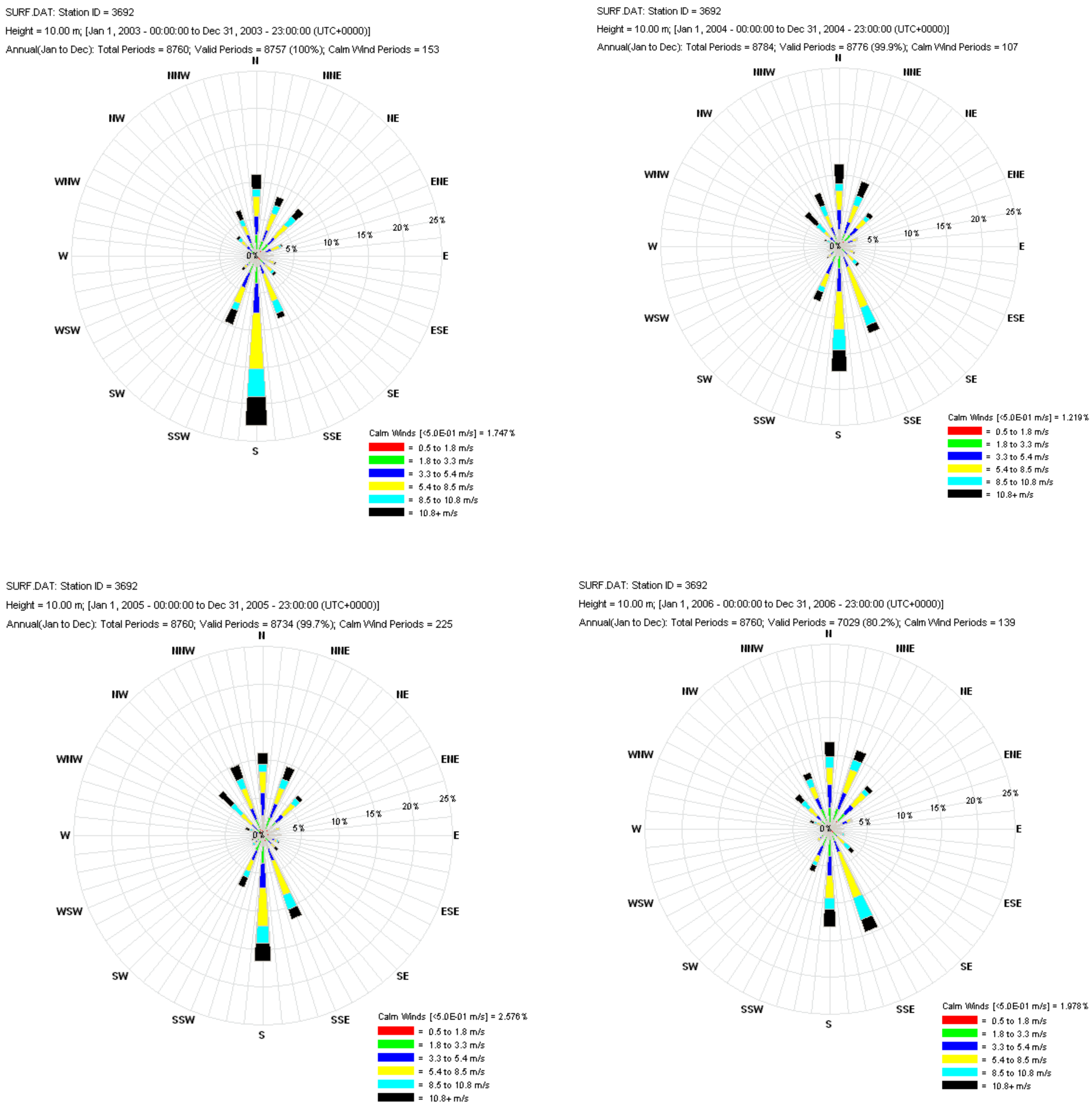


Figure 7-2. Annual wind roses of 10 meter winds observed at Bakkahofdi for each year (January to December) of the four-year period (2003-2006).

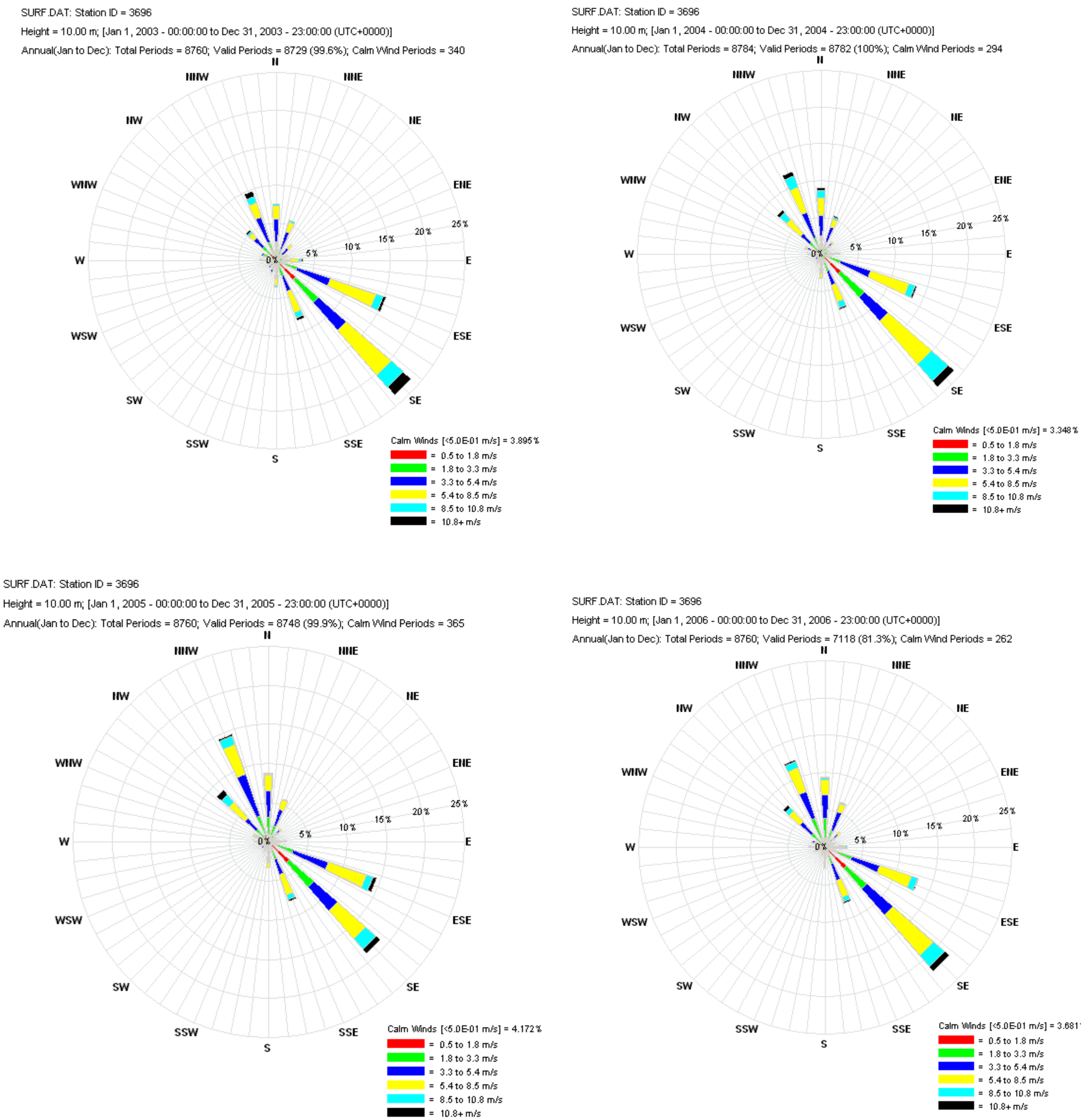


Figure 7-3. Annual wind roses of 10 meter winds observed at Húsavík for each year (January to December) of the four-year period (2003-2006).

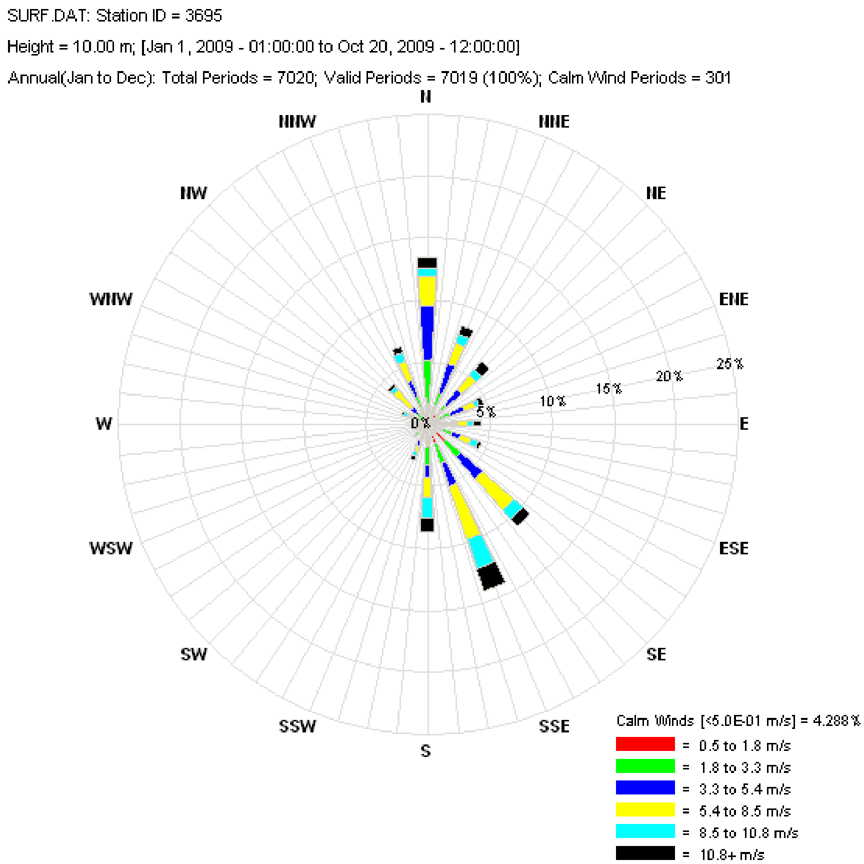
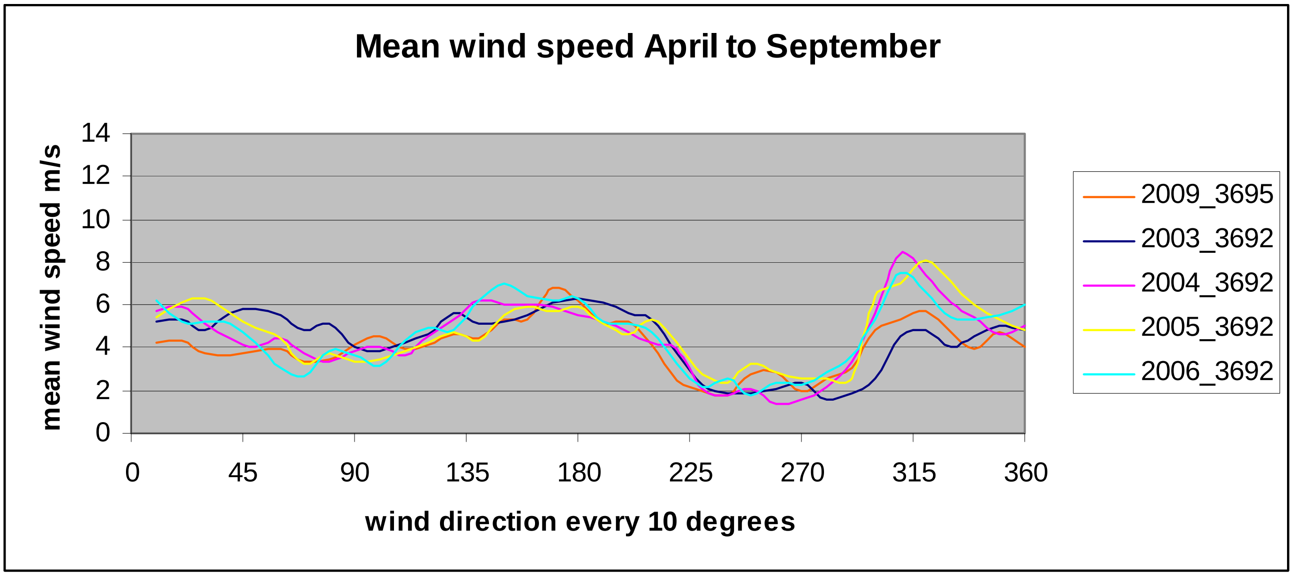


Figure 7-4. Annual (January 1 to October 20) wind rose of 10 meter winds observed at Hedinshofdi for 2009.



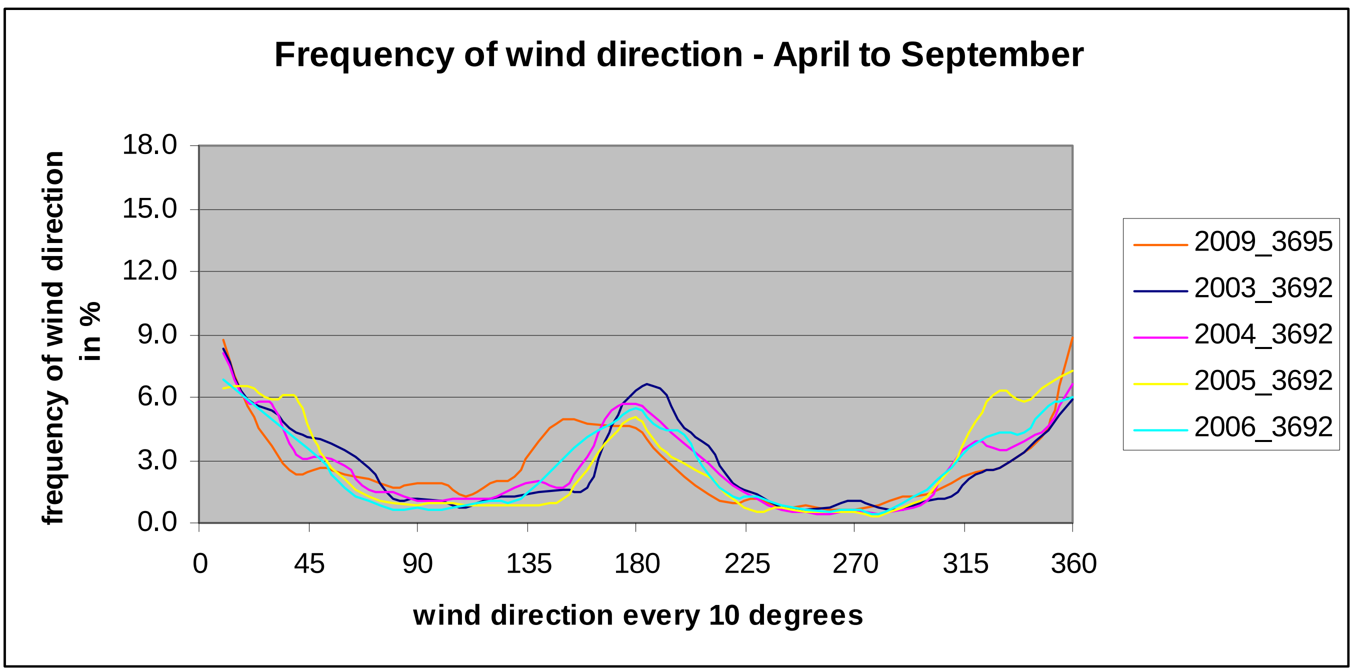
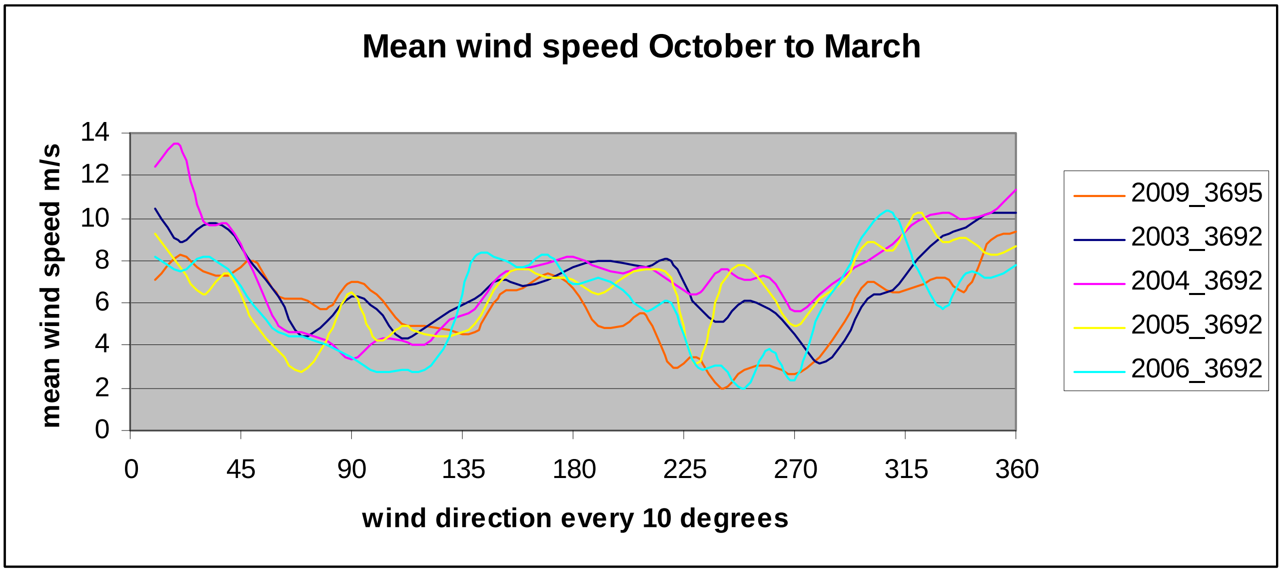


Figure 7-5. Mean wind speed and frequency in % of total hours over the period plotted as a function of wind direction at Bakkahofdi station for 2003, 2004, 2005 and 2006. The period selected is April to September of each year. Each color represents a different year. The dark blue line is the year modeled. As a comparison, Station 3695 for 2009 has been added as an orange line.



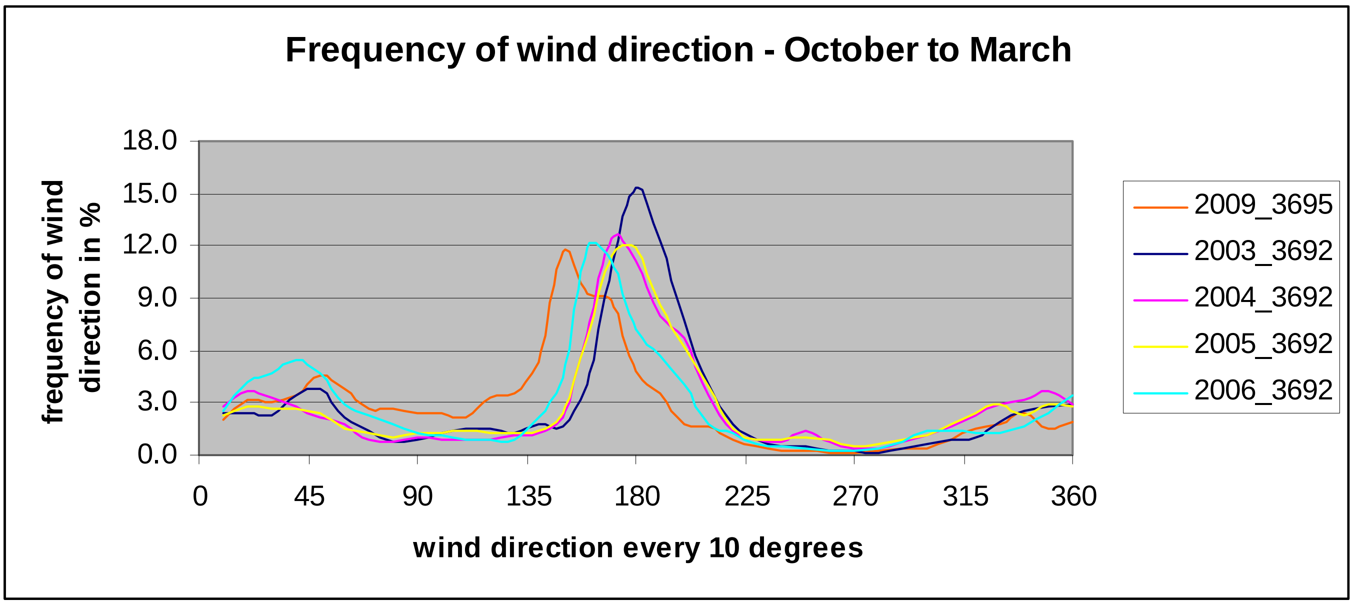
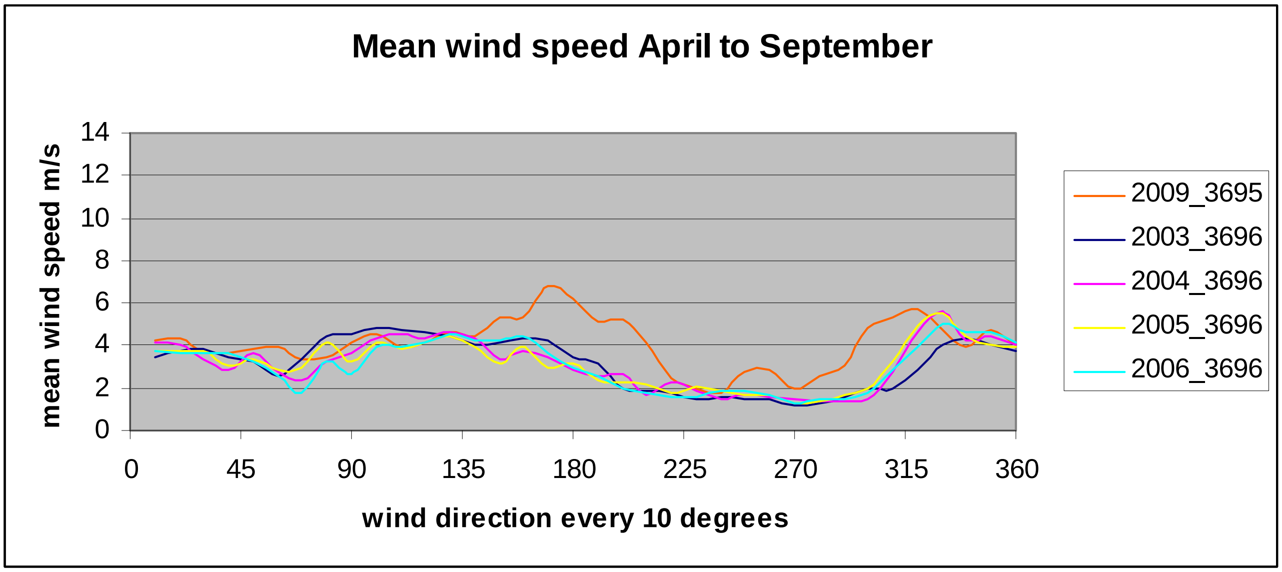


Figure 7-6. Mean wind speed and frequency in % of total hours over the period plotted as a function of wind direction at Bakkahofdi station for 2003, 2004, 2005 and 2006. The period selected is January to March and October to December of the same year. Each color represents a different year. The dark blue line is the year modeled. As a comparison, Station 3695 for 2009 has been added as an orange line. The years 2006 and 2009 have less recorded data. December and November winds are missing for these two years.



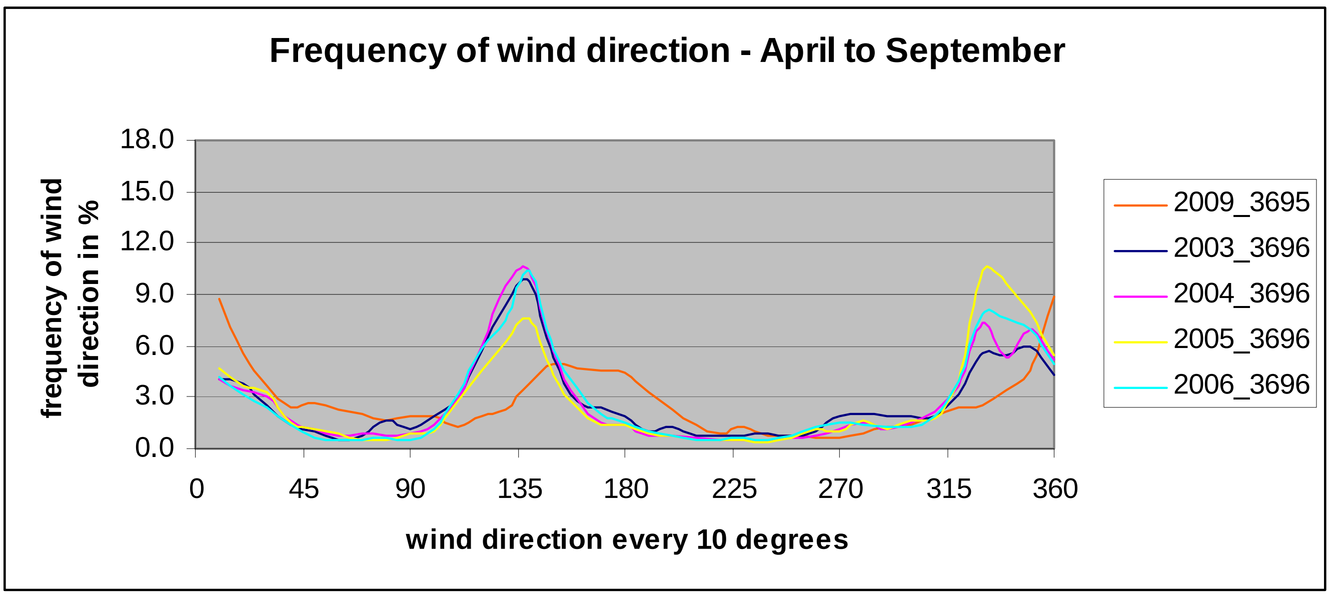
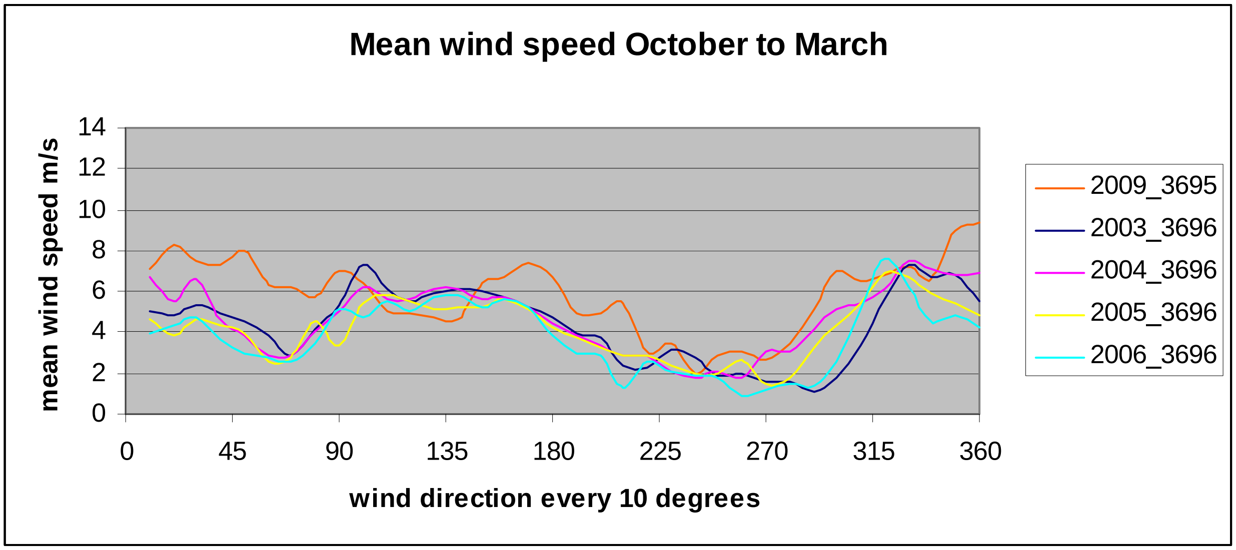


Figure 7-7. Mean wind speed and frequency in % of total hours over the period plotted as a function of wind direction at Húsavík station for 2003, 2004, 2005 and 2006. The period selected is April to September of each year. Each color represents a different year. The dark blue line is the year modeled. As a comparison, Station 3695 for 2009 has been added as an orange line. The years 2006 and 2009 have less recorded data. December and November winds are missing for these two years.



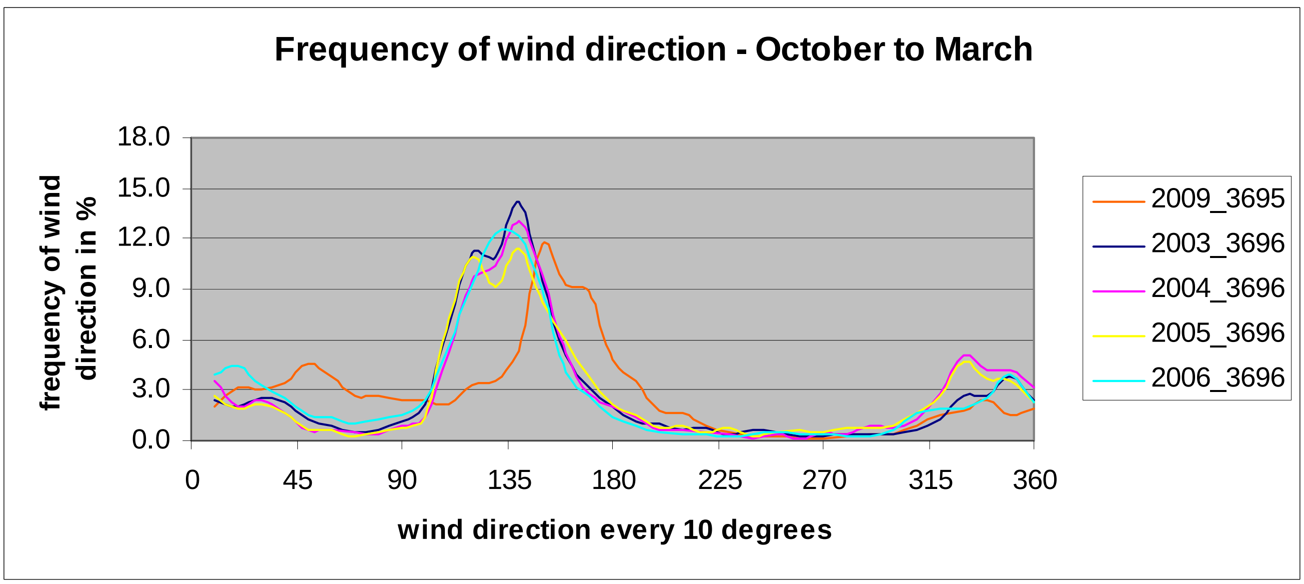


Figure 7-8. Mean wind speed and frequency in % of total hours over the period plotted as a function of wind direction at Húsavík station for 2003, 2004, 2005 and 2006. The period selected is January to March and October to December of the same year. Each color represents a different year. The dark blue line is the year modeled. As a comparison, Station 3695 for 2009 has been added as an orange line.

Table 7-1. Number of Occurrences of Calm Events[1] at Bakkahofdi station (3692) and at Húsavík station (3696) for 2003, 2004 and 2006 (Jan-Dec) and at Hedinshofdi station for 2009 (Jan-Oct) – Length of an Event Varies from 1h to 13h.

Year	Station ID	No. of Events of 1h	No. of Events of 2h	No. of Events of 3h	No. of Events of 4h	No. of Events of 5h	No. of Events from 6h to 22h	Maximum No. of hours of consecutive calm wind	Number of occurrence of max (previous column)	Total No. of Events Per Year
2003	3692	222	64	25	13	5	4	10h	1	333
2004	3692	211	67	21	5	7	2	6h	2	313
2005	3692	260	63	32	14	7	7	12h	1	383
2006	3692	223	46	22	14	4	6	13h	1	315
2003	3696	251	83	50	18	17	22	15h	6	441
2004	3696	268	96	40	14	14	17	12h	1	449
2005	3696	267	97	43	21	14	20	20h	3	462
2006	3696	254	85	30	20	8	18	22h	2	415
2009	3695	177	74	38	12	13	20	11-12h	6	334

1 A calm event is defined as winds less than or equal to 1 m/s.

Table 7-2. Number of Occurrences of Substantial Wind Intensity[1]. (Day 1 to Day 292) at three stations Bakkahofdi (3692), Húsavík (3696) and Hedinshofdi (3695)

Station ID	Year 2003	Year 2004	Year 2005	Year 2006	Year 2009
3692	201 days	204 days	201 days	195 days	N/A
3696	137 days	144 days	136 days	128 days	N/A
3695	N/A	N/A	N/A	N/A	147 days

1 A substantial wind intensity event is defined as more than 9 hours in a day with winds stronger than 5 m/s.

8. RESULTS

8.1 Ambient Standards

Table 8-1 summarizes the air quality guidelines that need to be met for this study. These guidelines are from Icelandic regulations, European Union directives and Norwegian regulatory guidance. Both short-term (1h and 24h) and long-term (seasonal and annual) averages are covered. The EFA (*European Federation of Asthma and Allergy Associations*) and Norwegian authorities have established ambient standards for HF designed to protect vegetation and human health. Icelandic regulations have placed upper and lower evaluation limits for SO_2 in the winter season for the ecosystem. Note also, that some limits are allowed to be exceeded a specified number of times per year.

The air quality analysis is performed in two steps. First, the maximum predicted concentrations resulting from the proposed facility emissions are evaluated and compared to the corresponding guideline concentrations. If the predicted maximum concentrations exceed the guideline limits, then a second step is taken in order to determine the number of averaging periods for which the guideline limit values are exceeded. This number is then compared with the number of exceedances allowed.

Table 8-2 and Table 8-3 summarize the predicted number of exceedances outside the industrial zone for all modeled species for the base case scenario and the wet scrubber scenario, respectively. Runs using annual average emission rates, evaluate the impacts of SO_2, HF, PM_{10}, PAH and BaP for all regulated averaging time periods.

The results for Base Case Scenario are shown in Figures 8-1 to 8-13. The results for Wet Scrubber Scenario are displayed in Figures 8-14 and 8-25. These results show that the predicted impacts from the Alcoa facility will be in compliance with the applicable standards and guidelines for the two scenarios considered if the industrial zone can be extended approximately 100m south. The following sections describe in detail the modeling results for each pollutant.

8.2 HF Concentrations

For HF concentrations, there are two relevant averaging periods with applicable guidelines: the 24-hour average and the growing season average. The growing season is defined as the period between April 1 and September 30, 2003. The highest predicted 24-hour average concentration values occur inside the industrial zone: 23.92 $\mu g/m^3$ in Base Case Scenario (Figure 8-1), 23.9 $\mu g/m^3$ in Wet Scrubber Scenario (Figure 8-14). Both are smaller then the 24-hour average HF concentration guideline of 25 $\mu g/m^3$. Outside the industrial zone, the maximum 24-hour average concentration values are four time smaller than inside the industrial zone. HF growing season average concentration predictions inside the industrial zone exceed the 0.3 μg/m^3 guideline for the Base Case Scenario and Wet Scrubber Scenario, Figures 8-2 and 8-15, respectively. However, the 0.3 guideline is not exceeded outside the industrial zone, except for 3 receptors less than 100m south of the industrial zone for Base Case Scenario (Figure 8-3) and 4 receptors less than 100m south of the industrial zone for Wet Scrubber Scenario (Figure 8-16). If the industrial zone can be extended approximately 100m more south, the proposed facility would be in compliance with HF air quality regulations.

8.3 SO_2 Concentrations

Four different averaging periods are considered for SO_2 concentrations. The first is the 1-hour average. In Base Case Scenario, the highest 1-hour peak is 879.3 μg/m^3. This value occurs outside the industrial zone on the water north of the facility (Figure 8-4). The 350 μg/m^3 impact level is reached several times in different locations outside the industrial zone for Base Case Scenario, but never more than 4 times at the same receptor (Figure 8-5), while up to 24 times are allowed. In Wet Scrubber Scenario, the maximum 1-hour peak of 455.4 μg/m^3 occurs inside the industrial zone (Figure 8-17). There is one exceedance of the 350 μg/m^3 impact level outside the industrial zone in Wet Scrubber Scenario (Figure 8-18).

For the 24-hour average, in Base Case Scenario the highest concentrations occur on the sea north of the facility (Figure 8-6). The 24-hour average guideline value of 50 μg/m^3 is never exceeded more than 1 times at the same receptor for Base Case Scenario (Figure 8-7), while up to 7 exceedances are allowed in a given year. The 24h-average threshold is never reached outside the industrial zone in Wet Scrubber Scenario (Figure 8-19). The maximum annual average values for both Base Case Scenario and Wet Scrubber Scenario occur inside the industrial zone and have values of 14.6 μg/m^3 (Figure 8-9) for Base Case Scenario and 18.6 μg/m^3 (Figure 8-21) for Wet Scrubber Scenario. Both of these values fall below the guideline value of 20 μg/m^3. The winter period (from January 1 to March 31, 2003 added to October 1 to December 31, 2003) also needs to be considered. The highest SO_2 predicted concentration average over this period is 15.77 μg/m^3 in Base Case Scenario (Figure 8-8) and 19.8 μg/m^3 in Wet Scrubber Scenario (Figure 8-20). Both values occur inside the industrial zone, and fall below the guideline value of 20 μg/m^3. No violations of any SO_2 air quality guidelines are predicted due to emissions from the proposed facility. Therefore, the proposed facility is predicted to be in compliance with SO_2 ambient air quality guidelines.

8.4 PM_{10} Concentrations

For PM_{10}, the peak predicted 24-hour average concentration is 10.93 μg/m^3 (Figure 8-10) for Base Case Scenario and 11.0 μg/m^3 (Figure 8-22) for Wet Scrubber Scenario. Both of these values occur inside the industrial zone and are much lower than the guideline value of 50 μg/m^3. For the annual average PM_{10} concentrations, a maximum value of 2.15 μg/m^3 is predicted (Figure 8-11) for Base Case Scenario and 2..37 μg/m^3 (Figure 8-23) for Wet Scrubber Scenario. Both values occur inside the industrial zone, and fall well below the guideline value of 20 μg/m^3. No violations of any PM_{10} air quality regulations are predicted due to emissions from the proposed facility. Therefore, the proposed facility is predicted to be in compliance with PM_{10} ambient air quality guidelines.

8.5 PAH Concentrations

The predicted PAH annual average concentrations all fall below the target value of 100 ng/m^3 (based on 100 times BaP guideline) outside the industrial zone. The maximum predicted PAH concentration outside the industrial zone is 0.79 ng/m^3 in Base Case Scenario (Figure 8-12) and 0.85 ng/m^3 in Wet Scrubber Scenario (Figure 8-24). Therefore, the proposed facility is predicted to be in compliance with PAH target values.

8.6 BaP Concentrations

The predicted BaP annual average concentrations are all below the guideline values of 1 ng/m^3. The maximum predicted BaP concentration outside the industrial zone is 0.008 ng/m^3 in Base Case Scenario (Figure 8-13) and 0.0098 ng/m^3 in Wet Scrubber Scenario (Figure 8-25). Therefore, the proposed facility is predicted to be in compliance with BaP ambient air quality guidelines.

Table 8-1. Summary of Relevant Air Standards and Guidelines.

Parameter	Averaging Period	Impact Level Value (μg/m³)	Allowed Exceedances (4)	Source
HF	24-consecutive hours	25	0	Norwegian guidelines – Protection of human health
	Growing season (April 1 – September 30)	0.3	0	EFA guideline for existing aluminum plants in Iceland (Norwegian guidelines) Protection of vegetation
SO_2	1-hour	350	24 times/year	Icelandic regulation No. 251/2002
	24- consecutive hours	125	3 times/year	Icelandic regulation No. 251/2002
		75-50(1)	3 times/year	Icelandic regulation No. 251/2002
		50	7 times/year	Icelandic regulation No. 251/2002
	Winter season (October 1- March 31)	20	0	Icelandic regulation No. 251/2002
		12-8(2)	0	Icelandic regulation No. 251/2002
	Annual	20	0	Icelandic regulation No. 251/2002
PM_{10}	24-consecutive hours	50	7 times/year	Icelandic regulation from 2010
		30-20(1)	7 times/year	Icelandic regulation No. 251/2002
	Annual	20	0	Icelandic regulation No. 251/2002
		14-10(3)	0	Icelandic regulation No. 251/2002
PAH	Annual	100 ng/m³		Target Value (100 times BaP Guideline)
BaP	Annual	1 ng/m³	0	Icelandic Regulation No. 410/2008, based on European directive 2004/107/EC

(1) Upper and lower threshold for monitoring.

(2) Upper and lower evaluation limit for ecosystem.

(3) Upper and lower assessment threshold.

(4) Number of exceedances allowed at a particular receptor in a given year outside the industrial zone.

Table 8-2. Summary of CALPUFF Modeling Results for Base Case Scenario.

Parameter	Averaging Period	Impact Level Value ($\mu g/m^3$)	Number of Exceedances Allowed	Number of Exceedances Predicted outside industrial zone [1]	Number of Receptors with Violations Predicted outside industrial zone	In Compliance?	Maximum peak ($\mu g/m^3$)	Maximum Peak outside industrial zone ($\mu g/m^3$)
HF	24-consecutive hours	25	0	0	0	Yes	23.92	6.65
	Growing season (April 1 – September 30)	0.3	0	1	3	No/Yes[2]	6.17	0.32
SO_2	1-hour	350	24	4	377	Yes	879.3	879.3
	24-consecutive hours	50	7	1	47	Yes	83.42	83.42
	Winter season (October 1-March 31)	20	0	0	0	Yes	15.77	1.88
	Annual	20	0	0	0	Yes	14.62	1.63
PM_{10}	24-consecutive hours	50	7	0	0	Yes	10.93	5.72
	Annual	20	0	0	0	Yes	2.15	0.35
PAH	Annual	100 ng/m^3	0	0	0	Yes	15.39 ng/m^3	0.79 ng/m^3
BaP	Annual	1 ng/m^3	0	0	0	Yes	0.15 ng/m^3	0.0079 ng/m^3

(1). Maximum number of exceedances based on industrial zone coordinates provided in 11/13/2009 email from M. Palazzolo.
(2) With the industrial zone extended 100m south, this scenario is in compliance.

Table 8-3. Summary of CALPUFF Modeling Results for the Sea Water Scrubber Scenario.

Parameter	Averaging Period	Limit Value ($\mu g/m^3$)	Number of Exceedances Allowed	Number of Exceedances Predicted outside industrial zone (1)	Number of Receptors with Violations Predicted outside industrial zone	In Compliance?	Maximum peak ($\mu g/m^3$)	Maximum Peak outside industrial zone ($\mu g/m^3$)
HF	24-consecutive hours	25	0	0	0	Yes	23.9	6.66
	Growing season (April 1 – September 30)	0.3	0	1	4	No/Yes(2)	6.19	0.36
SO_2	1-hour	350	24	1	1	Yes	455.4	382.5
	24-consecutive hours	50	7	0	0	Yes	63.2	22.1
	Winter season (October 1-March 31)	20	0	0	0	Yes	19.8	2.8
	Annual	20	0	0	0	Yes	18.6	2.2
PM_{10}	24-consecutive hours	50	7	0	0	Yes	11.0	7.2
	Annual	20	0	0	0	Yes	2.37	0.66
PAH	Annual	100 ng/m^3	0	0	0	Yes	15.48 ng/m^3	0.85 ng/m^3
BaP	Annual	1 ng/m^3	0	0	0	Yes	0.16 ng/m^3	0.0098 ng/m^3

(1). Maximum number of exceedances based on industrial zone coordinates provided in 11/13/2009 email from M. Palazzolo.
(2) With the industrial zone extended 100m south, this scenario is in compliance.

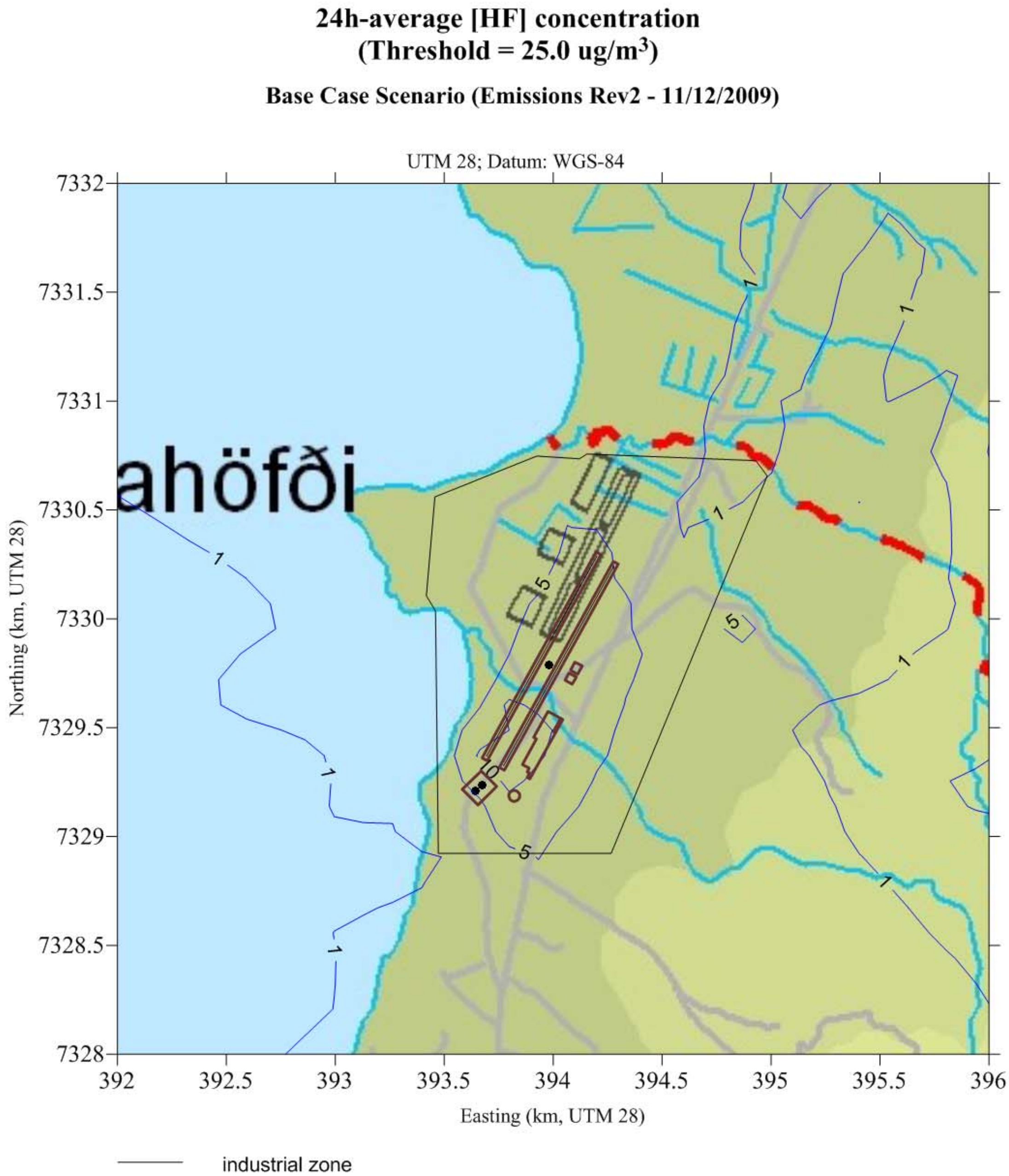


Figure 8-1. Predicted highest 24-hour average HF concentrations at each receptor (μg/m^3) for Base Case Scenario. Threshold limit of 25 μg/m^3 not reached. [Contour Levels = 0.5, 1.0, 5.0, 10.0, 12.0, 25.0 μg/m^3]

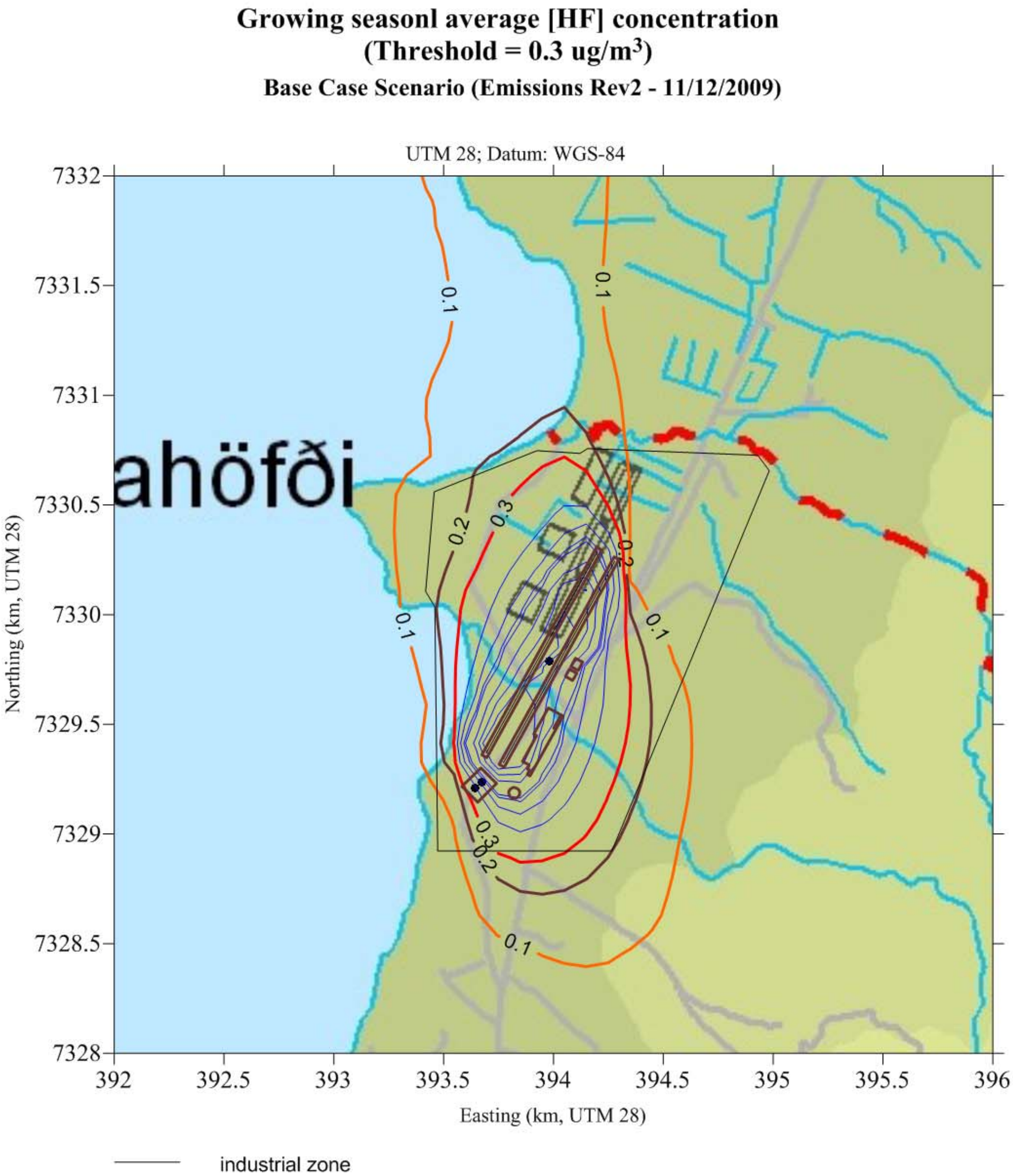


Figure 8-2. Predicted growing season average of HF concentrations (μg/m^3) for Base Case Scenario. Growing season threshold of 0.3μg/m^3 is plotted in red, 0.2 μg/m^3 in brown and 0.1 μg/m^3 in orange.

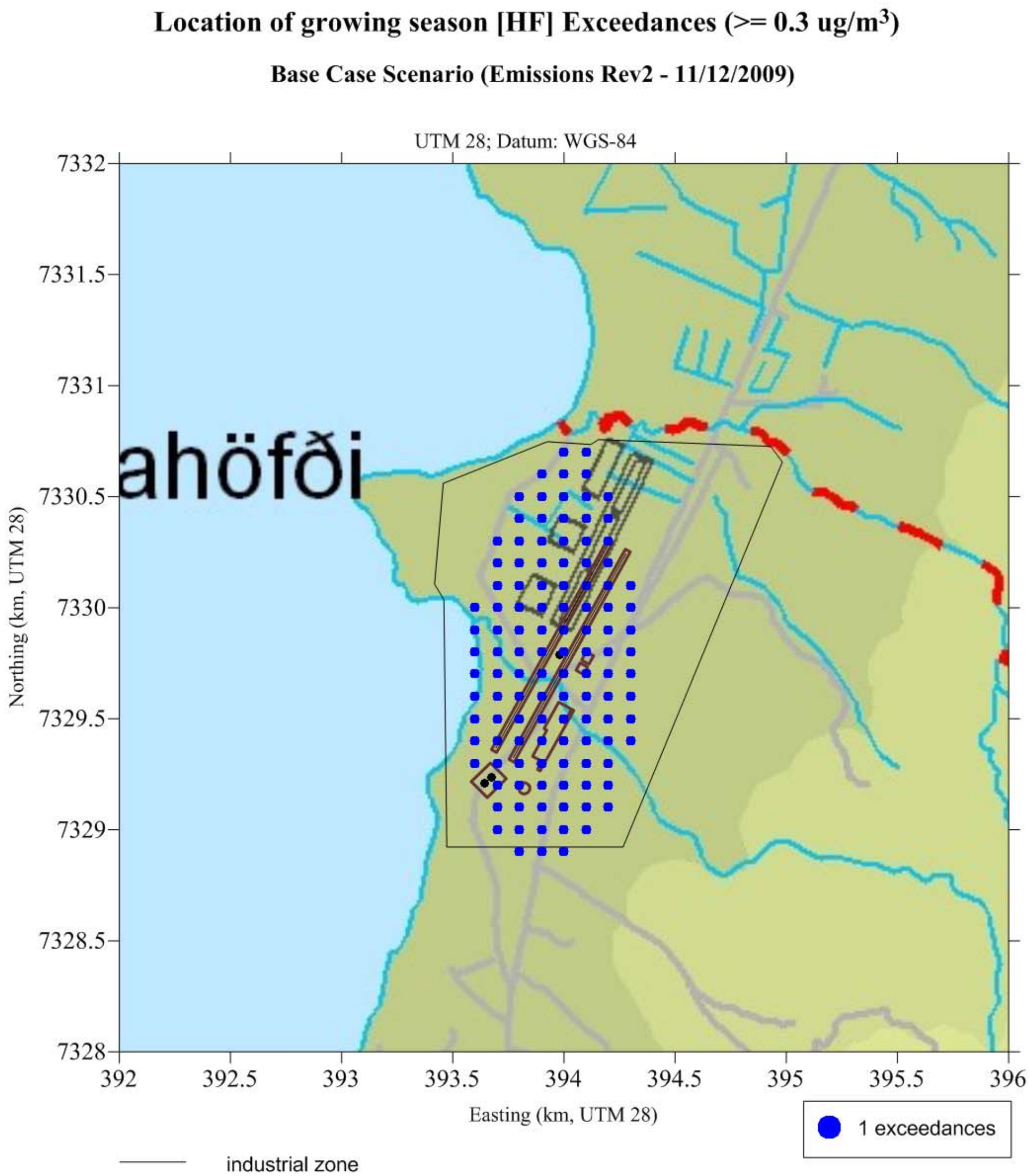


Figure 8-3. Predicted growing season exceedances of HF concentrations (μg/m^3) for Base Case Scenario.

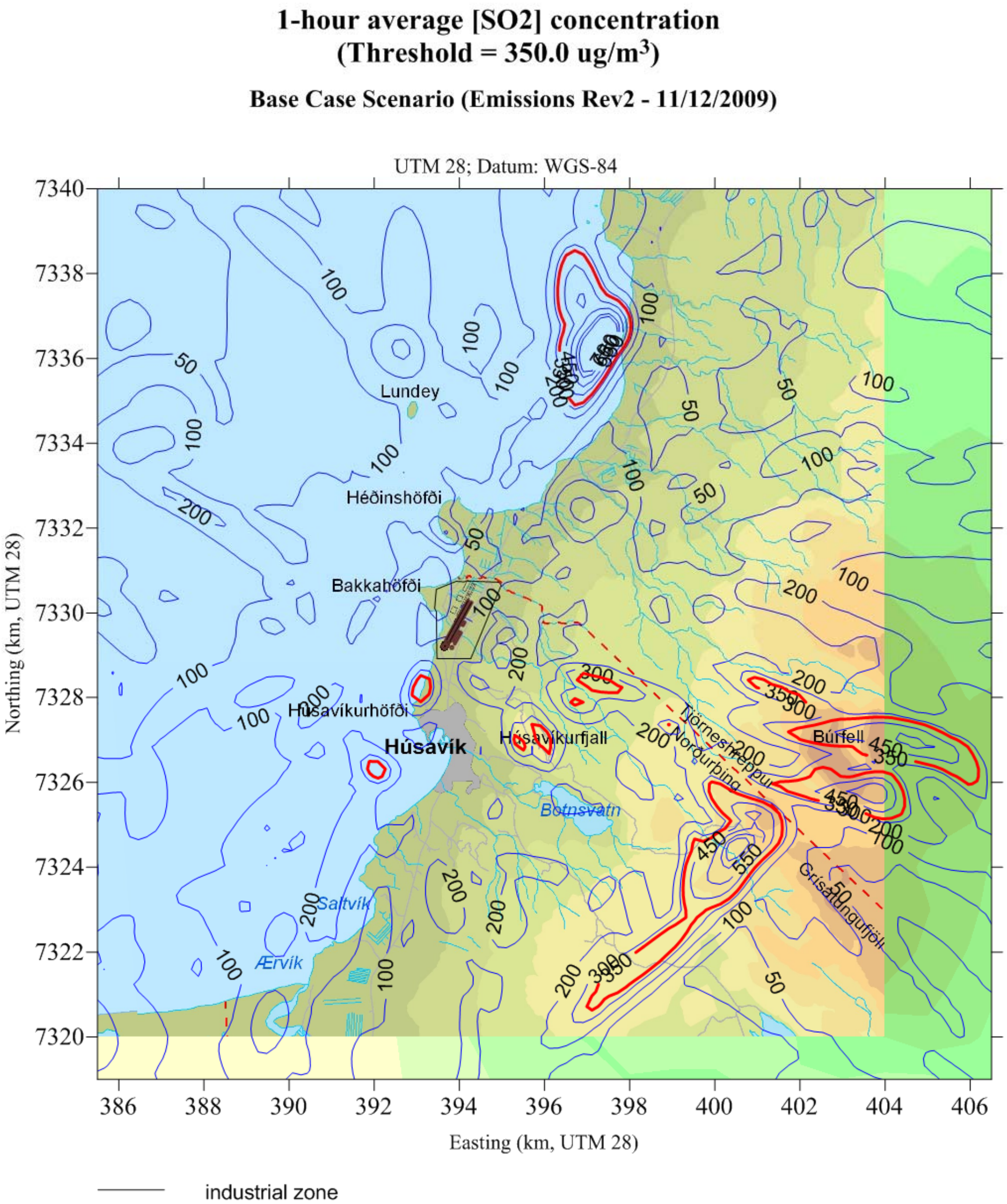


Figure 8-3. Predicted highest 1-hour average SO_2 concentrations at each receptor ($\mu g/m^3$) for Base Case Scenario. The 350 $\mu g/m^3$ threshold is plotted in red.

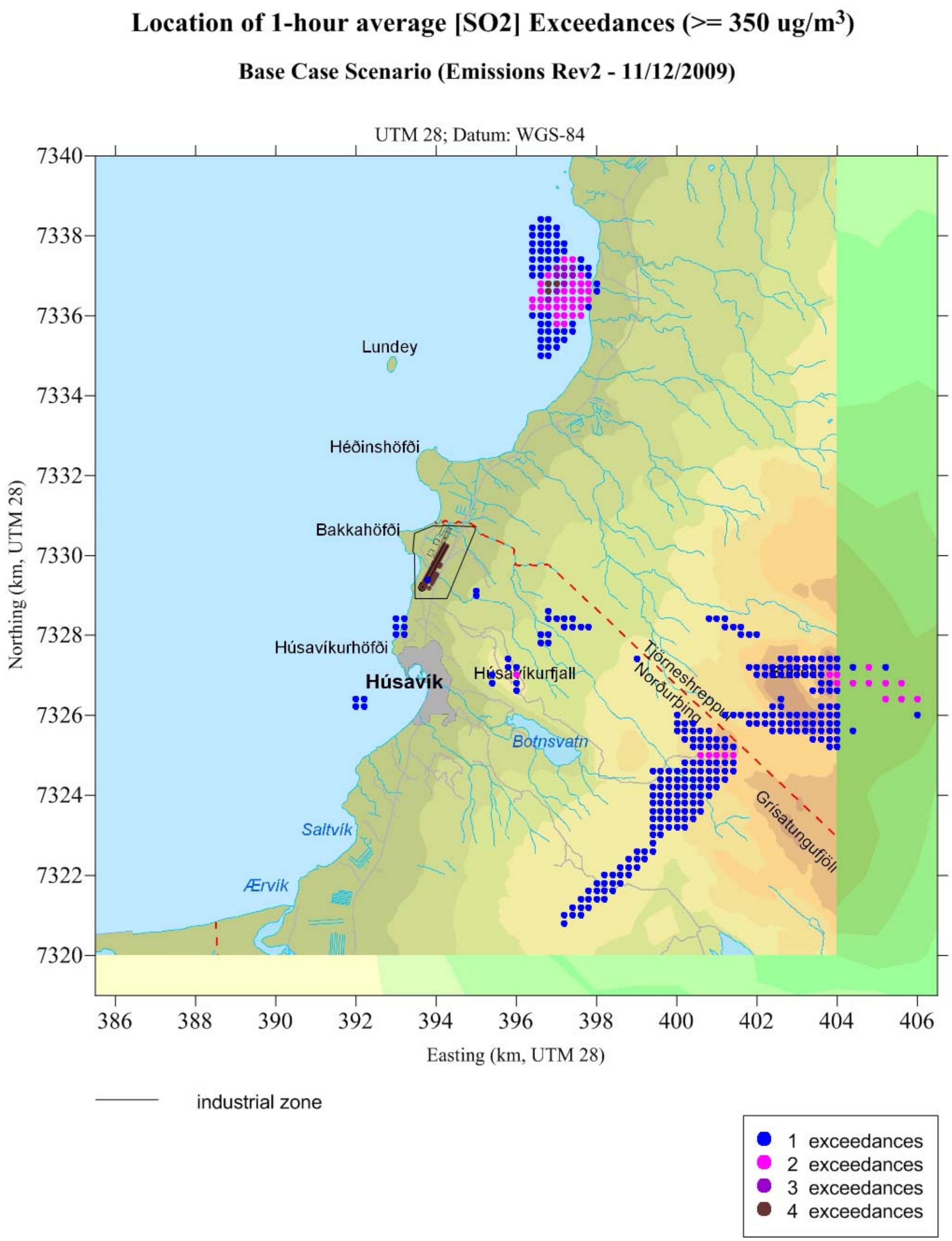


Figure 8-5. SO_2 1-hour averages: Number of exceedances of the 350 μg/m^3 threshold (in hours) for Base Case Scenario.

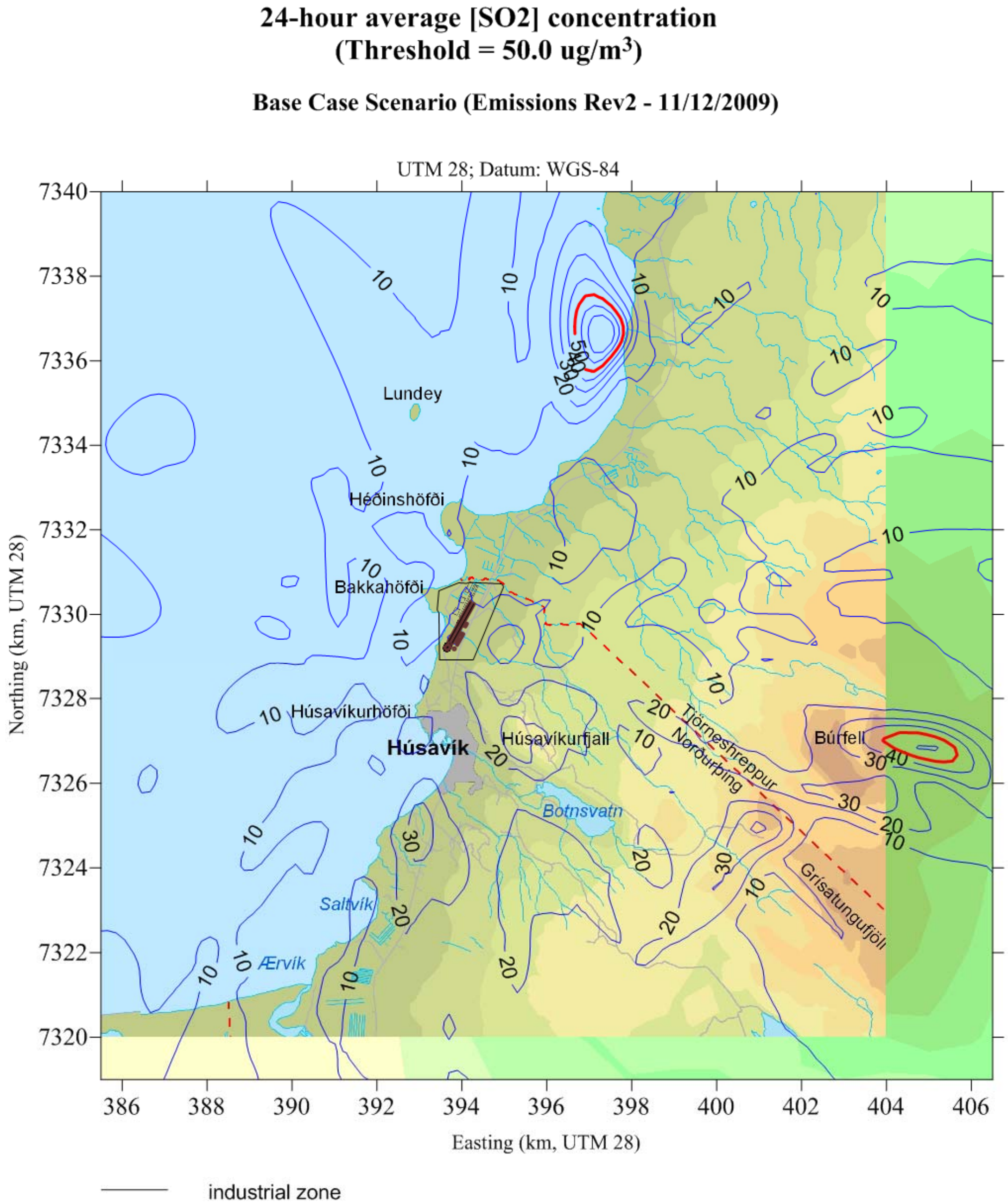


Figure 8-6. Predicted highest 24-hour average SO_2 concentrations at each receptor ($\mu g/m^3$) for Base Case Scenario. The 50 $\mu g/m^3$ threshold is plotted in red.

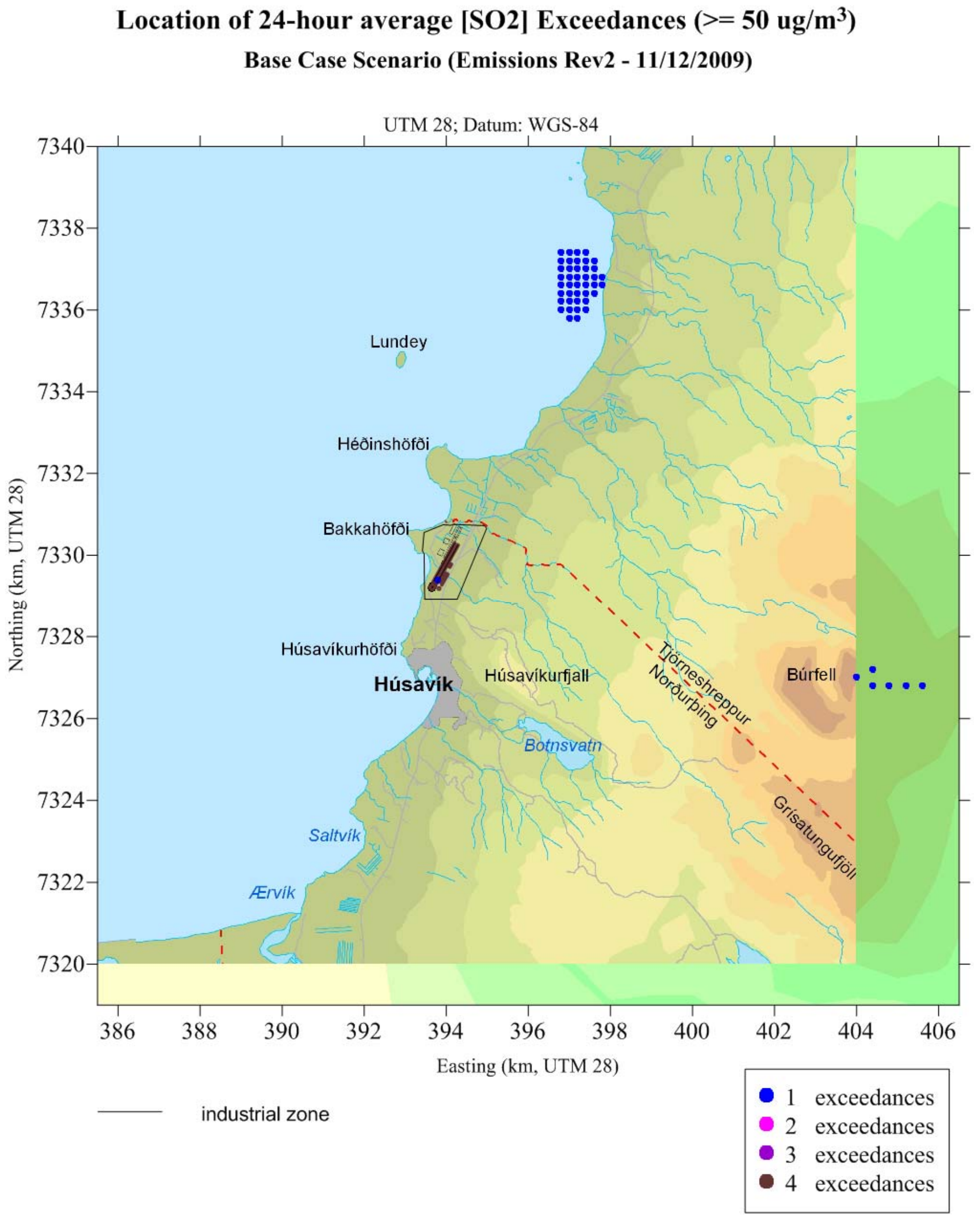


Figure 8-7. SO_2 24-hour averages: Number of exceedances of the 50 μg/m^3 threshold (in days) for Base Case Scenario.

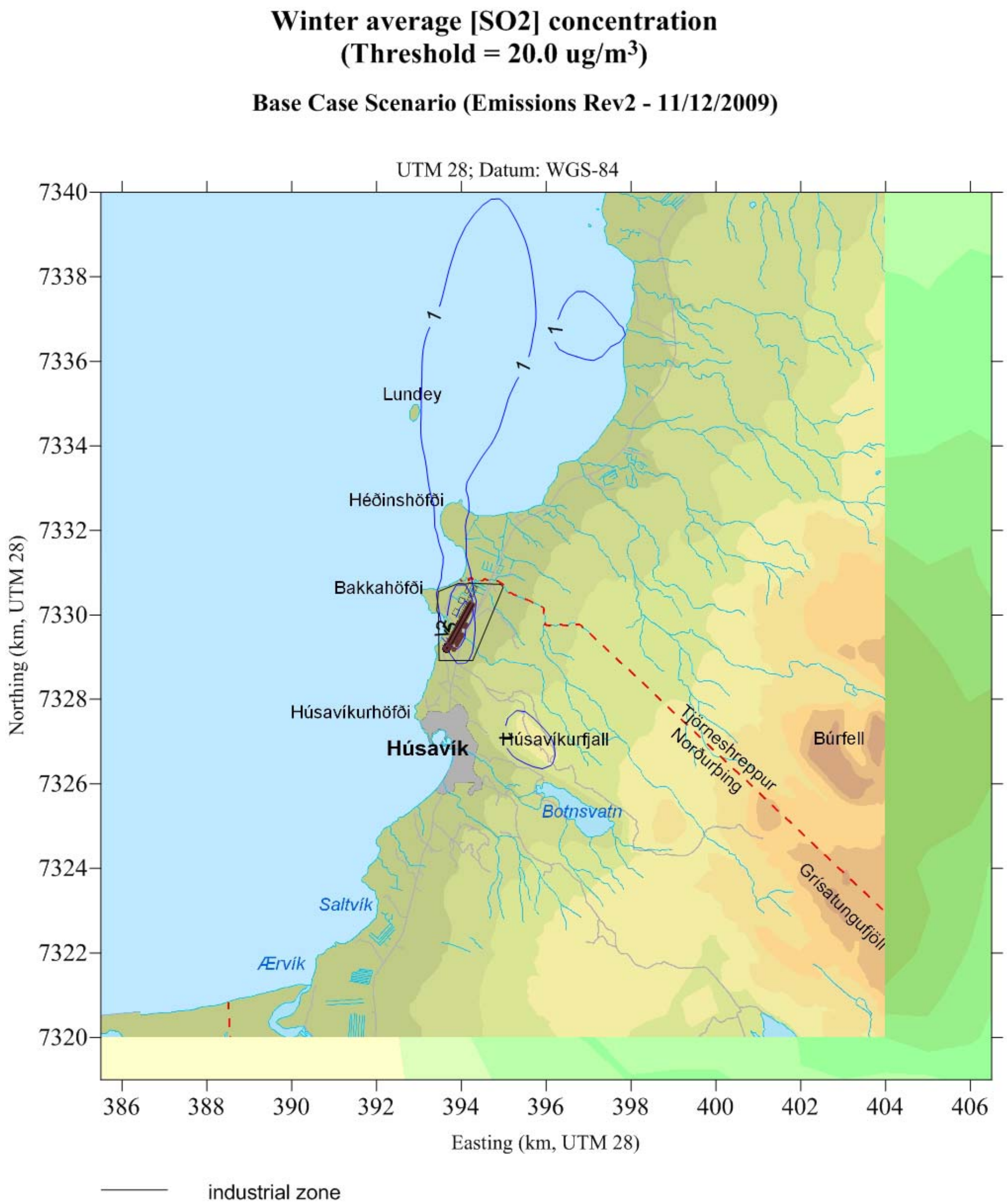


Figure 8-8. Predicted winter average SO_2 concentrations ($\mu g/m^3$) for Base Case Scenario. The 20 $\mu g/m^3$ threshold is not reached.

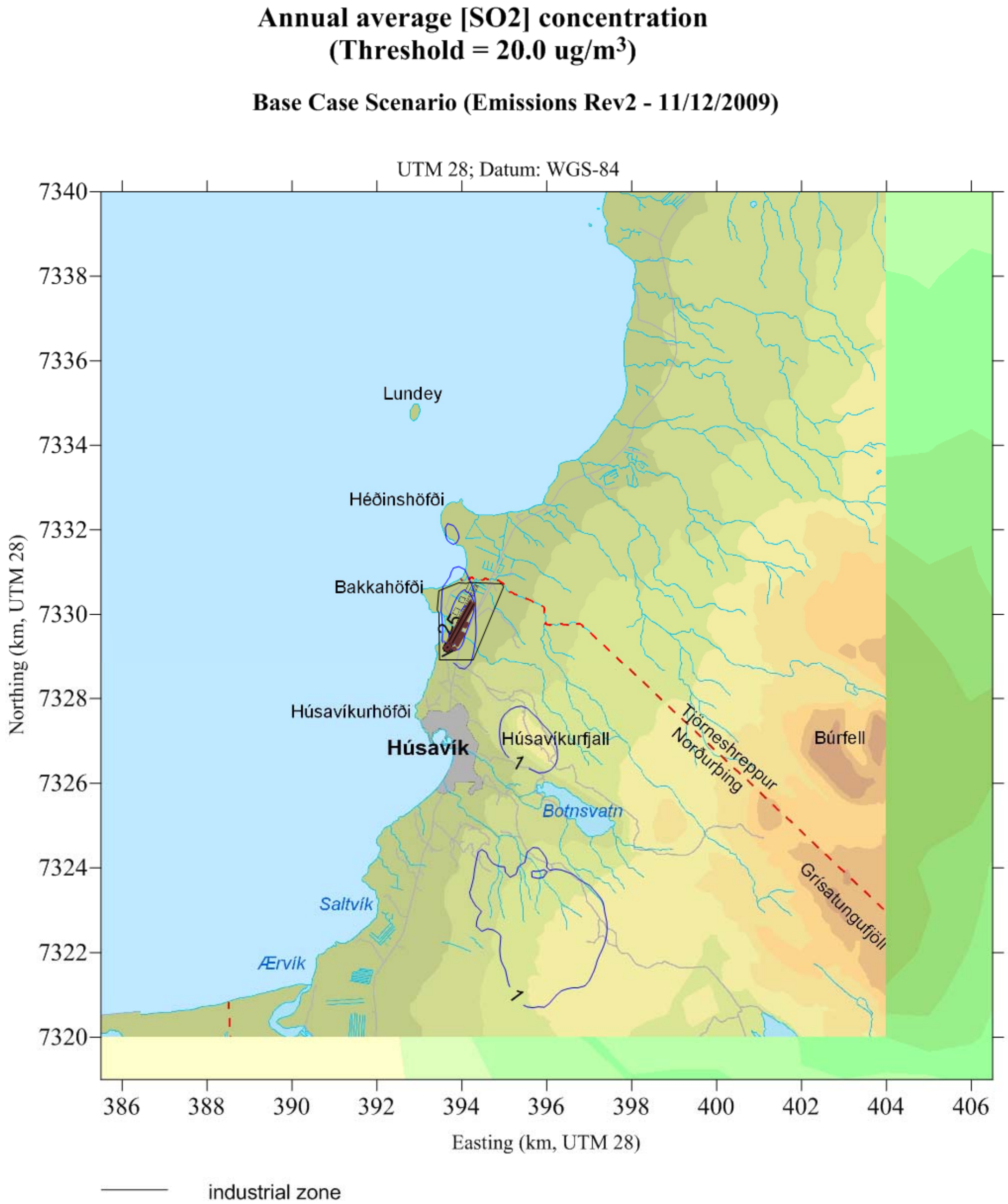


Figure 8-9. Predicted annual average SO_2 concentrations ($\mu g/m^3$) for Base Case Scenario. The 20 $\mu g/m^3$ threshold is not reached.

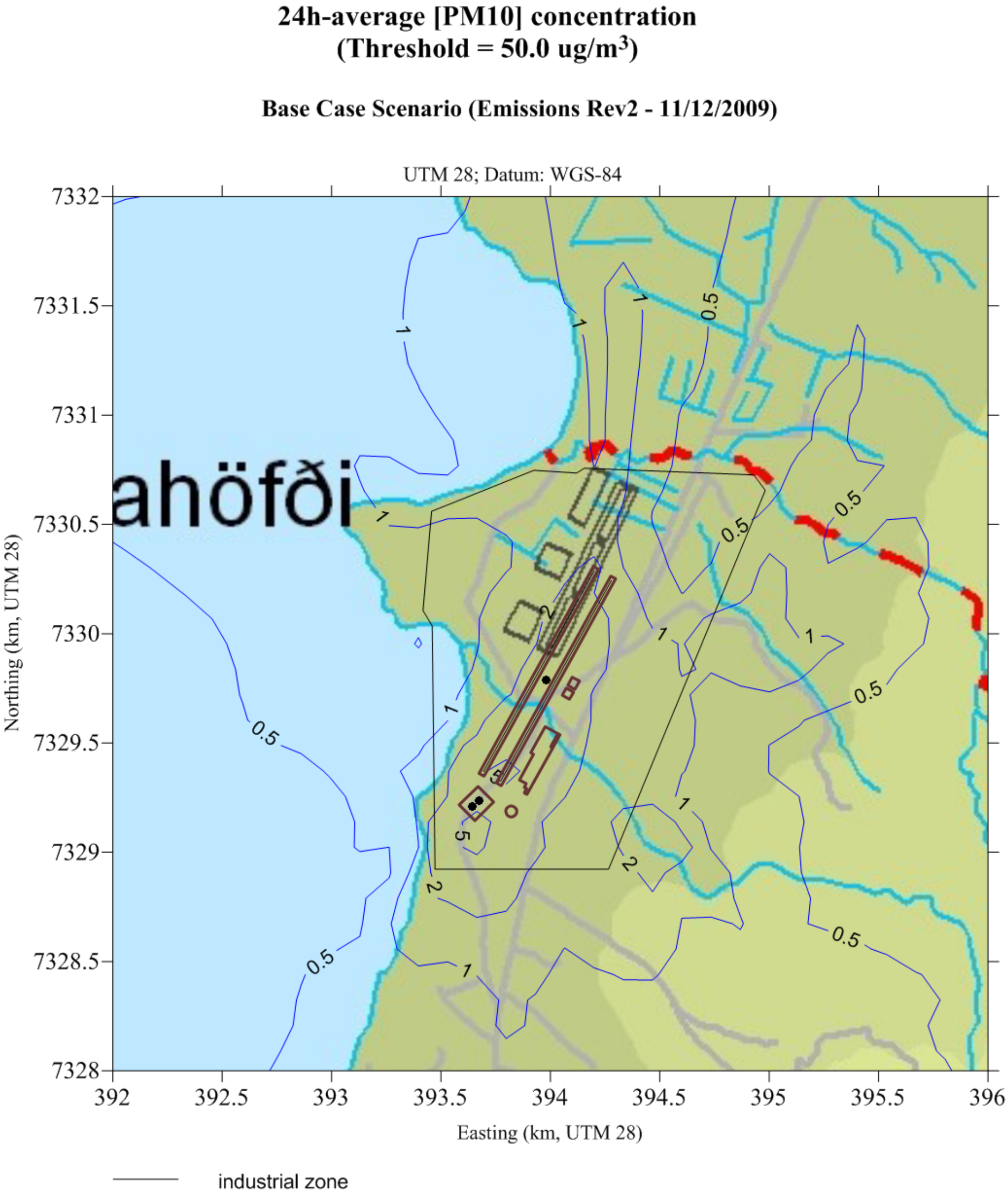


Figure 8-10. Predicted highest 24-hour average PM_{10} concentrations at each receptor ($\mu g/m^3$) for Base Case Scenario. The 50 $\mu g/m^3$ threshold is not reached.

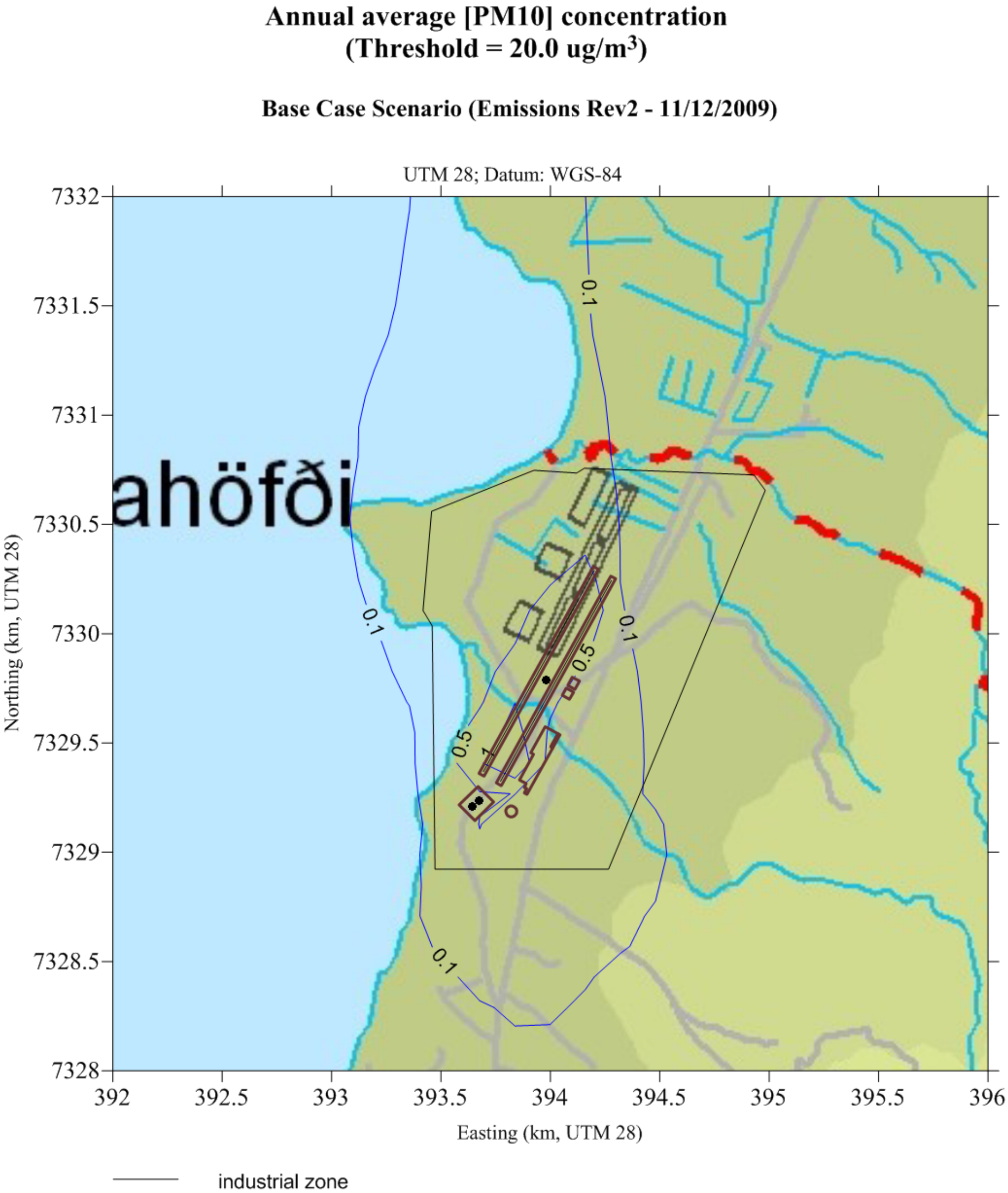


Figure 8-11. Predicted annual average PM_{10} concentrations ($\mu g/m^3$) for Base Case Scenario. The 20 $\mu g/m^3$ threshold is not reached.

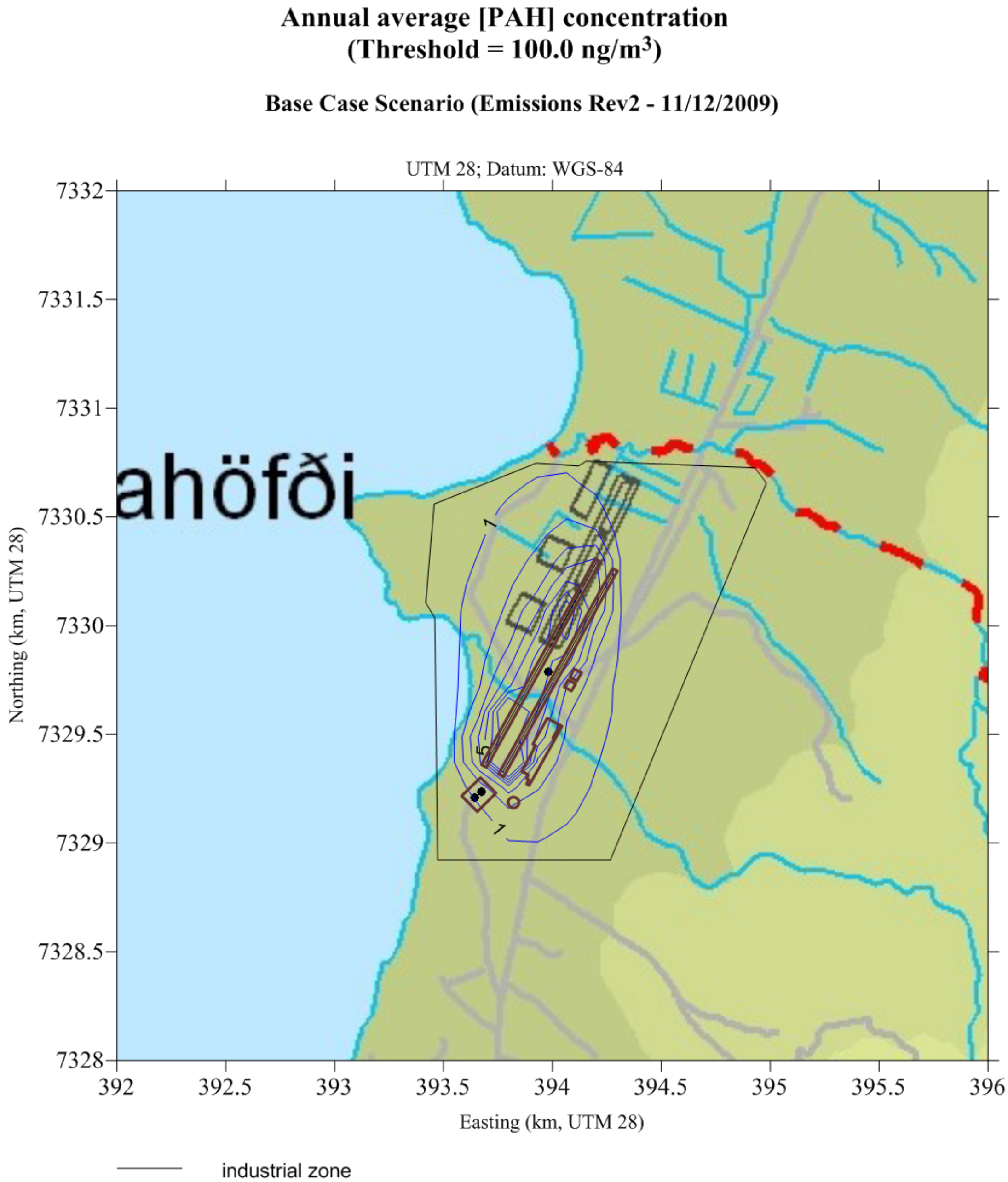


Figure 8-12. Predicted annual average PAH concentrations (ng/m^3) for Base Case Scenario. The 100 ng/m^3 threshold is not reached outside the industrial zone.

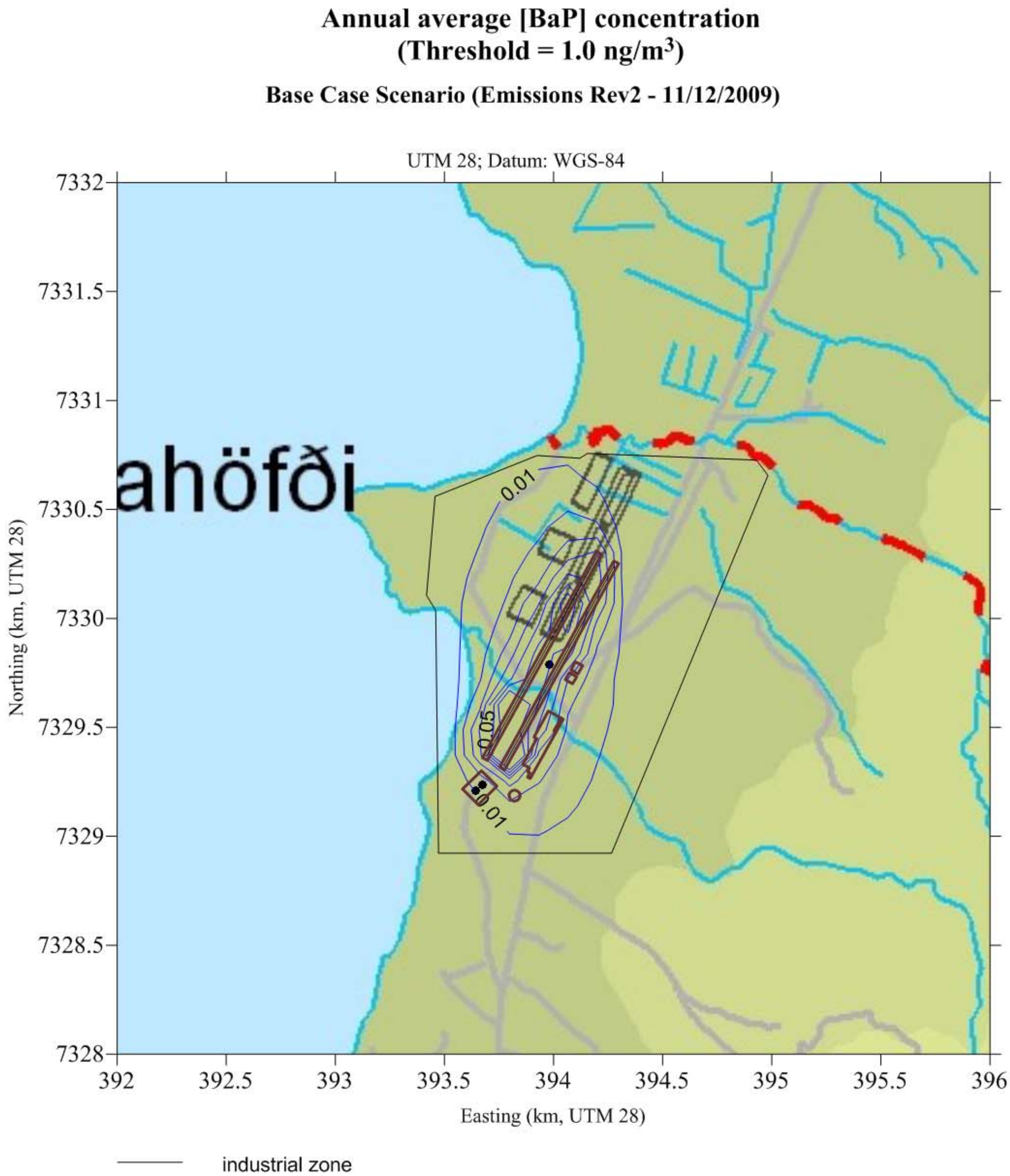


Figure 8-13. Predicted annual average BaP concentrations (ng/m^3) for Base Case Scenario. The 1.0 ng/m^3 threshold is not reached outside the industrial zone.

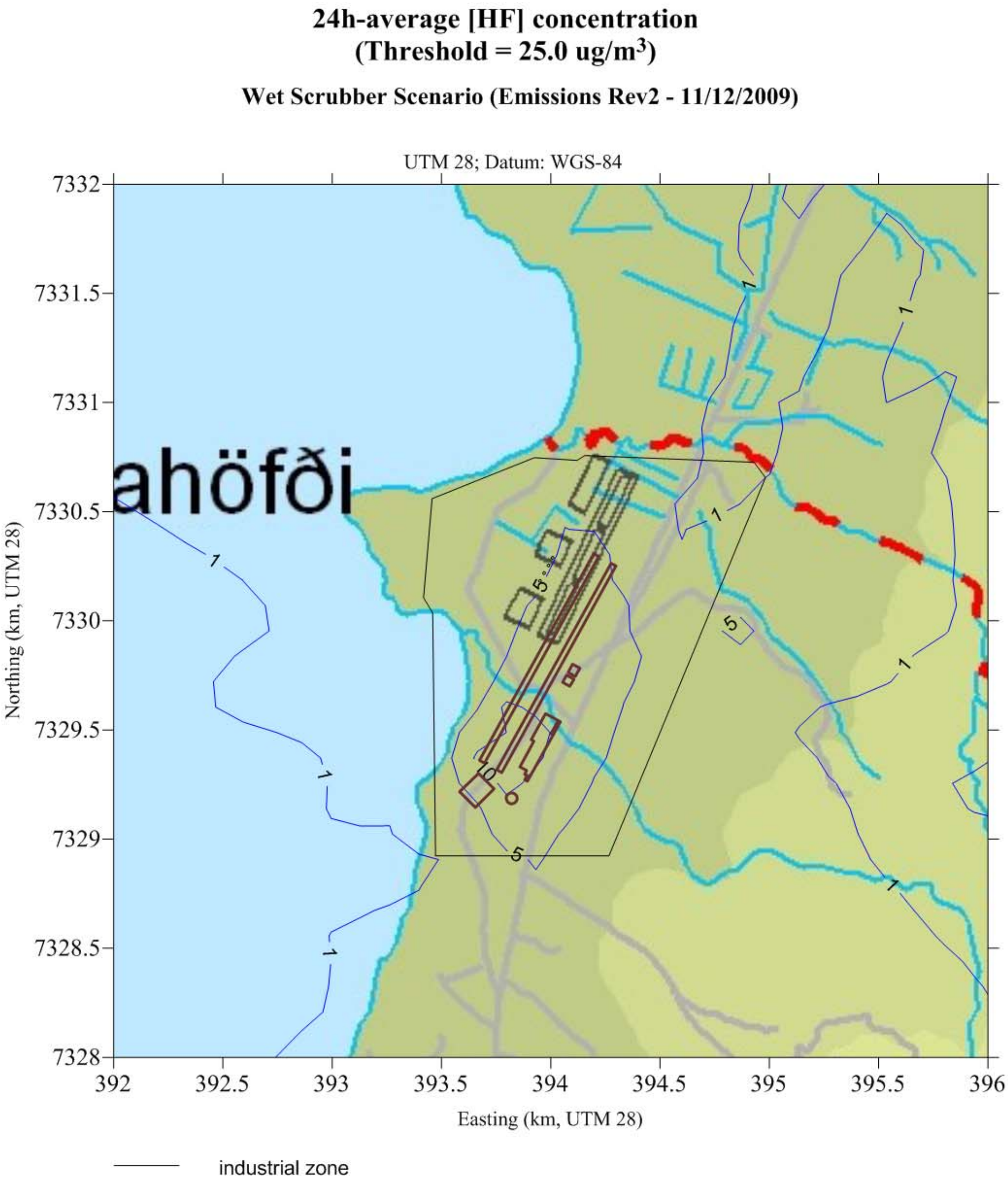


Figure 8-14. Predicted highest 24-hour average HF concentrations at each receptor (μg/m^3) for Wet Scrubber Scenario. Threshold limit of 25 μg/m^3 not reached. [Contour Levels = 0.5, 1.0, 5.0, 10.0, 25.0 μg/m^3]

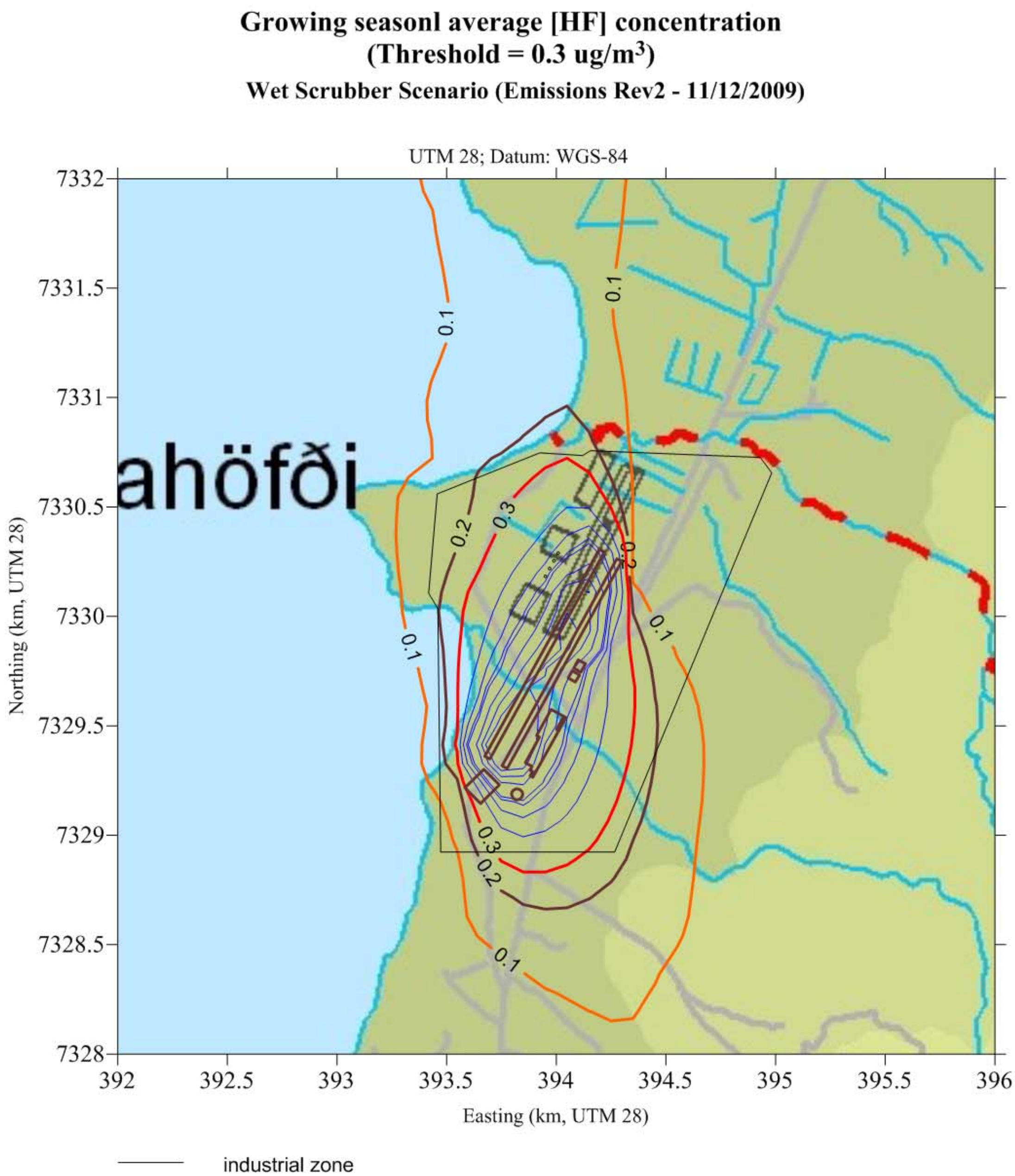


Figure 8.15. Predicted growing season average of HF concentrations (μg/m^3) for Wet Scrubber Scenario. Growing season threshold of 0.3μg/m^3 is plotted in red, 0.2 μg/m^3 in brown and 0.1 μg/m^3 in orange.

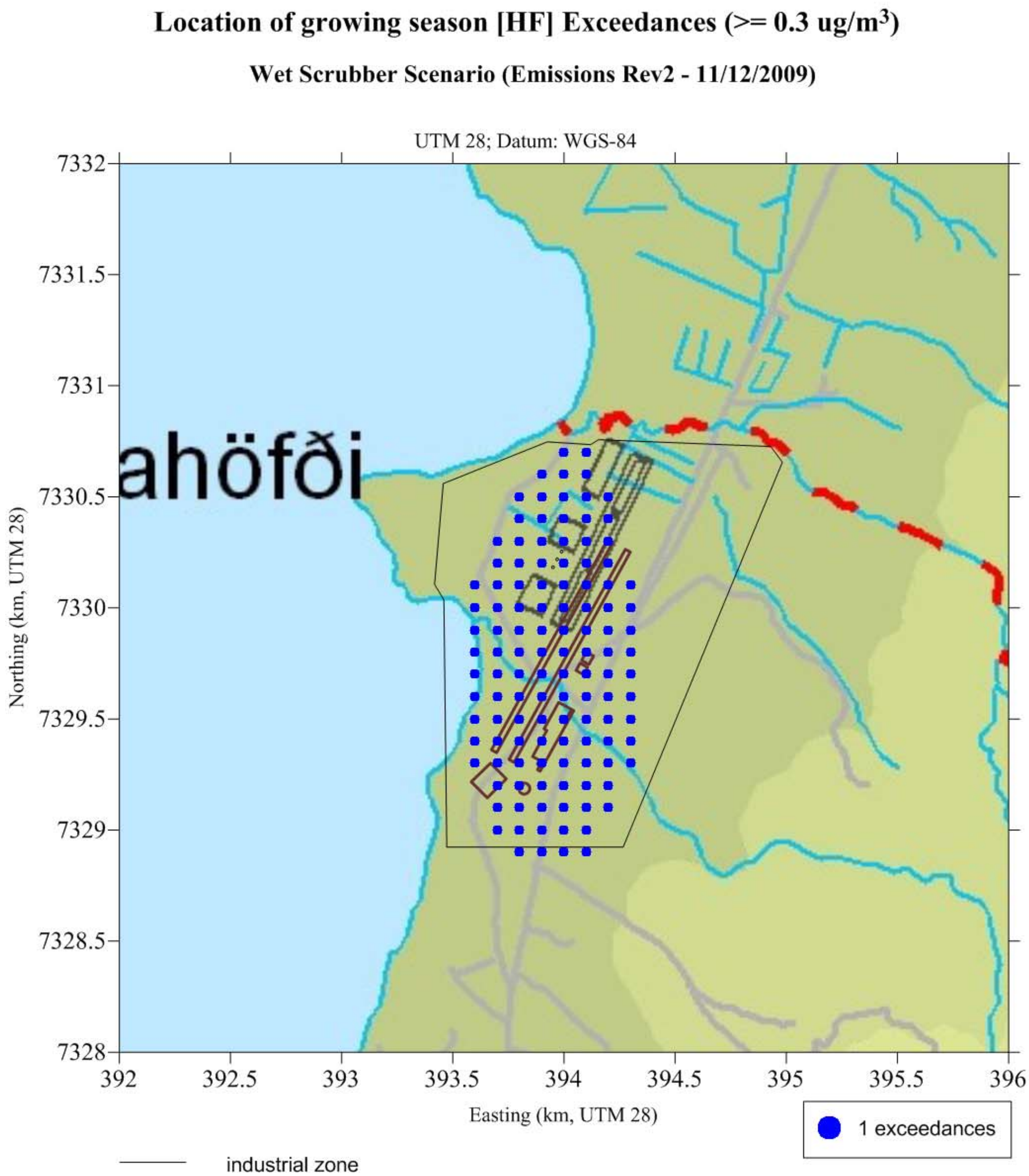


Figure 8-16. Predicted growing season exceedances of HF concentrations ($\mu g/m^3$) for Wet Scrubber Scenario.

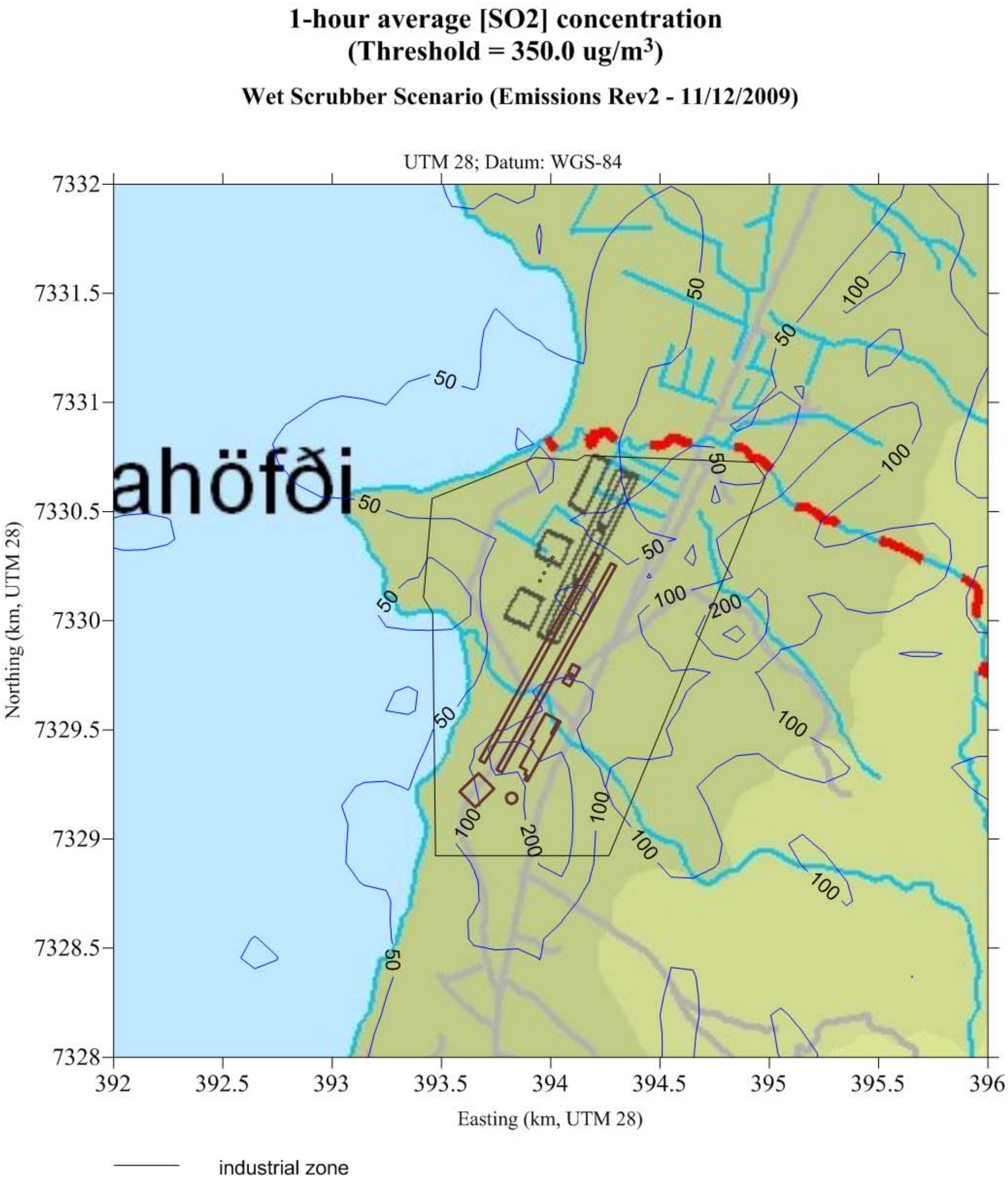


Figure 8-17. Predicted highest 1-hour average SO_2 concentrations at each receptor ($\mu g/m^3$) for Wet Scrubber Scenario.

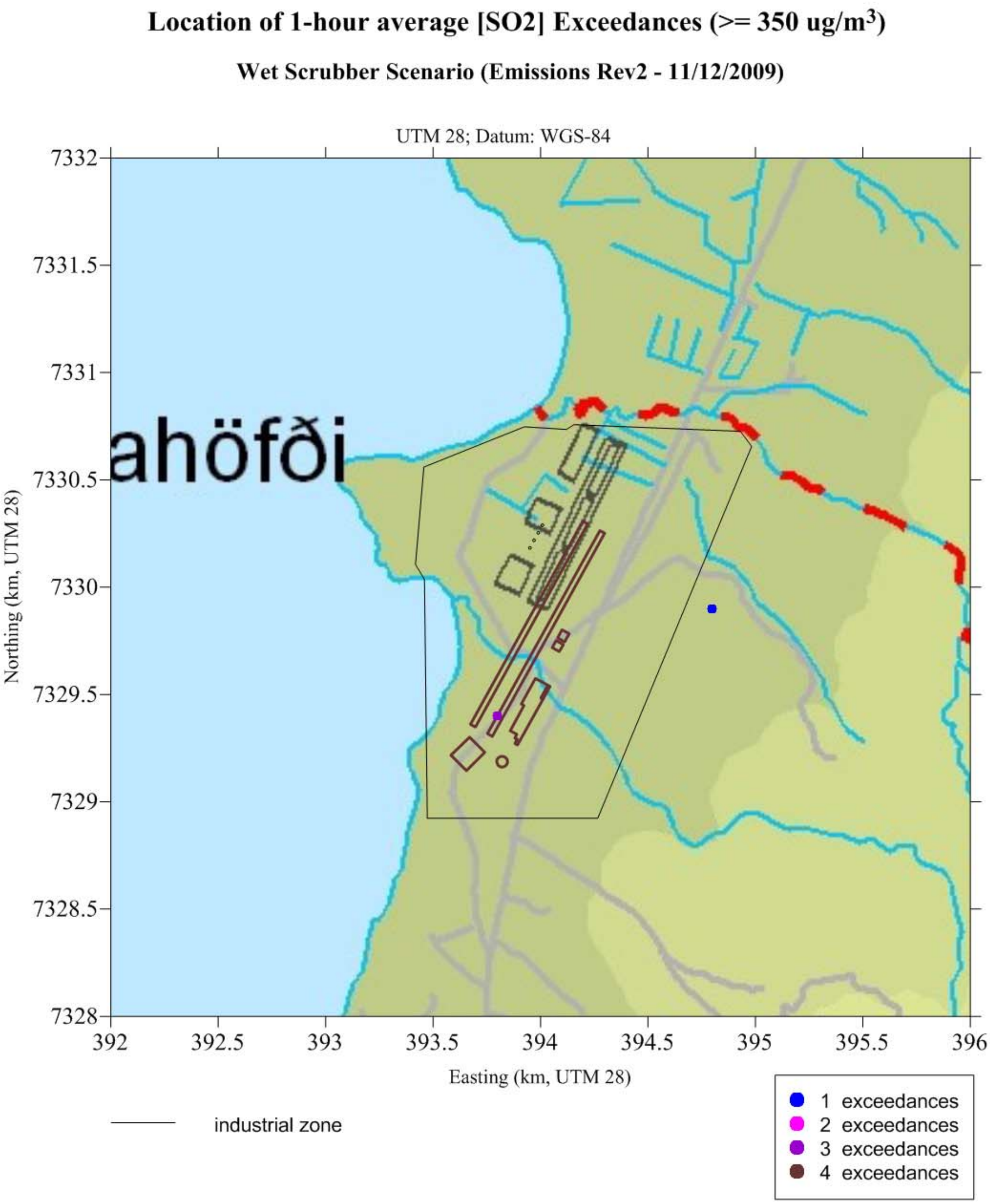


Figure 8-18. SO_2 1-hour averages: Number of exceedances of the 350 μg/m^3 threshold (in hours) for Wet Scrubber Scenario.

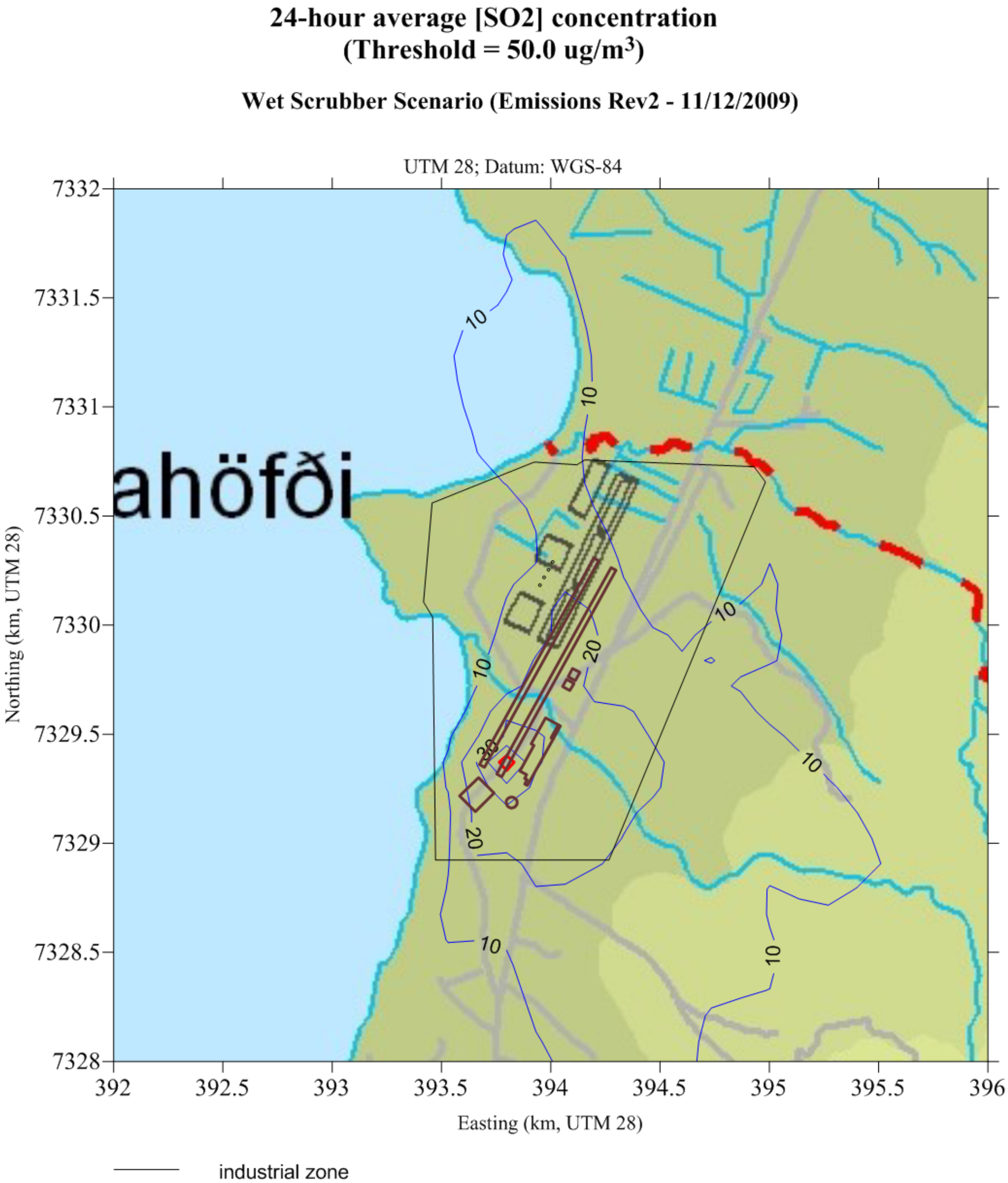


Figure 8-19. Predicted highest 24-hour average SO_2 concentrations at each receptor ($\mu g/m^3$) for Wet Scrubber Scenario. No exceedances of the $50 \mu g/m^3$ threshold occur outside the industrial zone.

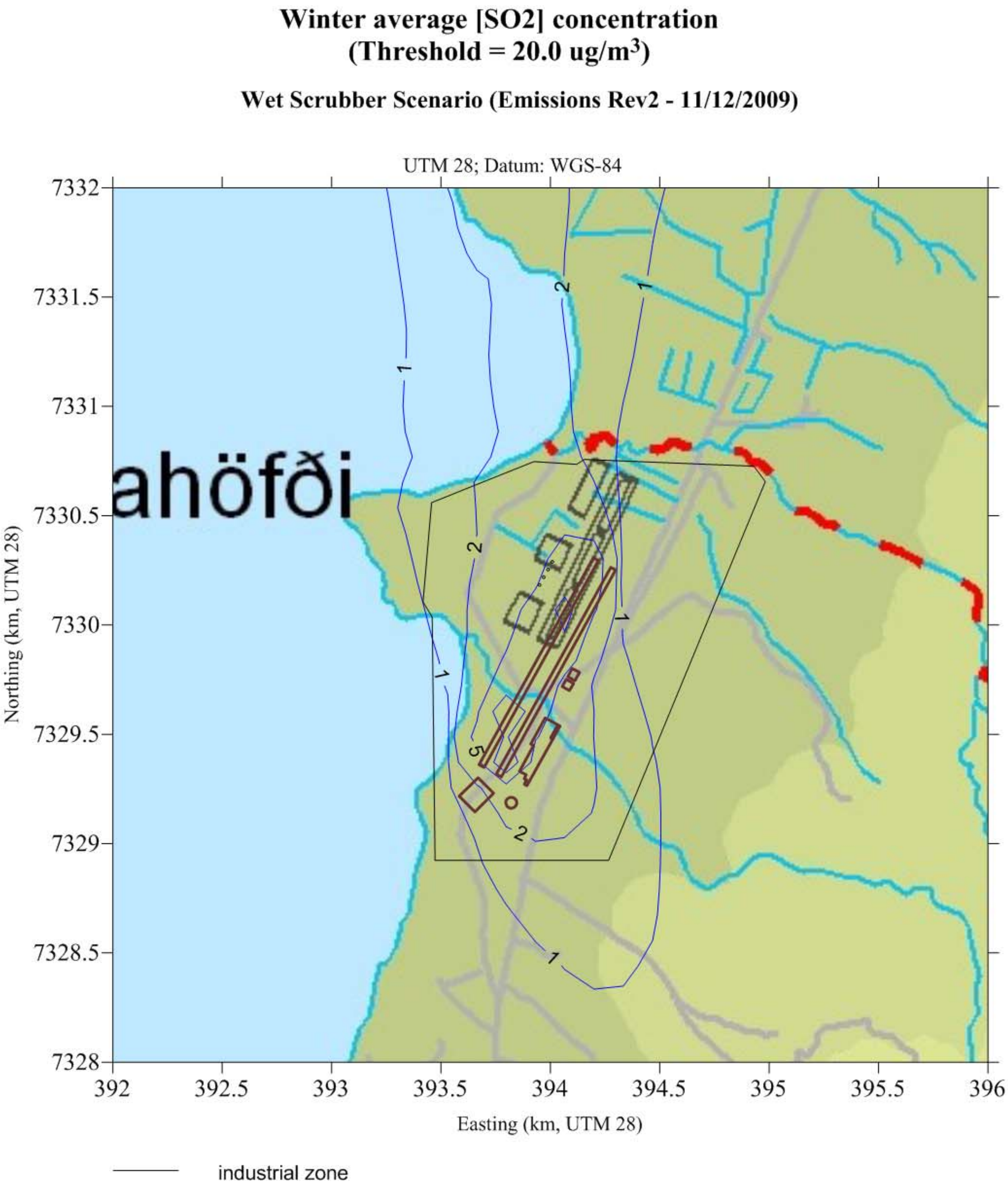


Figure 8-20. Predicted winter average SO_2 concentrations ($\mu g/m^3$) for Wet Scrubber Scenario. The 20 $\mu g/m^3$ threshold is not reached.

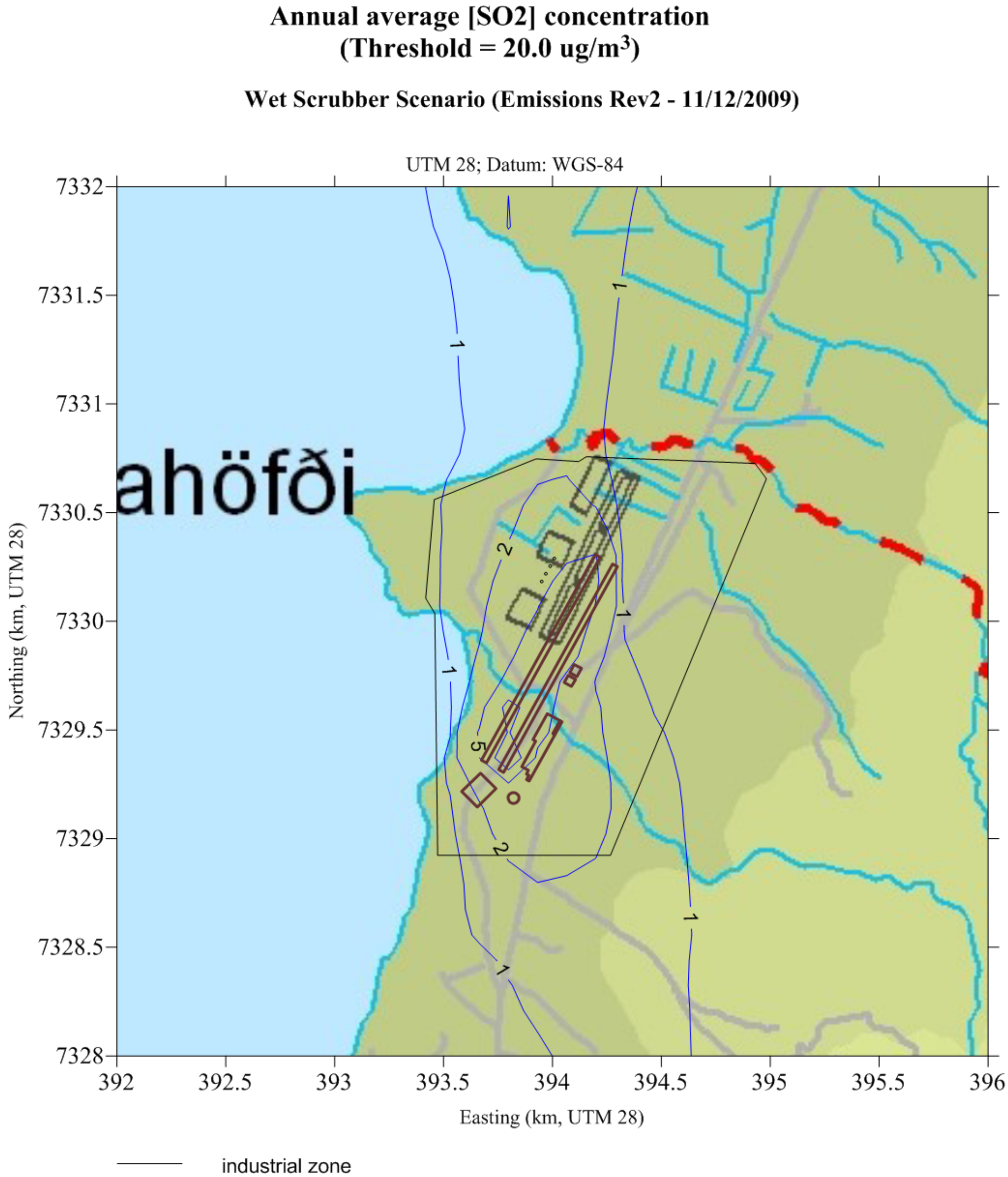


Figure 8-21. Predicted annual average SO_2 concentrations ($\mu g/m^3$) for Wet Scrubber Scenario. The 20 $\mu g/m^3$ threshold is not reached.

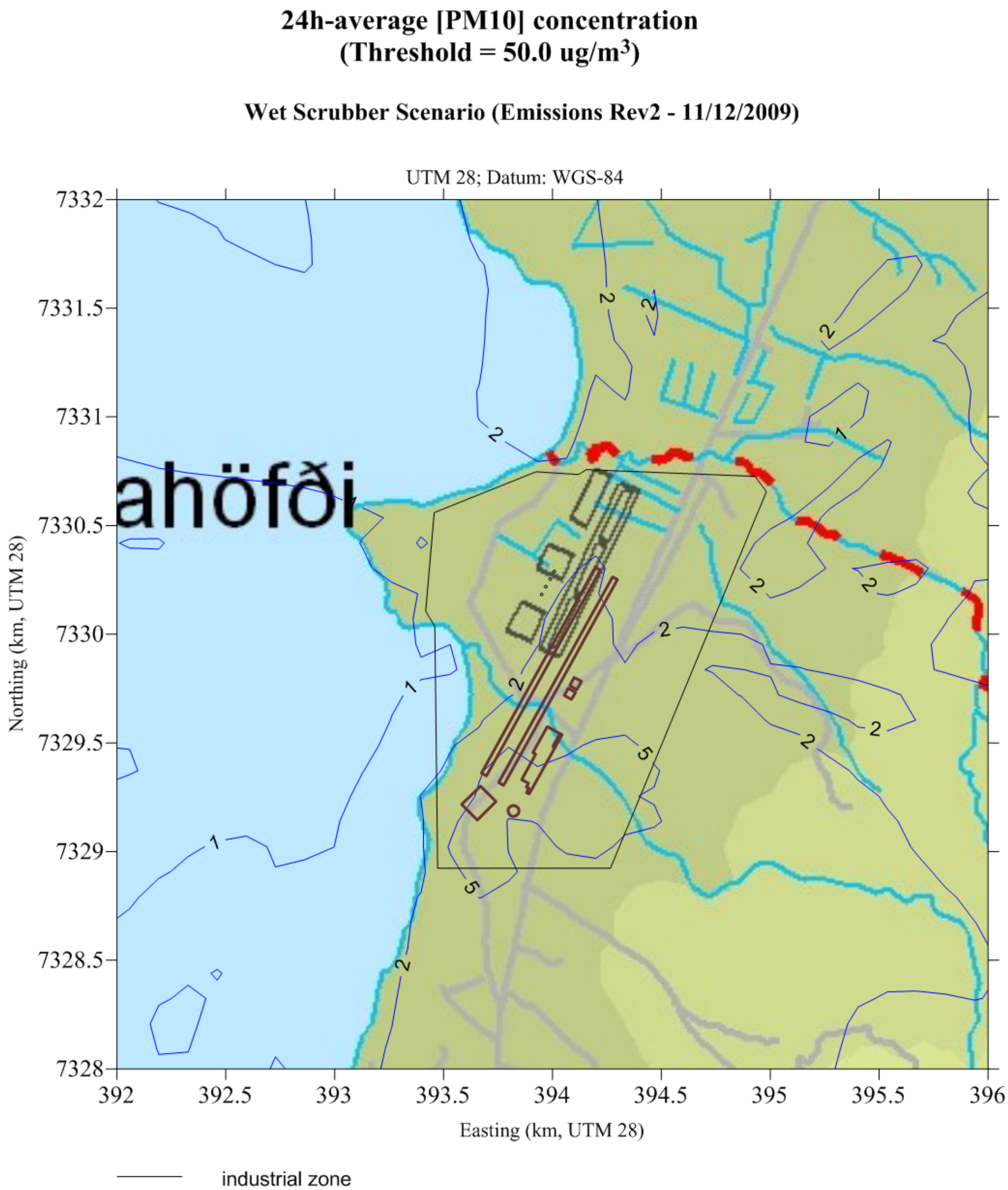


Figure 8-22. Predicted highest 24-hour average PM_{10} concentrations at each receptor ($\mu g/m^3$) for Wet Scrubber Scenario. The 50 $\mu g/m^3$ threshold is not reached.

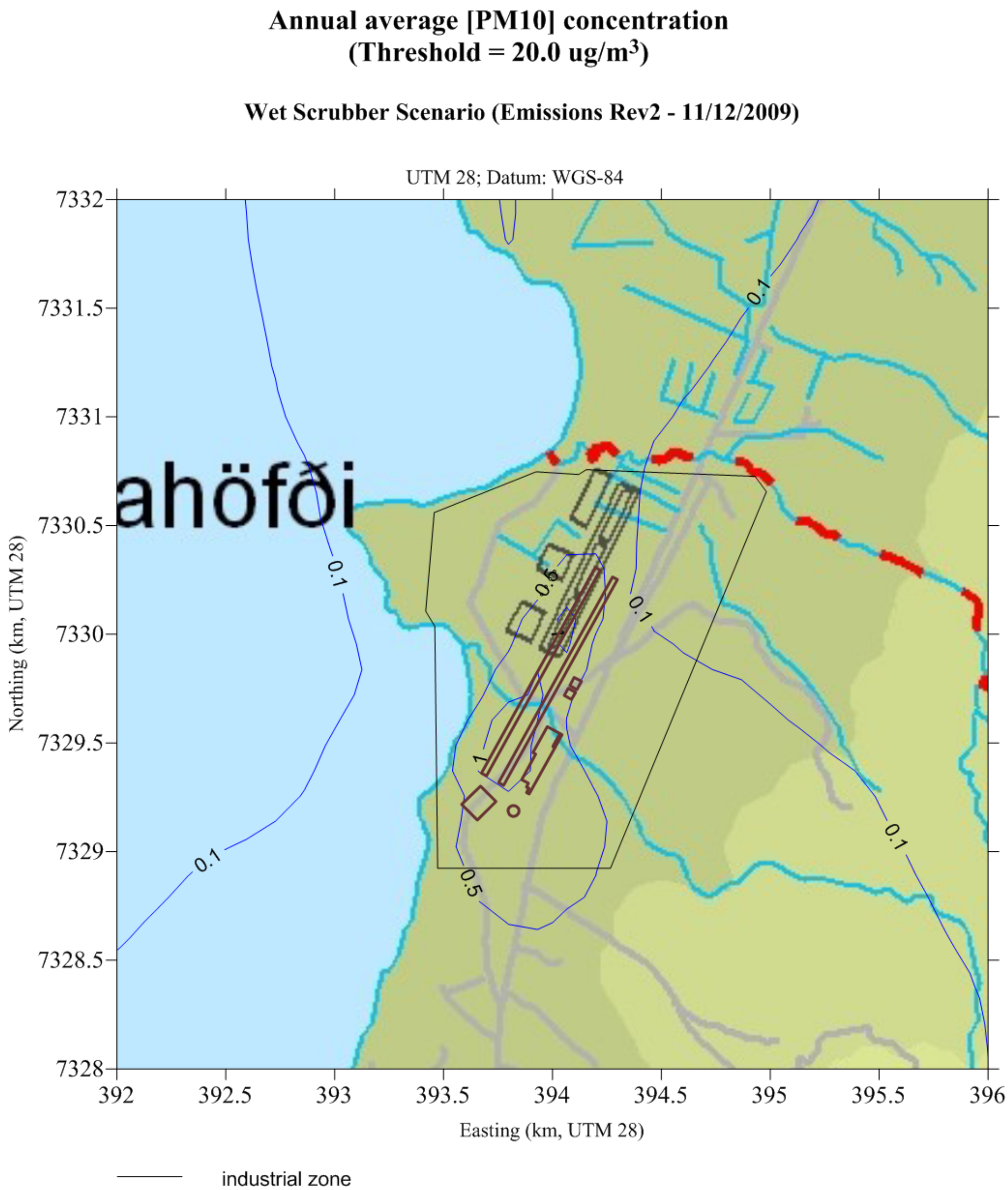


Figure 8-23. Predicted annual average PM_{10} concentrations ($\mu g/m^3$) for Wet Scrubber Scenario. The 20 $\mu g/m^3$ threshold is not reached.

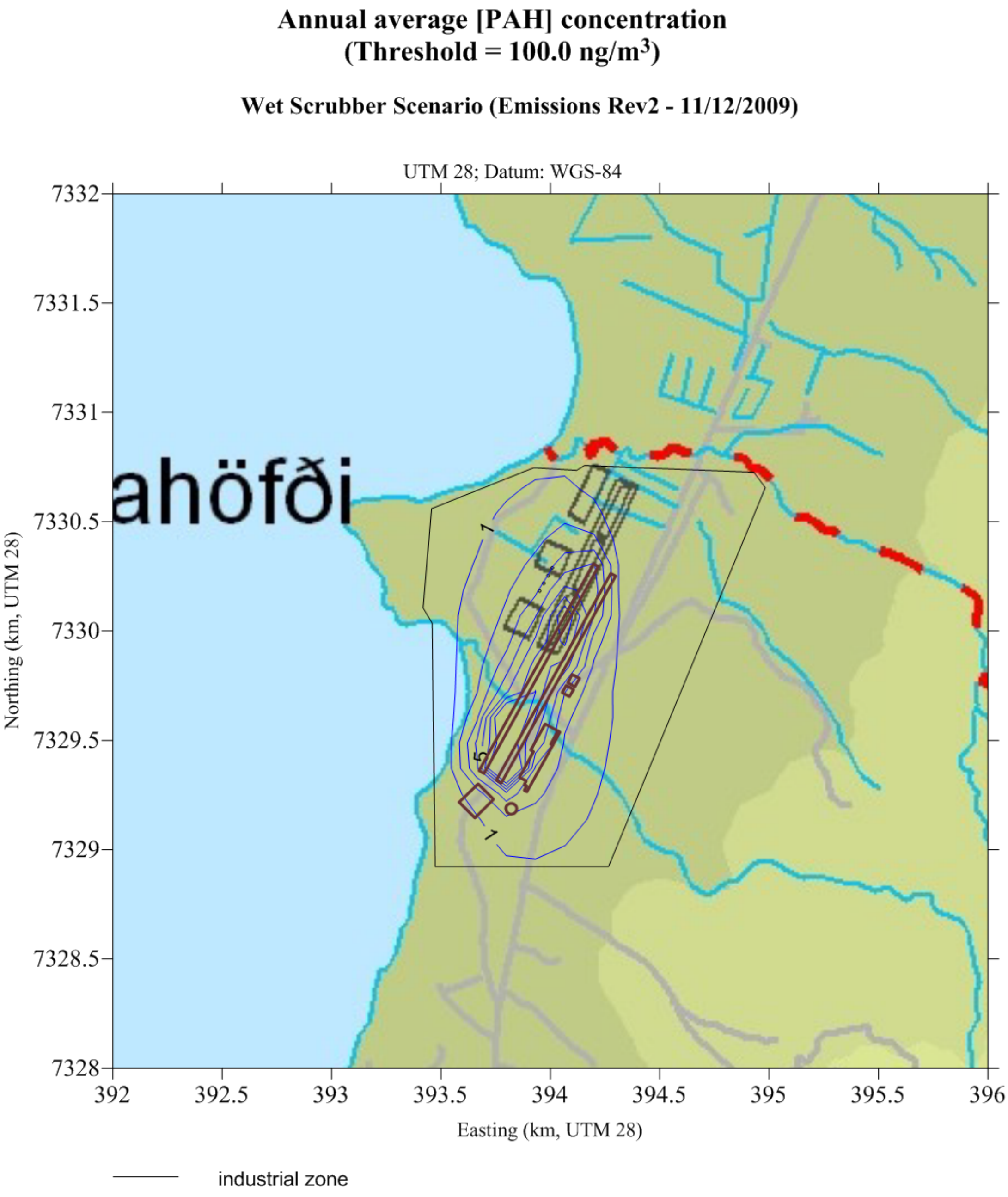


Figure 8-24. Predicted annual average PAH concentrations (ng/m^3) for Wet Scrubber Scenario. The 100 ng/m^3 threshold is not reached outside the industrial zone.

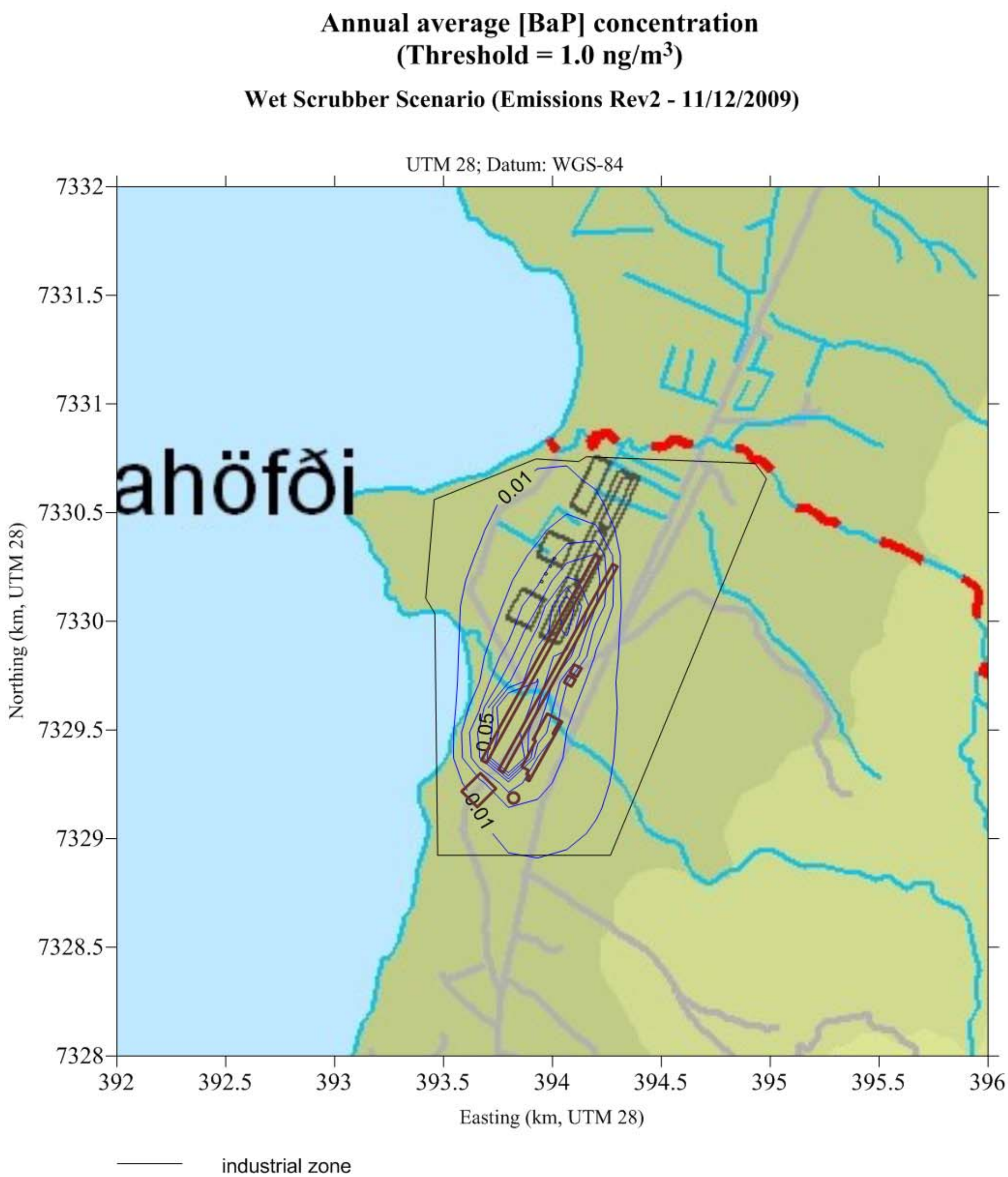


Figure 8-25. Predicted annual average BaP concentrations (ng/m^3) for Wet Scrubber Scenario. The 1.0 ng/m^3 threshold is not reached outside the industrial zone.

9. REFERENCES

Allwine, K.J. and C.D. Whiteman, 1985: MELSAR: A mesoscale air quality model for complex terrain: Vol. 1--Overview, technical description and user's guide. Pacific Northwest Lab, Richland, WA.

Bennett, M.J, M.E. Yansura, I.G. Hornyik, J.M. Nall, D.G. Caniparoli and C.G. Ashmore, 2002. Evaluation of the CALPUFF Long-range Transport Screening Technique by Comparison to Refined CALPUFF Results for Several Power Plants in Both the Eastern and Western United States. Proceedings of the Air & Waste Management Association's 95th Annual Conference, June 23-27, 2002; Baltimore, MD. Paper #43454.

Bromwich, D.H., J.J. Cassano, T. Kelin, G. Heinemann, K.M. Hines, K. Steffen and J.E. Box, 2001: Mesoscale Modeling of Katabatic Winds over Greenland with the Polar MM5, *Mon. Wea. Rev*., 129, 2290-2309.

Campbell, S.A., 1998: Gas Scavenging Coefficients for Use in the ISC3 Wet Deposition\Algorithms. Paper 98-TAB.05P. Air & Waste Management Association 91th Annual Meeting & Exhibition, San Diego, California, USA. 14-18 June 1998.

Cassano, J.J., J.E. Box, D.H. Bromwich, L. Li and K. Steffen, 2001: Evaluation of Polar MM5 simulations of Greenland's atmospheric circulation, *J. Geophys. Res*., 106, 33867-33889.

Carson, D.J., 1973: The development of a dry, inversion-capped, convectively unstable boundary layer. *Quart. J. Roy. Meteor. Soc*., **99**, 450-467.

Douglas, S. and R. Kessler, 1988: User's guide to the diagnostic wind model, California Air Resources Board, Sacramento, CA.

Dudhia, J., D. Gill, Y-R Guo, D. Hassen, K. Manning, and W. Wang, 2000: PSU/NCAR Mesoscale Modeling System, Tutorial Class Notes and User's Guide: MM5 Modeling System Version 3, Mesoscale and Microscale Meteorology Division, National Center for Atmospheric Research.

Earth Tech, 2000: Air Toxics Modeling Analysis for the Alcoa Facility in Badin, NC, October 2000.

Grell, G.A., J. Dudhia and D.R. Stauffer, 1995: A Description of the Fifth Generation Penn State/NCAR Mesoscale Model (MM5). NCAR Tech. Note, NCAR/TN-398+STR, 122 pp.

Hack, J.J., B.A. Boville, B.P. Briegleb, J.T. Kiehl, P.J. Rasch and D.L. Wiiliamson, 1993: Description of the NCAR community climate model (CCM2), NCAR Tech. Note, NCAR/TN-382+STR, Natl. Cent. for Atmos. Res., Boulder, Colo.

Holtslag, A.A.M. and A.P. van Ulden, 1983: A simple scheme for daytime estimates of the surface fluxes from routine weather data. *J. Clim. and Appl. Meteor.*, **22**, 517-529.

Levy, J.I., J.D. Spengler, D. Hlinka, D. Sullivan, D. Moon, 2002: Using CALPUFF to evaluate the impacts of power plant emissions in Illinois: mode sensitivity and implications. *Atmos. Environ.* **36(6)**, 1063-1075.

Liu, M.K. and M. A. Yocke, 1980: Siting of wind turbine generators in complex terrain. *J. Energy*, **4**, 10:16.

Mahrt, L., 1982: Momentum Balance of Gravity Flows. *Journal of Atmos.Sci.*, **39**, 2701-2711.

Maul, P.R., 1980: Atmospheric transport of sulfur compound pollutants. Central Electricity Generating Bureau MID/SSD/80/0026/R. Nottingham, England.

Morrison, K., Z-X Wu, J.S. Scire, J. Chenier and T. Jeffs-Schonewille, 2003: CALPUFF-Based Predictive and Reactive Emission Control System. 96th A&WMA Annual Conference & Exhibition, 22-26 June 2003, San Diego, CA.

O'Brien, J.J., 1970: A note on the vertical structure of the eddy exchange coefficient in the planetary boundary layer. *J. Atmos. Sci.*, **27**, 1213-1215.

Perry, S.G., D.J. Burns, L.H. Adams, R.J. Paine, M.G. Dennis, M.T. Mills, D.G. Strimaitis, R.J. Yamartino, E.M. Insley, 1989: User's Guide to the Complex Terrain Dispersion Model Plus Algorithms for Unstable Situations (CTDMPLUS) Volume 1: Model Description and User Instructions. EPA/600/8-89/041, U.S. Environmental Protection Agency, RTP, NC.

Reisner, J., R.M. Rasmussen and R.T. Bruintjes, 1998: Explicit forecasting of supercooled liquid water in winter storms using the MM5 mesoscale model, *Q.J.R. Meteorol. Soc.*, **124**, 1071-1107.

Robe, F.R., Z-X. Wu and J.S. Scire, 2002: Real-time SO_2 Forecasting System with Combined ETA Analysis and CALPUFF Modeling. Proceedings of the 8th International Conference on Harmonisation within Atmospheric Dispersion Modelling for Regulatory Purposes, 14-17 October 2002, Sofia, Bulgaria.

Scire, J.S., and L.L. Schulman, 1981: Evaluation of the BLP and ISC models with SF_6 tracer data and SO_2 measurements at aluminum reduction plants. Specialty Conference on Dispersion Modeling from Complex Sources, April 7-9, St. Louis, MO.

Scire, J.S. and F.R. Robe, 1997: Fine-Scale Application of the CALMET Meteorological Model to a Complex Terrain Site. Paper 97-A1313. Air & Waste Management Association 90th Annual Meeting & Exhibition, Toronto, Ontario, Canada. 8-13 June 1997.

Scire, J.S., F.R. Robe, M.E. Fernau, and R.J. Yamartino, 2000a: A User's Guide for the CALMET Meteorological Model (Version 5). Earth Tech, Inc., Concord, MA.

Scire, J.S., D.G. Strimaitis, and R.J. Yamartino, 2000b: A User's Guide for the CALPUFF Dispersion Model (Version 5). Earth Tech, Inc., Concord, MA.

Scire, J.S., X-Z. Wu and G.E. Moore, 2003: Evaluation of the CALPUFF Model in Predicting Concentration, Visibility and Deposition Impacts at Class I Areas in Wyoming. A&WMA Specialty Conference, Guideline on Air Quality Models: The Path Forward, 22-24 October 2003, Mystic, CT.

Strimaitis D.G., J.S. Scire, and J.C Chang, 1998: Evaluation of the CALPUFF dispersion model with two power plant data sets. Preprints 10th Joint AMS/AWMA Conference on the Applications of Air Pollution Meteorology, 11-16 January 1998, Phoenix, Arizona.

Zhou, Y, J.I. Levy, J.K. Hammitt, J.S. Evans, 2003: Estimating population exposure to power plant emissions using CALPUFF: a case study in Beijing, China. *Atmos. Environ*. **37(6)**, 815-826

.

APPENDIX A

POTROOM TEMPERATURE MEASUREMENTS AT THE DESCHAMBAULT FACILITY

Date	Roof Temperature (degree C)	Ambiant Temperature (degree C)	Delta Temperature (degree C)
1/1/2001	13.17	-6.2	19.4
1/2/2001	8.66	-11.1	19.7
1/3/2001	11.05	-13.5	24.6
1/4/2001	10.13	-7.7	17.8
1/5/2001	8.79	-15.4	24.2
1/6/2001	14.68	-6.5	21.2
1/7/2001	12.68	-7.4	20.1
1/8/2001	11.18	-10.7	21.9
1/9/2001	5.29	-15.1	20.4
1/10/2001	5.03	-16.7	21.7
1/11/2001	7.95	-13.0	20.9
1/12/2001	6.02	-14.7	20.7
1/13/2001	8.28	-15.6	23.9
1/14/2001	10.71	-8.7	19.4
1/15/2001	11.29	-11.3	22.6
1/16/2001	14.04	-6.0	20.0
1/17/2001	5.36	-14.1	19.4
1/18/2001	8.53	-17.1	25.6
1/19/2001	10.59	-7.7	18.3
1/20/2001	1.91	-19.4	21.3
1/21/2001	3.14	-21.3	24.4
1/22/2001	4.48	-19.8	24.3
1/23/2001	16.28	-7.8	24.0
1/24/2001	17.19	-3.8	20.9
1/25/2001	7.89	-12.0	19.9
1/26/2001	11.04	-14.9	25.9
1/27/2001	14.57	-7.2	21.7
1/28/2001	6.1	-13.5	19.6
1/29/2001	8.39	-16.4	24.8
1/30/2001	14.49	-8.5	22.9
1/31/2001	10.99	-8.7	19.7
2/1/2001	12.74	-8.8	21.5
2/2/2001	15.27	-7.3	22.6
2/3/2001	7.93	-10.2	18.2
2/4/2001	7.81	-16.8	24.6
2/5/2001	15.54	-8.0	23.5
2/6/2001	18.44	-3.0	21.5
2/7/2001	14.67	-5.4	20.1
2/8/2001	12.39	-11.7	24.1
2/9/2001	17.28	-6.7	24.0
2/10/2001	7.45	-6.5	14.0
2/11/2001	3.82	-16.1	19.9
2/12/2001	6.37	-16.8	23.2
2/13/2001	10.36	-11.9	22.3
2/14/2001	14.08	-9.6	23.7
2/15/2001	12.2	-7.9	20.1
2/16/2001	12.05	-13.2	25.2
2/17/2001	7.06	-10.9	18.0
2/18/2001	7.82	-18.6	26.4
2/19/2001	17.47	-5.3	22.8
2/20/2001	20.84	0.1	20.8
2/21/2001	3.74	-11.8	15.6
2/22/2001	0.99	-21.5	22.4
2/23/2001	9.45	-12.2	21.6
2/24/2001	4.96	-15.7	20.7
2/25/2001	14.3	-10.2	24.5
2/26/2001	15.91	-1.6	17.5
2/27/2001	9.69	-10.2	19.9
2/28/2001	5.2	-16.8	22.0

Date	Roof Temperature (degree C)	Ambiant Temperature (degree C)	Delta Temperature (degree C)
3/1/2001	3.15	-19.5	22.7
3/2/2001	3.38	-18.7	22.1
3/3/2001	5.8	-18.8	24.6
3/4/2001	11.41	-13.4	24.8
3/5/2001	18.05	-6.3	24.3
3/6/2001	20.06	-0.7	20.8
3/7/2001	17.64	-3.4	21.1
3/8/2001	18.83	-5.2	24.0
3/9/2001	19.85	-1.7	21.5
3/10/2001	21.66	-1.1	22.7
3/11/2001	15.46	-3.1	18.6
3/12/2001	12.37	-10.2	22.6
3/13/2001	15.75	-4.7	20.4
3/14/2001	19.53	-1.8	21.4
3/15/2001	18.64	-1.4	20.0
3/16/2001	16.22	-4.3	20.5
3/17/2001	20.16	-7.0	27.1
3/18/2001	21.53	-0.6	22.2
3/19/2001	23.61	2.8	20.8
3/20/2001	21.28	0.0	21.3
3/21/2001	23.12	1.9	21.2
3/22/2001	19.15	1.1	18.1
3/23/2001	18.72	0.3	18.5
3/24/2001	14.88	-1.5	16.3
3/25/2001	11.45	-6.4	17.9
3/26/2001	12.85	-7.6	20.5
3/27/2001	15.55	-3.9	19.4
3/28/2001	16.3	-1.4	17.7
3/29/2001	18.29	-2.0	20.3
3/30/2001	20.81	1.4	19.4
3/31/2001	18.6	0.6	18.0
4/1/2001	18.49	-0.1	18.6
4/2/2001	18.63	-1.4	20.0
4/3/2001	20.61	1.6	19.0
4/4/2001	21.24	2.0	19.3
4/5/2001	21.11	2.0	19.1
4/6/2001	19.44	0.2	19.2
4/7/2001	21.35	1.9	19.4
4/8/2001	20.03	2.0	18.0
4/9/2001	22.36	4.3	18.1
4/10/2001	21.43	3.5	17.9
4/11/2001	22.16	3.6	18.5
4/12/2001	20.58	3.6	17.0
4/13/2001	19.72	4.1	15.6
4/14/2001	16.91	0.2	16.7
4/15/2001	20.41	1.8	18.6
4/16/2001	22.75	4.1	18.7
4/17/2001	20.03	2.2	17.9
4/18/2001	19.13	1.4	17.7
4/19/2001	19.63	1.4	18.2
4/20/2001	22.89	3.5	19.4
4/21/2001	30.83	9.5	21.3
4/22/2001	25.1	9.8	15.3
4/23/2001	24.34	5.7	18.7
4/24/2001	25.9	10.6	15.3
4/25/2001	21.12	4.3	16.8
4/26/2001	27.42	7.0	20.4
4/27/2001	22.55	7.5	15.0
4/28/2001	19.62	3.1	16.5
4/29/2001	24.86	4.7	20.2
4/30/2001	26.34	8.1	18.2

Date	Roof Temperature (degree C)	Ambiant Temperature (degree C)	Delta Temperature (degree C)
5/1/2001	34.29	14.7	19.6
5/2/2001	37.4	17.2	20.2
5/3/2001	37.29	14.0	23.2
5/4/2001	30.67	14.2	16.5
5/5/2001	24.3	7.5	16.8
5/6/2001	27.15	8.3	18.9
5/7/2001	30	10.4	19.6
5/8/2001	33.47	13.4	20.0
5/9/2001	33.33	13.8	19.6
5/10/2001	34.96	15.4	19.6
5/11/2001	35.67	16.2	19.5
5/12/2001	26.3	11.3	15.0
5/13/2001	26.08	8.8	17.3
5/14/2001	28.9	10.4	18.5
5/15/2001	28.1	10.0	18.1
5/16/2001	27.7	11.8	15.9
5/17/2001	29.16	11.5	17.7
5/18/2001	30.08	12.2	17.9
5/19/2001	30.21	12.9	17.3
5/20/2001	33.51	14.3	19.2
5/21/2001	36.18	17.6	18.6
5/22/2001	35.36	17.4	18.0
5/23/2001	34.43	16.8	17.6
5/24/2001	34.44	15.3	19.1
5/25/2001	36.54	18.5	18.0
5/26/2001	36.7	17.4	19.3
5/27/2001	31.76	14.1	17.6
5/28/2001	31.06	13.7	17.4
5/29/2001	28.01	12.6	15.4
5/30/2001	23.27	7.0	16.3
5/31/2001	26.96	10.3	16.7
6/1/2001	32.94	13.0	19.9
6/2/2001	28.35	11.7	16.6
6/3/2001	29.37	12.4	17.0
6/4/2001	29.72	13.0	16.7
6/5/2001	31.83	14.7	17.1
6/6/2001	32.05	15.2	16.8
6/7/2001	34.78	15.7	19.1
6/8/2001	34.43	15.2	19.2
6/9/2001	34.71	15.2	19.5
6/10/2001	35.29	16.9	18.4
6/11/2001	36.19	17.8	18.4
6/12/2001	35.71	16.8	18.9
6/13/2001	38.2	14.0	24.2
6/14/2001	41.29	21.2	20.1
6/15/2001	43.59	24.4	19.2
6/16/2001	41.93	23.7	18.3
6/17/2001	37.12	20.7	16.4
6/18/2001	36.23	17.2	19.0
6/19/2001	39.06	20.3	18.8
6/20/2001	36.04	19.0	17.0
6/21/2001	37.29	17.8	19.5
6/22/2001	33.2	15.3	17.9
6/23/2001	35.15	18.2	16.9
6/24/2001	36.9	19.3	17.6
6/25/2001	39.6	20.4	19.2
6/26/2001	41.63	23.2	18.4
6/27/2001	40.63	6.8	33.8
6/28/2001	34.57	17.4	17.2
6/29/2001	35.1	14.6	20.5
6/30/2001	38.46	20.0	18.5

Date	Roof Temperature (degree C)	Ambiant Temperature (degree C)	Delta Temperature (degree C)
7/1/2001	33.02	18.3	14.7
7/2/2001	30.78	13.2	17.6
7/3/2001	32.96	13.7	19.3
7/4/2001	34.71	16.9	17.8
7/5/2001	34.02	17.4	16.6
7/6/2001	30.98	12.9	18.1
7/7/2001	35.72	17.4	18.4
7/8/2001	34.66	16.8	17.8
7/9/2001	36.36	18.8	17.6
7/10/2001	35.38	17.4	17.9
7/11/2001	33.86	16.1	17.8
7/12/2001	31.98	15.0	17.0
7/13/2001	33.26	16.0	17.2
7/14/2001	34.87	16.7	18.2
7/15/2001	35.09	18.0	17.1
7/16/2001	33.95	16.6	17.4
7/17/2001	33.91	16.3	17.6
7/18/2001	35.45	17.9	17.5
7/19/2001	37.96	19.0	18.9
7/20/2001	39.29	19.7	19.6
7/21/2001	40.18	20.2	20.0
7/22/2001	38.78	20.9	17.8
7/23/2001	41.94	22.4	19.6
7/24/2001	40.62	22.7	17.9
7/25/2001	35.69	18.4	17.3
7/26/2001	31.06	12.6	18.4
7/27/2001	32.47	13.8	18.7
7/28/2001	35.21	15.8	19.4
7/29/2001	37.73	18.1	19.6
7/30/2001	38.38	19.3	19.1
7/31/2001	39.82	20.3	19.5
8/1/2001	40.93	21.0	19.9
8/2/2001	41.84	22.4	19.4
8/3/2001	39.88	21.9	18.0
8/4/2001	38.83	19.4	19.5
8/5/2001	41.23	20.2	21.1
8/6/2001	38.33	21.6	16.7
8/7/2001	34.55	23.0	11.5
8/8/2001	32.09	18.5	13.6
8/9/2001	37.15	25.1	12.1
8/10/2001	38.49	22.6	15.9
8/11/2001	35.37	15.7	19.6
8/12/2001	40.25	19.2	21.0
8/13/2001	36.7	18.3	18.4
8/14/2001	36.32	15.4	20.9
8/15/2001	38.43	17.1	21.3
8/16/2001	40.93	19.1	21.8
8/17/2001	39.22	19.4	19.8
8/18/2001	38.27	19.2	19.1
8/19/2001	39.08	19.1	20.0
8/20/2001	34.35	15.9	18.5
8/21/2001	36.96	18.0	19.0
8/22/2001	38.89	19.7	19.2
8/23/2001	36.49	17.0	19.5
8/24/2001	32.9	14.3	18.6
8/25/2001	33.15	13.9	19.3
8/26/2001	35.41	15.7	19.7
8/27/2001	36.62	18.3	18.3
8/28/2001	33.62	15.5	18.1
8/29/2001	30.47	8.2	22.2
8/30/2001	33.86	12.8	21.0
8/31/2001	36.59	18.3	18.3

Date	Roof Temperature (degree C)	Ambiant Temperature (degree C)	Delta Temperature (degree C)
9/1/2001	28.22	12.4	15.8
9/2/2001	30.05	10.0	20.1
9/3/2001	35.44	15.5	20.0
9/4/2001	31.83	15.3	16.6
9/5/2001	30.04	11.2	18.8
9/6/2001	32.25	12.2	20.1
9/7/2001	37.09	16.4	20.7
9/8/2001	41.37	21.8	19.5
9/9/2001	42.21	22.7	19.5
9/10/2001	37.74	20.0	17.7
9/11/2001	31.45	14.4	17.0
9/12/2001	32.22	12.8	19.5
9/13/2001	28.12	12.0	16.1
9/14/2001	26.27	8.3	18.0
9/15/2001	28.48	9.1	19.4
9/16/2001	30.56	12.1	18.4
9/17/2001	33.28	13.3	20.0
9/18/2001	31.02	14.1	16.9
9/19/2001	31.88	12.8	19.1
9/20/2001	32.43	14.4	18.0
9/21/2001	34.69	16.6	18.1
9/22/2001	34.3	16.4	17.9
9/23/2001	33.96	16.1	17.9
9/24/2001	35.75	17.3	18.5
9/25/2001	31.51	15.1	16.4
9/26/2001	30.34	13.3	17.0
9/27/2001	27.28	10.5	16.7
9/28/2001	26.92	9.5	17.4
9/29/2001	25.99	8.1	17.9
9/30/2001	26.42	7.6	18.8
10/1/2001	29.96	9.5	20.5
10/2/2001	30.57	11.7	18.8
10/3/2001	27.11	8.4	18.7
10/4/2001	30.61	12.8	17.8
10/5/2001	26.71	9.8	16.9
10/6/2001	23.1	6.8	16.3
10/7/2001	21.65	4.2	17.5
10/8/2001	19.73	2.3	17.5
10/9/2001	23.69	4.5	19.2
10/10/2001	25.53	8.0	17.5
10/11/2001	32.67	13.3	19.4
10/12/2001	30.98	13.8	17.2
10/13/2001	30.17	13.0	17.2
10/14/2001	33.25	15.2	18.0
10/15/2001	28.48	11.9	16.6
10/16/2001	28.29	9.5	18.8
10/17/2001	22.77	8.1	14.7
10/18/2001	18.82	3.1	15.7
10/19/2001	24.79	4.5	20.3
10/20/2001	25.93	7.4	18.6
10/21/2001	25.72	7.1	18.6
10/22/2001	21.81	5.2	16.7
10/23/2001	24.1	4.9	19.2
10/24/2001	29.21	11.4	17.8
10/25/2001	25.7	10.3	15.4
10/26/2001	21.79	6.2	15.6
10/27/2001	19.94	4.3	15.6
10/28/2001	17.69	0.6	17.0
10/29/2001	20.17	1.9	18.2
10/30/2001	16.71	-0.1	16.9
10/31/2001	16.73	-1.9	18.7

Date	Roof Temperature (degree C)	Ambiant Temperature (degree C)	Delta Temperature (degree C)
11/1/2001	23.33	4.0	19.3
11/2/2001	29.38	10.7	18.7
11/3/2001	24.74	8.3	16.5
11/4/2001	22.63	3.7	18.9
11/5/2001	22.8	5.2	17.6
11/6/2001	21.34	4.1	17.3
11/7/2001	19.72	3.8	15.9
11/8/2001	18.3	0.4	17.9
11/9/2001	16.6	1.5	15.1
11/10/2001	15.89	-0.8	16.7
11/11/2001	14.56	-1.5	16.1
11/12/2001	13.08	-2.6	15.7
11/13/2001	14.92	-4.5	19.5
11/14/2001	20	1.2	18.8
11/15/2001	25.5	5.3	20.2
11/16/2001	18.07	4.5	13.6
11/17/2001	16.4	-2.3	18.7
11/18/2001	20.36	1.4	19.0
11/19/2001	26.89	6.0	20.9
11/20/2001	16.47	1.6	14.9
11/21/2001	16.9	-2.0	18.9
11/22/2001	20.04	-0.1	20.1
11/23/2001	21.56	2.4	19.2
11/24/2001	26.61	5.6	21.1
11/25/2001	30.7	10.3	20.4
11/26/2001	26.52	9.4	17.1
11/27/2001	18.46	-0.3	18.8
11/28/2001	16.79	-1.6	18.4
11/29/2001	15.71	-4.3	20.0
11/30/2001	19.07	-0.7	19.8
12/1/2001	23.41	3.2	20.2
12/2/2001	21.66	2.0	19.6
12/3/2001	21.75	0.6	21.1
12/4/2001	22.41	2.2	20.2
12/5/2001	23.69	3.2	20.5
12/6/2001	25.49	7.1	18.4
12/7/2001	19.11	0.8	18.3
12/8/2001	16.12	-3.2	19.4
12/9/2001	16.15	-3.7	19.9
12/10/2001	19.19	-2.1	21.3
12/11/2001	19.4	-0.7	20.1
12/12/2001	19.02	-2.2	21.2
12/13/2001	22.42	0.2	22.2
12/14/2001	21.56	1.5	20.0
12/15/2001	15.11	-4.2	19.3
12/16/2001	13.77	-6.9	20.7
12/17/2001	17.38	-5.7	23.1
12/18/2001	19.14	-1.8	21.0
12/19/2001	20.14	-1.3	21.4
12/20/2001	18.97	-1.7	20.6
12/21/2001	16.03	-3.5	19.6
12/22/2001	11.82	-7.9	19.7
12/23/2001	14.91	-9.1	24.0
12/24/2001	19.4	-1.2	20.6
12/25/2001	18.84	-2.6	21.5
12/26/2001	18.8	-2.6	21.4
12/27/2001	14.48	-5.8	20.3
12/28/2001	13.48	-9.3	22.8
12/29/2001	13.13	-7.1	20.2
12/30/2001	12.2	-8.2	20.4
12/31/2001	9.89	-10.8	20.7
	========		
	24.61		
			19.2

APPENDIX B

BPIP OUTPUT FILE

BPIP

BPIP (Dated: 04112)

DATE : 12/22/2009
TIME : 14:20: 2
BPIP

============================
BPIP PROCESSING INFORMATION:
============================

The ST flag has been set for preparing downwash data for an ISCST run.

Inputs entered in KILOMETERS will be converted to meters using a conversion factor of 1000.0000. Output will be in meters.

UTMP is set to UTMN. The input is assumed to be in a local X-Y coordinate system as opposed to a UTM coordinate system. True North is in the positive Y direction.

Plant north is set to 0.00 degrees with respect to True North.

BPIP

PRELIMINARY* GEP STACK HEIGHT RESULTS TABLE
(Output Units: meters)

Stack Name	Stack Height	Stack-Building Base Elevation Differences	GEP** EQN1	Preliminary* GEP Stack Height Value
Anode	40.00	0.00	57.50	65.00
Furnace1	29.50	0.00	131.50	131.50
Furnace2	29.50	0.00	131.50	131.50
wscrb1	40.00	0.00	44.50	65.00
wscrb2	40.00	0.00	44.50	65.00
wscrb3	40.00	0.00	44.50	65.00
wscrb4	40.00	0.00	44.50	65.00

* Results are based on Determinants 1 & 2 on pages 1 & 2 of the GEP Technical Support Document. Determinant 3 may be investigated for additional stack height credit. Final values result after Determinant 3 has been taken into consideration.

** Results were derived from Equation 1 on page 6 of GEP Technical Support Document. Values have been adjusted for any stack-building base elevation differences.

Note: Criteria for determining stack heights for modeling emission limitations for a source can be found in Table 3.1 of the GEP Technical Support Document.

```
                          BPIP (Dated: 04112)
DATE : 12/22/2009
TIME : 14:20: 2


BPIP

 BPIP output is in meters


    SO BUILDHGT Anode      22.50   22.50    0.00   22.50   22.50   22.50
    SO BUILDHGT Anode      22.50   22.50   22.50   22.50   22.50   22.50
    SO BUILDHGT Anode      22.50   22.50   22.50   22.50   22.50   22.50
    SO BUILDHGT Anode      22.50   22.50    0.00   22.50   22.50   22.50
    SO BUILDHGT Anode      22.50   22.50   22.50   22.50   23.00   23.00
    SO BUILDHGT Anode      23.00   23.00   22.50   22.50   22.50   22.50
    SO BUILDWID Anode     374.81  193.00    0.00  233.00  412.50  580.50
    SO BUILDWID Anode     730.00  857.50  959.00 1031.00 1072.00 1081.50
    SO BUILDWID Anode    1066.00 1018.00  939.25  831.75  699.25  545.31
    SO BUILDWID Anode     374.81  193.00    0.00  233.00  413.00  580.00
    SO BUILDWID Anode     729.50  857.50  958.50 1031.00   43.00   38.00
    SO BUILDWID Anode      44.00   48.50  939.25  831.75  699.12  545.28


    SO BUILDHGT Furnace1   22.00   22.00   22.00   22.00   22.00   22.00
    SO BUILDHGT Furnace1   22.00   22.00   22.00   22.00   22.00   22.00
    SO BUILDHGT Furnace1   22.00   22.00   22.00   22.00   22.00   22.00
    SO BUILDHGT Furnace1   22.00   22.00   22.00   22.00   22.00   22.00
    SO BUILDHGT Furnace1   22.00   22.00   55.00   55.00   55.00   22.00
    SO BUILDHGT Furnace1   22.00   22.00   22.00   22.00   22.00   22.00
    SO BUILDWID Furnace1  153.19  143.75  130.25  112.50  110.00  128.00
    SO BUILDWID Furnace1  141.50  151.00  156.00  156.00  151.50  142.50
    SO BUILDWID Furnace1  129.00  129.50  143.50  153.00  157.88  157.94
    SO BUILDWID Furnace1  153.19  143.75  130.00  112.50  110.00  128.00
    SO BUILDWID Furnace1  141.50  151.00   50.00   50.50   50.00  142.50
    SO BUILDWID Furnace1  129.00  129.50  143.75  153.00  157.88  157.94


    SO BUILDHGT Furnace2   22.00   22.00   22.00   22.00   22.00   22.00
    SO BUILDHGT Furnace2   22.00   22.00   22.00   22.00   22.00   22.00
    SO BUILDHGT Furnace2   22.00   22.00   22.00   22.00   22.00   22.00
    SO BUILDHGT Furnace2   22.00   22.00   22.50   22.50   22.50   22.50
    SO BUILDHGT Furnace2   22.00   22.00   22.00   55.00   55.00   55.00
    SO BUILDHGT Furnace2   22.00   22.00   22.00   22.00   22.00   22.00
    SO BUILDWID Furnace2  153.19  143.75  130.25  112.50  110.00  128.00
    SO BUILDWID Furnace2  141.50  151.00  156.00  156.00  151.50  142.50
    SO BUILDWID Furnace2  129.00  129.50  143.50  153.00  157.88  157.94
    SO BUILDWID Furnace2  153.19  143.75   46.00  233.00  413.00  580.00
    SO BUILDWID Furnace2  141.50  151.00  156.00   50.50   50.00   50.00
    SO BUILDWID Furnace2  129.00  129.50  143.75  153.00  157.88  157.94


    SO BUILDHGT wscrb1     25.00   25.00   25.00   25.00   25.00   25.00
    SO BUILDHGT wscrb1     25.00   25.00   25.00   25.00   25.00   25.00
    SO BUILDHGT wscrb1     25.00   25.00   25.00   25.00   25.00   25.00
```

```
SO BUILDHGT wscrb1      25.00   25.00   25.00   25.00   25.00   25.00
SO BUILDHGT wscrb1      25.00   25.00   25.00   25.00   25.00   25.00
SO BUILDHGT wscrb1      25.00   25.00   25.00   25.00   25.00   25.00
SO BUILDWID wscrb1      12.19   12.25   12.25   12.50   12.00   12.50
SO BUILDWID wscrb1      12.50   13.00   13.00   13.00   12.50   12.50
SO BUILDWID wscrb1      12.50   12.50   12.25   12.25   12.25   12.38
SO BUILDWID wscrb1      12.19   12.50   12.25   12.50   12.50   12.50
SO BUILDWID wscrb1      12.50   13.00   12.50   13.00   12.50   12.50
SO BUILDWID wscrb1      12.00   12.50   12.25   12.25   12.25   12.41


SO BUILDHGT wscrb2      25.00   25.00   25.00   25.00   25.00   25.00
SO BUILDHGT wscrb2      25.00   25.00   25.00   25.00   25.00   25.00
SO BUILDHGT wscrb2      25.00   25.00   25.00   25.00   25.00   25.00
SO BUILDHGT wscrb2      25.00   25.00   25.00   25.00   25.00   25.00
SO BUILDHGT wscrb2      25.00   25.00   25.00   25.00   25.00   25.00
SO BUILDHGT wscrb2      25.00   25.00   25.00   25.00   25.00   25.00
SO BUILDWID wscrb2      12.19   12.25   12.25   12.50   12.00   12.50
SO BUILDWID wscrb2      12.50   12.50   12.50   13.00   12.50   12.50
SO BUILDWID wscrb2      12.00   12.00   12.25   12.25   12.25   12.41
SO BUILDWID wscrb2      12.25   12.50   12.25   12.50   12.50   12.50
SO BUILDWID wscrb2      12.50   13.00   13.00   13.00   12.50   12.50
SO BUILDWID wscrb2      12.00   12.50   12.25   12.25   12.12   12.38


SO BUILDHGT wscrb3      25.00   25.00   25.00   25.00   25.00   25.00
SO BUILDHGT wscrb3      25.00   25.00   25.00   25.00   25.00   25.00
SO BUILDHGT wscrb3      25.00   25.00   25.00   25.00   25.00   25.00
SO BUILDHGT wscrb3      25.00   25.00   25.00   25.00   25.00   25.00
SO BUILDHGT wscrb3      25.00   25.00   25.00   25.00   25.00   25.00
SO BUILDHGT wscrb3      25.00   25.00   25.00   25.00   25.00   25.00
SO BUILDWID wscrb3      12.19   12.25   12.25   12.50   12.50   12.50
SO BUILDWID wscrb3      12.50   13.00   12.50   13.00   12.50   12.50
SO BUILDWID wscrb3      12.50   12.00   12.25   12.25   12.12   12.38
SO BUILDWID wscrb3      12.19   12.25   12.25   12.50   12.50   12.50
SO BUILDWID wscrb3      13.00   13.00   12.50   13.00   12.50   12.50
SO BUILDWID wscrb3      12.50   12.00   12.25   12.50   12.25   12.41


SO BUILDHGT wscrb4      25.00   25.00   25.00   25.00   25.00   25.00
SO BUILDHGT wscrb4      25.00   25.00   25.00   25.00   25.00   25.00
SO BUILDHGT wscrb4      25.00   25.00   25.00   25.00   25.00   25.00
SO BUILDHGT wscrb4      25.00   25.00   25.00   25.00   25.00   25.00
SO BUILDHGT wscrb4      25.00   25.00   25.00   25.00   25.00   25.00
SO BUILDHGT wscrb4      25.00   25.00   25.00   25.00   25.00   25.00
SO BUILDWID wscrb4      12.19   12.25   12.25   12.50   12.50   12.00
SO BUILDWID wscrb4      12.50   13.00   13.00   13.00   12.50   12.50
SO BUILDWID wscrb4      12.50   12.00   12.25   12.25   12.25   12.41
SO BUILDWID wscrb4      12.19   12.25   12.25   12.50   12.00   12.50
SO BUILDWID wscrb4      13.00   13.00   12.50   13.00   13.00   12.50
SO BUILDWID wscrb4      12.50   12.00   12.25   12.50   12.25   12.38
```

APPENDIX C

SUMMER WIND ROSES FOR EARLY MORNING HOURS AND AFTERNOON HOURS AT BAKKAHOFDI STATION AND HÚSAVÍK STATION FOR 4 YEARS 2003 TO 2006 AND AT HEDINSHOFDI STATION FOR YEAR 2009

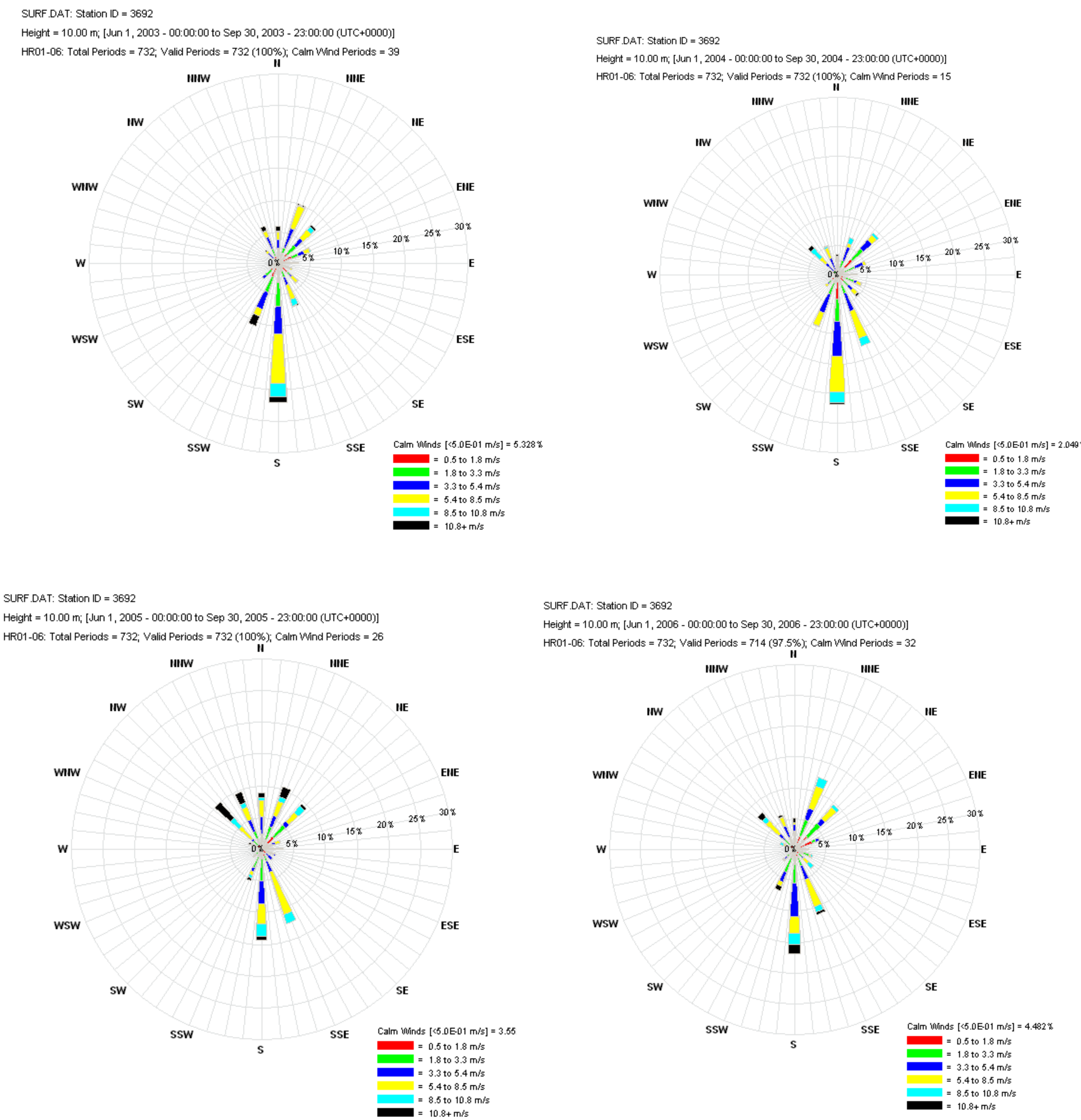
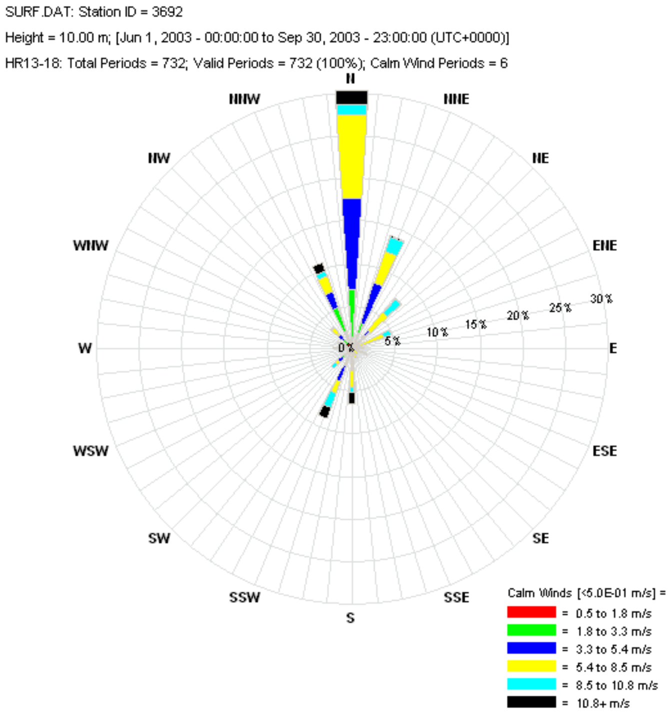
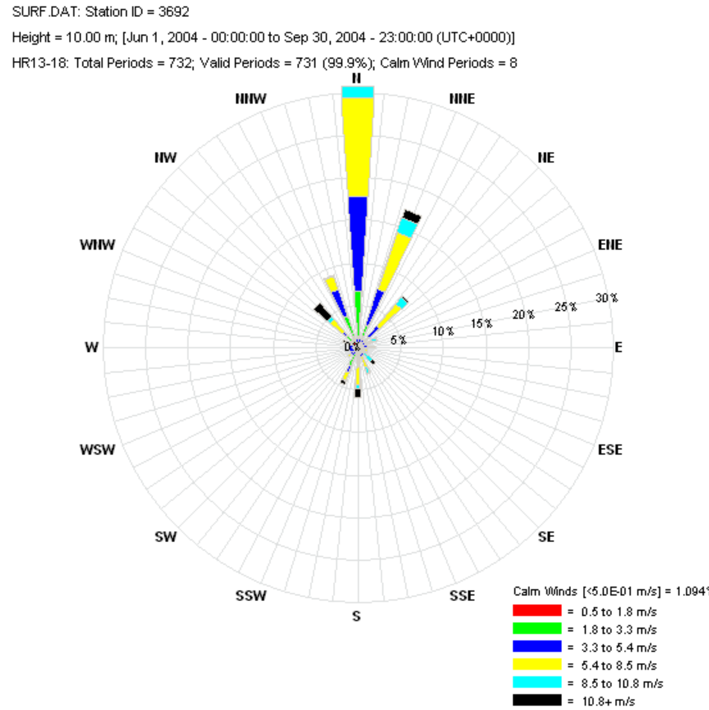
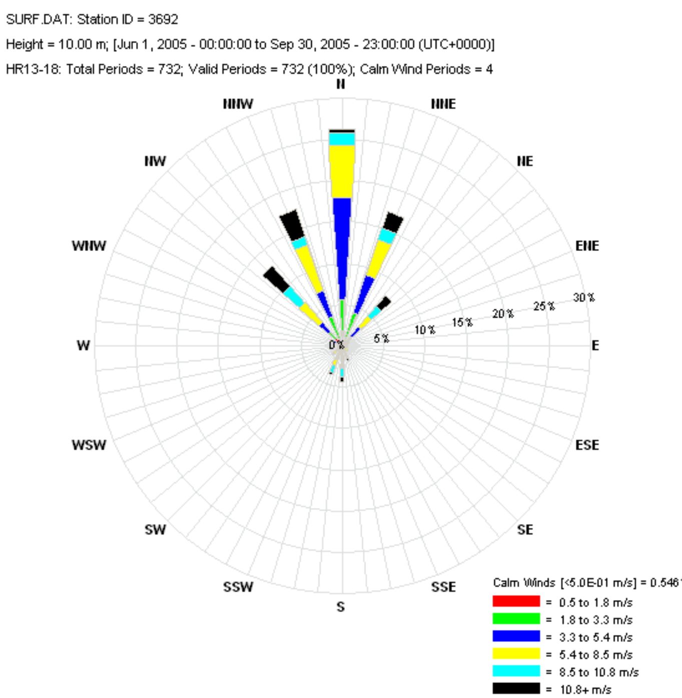


Figure C-1. Early morning wind roses average of summer months (June to September) for year 2003 (top left), year 2004 (top right), year 2005 (bottom left) and year 2006 (bottom right) at Station Bakkahofdi (3692).







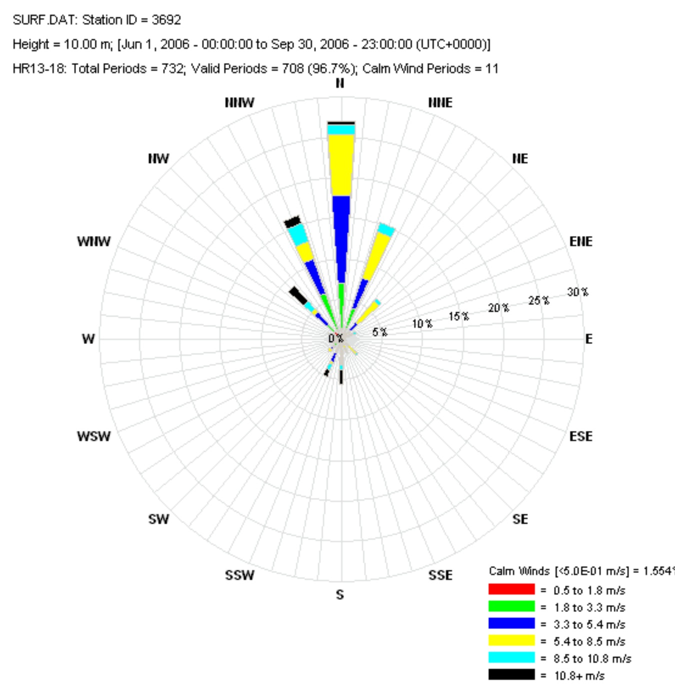


Figure E-2. Afternoon wind roses average of summer months (June to September) year 2003 (top left), year 2004 (top right), year 2005 (bottom left) and year 2006 (bottom right) at Station Bakkahofdi (3692).

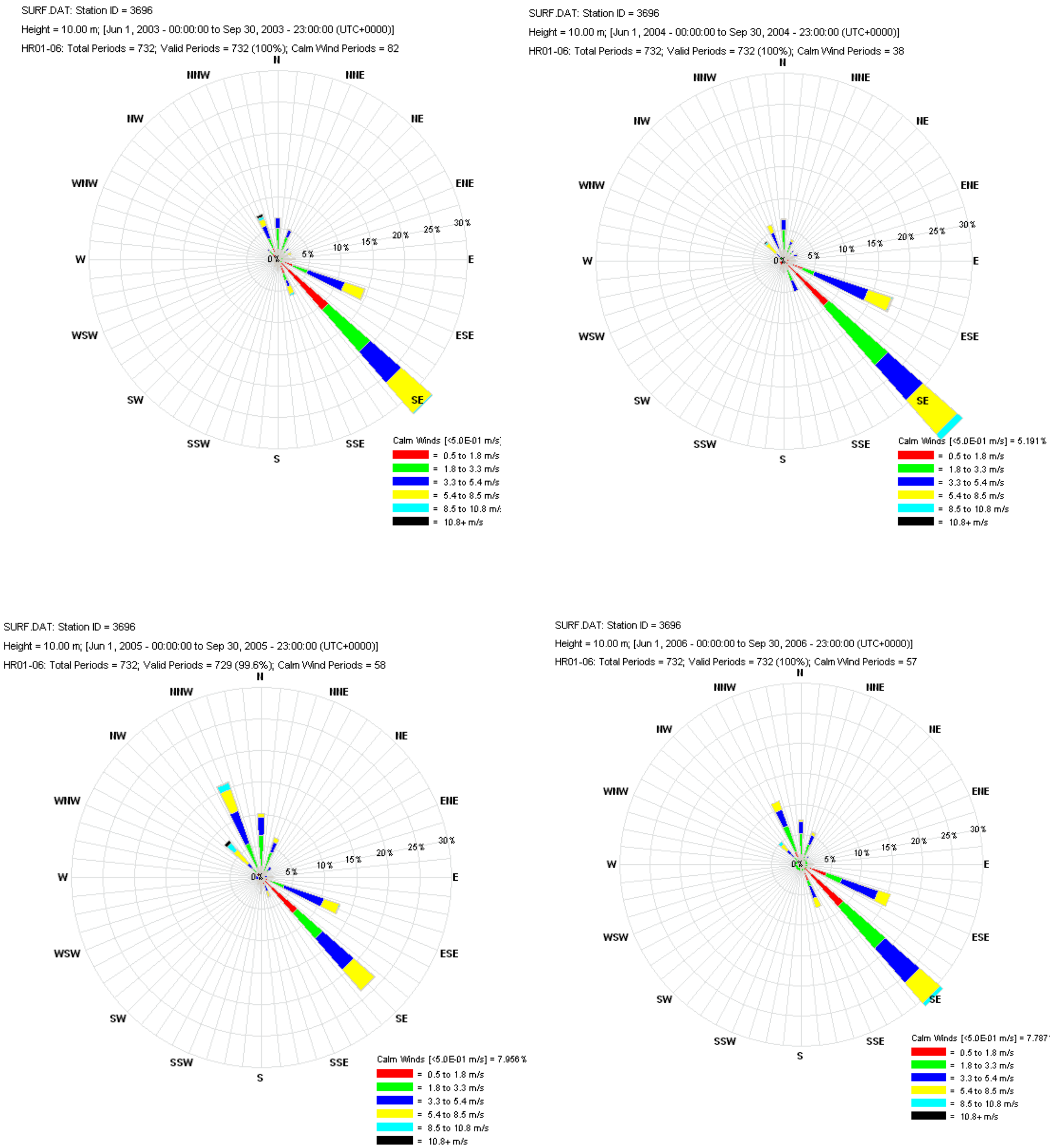


Figure E-3. Early morning wind roses average of summer months (June to September) year 2003 (top left), year 2004 (top right), year 2005 (bottom left) and year 2006 (bottom right) at Station Húsavík (3696).

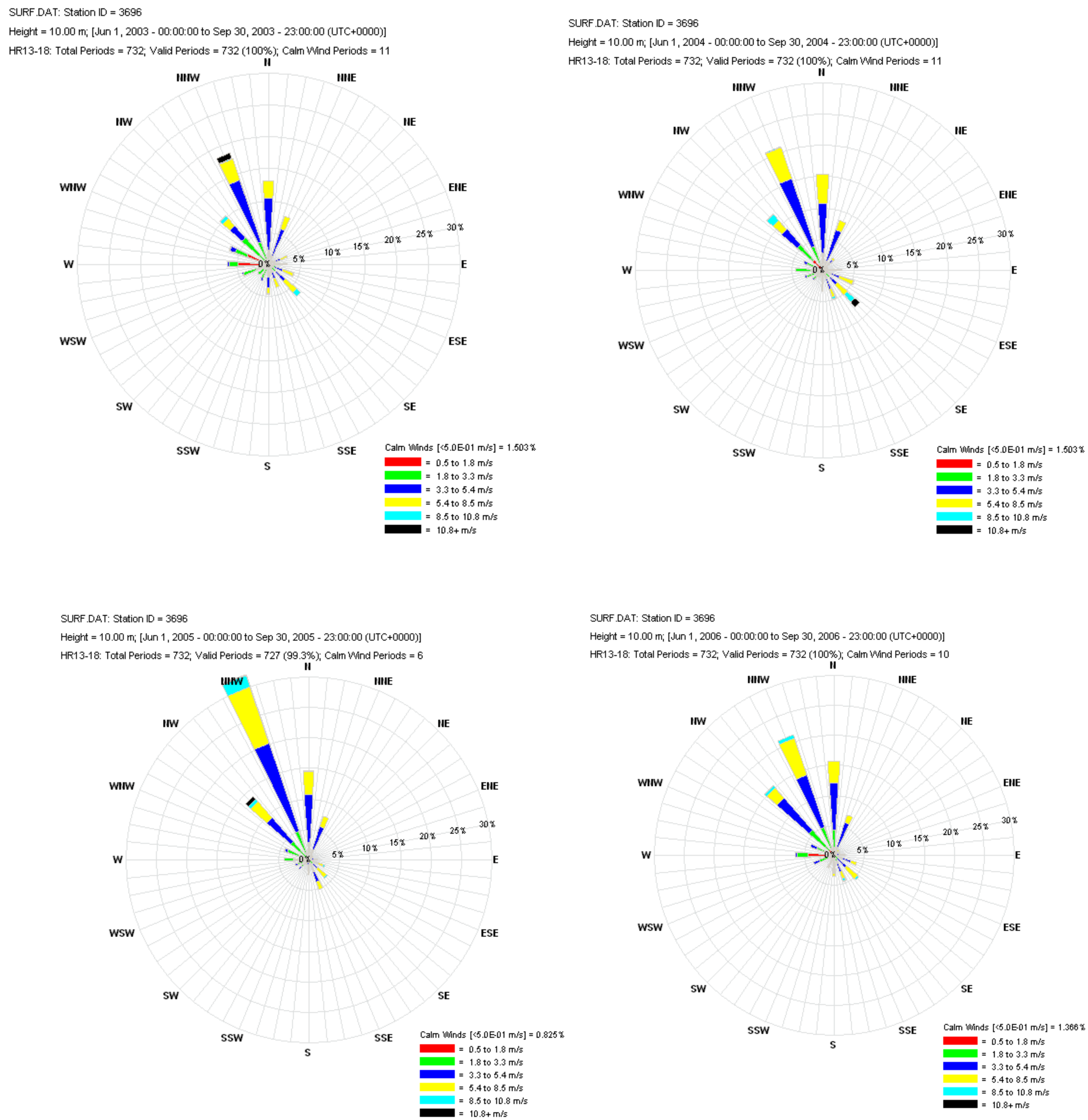
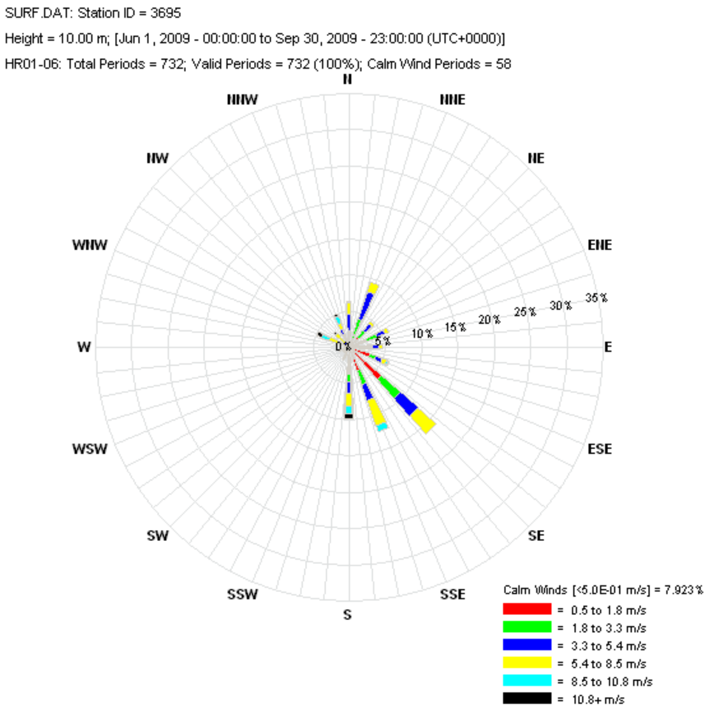


Figure E-4. Afternoon wind roses average of summer months (June to September) year 2003 (top left), year 2004 (top right), year 2005 (bottom left) and year 2006 (bottom right) at Station Húsavík (3696).



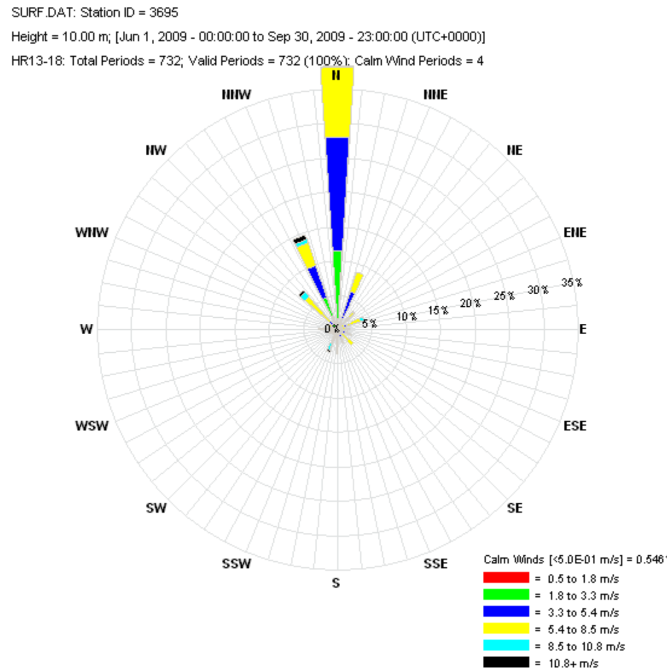


Figure E-5. Early morning wind roses average of summer months (June to September) year 2009 (left), and afternoon wind roses average of summer months (June to September) year 2009 (right) at Station Hedinshofdi (3695)

APPENDIX D

CALMET INPUT CONTROL FILE

```
CALMET.INP      2.1             Hour Start and End Times with Seconds
1-km resolution CALMET simulation for Húsavík Iceland Project
with MM5 data and 9 surface met stations.  One surface and one upper
air met stations from MM5 were added for missing data - Run with V6.326
---------------- 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_1km_win.dat  !
SURF.DAT      input    ! SRFDAT=surf_hus_obs_fill.dat !
CLOUD.DAT     input    * CLDDAT=            *
PRECIP.DAT    input    * PRCDAT=PRECIP.DAT  *
WT.DAT        input    * WTDAT=             *

CALMET.LST    output   ! METLST=cmet04_hus_v6326.lst    !
CALMET.DAT    output   ! METDAT=cmet04_hus_v6326.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 =  1  !
    Number of overwater met stations
                                 (NOWSTA) No default     ! NOWSTA =  0  !

NUMBER OF PROGNOSTIC and IGF-CALMET FILEs:

    Number of MM4/MM5/3D.DAT files
                                 (NM3D) No default       ! NM3D =  29  !

    Number of IGF-CALMET.DAT files
                                 (NIGF)   No default     ! NIGF =  0  !

                       !END!
--------------------------------------------------------------------------------
Subgroup (b)
---------------------------------
Upper air files (one per station)
---------------------------------
Default Name  Type       File Name
------------  ----       ---------
UP1.DAT       input     1  ! UPDAT=upmm5.dat !    !END!
--------------------------------------------------------------------------------
Subgroup (c)
-----------------------------------------
Overwater station files (one per station)
-----------------------------------------
Default Name  Type       File Name
------------  ----       ---------
SEA1.DAT       input     1  * SEADAT=4007.DAT *    *END*
--------------------------------------------------------------------------------
Subgroup (d)
------------------------------------------------
MM4/MM5/3D.DAT files (consecutive or overlapping)
------------------------------------------------
Default Name  Type       File Name
------------  ----       ---------
```

```
MM51.DAT       input     1  * M3DDAT=LSP2003.DAT *    *END*


     ! M3DDAT = ../opt6/mm5d4/husd4_20031009.m3d !  !END!
     ! M3DDAT = ../opt6/mm5d4/husd4_20031012.m3d !  !END!
     ! M3DDAT = ../opt6/mm5d4/husd4_20031015.m3d !  !END!
     ! M3DDAT = ../opt6/mm5d4/husd4_20031018.m3d !  !END!
     ! M3DDAT = ../opt6/mm5d4/husd4_20031021.m3d !  !END!
     ! M3DDAT = ../opt6/mm5d4/husd4_20031024.m3d !  !END!
     ! M3DDAT = ../opt6/mm5d4/husd4_20031027.m3d !  !END!
     ! M3DDAT = ../opt6/mm5d4/husd4_20031030.m3d !  !END!
     ! M3DDAT = ../opt6/mm5d4/husd4_20031102.m3d !  !END!
     ! M3DDAT = ../opt6/mm5d4/husd4_20031105.m3d !  !END!
     ! M3DDAT = ../opt6/mm5d4/husd4_20031108.m3d !  !END!
     ! M3DDAT = ../opt6/mm5d4/husd4_20031111.m3d !  !END!
     ! M3DDAT = ../opt6/mm5d4/husd4_20031114.m3d !  !END!
     ! M3DDAT = ../opt6/mm5d4/husd4_20031117.m3d !  !END!
     ! M3DDAT = ../opt6/mm5d4/husd4_20031120.m3d !  !END!
     ! M3DDAT = ../opt6/mm5d4/husd4_20031123.m3d !  !END!
     ! M3DDAT = ../opt6/mm5d4/husd4_20031126.m3d !  !END!
     ! M3DDAT = ../opt6/mm5d4/husd4_20031129.m3d !  !END!
     ! M3DDAT = ../opt6/mm5d4/husd4_20031202.m3d !  !END!
     ! M3DDAT = ../opt6/mm5d4/husd4_20031205.m3d !  !END!
     ! M3DDAT = ../opt6/mm5d4/husd4_20031208.m3d !  !END!
     ! M3DDAT = ../opt6/mm5d4/husd4_20031211.m3d !  !END!
     ! M3DDAT = ../opt6/mm5d4/husd4_20031214.m3d !  !END!
     ! M3DDAT = ../opt6/mm5d4/husd4_20031217.m3d !  !END!
     ! M3DDAT = ../opt6/mm5d4/husd4_20031220.m3d !  !END!
     ! M3DDAT = ../opt6/mm5d4/husd4_20031223.m3d !  !END!
     ! M3DDAT = ../opt6/mm5d4/husd4_20031226.m3d !  !END!
     ! M3DDAT = ../opt6/mm5d4/husd4_20031229.m3d !  !END!
     ! M3DDAT = ../opt6/mm5d4/husd4_20040101.m3d !  !END!

-------------------------------------------------------------------------------
Subgroup (e)
-------------------------------------------------
IGF-CALMET.DAT files (consecutive or overlapping)
-------------------------------------------------
Default Name  Type       File Name
------------  ----       ---------
IGFn.DAT       input     1  * IGFDAT=CALMET0.DAT *    *END*
-------------------------------------------------------------------------------
Subgroup (f)
----------------
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=                  *
DCST.GRD      output     * DCSTGD=                  *

-------------------------------------------------------------------------------
NOTES: (1) File/path names can be up to 70 characters in length
       (2) Subgroups (a) and (f) must have ONE 'END' (surrounded by
           delimiters) at the end of the group
       (3) Subgroups (b) through (e) are included ONLY if the corresponding
           number of files (NUSTA, NOWSTA, NM3D, NIGF) is not 0, and each 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  =  2003  !
                       Month  (IBMO)  --    No default   ! IBMO  =  10  !
                       Day    (IBDY)  --    No default   ! IBDY  =  11  !
     Starting time:    Hour   (IBHR)  --    No default   ! IBHR  =  0  !
                       Second (IBSEC) --    No default   ! IBSEC =  0  !

     Ending date:      Year   (IEYR)  --    No default   ! IEYR  =  2004  !
                       Month  (IEMO)  --    No default   ! IEMO  =  1  !
                       Day    (IEDY)  --    No default   ! IEDY  =  1  !
     Ending time:      Hour   (IEHR)  --    No default   ! IEHR  =  0  !
                       Second (IESEC) --    No default   ! IESEC =  0  !

      UTC time zone         (ABTZ) -- No default       ! ABTZ= UTC-0000 !
         (character*8)
         PST = UTC-0800, MST = UTC-0700 , GMT = UTC-0000
         CST = UTC-0600, EST = UTC-0500

     Length of modeling time-step (seconds)
     Must divide evenly into 3600 (1 hour)
     (NSECDT)                       Default:3600     ! NSECDT =  3600  !
                                    Units: seconds


     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

     Test options specified to see if
     they conform to regulatory
     values? (MREG)                   No Default       ! MREG =  0   !

        0 = NO checks are made
        1 = Technical options must conform to USEPA guidance
                  IMIXH    -1       Maul-Carson convective mixing height
                                    over land; OCD mixing height overwater
                  ICOARE   0        OCD deltaT method for overwater fluxes
                  THRESHL  0.0      Threshold buoyancy flux over land needed
                  ISURFT   > 0    in OBS mode (pick one representative station)
                           -2     in NOOBS mode (itprog=2) (average all
                                  surface prognostic temperatures to get
                                  a single representative sf. temp)
                  IUPT     > 0    in OBS mode (pick one representative station)
                           -2     in NOOBS mode (ITPROG>0) (average all surface
                                  prognostic temperatures to get a single
                                  representative sf. temp)
                                          to sustain convective mixing height growth


!END!
```

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

INPUT GROUP: 2 -- Map Projection and Grid control parameters
--------------

     Projection for all (X,Y):
     -------------------------

     Map projection
     (PMAP)                     Default: UTM    ! PMAP = UTM  !

         UTM :  Universal Transverse Mercator
         TTM :  Tangential Transverse Mercator
         LCC :  Lambert Conformal Conic
          PS :  Polar Stereographic
          EM :  Equatorial Mercator
        LAZA :  Lambert Azimuthal Equal Area

     False Easting and Northing (km) at the projection origin
     (Used only if PMAP= TTM, LCC, or LAZA)
     (FEAST)                    Default=0.0     ! FEAST  = 0.000  !
     (FNORTH)                   Default=0.0     ! FNORTH = 0.000  !

     UTM zone (1 to 60)
     (Used only if PMAP=UTM)
     (IUTMZN)                   No Default      ! IUTMZN =  28   !

     Hemisphere for UTM projection?
     (Used only if PMAP=UTM)
     (UTMHEM)                   Default: N      ! UTMHEM = N  !
         N   :  Northern hemisphere projection
         S   :  Southern hemisphere projection

     Latitude and Longitude (decimal degrees) of projection origin
     (Used only if PMAP= TTM, LCC, PS, EM, or LAZA)
     (RLAT0)                    No Default      ! RLAT0 = 40N  !
     (RLON0)                    No Default      ! RLON0 = 90W  !

         TTM :  RLON0 identifies central (true N/S) meridian of projection
                RLAT0 selected for convenience
         LCC :  RLON0 identifies central (true N/S) meridian of projection
                RLAT0 selected for convenience
         PS  :  RLON0 identifies central (grid N/S) meridian of projection
                RLAT0 selected for convenience
         EM  :  RLON0 identifies central meridian of projection
                RLAT0 is REPLACED by 0.0N (Equator)
         LAZA:  RLON0 identifies longitude of tangent-point of mapping plane
                RLAT0 identifies latitude of tangent-point of mapping plane

     Matching parallel(s) of latitude (decimal degrees) for projection
     (Used only if PMAP= LCC or PS)
     (XLAT1)                    No Default      ! XLAT1 = 30N  !
     (XLAT2)                    No Default      ! XLAT2 = 60N  !

         LCC :  Projection cone slices through Earth's surface at XLAT1 and XLAT2
         PS  :  Projection plane slices through Earth at XLAT1
                (XLAT2 is not used)

     ----------
     Note:  Latitudes and longitudes should be positive, and include a
            letter N,S,E, or W indicating north or south latitude, and
            east or west longitude.  For example,
            35.9  N Latitude  =  35.9N
            118.7 E Longitude = 118.7E


     Datum-region
     ------------

     The Datum-Region for the coordinates is identified by a character
```

```
     string.  Many mapping products currently available use the model of the
     Earth known as the World Geodetic System 1984 (WGS-84).  Other local
     models may be in use, and their selection in CALMET will make its output
     consistent with local mapping products.  The list of Datum-Regions with
     official transformation parameters is provided by the National Imagery and
     Mapping Agency (NIMA).

     NIMA Datum - Regions(Examples)
     ------------------------------------------------------------------------------
     WGS-84    WGS-84 Reference Ellipsoid and Geoid, Global coverage (WGS84)
     NAS-C     NORTH AMERICAN 1927 Clarke 1866 Spheroid, MEAN FOR CONUS (NAD27)
     NAR-C     NORTH AMERICAN 1983 GRS 80 Spheroid, MEAN FOR CONUS (NAD83)
     NWS-84    NWS 6370KM Radius, Sphere
     ESR-S     ESRI REFERENCE 6371KM Radius, Sphere

     Datum-region for output coordinates
     (DATUM)                    Default: WGS-84    ! DATUM = WGS-84  !


     Horizontal grid definition:
     ---------------------------

     Rectangular grid defined for projection PMAP,
     with X the Easting and Y the Northing coordinate

            No. X grid cells (NX)      No default     ! NX =   56  !
            No. Y grid cells (NY)      No default     ! NY =   51  !

     Grid spacing (DGRIDKM)            No default     ! DGRIDKM = 1. !
                                       Units: km

     Reference grid coordinate of
     SOUTHWEST corner of grid cell (1,1)

        X coordinate (XORIGKM)         No default     ! XORIGKM = 369.5 !
        Y coordinate (YORIGKM)         No default     ! YORIGKM = 7299.5 !
                                       Units: km


     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.,320.,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 =  1  !

          Print distance to land
          internal variables (LDBCST)      Default: F       ! LDBCST = F !
          (F = Do not print, T = print)
          (Output in .GRD file DCST.GRD, defined in input group 0)

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

    NO OBSERVATION MODE             (NOOBS)  Default: 0     ! NOOBS =  0   !
          0 = Use surface, overwater, and upper air stations
          1 = Use surface and overwater stations (no upper air observations)
              Use MM4/MM5/3D for upper air data
          2 = No surface, overwater, or upper air observations
              Use MM4/MM5/3D for surface, overwater, and upper air data

    NUMBER OF SURFACE & PRECIP. METEOROLOGICAL STATIONS

       Number of surface stations   (NSSTA)  No default     ! NSSTA =  9  !
```

```
      Number of precipitation stations
      (NPSTA=-1: flag for use of MM5/3D precip data)
                             (NPSTA)  No default     ! NPSTA =  0  !

   CLOUD DATA OPTIONS
      Gridded cloud fields:
                            (ICLOUD)  Default: 0     ! ICLOUD =  4  !
      ICLOUD = 0 - Gridded clouds not used
      ICLOUD = 1 - Gridded CLOUD.DAT generated as OUTPUT
      ICLOUD = 2 - Gridded CLOUD.DAT read as INPUT
      ICLOUD = 3 - Gridded cloud cover computed from prognostic fields
      ICLOUD = 4 - Gridded cloud cover from Prognostic Rel. Humidity
                   at all levels (MM5toGrads algorithm)

   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 airq 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 = -1 , -1 , -1 , -1 , -1 , -1 , -1 , -.5 ,  .5 ,  1  !
                         * 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 =  14  !
   (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 MM5/3D.DAT file as Step 1 field [IWFCOD = 0]
    14 = Yes, use winds from MM5/3D.DAT file as initial guess field [IWFCOD = 1]
    15 = Yes, use winds from MM5/3D.DAT file as observations [IWFCOD = 1]

   Timestep (hours) of the prognostic
   model input data   (ISTEPPG)        Default: 1      ! ISTEPPG =  1   !

   Use coarse CALMET fields as initial guess fields (IGFMET)
   (overwrites IGF based on prognostic wind fields if any)
                                       Default: 0      ! IGFMET =  0  !

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 = 10. !
                                       Units: km
   Maximum radius of influence over land
   aloft (RMAX2)                       No default      ! RMAX2 = 10. !
                                       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 = 8. !

                                       Units: km
   Relative weighting of the first
   guess field and observations in the
```

```
      SURFACE layer (R1)                     No default      ! R1 = 2. !
      (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 =
5 ,  5 ,  5 ,  5 ,  5 ,  5 ,  5 ,  5 ,  5 ,  5  !

      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., 0. !
      (Used only if IEXTRP = 3 or -3)


   BARRIER INFORMATION

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

      Level (1 to NZ) up to which barriers
      apply (KBAR)                           Default: NZ     ! KBAR =  10  !

      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)   Default: -1    ! ISURFT = -1  !
      (Must be a value from 1 to NSSTA,
       or -1 to use 2-D spatially varying
          surface temperatures,
       or -2 to use a domain-average prognostic
          surface temperatures (only with ITPROG=2))
      (Used only if IDIOPT1 = 0)
      --------------------------

   Temperature lapse rate used in the    Default: 0     ! IDIOPT2 =  0  !
      computation of terrain-induced
      circulations (IDIOPT2)
      0 = Compute internally from (at least) twice-daily
          upper air observations or prognostic fields
      1 = Read hourly preprocessed values
          from a data file (DIAG.DAT)

      Upper air station to use for
      the domain-scale lapse rate (IUPT) Default: -1    ! IUPT   = -1  !
      (Must be a value from 1 to NUSTA,
       or -1 to use 2-D spatially varying lapse rate,
       or -2 to use a domain-average prognostic
          lapse rate (only with ITPROG>0))
      (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 =  0 !
       (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 =  1  !
```

```
                                      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)


CONVECTIVE MIXING HEIGHT OPTIONS:
   Method to compute the convective
   mixing height(IMIHXH)              Default: 1      ! IMIXH =  1  !
       1: Maul-Carson for land and water cells
      -1: Maul-Carson for land cells only -
          OCD mixing height overwater
       2: Batchvarova and Gryning for land and water cells
      -2: Batchvarova and Gryning for land cells only
          OCD mixing height overwater

   Threshold buoyancy flux required to
   sustain convective mixing height growth
   overland (THRESHL)                 Default: 0.05   ! THRESHL = 0.05 !
   (expressed as a heat flux          units: W/m3
    per meter of boundary layer)


   Threshold buoyancy flux required to
   sustain convective mixing height growth
   overwater (THRESHW)                Default: 0.05   ! THRESHW = 0.05 !
   (expressed as a heat flux          units: W/m3
    per meter of boundary layer)


   Option for overwater lapse rates used
   in convective mixing height growth
   (ITWPROG)                          Default: 0      ! ITWPROG =  2  !
   0 : use SEA.DAT lapse rates and deltaT (or assume neutral
       conditions if missing)
   1 : use prognostic lapse rates (only if IPROG>2)
       and SEA.DAT deltaT (or neutral if missing)
   2 : use prognostic lapse rates and prognostic delta T
       (only if iprog>12 and 3D.DAT version# 2.0 or higher)

   Land Use category ocean in 3D.DAT datasets
   (ILUOC3D)                          Default: 16     ! ILUOC3D =  16  !
   Note: if 3D.DAT from MM5 version 3.0, iluoc3d = 16
         if MM4.DAT,           typically iluoc3d = 7


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 = 2500. !
   (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 = 2500. !
   (ZIMAXW) -- (Not used if observed  Units: meters
   overwater mixing hts. are used)
```

```
OVERWATER SURFACE FLUXES METHOD and PARAMETERS
      (ICOARE)                         Default: 10      ! ICOARE =  10   !
       0: original deltaT method (OCD)
      10: COARE with no wave parameterization (jwave=0, Charnock)
      11: COARE with wave option jwave=1 (Oost et al.)
          and default wave properties
     -11: COARE with wave option jwave=1 (Oost et al.)
          and observed wave properties (must be in SEA.DAT files)
      12: COARE with wave option 2 (Taylor and Yelland)
           and default wave properties
     -12: COARE with wave option 2 (Taylor and Yelland)
          and observed wave properties (must be in SEA.DAT files)

      Coastal/Shallow water length scale (DSHELF)
      (for modified z0 in shallow water)
      ( COARE fluxes only)
                                    Default : 0.        ! DSHELF = 0. !
                                    units: km

       COARE warm layer computation (IWARM)             ! IWARM =  0   !
       1: on - 0: off (must be off if SST measured with
       IR radiometer)               Default: 0

       COARE cool skin layer computation (ICOOL)        ! ICOOL =  0   !
       1: on - 0: off (must be off if SST measured with
       IR radiometer)               Default: 0

RELATIVE HUMIDITY PARAMETERS

   3D relative humidity from observations or
   from prognostic data? (IRHPROG)     Default:0        ! IRHPROG =  0   !

      0 = Use RH from SURF.DAT file
          (only if NOOBS = 0,1)
      1 = Use prognostic RH
          (only if NOOBS = 0,1,2)

TEMPERATURE PARAMETERS

   3D temperature from observations or
   from prognostic data? (ITPROG)      Default:0        ! ITPROG =  2   !

      0 = Use Surface and upper air stations
          (only if NOOBS = 0)
      1 = Use Surface stations (no upper air observations)
          Use MM5/3D for upper air data
          (only if NOOBS = 0,1)
      2 = No surface or upper air observations
          Use MM5/3D for surface and upper air data
          (only if NOOBS = 0,1,2)

   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        Units: K/m
   water (TGDEFB)
```

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

       Beginning (JWAT1) and ending (JWAT2)
       land use categories for temperature                   ! JWAT1 =  55  !
       interpolation over water -- Make                      ! JWAT2 =  55  !
       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  (SIGMAP)         Default: 100.0   ! SIGMAP = 50. !
        (0.0 => use half dist. btwn          Units: km
         nearest stns w & w/out
         precip when NFLAGP = 3)
       Minimum Precip. Rate Cutoff (CUTP)    Default: 0.01    ! CUTP = 0.01 !
        (values < CUTP = 0.0 mm/hr)          Units: mm/hr
!END!


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

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

     SURFACE STATION VARIABLES
     (One record per station --  5  records in all)


             1     2
         Name   ID            X coord.   Y coord.   Time   Anem.
                               (km)       (km)      zone   Ht.(m)
       ----------------------------------------------------------
! SS1  ='SS1'     40630       633.996    7287.687     1    10  !
! SS2  ='SS2'     40730       448.578    7279.461     1    10  !
! SS3  ='SS3'     40770       457.645    7370.392     1    10  !
! SS4  ='SS4'      3691       393.499    7325.584     1    10  !
! SS5  ='SS5'      3692       393.186    7330.505     1    10  !
! SS6  ='SS6'      3693       392.098    7324.522     1    10  !
! SS7  ='SS7'      3694       394.941    7327.762     1    10  !
! SS8  ='SS8'      3696       394.533    7326.550     1    10  !
! SS9  ='SS9'       479       405.449    7343.789     1    10  !
-------------------
      1
        Four character string for station name
        (MUST START IN COLUMN 9)

      2
        Six digit integer for station ID

!END!


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

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

     UPPER AIR STATION VARIABLES
     (One record per station --  3  records in all)

             1     2
         Name    ID      X coord.   Y coord.  Time zone
                           (km)       (km)
        ----------------------------------------------
! US1  ='US1 '   93691    393.499   7325.584    1  !
-------------------
      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 --  16  records in all)
     (NOT INCLUDED IF NPSTA = 0)

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

* PS1  ='ME03'   170273    437.512   4905.276      *
* PS2  ='ME15'   176905    395.159   4833.606      *

-------------------
      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 E

CALPUFF INPUT CONTROL FILE

```
ALCOA Iceland North (January 2009) -Option 6 Scenario - Base Case
Anode Cooling Stack - TALL - PM10/HF = 1g/s - SO2/BaP/PAH = 1g/s
Full year - Receptor resolution 100m and 200m and 400m
---------------- 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 =PUF_ANODE_01_OPT6.LST  !
CONC.DAT      output   ! CONDAT =PUF_ANODE_01_OPT6.CON     !
DFLX.DAT      output   ! DFDAT  =PUF_ANODE_01_OPT6.DRY     !
WFLX.DAT      output   ! WFDAT  =PUF_ANODE_01_OPT6.WET     !

VISB.DAT      output   * VISDAT =             *
TK2D.DAT      output   * T2DDAT =             *
RHO2D.DAT     output   * RHODAT =             *
RESTARTE.DAT  output   * RSTARTE=             *
--------------------------------------------------------------------------------
Emission Files
--------------
PTEMARB.DAT   input    * PTDAT  =             *
VOLEMARB.DAT  input    * VOLDAT =             *
BAEMARB.DAT   input    * ARDAT  =             *
LNEMARB.DAT   input    * LNDAT  =             *
--------------------------------------------------------------------------------
Other Files
-----------
OZONE.DAT     input    * OZDAT  =             *
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=             *
RISE.DAT      output   * RISDAT=             *
--------------------------------------------------------------------------------
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
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 =   4   !
```

```
     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_refined/CMET01_HUS_V6326.DAT     !  !END!
 none         input    ! METDAT=../CALMET_refined/CMET02_HUS_V6326.DAT     !  !END!
 none         input    ! METDAT=../CALMET_refined/CMET03_HUS_V6326.DAT     !  !END!
 none         input    ! METDAT=../CALMET_refined/CMET04_HUS_V6326.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  =  2003  !
                       Month  (IBMO)  --    No default   ! IBMO  =  1  !
                       Day    (IBDY)  --    No default   ! IBDY  =  1  !
     Starting time:    Hour   (IBHR)  --    No default   ! IBHR  =  0  !
                       Minute (IBMIN) --    No default   ! IBMIN =  0  !
                       Second (IBSEC) --    No default   ! IBSEC =  0  !

     Ending date:      Year   (IEYR)  --    No default   ! IEYR  =  2003  !
                       Month  (IEMO)  --    No default   ! IEMO  =  2  !
                       Day    (IEDY)  --    No default   ! IEDY  =  2  !
     Ending time:      Hour   (IEHR)  --    No default   ! IEHR  =  23  !
                       Minute (IEMIN) --    No default   ! IEMIN =  0  !
                       Second (IESEC) --    No default   ! IESEC =  0  !

     (These are only used if METRUN = 0)

     Base time zone        (XBTZ) -- No default       ! XBTZ= 0.0  !
     The zone is the number of hours that must be
     ADDED to the time to obtain UTC (or GMT)
     Examples: PST = 8., MST = 7.
               CST = 6., EST = 5.

     Length of modeling time-step (seconds)
     Equal to update period in the primary
     meteorological data files, or an
     integer fraction of it (1/2, 1/3 ...)
     Must be no larger than 1 hour
     (NSECDT)                   Default:3600     ! NSECDT =  3600  !
                                Units: seconds

     Number of chemical species (NSPEC)
                                Default: 5       ! NSPEC =  7   !

     Number of chemical species
```

```
     to be emitted  (NSE)            Default: 3       ! NSE =  7   !

     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 =  0   !

           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)
           METFM = 5 - AERMET tower file (PROFILE.DAT) and
                       surface parameters file (SURFACE.DAT)

     Meteorological Profile Data Format (MPRFFM)
            (used only for METFM = 1, 2, 3)
                                     Default: 1       ! MPRFFM =  1   !

           MPRFFM = 1 - CTDM plus tower file (PROFILE.DAT)
           MPRFFM = 2 - AERMET tower file (PROFILE.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 slugs? (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)

Method used to compute plume rise for
point sources not subject to building
downwash? (MRISE)                     Default: 1     ! MRISE =  1  !
   1 = Briggs plume rise
   2 = Numerical plume rise

Method used to simulate building
downwash? (MBDW)                      Default: 1     ! MBDW =   1  !
   1 = ISC method
   2 = PRIME method

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 =  0   !
   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)
```

```
Gravitational settling (plume tilt)
modeled ? (MTILT)                     Default: 0     ! MTILT =  0   !
   0 = no
   1 = yes
   (puff center falls at the gravitational
    settling velocity for 1 particle species)

Restrictions:
    - MDRY  = 1
    - NSPEC = 1  (must be particle species as well)
    - sg    = 0  GEOMETRIC STANDARD DEVIATION in Group 8 is
                 set to zero for a single particle diameter

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, 5)
   2 = use sigma-w measurements
       from PROFILE.DAT to compute sigma-z
       (valid for METFM = 1, 2, 3, 4, 5)
   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, 5)
   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.

[DIAGNOSTIC FEATURE]
Method used for Lagrangian timescale for Sigma-y
(used only if MDISP=1,2 or MDISP2=1,2)
(MTAULY)                              Default: 0     ! MTAULY =  0  !
   0 = Draxler default 617.284 (s)
   1 = Computed as Lag. Length / (.75 q) -- after SCIPUFF
  10 < Direct user input (s)             -- e.g., 306.9


[DIAGNOSTIC FEATURE]
Method used for Advective-Decay timescale for Turbulence
```

```
(used only if MDISP=2 or MDISP2=2)
(MTAUADV)                             Default: 0     ! MTAUADV =  0  !
   0 = No turbulence advection
   1 = Computed (OPTION NOT IMPLEMENTED)
  10 < Direct user input (s)   -- e.g., 800


Method used to compute turbulence sigma-v &
sigma-w using micrometeorological variables
(Used only if MDISP = 2 or MDISP2 = 2)
(MCTURB)                              Default: 1     ! MCTURB =  1  !
   1 = Standard CALPUFF subroutines
   2 = AERMOD subroutines

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 modeled for
point sources?
(MPARTL)
   0 = no
   1 = yes

Partial plume penetration of          Default: 1     ! MPARTLBA =  1  !
elevated inversion modeled for
buoyant area sources?
(MPARTLBA)
   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, using formatted BCON.DAT file
   2 = yes, using unformatted CONC.DAT file

Note:  MBCON > 0 requires that the last species modeled
       be 'BCON'.  Mass is placed in species BCON when
       generating boundary condition puffs so that clean
       air entering the modeling domain can be simulated
       in the same way as polluted air.  Specify zero
       emission of species BCON for all regular sources.

Individual source contributions saved?
                                      Default: 0     ! MSOURCE = 0  !
(MSOURCE)
   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
            Long Range Transport (LRT) guidance
                       METFM    1 or 2
                       AVET     60. (min)
                       PGTIME   60. (min)
                       MGAUSS   1
                       MCTADJ   3
                       MTRANS   1
                       MTIP     1
                       MRISE    1
                       MCHEM    1 or 3 (if modeling SOx, NOx)
                       MWET     1
                       MDRY     1
                       MDISP    2 or 3
                       MPDF     0 if MDISP=3
                                1 if MDISP=2
                       MROUGH   0
                       MPARTL   1
                       MPARTLBA 0
                       SYTDEP   550. (m)
                       MHFTSZ   0
                       SVMIN    0.5 (m/s)


!END!


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

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

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

  The following species are modeled:

! CSPEC =          SO2 !         !END!
! CSPEC =         PM10 !         !END!
! CSPEC =           HF !         !END!
! CSPEC =           PF !         !END!
! CSPEC =          PAH !         !END!
! CSPEC =          BAP !         !END!
! CSPEC =          TPM !         !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   !
!         PM10  =         1,               1,           2,                 0   !
!           HF  =         1,               1,           1,                 0   !
!           PF  =         1,               1,           2,                 0   !
!          PAH  =         1,               1,           2,                 0   !
!          BAP  =         1,               1,           2,                 0   !
!          TPM  =         1,               1,           2,                 0   !

!END!

  Note:  The last species in (3a) must be 'BCON' when using the
         boundary condition option (MBCON > 0).  Species BCON should
         typically be modeled as inert (no chem transformation or
         removal).


-------------
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 -- Map Projection and Grid control parameters
--------------

     Projection for all (X,Y):
     -------------------------

     Map projection
     (PMAP)                     Default: UTM    ! PMAP = UTM  !

         UTM :  Universal Transverse Mercator
         TTM :  Tangential Transverse Mercator
         LCC :  Lambert Conformal Conic
          PS :  Polar Stereographic
          EM :  Equatorial Mercator
        LAZA :  Lambert Azimuthal Equal Area

     False Easting and Northing (km) at the projection origin
     (Used only if PMAP= TTM, LCC, or LAZA)
     (FEAST)                    Default=0.0     ! FEAST  = 0.000  !
     (FNORTH)                   Default=0.0     ! FNORTH = 0.000  !

     UTM zone (1 to 60)
     (Used only if PMAP=UTM)
     (IUTMZN)                   No Default      ! IUTMZN =  28   !

     Hemisphere for UTM projection?
     (Used only if PMAP=UTM)
     (UTMHEM)                   Default: N      ! UTMHEM = N  !
         N   :  Northern hemisphere projection
         S   :  Southern hemisphere projection

     Latitude and Longitude (decimal degrees) of projection origin
     (Used only if PMAP= TTM, LCC, PS, EM, or LAZA)
```

```
     (RLAT0)                    No Default      ! RLAT0 = 0N  !
     (RLON0)                    No Default      ! RLON0 = 0E  !

         TTM :  RLON0 identifies central (true N/S) meridian of projection
                RLAT0 selected for convenience
         LCC :  RLON0 identifies central (true N/S) meridian of projection
                RLAT0 selected for convenience
         PS  :  RLON0 identifies central (grid N/S) meridian of projection
                RLAT0 selected for convenience
         EM  :  RLON0 identifies central meridian of projection
                RLAT0 is REPLACED by 0.0N (Equator)
         LAZA:  RLON0 identifies longitude of tangent-point of mapping plane
                RLAT0 identifies latitude of tangent-point of mapping plane

     Matching parallel(s) of latitude (decimal degrees) for projection
     (Used only if PMAP= LCC or PS)
     (XLAT1)                    No Default      ! XLAT1 = 0N  !
     (XLAT2)                    No Default      ! XLAT2 = 0N  !

         LCC :  Projection cone slices through Earth's surface at XLAT1 and XLAT2
         PS  :  Projection plane slices through Earth at XLAT1
                (XLAT2 is not used)

     ----------
     Note:  Latitudes and longitudes should be positive, and include a
            letter N,S,E, or W indicating north or south latitude, and
            east or west longitude.  For example,
            35.9  N Latitude  =  35.9N
            118.7 E Longitude = 118.7E


     Datum-region
     ------------

     The Datum-Region for the coordinates is identified by a character
     string.  Many mapping products currently available use the model of the
     Earth known as the World Geodetic System 1984 (WGS-84).  Other local
     models may be in use, and their selection in CALMET will make its output
     consistent with local mapping products.  The list of Datum-Regions with
     official transformation parameters is provided by the National Imagery and
     Mapping Agency (NIMA).

     NIMA Datum - Regions(Examples)
     ------------------------------------------------------------------------------
     WGS-84    WGS-84 Reference Ellipsoid and Geoid, Global coverage (WGS84)
     NAS-C     NORTH AMERICAN 1927 Clarke 1866 Spheroid, MEAN FOR CONUS (NAD27)
     NAR-C     NORTH AMERICAN 1983 GRS 80 Spheroid, MEAN FOR CONUS (NAD83)
     NWS-84    NWS 6370KM Radius, Sphere
     ESR-S     ESRI REFERENCE 6371KM Radius, Sphere

     Datum-region for output coordinates
     (DATUM)                    Default: WGS-84    ! DATUM = WGS-84  !


METEOROLOGICAL Grid:

     Rectangular grid defined for projection PMAP,
     with X the Easting and Y the Northing coordinate

            No. X grid cells (NX)      No default     ! NX =  56   !
            No. Y grid cells (NY)      No default     ! NY =  51   !
         No. vertical layers (NZ)      No default     ! NZ =  10   !

           Grid spacing (DGRIDKM)      No default     ! DGRIDKM = 1.0 !
                                       Units: km

               Cell face heights
                   (ZFACE(nz+1))       No defaults
                                       Units: m
   ! ZFACE = .0, 20.0, 40.0, 80.0, 160.0, 320.0, 600.0, 1000.0, 1500.0, 2200.0,
             3000.0 !
```

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

            X coordinate (XORIGKM)     No default     ! XORIGKM = 369.5 !
            Y coordinate (YORIGKM)     No default     ! YORIGKM = 7299.5 !
                                      Units: km


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 =  56   !
                  (1 <= IECOMP <= NX)

        Y index of UR corner (JECOMP)      No default     ! JECOMP =  51   !
                  (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 =  1   !
         (IBCOMP <= IBSAMP <= IECOMP)

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


        X index of UR corner (IESAMP)      No default     ! IESAMP =  56   !
         (IBCOMP <= IESAMP <= IECOMP)

        Y index of UR corner (JESAMP)      No default     ! JESAMP =  51   !
         (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 =  1   !
   Wet Fluxes (IWET)                  1                     !  IWET =  1   !
   2D Temperature (IT2D)              0                     !  IT2D =  0   !
   2D Density (IRHO)                  0                     !  IRHO =  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


    QA PLOT FILE OUTPUT OPTION:

       Create a standard series of output files (e.g.
       locations of sources, receptors, grids ...)
       suitable for plotting?
       (IQAPLOT)                       Default: 1          !  IQAPLOT =  1   !
         0 = no
         1 = yes

    DIAGNOSTIC MASS FLUX OUTPUT OPTIONS:

       Mass flux across specified boundaries
       for selected species reported?
       (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?
       (IMBAL)                         Default: 0          ! IMBAL =  0  !
         0 = no
         1 = yes (MASSBAL.DAT filename is
              specified in Input Group 0)


    NUMERICAL RISE OUTPUT OPTION:

       Create a file with plume properties for each rise
       increment, for each model timestep?
       This applies to sources modeled with numerical rise
       and is limited to ONE source in the run.
       (INRISE)                        Default: 0          ! INRISE =  0  !
         0 = no
         1 = yes (RISE.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 timesteps            Default: 1          ! ICFRQ =  1   !
       Dry flux print interval
       (IDFRQ) in timesteps            Default: 1          ! IDFRQ =  1   !
       Wet flux print interval
```

```
        (IWFRQ) in timesteps            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   !
!         PM10 =     0,           1,           0,           1,           0,           1,
0   !
!           HF =     0,           1,           0,           1,           0,           1,
0   !
!           PF =     0,           1,           0,           1,           0,           1,
0   !
!          PAH =     0,           1,           0,           1,           0,           1,
0   !
!          BAP =     0,           1,           0,           1,           0,           1,
0   !
!          TPM =     0,           1,           0,           1,           0,           1,
0   !

  Note:  Species BCON (for MBCON > 0) does not need to be saved on disk.


      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 =  10  !

        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 =  2   !
       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 = 1.0 !
       to meters (MHILL=1)

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

       X-origin of CTDM system relative to      No Default     ! XCTDMKM = 0 !
       CALPUFF coordinate system, in Kilometers (MHILL=1)

       Y-origin of CTDM system relative to      No Default     ! YCTDMKM = 0 !
       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 =      .1509,        1000.0,           8.0,                .0,
.04 !
!           HF =      .1628,           1.0,          18.0,                .0,
.0000001 !

!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)
      -------      -------------------        ------------------
!         PM10 =          .48,                     2.0   !
!           PF =          7.1,                     6.5   !
!          PAH =          7.1,                     6.5   !
!          BAP =          7.1,                     6.5   !
!          TPM =          .48,                     2.0   !

!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 = 5.0 !
     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 !
!         PM10 =         1.0E-04,             3.0E-05 !
!           HF =         7.1E-05,              0.0E00 !
!           PF =         4.5E-04,             1.5E-04 !
!          PAH =         4.5E-04,             1.5E-04 !
!          BAP =         4.5E-04,             1.5E-04 !
!          TPM =         1.0E-04,             3.0E-05 !

!END!


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


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

     Ozone data input option (MOZ)     Default: 1           ! MOZ =  0   !
     (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 = 80.00, 80.00, 80.00, 80.00, 80.00, 80.00, 80.00, 80.00, 80.00, 80.00, 80.00,
80.00 !

     Monthly ammonia concentrations
     (Used only if MCHEM = 1, or 3)
     (BCKNH3) in ppb                    Default: 12*10.
     !  BCKNH3 = 10.00, 10.00, 10.00, 10.00, 10.00, 10.00, 10.00, 10.00, 10.00, 10.00, 10.00,
10.00 !

     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 = 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 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 = 2,3,4,5)

        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 = 4,5 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 = 1.0  !

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

Maximum sigma z (m) allowed to avoid
numerical problem in calculating virtual
time or distance.  Cap should be large
enough to have no influence on normal events.
Enter a negative cap to disable.
(SZCAP_M)                                   Default: 5.0e06 ! SZCAP_M = 5.0E06 !

Default minimum turbulence velocities sigma-v and sigma-w
for each stability class over land and over water (m/s)
(SVMIN(12) and SWMIN(12))

                ----------  LAND  ----------       ---------  WATER  ----------
   Stab Class :  A    B    C    D    E    F         A    B    C    D    E    F
                ---  ---  ---  ---  ---  ---       ---  ---  ---  ---  ---  ---
Default SVMIN : .50, .50, .50, .50, .50, .50,      .37, .37, .37, .37, .37, .37
Default SWMIN : .20, .12, .08, .06, .03, .016,     .20, .12, .08, .06, .03, .016

        ! SVMIN = 0.500, 0.500, 0.500, 0.500, 0.500, 0.500, 0.370, 0.370, 0.370, 0.370, 0.370,
0.370!
        ! SWMIN = 0.200, 0.120, 0.080, 0.060, 0.030, 0.016, 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 !

Search radius (number of cells) for nearest
land and water cells used in the subgrid
TIBL module
(NLUTIBL)                                   Default: 4      ! NLUTIBL =  4  !

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 = 5.0 !

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 !

       Boundary Condition (BC) Puff control variables ------------------------

       Minimum height (m) to which BC puffs are mixed as they are emitted
       (MBCON=2 ONLY).  Actual height is reset to the current mixing height
       at the release point if greater than this minimum.
       (HTMINBC)                          Default:   500.     ! HTMINBC = 500.0 !

       Search radius (km) about a receptor for sampling nearest BC puff.
       BC puffs are typically emitted with a spacing of one grid cell
       length, so the search radius should be greater than DGRIDKM.
       (RSAMPBC)                          Default:   10.      ! RSAMPBC = 10.0 !

       Near-Surface depletion adjustment to concentration profile used when
       sampling BC puffs?
       (MDEPBC)                           Default:   1        ! MDEPBC =  1  !
          0 = Concentration is NOT adjusted for depletion
          1 = Adjust Concentration for depletion

!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         Y       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 = ANODE_TALL !
   1 ! X = 393.9825, 7329.787,    78.0,  20.0,      9.45,  19.0, 362.15,  1.0, 1.0E00,  1.0E00,
1.0E00,
       1.0E00,  1.0E00,  1.0E00,  1.0E00 !
   1 ! ZPLTFM  =       .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)
     ZPLTFM  is the platform height (m) for sources influenced by an isolated
             structure that has a significant open area between the surface
             and the bulk of the structure, such as an offshore oil platform.
             The Base Elevation is that of the surface (ground or ocean),
             and the Stack Height is the release height above the Base (not
             above the platform).  Building heights entered in Subgroup 13c
             must be those of the buildings on the platform, measured from
             the platform deck.  ZPLTFM is used only with MBDW=1 (ISC
             downwash method) for sources with building downwash.
             (Default: 0.0)
```

```
    b
     0. = No building downwash modeled
     1. = Downwash modeled for buildings resting on the surface
     2. = Downwash modeled for buildings raised above the surface (ZPLTFM > 0.)
     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 height, width, length and X/Y offset (in meters)
           every 10 degrees.  LENGTH, XBADJ, and YBADJ are only needed for
           MBDW=2 (PRIME downwash option)
------     --------------------------------------------------------------------

 1    ! SRCNAM  =   ANODE_TALL !
 1    ! HEIGHT  =  22.5,   22.5,   .0,   22.5,   22.5,   22.5,
                   22.5,   22.5,   22.5,   22.5,   22.5,   22.5,
                   22.5,   22.5,   22.5,   22.5,   22.5,   22.5,
                   22.5,   22.5,   .0,   22.5,   22.5,   22.5,
                   22.5,   22.5,   22.5,   22.5,   23.0,   23.0,
                   23.0,   23.0,   22.5,   22.5,   22.5,   22.5!
 1    ! WIDTH  =   374.81,   193.0,   .0,   233.0,   412.5,   580.5,
                   730.0,   857.5,   959.0,   1031.0,   1072.0,   1081.5,
                   1066.0,   1018.0,   939.25,   831.75,   699.25,   545.31,
                   374.81,   193.0,   .0,   233.0,   413.0,   580.0,
                   729.5,   857.5,   958.5,   1031.0,   43.0,   38.0,
                   44.0,   48.5,   939.25,   831.75,   699.12,   545.28!
 1    ! LENGTH =   .0,   .0,   .0,   .0,   .0,   .0,
                   .0,   .0,   .0,   .0,   .0,   .0,
                   .0,   .0,   .0,   .0,   .0,   .0,
                   .0,   .0,   .0,   .0,   .0,   .0,
                   .0,   .0,   .0,   .0,   .0,   .0,
                   .0,   .0,   .0,   .0,   .0,   .0!
 1    ! XBADJ  =   .0,   .0,   .0,   .0,   .0,   .0,
                   .0,   .0,   .0,   .0,   .0,   .0,
                   .0,   .0,   .0,   .0,   .0,   .0,
                   .0,   .0,   .0,   .0,   .0,   .0,
                   .0,   .0,   .0,   .0,   .0,   .0,
                   .0,   .0,   .0,   .0,   .0,   .0!
 1    ! YBADJ  =   .0,   .0,   .0,   .0,   .0,   .0,
                   .0,   .0,   .0,   .0,   .0,   .0,
                   .0,   .0,   .0,   .0,   .0,   .0,
                   .0,   .0,   .0,   .0,   .0,   .0,
                   .0,   .0,   .0,   .0,   .0,   .0,
                   .0,   .0,   .0,   .0,   .0,   .0!
!END!

--------

    a
     Building height, width, length, and X/Y offset from the source are treated
     as a separate input subgroup for each source and therefore must end with
     an input group terminator.  The X/Y offset is the position, relative to the
     stack, of the center of the upwind face of the projected building, with the
     x-axis pointing along the flow direction.

---------------
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 (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 = 1090.0 !
                                                   (in meters)

        Average building height (HBL)              No default   ! HBL = 20.0 !
                                                   (in meters)

        Average building width (WBL)               No default   ! WBL = 30.0 !
                                                   (in meters)

        Average line source width (WML)            No default   ! WML = 2.4 !
                                                   (in meters)

        Average separation between buildings (DXL)  No default   ! DXL = 40.0 !
                                                   (in meters)

        Average buoyancy parameter (FPRIMEL)        No default   ! FPRIMEL = 1269.8 !
                                                   (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           Y        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 =  17585   !

!END!

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

                   X            Y          Ground       Height   b
Receptor       Coordinate   Coordinate    Elevation   Above Ground
  No.             (km)         (km)          (m)          (m)
--------       ----------   ----------    ---------   ------------
     1 ! X =   384.20001,  7320.2002,       6.000,       0.000!   !END!
     2 ! X =   384.39999,  7320.2002,       6.000,       0.000!   !END!
     3 ! X =   384.60001,  7320.2002,       6.000,       0.000!   !END!

…………
17583 ! X =   414.39999,  7344.3999,       0.000,       0.000!   !END!
 17584 ! X =   414.39999,  7344.7998,       0.000,       0.000!   !END!
 17585 ! X =   414.39999,  7345.2002,       0.000,       0.000!   !END!



-------------
    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.
```