Health Consultation

Review of Formaldehyde Emissions from

TRANSCONTINENTAL PIPELINE, COMPRESSOR STATION #130

COMER, GEORGIA

APRIL 18, 2011

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Agency for Toxic Substances and Disease Registry
Division of Health Assessment and Consultation
Atlanta, Georgia 30333

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A health consultation is a verbal or written response from ATSDR or ATSDR's Cooperative Agreement Partners to a specific request for information about health risks related to a specific site, a chemical release, or the presence of hazardous material. In order to prevent or mitigate exposures, a consultation may lead to specific actions, such as restricting use of or replacing water supplies; intensifying environmental sampling; restricting site access; or removing the contaminated material.

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HEALTH CONSULTATION

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Prepared By:

U.S. Department of Health and Human Services
Agency for Toxic Substances and Disease Registry
Division of Health Assessment and Consultation

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Summary

Introduction

Community concerns about large releases of formaldehyde from a natural gas pipeline compressor station – Transcontinental Gas Pipeline, Compressor Station #130 in Comer, Georgia – were expressed to the Georgia Department of Public Health (GDPH). GDPH requested ATSDR assistance in evaluating formaldehyde emissions from that facility. Comer is in a sparsely populated rural area approximately 20 miles northeast of Athens, Georgia. ATSDR conducted a site visit February 18, 2010, reviewed information provided by the facility, and applied the site-specific parameters in an air dispersion model to estimate formaldehyde levels in the community.

Conclusion

ATSDR used the measured data points, estimated emissions levels, and area-specific meteorological data in a computer model to help predict the formaldehyde concentrations that might be present over various durations of time in the air in residential areas near Transcontinental Pipeline, Compressor Station #130 in Comer, Georgia. ATSDR then compared the predicted modeled values with various health and regulatory values to help determine if harmful health effects are indicated at those predicted values.

At the formaldehyde air levels predicted in the closest residential areas to Transcontinental Pipeline, Compressor Station #130 in Comer, Georgia, exposure is not expected to cause harmful health effects. Therefore, the current predicted formaldehyde emissions from this facility are not expected to harm people's health.

Conclusion Basis

The highest predicted formaldehyde air concentrations in residential areas are 1-hour averages and range between 350 and 399 µg/m^3**.** This is below the irritation level of 612 µg/m^3 and the U.S. Environmental Protection Agency (EPA) Acute Exposure Guideline Level (AEGL) of 1,100 µg/m^3 (AEGL-1)[1]. The highest 24-hour predicted formaldehyde levels in air in the residential areas are between 56 and 70 µg/m^3. This is slightly higher than ATSDR's acute minimal risk level (MRL)[2] of 50 µg/m^3**.** Although this maximum level is slightly higher than ATSDR's acute MRL, the 24-hour averages (including adding an estimated

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[1] AEGLs represent threshold exposure limits for the general public and are applicable to emergency exposure periods ranging from 10 minutes to 8 hours.. AEGL-1 is the airborne concentration, expressed as parts per million or milligrams per cubic meter (ppm or mg/m3) of a substance above which it is predicted that the general population, including susceptible individuals, could experience notable discomfort, irritation, or certain asymptomatic nonsensory effects. However, the effects are not disabling and are transient and reversible upon cessation of exposure. http://www.epa.gov/opptintr/aegl/pubs/define.htm

[2] ATSDR uses the no observed adverse effect level/uncertainty factor (NOAEL/UF) approach to derive MRLs for hazardous substances. They are set below levels that, based on current information, might cause adverse health effects in the people most sensitive to such substance induced effects. An acute MRL is based on exposure of more than 24 hours and up to two weeks. Chronic MRLs are based on exposures 365 days or longer.

background concentration of 1.5 µg/m^3) only exceeded the acute MRL at the closest residential area 5 days over the 5 year period. The predicted 24-hr median concentration at the closest residence was 3.35 µg/m^3 and the 75th percentile was 11.56 µg/m^3. Predicted residential chronic levels are between 5 and 7 µg/m^3 which are lower than ATSDR's 10 µg/m^3 chronic MRL[2]. Therefore acute and chronic non-cancer health effects are unlikely from those formaldehyde emissions.

The Environmental Protection Agency (EPA), the National Toxicology Program (NTP), and the International Agency for Research on Cancer (IARC) all consider formaldehyde a probable human carcinogen, however, the predicted residential chronic levels including background are within the EPA acceptable risk range. Additionally, in 2008, Georgia Public Health, Northwest Health District conducted a door-to-door community health assessment of residents living within a one-mile radius of the facility to determine if the level of mortality/morbidity in this area was higher than that of other similar populations. They determined that the cancer morbidity rates were not found to be at unexpected levels given the ages and confounding risk behaviors of the respondents. An analysis of cancer in this zip code by the State of Georgia Cancer Registry showed no unusual cancer levels [GDPH 2008]. Therefore, cancer health effects are not likely from predicted formaldehyde emissions from Transcontinental Pipeline, Compressor Station #130, Comer, Georgia.

ATSDR used the AERMOD version 09292 air dispersion model to predict formaldehyde concentrations (graphical interface - AERMOD View version 6.6 (Lakes Environmental Software, Waterloo, Ontario, Canada). AERMOD is EPA's recommended steady-state Gaussian plume model that is applicable to rural and urban areas, flat and complex terrain, surface and elevated releases, and multiple sources (including, point, area and volume sources). Air models tend to overestimate air concentrations. The levels listed here are the highest predicted formaldehyde levels that may be seen in a 5 year period.

Because a general review of available information and predictive models include a level of uncertainty, the information provided in this consultation cannot be used to determine the health impacts of a specific individual particularly those with pre-existing respiratory or immune compromised systems. Those persons should consult with their own physicians about their health concerns. Also, we only considered formaldehyde and not other chemicals released from the facility nor other chemicals that people may be exposed to in their homes.

Next Steps

Re-evaluate the formaldehyde emissions from this facility if any of the following take place:

1. Additional stack testing is done at this facility.
2. Engines are added, replaced, or modified or usage changes that would increase emissions substantially.

Statement of Issues

Community concerns about large releases of formaldehyde from a natural gas pipeline compressor station – Transcontinental Gas Pipeline, Compressor Station #130 in Comer, Georgia – were expressed to the Chemical Hazards Division of Georgia Department of Community Health. In January 2010, Jane M. Perry, Director, Chemical Hazards Program, Environmental Health Branch, Georgia Department of Community Health, Division of Public Health (GDPH), requested ATSDR assistance in evaluating formaldehyde emissions from that facility. ATSDR conducted a site visit February 18, 2010, reviewed information provided by the facility, and applied the site-specific parameters in an air dispersion model to estimate formaldehyde levels in the community.

Site Description

Natural gas is highly pressurized as it travels through an interstate pipeline. To ensure that the natural gas flowing through the pipeline remains pressurized, periodic compression of the gas is required. To do this, compressor stations are usually placed at 40- to 100- mile intervals along the pipeline. The natural gas enters the compressor station where it is compressed by a turbine, motor, or engine [NGSA 2004]. Transcontinental Gas Pipeline Compressor Station #130 in Comer Georgia is a facility that compresses the natural gas using 16 natural gas fired internal combustion engines and two turbines (Figure 1). This pipeline and compressor station has been in continuous operation since 1952.

Engine and Turbine Emissions

Natural gas fired engines produce incomplete combustion products; primarily nitrogen oxides (NOx) and carbon monoxide (CO) and secondarily Volatile Organic Compounds (VOCs) including formaldehyde. The permit for Compressor Station #130 lists CO, NOx, particulate matter (<10 microns), sulfur dioxide (SO_2), hydrogen sulfide (H_2S), total reduced sulfur (includes H_2S), total Hazardous Air Pollutants (HAPs), and VOCs. The Georgia Title V Permit is available online at: http://airpermit.dnr.state.ga.us/gatv/GATV/ListApplications.asp?c=20. The emissions, in tons per year are as follows:

Table 1. Georgia Title V Permit Limits for Compressor Station #130 (Maximum estimated actual Emissions in tons per year)	
Carbon Monoxide (CO)	1,151
Nitrogen Oxides (NOx)	4,156
Particulate (<10 microns)	24.7
Sulfur Dioxide (SO_2)	7.7
Volatile Organic Compounds (VOCs)*	426
Hazardous Air Pollutants (HAPs)*	236.2
Acetaldehyde*	25.7
Acrolein*	25.7
Formaldehyde*	185
*HAPs are part of the VOC *Acetaldehyde, Acrolein, and Formaldehyde are part of the HAPs	

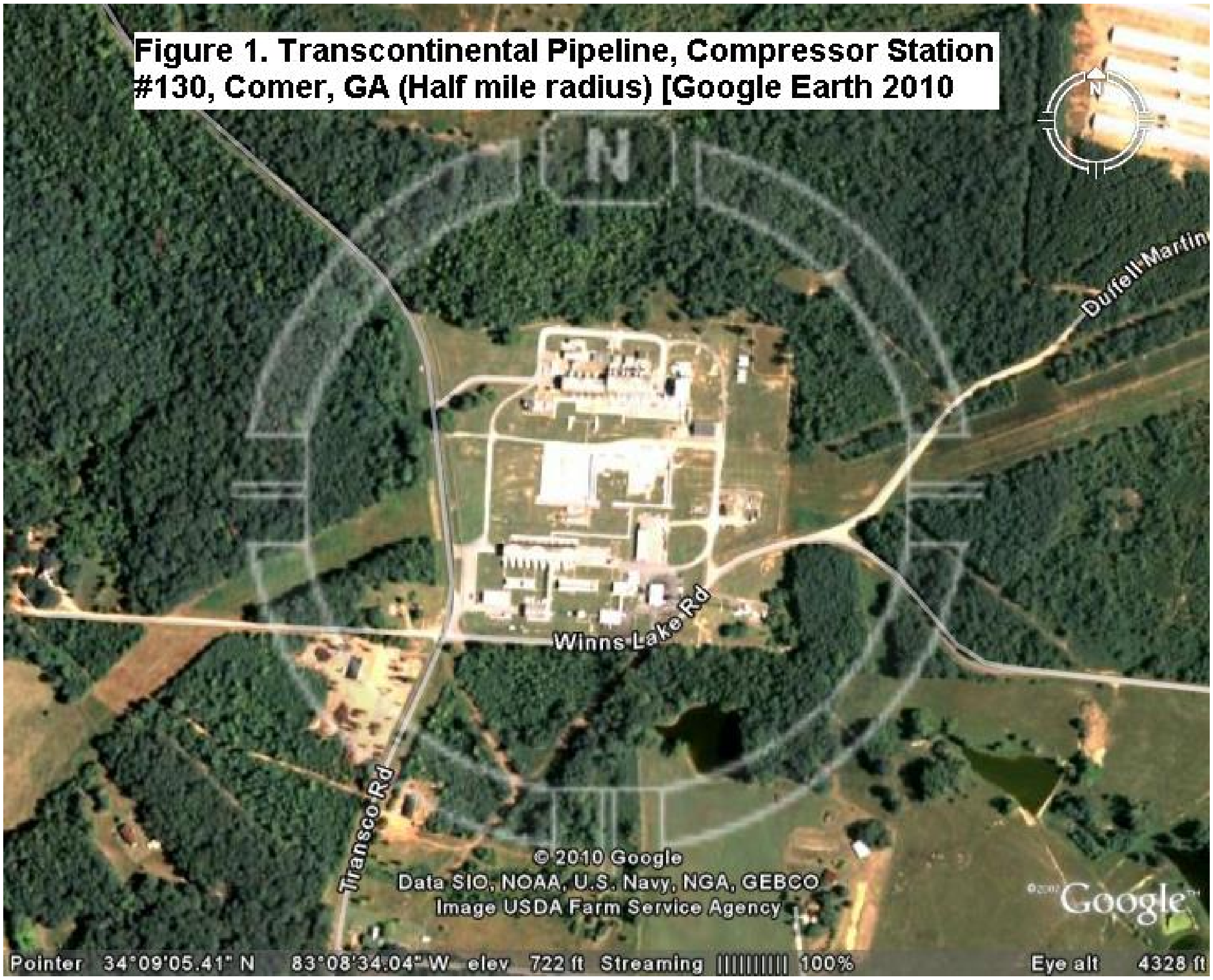
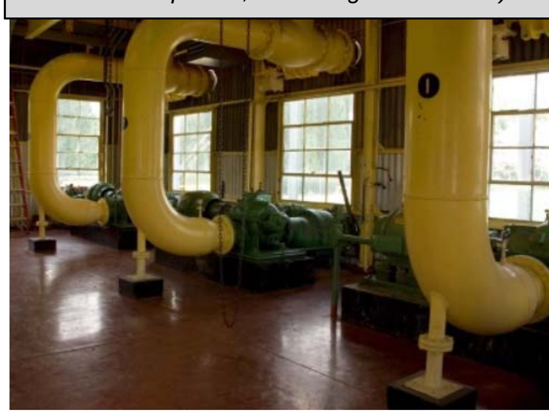


Figure 1. Transcontinental Pipeline, Compressor Station #130, Comer, GA (Half mile radius) [Google Earth 2010

Stock photos of a natural gas compressor sta
the Transco facility in Madison County. *(Sour*
Williams Companies, Inc. All rights reserved.)



Mary Beth Whitfield, Williams Gas Pipeline[3] air permit specialist, provided information on how they estimated the annual amount of formaldehyde released. They estimated their formaldehyde rate both on VOC emissions (some were measured in stack testing) and on AP-42[4]. The AP-42 formaldehyde emissions rate was approximately 71 tons/year and the rate based on percent of VOC emissions was approximately 185 tons/year. See Appendix A for details.

AP-42 for Natural Gas Turbines reads the following:

3.1.3.5 HAP Emissions - Available data indicate that emission levels of HAP are lower for gas turbines than for other combustion sources. This is due to the high combustion temperatures reached during normal operation. The emissions data also indicate that formaldehyde is the most significant HAP emitted from combustion turbines. For natural gas fired turbines, formaldehyde accounts for about two-thirds of the total HAP emissions. Polycyclic aromatic hydrocarbons (PAH), benzene, toluene, xylenes, and others account for the remaining one-third of HAP emissions. For more information on Turbines, see http://www.epa.gov/ttnchie1/ap42/ch03/final/c03s01.pdf . Also see AP-42 for Internal Combustion or Reciprocating Engines @ http://www.epa.gov/ttnchie1/ap42/ch03/final/c03s02.pdf

Background

ATSDR, GDPH, and the Georgia Environmental Protection Division (GEPD) conducted a site visit tour of the facility February 18, 2010 and discussed the facility operational parameters and air emissions with company representatives.

Following the visit, ATSDR considered approaches for estimating formaldehyde concentrations in the community surrounding the facility. After reviewing the available sampling methods, the information provided from Williams, and the location of the nearest housing, we chose air modeling over air sampling. Sampling would only provide estimates of concentrations at the point and time at which samples were taken and would not clearly define spatial coverage. Additionally, monitoring for chronic exposure can take up to a year. Modeling can provide realistic or worst case scenarios using location-specific meteorological conditions (EPA 2004a).

Demographics

The area around the Comer facility is very sparsely populated. In 2000, there were 635 people (98% white) and approximately 265 housing units within a two-mile radius of Compressor Station #130; 63 were children under 6 years of age and 88 were older than 65 years of age [U.S. Census Bureau, 2000]. The distance to the nearest residence is approximately 277 yards southwest of the facility [Google Earth © 2010].

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[3] Williams now owns Transcontinental Pipeline

[4] U.S. Environmental Protection Agency (EPA) compiles air pollution emission factors to facilitate estimation of emissions from various sources of pollution including internal combustion engines and turbines [EPA 2010 available at : http://www.epa.gov/ttnchie1/ap42/]

Methods

We chose the AERMOD version 09292 air dispersion model using a graphical front end computer program called AERMOD View version 6.6 (Lakes Environmental Software, Waterloo, Ontario, Canada). AERMOD is a steady-state Gaussian plume model that is applicable to rural and urban areas, flat and complex terrain, surface and elevated releases, and multiple sources (including, point, area and volume sources) [EPA 2004b, EPA 2010a]. AERMOD consists of three pre-processors and the dispersion model. A land-cover analysis program analyzes land-use information surrounding the meteorological site and provides albedo and Bowen ratios by sector. This information is used, along with meteorological observations by the AERMIC meteorological preprocessor (AERMET) provides AERMOD with the meteorological parameter information. AERMIC terrain pre-processor (AERMAP) both characterizes the terrain, and generates receptor grids for the dispersion model (AERMOD) [EPA 2004b].

Limited amounts of data are required as model inputs. Those include the following:

- pollutant emission rates
- facility/source location
- height of the emission release
- stack gas exit velocity
- stack diameter
- temperature of the off-gases
- pollutant properties and source location
- meteorological data
- landcover data

AERMOD estimates the magnitude and distribution of ambient air concentrations of the pollutant in the vicinity of each source. The model usually estimates these concentrations within a radial distance of up to 50 kilometers (30.8 miles) from the source [EPA 2010a]. We believe AERMOD's features make this model the appropriate model for this facility.

Model Assumptions

Table 2 lists a summary of the input parameters. Williams provided ATSDR with exhaust parameters for all the mainline compression sources (Appendix B). Model inputs were taken from the facility's Title V permit, available online from the Georgia Environmental Protection Division Title V data warehouse. We assumed the maximum formaldehyde discharge rate allowable in the permit (185 tons/yr or 5.3 grams/sec). The facility provided compressor building dimensions for building downwash calculations [Williams 2010]. The detailed inputs are listed in Appendix C, Tables C1, C2 and C3.

Table 2. Summary of Model Inputs and Other Information		
Parameter	**English units**	**Metric units**
Maximum estimated formaldehyde gas flow rate[1]	185 tons/yr	5.3 grams/second (g/s) (370,000 lbs/yr = 1013 lbs/day x day/86,400sec x 453 g/lb = g/s)
Gas exit velocity[2]	Range = 52.8 to 137 ft/s Ave= 88.3 ft/ s	Ave = 27.6 m/s
Stack height[2]	9 (22 ft), 4 (25 ft), 2 (31.3 ft), 1 (32.5 ft) , 1(43 ft), 1 (49.5 ft) Range =22 to 49.5 ft Ave = 27 ft	Range = 6.8 to 15.5 m Ave=8.4 m
Stack diameter[2]	Range =2 to 7.5 ft Ave = 2.5 ft	Range =0.625 to 2.34 m Ave = 0.8 m
Discharge temperature[2]	Range = 600 to 800 ^{o}F	Range =588 to 699.8 ^{o}K Ave = 702 ^{o}K
Distance to nearest non-occupational receptor population[3]	277 yards	260m (0.26 km)
Estimated receptor height	4.8 ft	1.5 m

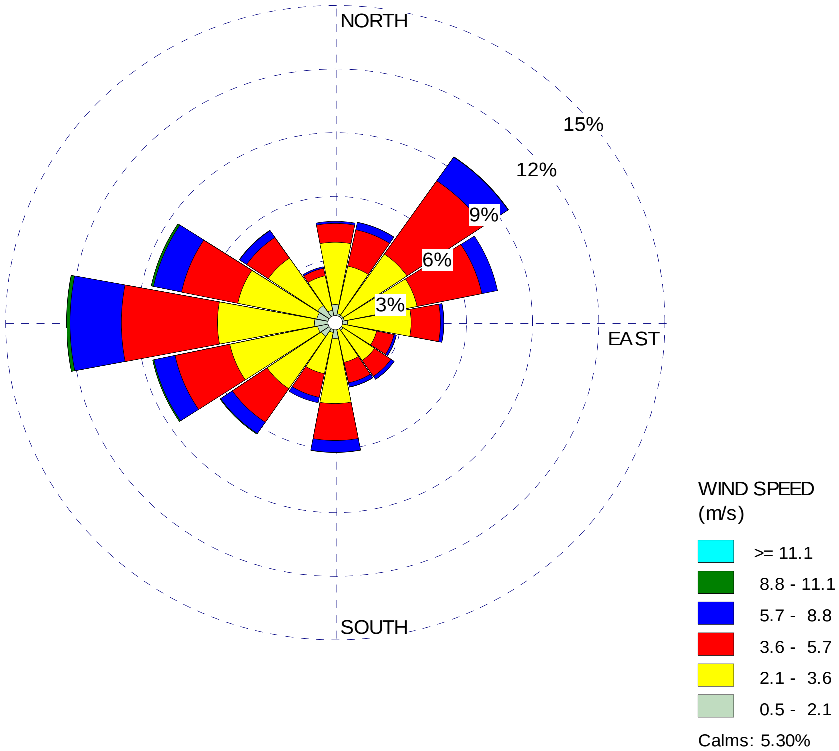
[1] This maximum rate is from the permit application.
[2] Mary Beth Whitfield with Williams Gas Pipeline provided us with the exit velocities, stack heights, stack diameters, and exit temperatures for all of the engines and turbines (Attachment A). We list here the minimum and maximum values followed by the average.
[3] Estimated from Google Earth ruler measurement.

Meteorological Data

Surface data from 1986-1990 and upper air data was obtained for the Athens/Ben Epps Airport from www.webmet.com. Land cover data was downloaded from the U.S. Geologic Survey (http://edcftp.cr.usgs.gov/pub/data/landcover/states/georgia.nlcd.bin.gz). We used the most recent, non-Automated Surface Observing System (ASOS) converted data[5] . The meteorological station is 27.5 kilometers (km) from the Transcontinental Site. This station has similar topography to the Comer location and has no significant features that would influence overall wind patterns. A windrose for this station is shown in Figure 2. Meteorological data was processed using Lakes AERMET View version 6. ATSDR also considered using ASOS data from Athens/Ben Epps and Upper Air data from Radiosonde readings taken at Peachtree City, Georgia, for November 8, 2005- December 5, 2010. Using ASOS meteorological data from the 2005-2010 period resulted in a higher rate (~25%) of calm winds (calms) in the surface file than the 1986-1990 period. Final 2005-2010 estimates were similar, but slightly lower than the 1986-1990 period data. A comparison of the surface files from AERMET for the 1986-1990 data and the 2005-2010 data are shown in Appendix D. Additionally contours of the AERMOD output are also shown in Appendix D.

[5] More recent data would come from ASOS converted meteorological stations. These stations do not process calms and those gaps could be interpreted by the model as insufficient data and create more uncertainty. The AERMOD developers have calibrated the model using NWS data versus ASOS data.

Figure 2: Athens Municipal Airport Windrose (1986-1990)



Receptor Data

Three nested discrete Cartesian receptor grids were established around the center of the facility. The fence line grid was 100 meters deep with 10 meter spacing. The inner grid receptor was 3,000 by 3,000 meter grid with receptors every 100 meters. The outer grid extended 5,000 meters by 5,000 meters with receptors spaced at 500 meters.

Terrain Data

The 7.5 minute digital elevation model (DEM) files were downloaded from http://www.webgis.com/terr_pages/GA/dem75/madison.html

These DEM files were the 7.5-min U.S. Geological Survey (USGS) DEMs have been converted from the Spatial Data Transfer Standard (SDTS) format to the native DEM format using the corrected SDTS2DEM conversion software produced by Dr. Gregg Townsend of the University of Arizona [http://www.cs.arizona.edu/projects/topovista/sdts2dem/]. The 7.5-min USGS DEMs are the corrected files produced by the USGS to correct positional errors that existed in previous DEMs produced prior to 2001.

Averaging Periods

We modeled the maximum formaldehyde concentrations for 1-hour, 8-hour, 24-hour and 5-year averages. Five years of meteorological data are typically recommended to capture most of the environmental variability around a site [EPA 2005].

Results

The area around the facility is sparsely populated. The nearest residence is approximately *277 yards* (260 meters or 0.26 km) *southwest* of the facility. The maximum predicted concentrations in that area were as follows:

Table 3. Maximum Predicted Formaldehyde Concentrations in the Residential Area Closest to the Facility

Time Average	Formaldehyde Concentration (ug/m^3)[1]	Row ID in Figure
1 hour	Between 350 and 399	Figure 3, Row 7
8 hour	Between 130 and 155	Figure 4, Row 5
24 hour	Between 56 and 70	Figure 5, Row 4
5 year	Between 5 and 7	Figure 6, Row 2

[+] micrograms per cubic meter

Predicted hourly formaldehyde levels at the nearest residential property ranged from 0.00017 to 394 $\mu g/m^3$. The predicted <u>hourly median</u> concentration was 1.8 $\mu g/m^3$ and the 75th percentile was 2.83 $\mu g/m^3$ (including the background concentration of 1.5 $\mu g/m^3$).

Formaldehyde maximum air levels at the nearest residential property averaged 7 $\mu g/m^3$over the five year period modeled (1986-1990). The predicted <u>24-hr</u> <u>median</u> concentration at the closest residence was 3.35 $\mu g/m^3$ and the 75th percentile was 11.56 $\mu g/m^3$.

Figures 3 through 6 show the model predictions. The model predicted levels in these figures do not include background levels typically found in outdoor air (estimated at approximately 1.5 $\mu g/m^3$ for Comer, Georgia).

Figure 3: Maximum 1-Hour Formaldehyde Concentrations (μg/m^3)

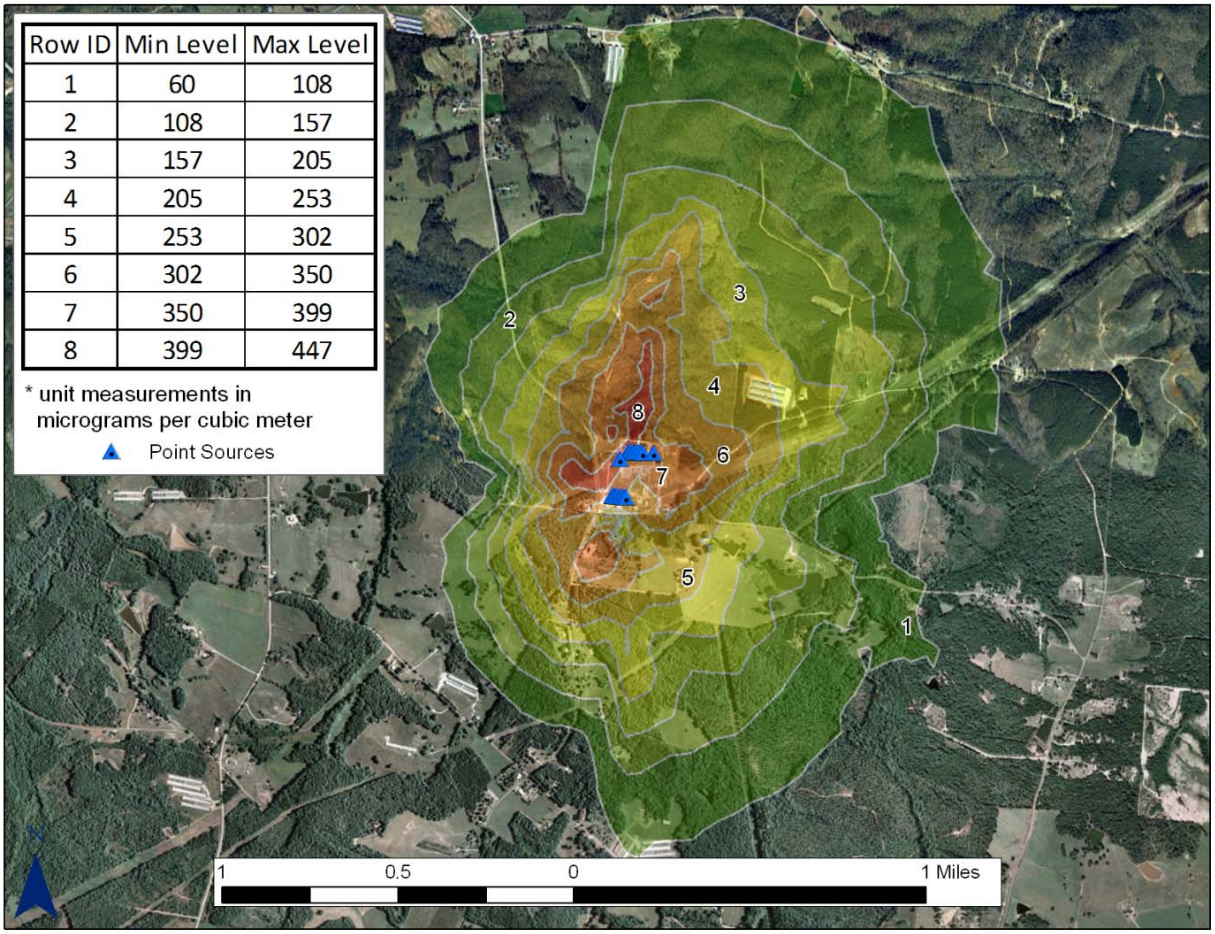


Figure 4: Maximum 8-hour Formaldehyde Concentrations ($\mu g/m^3$)

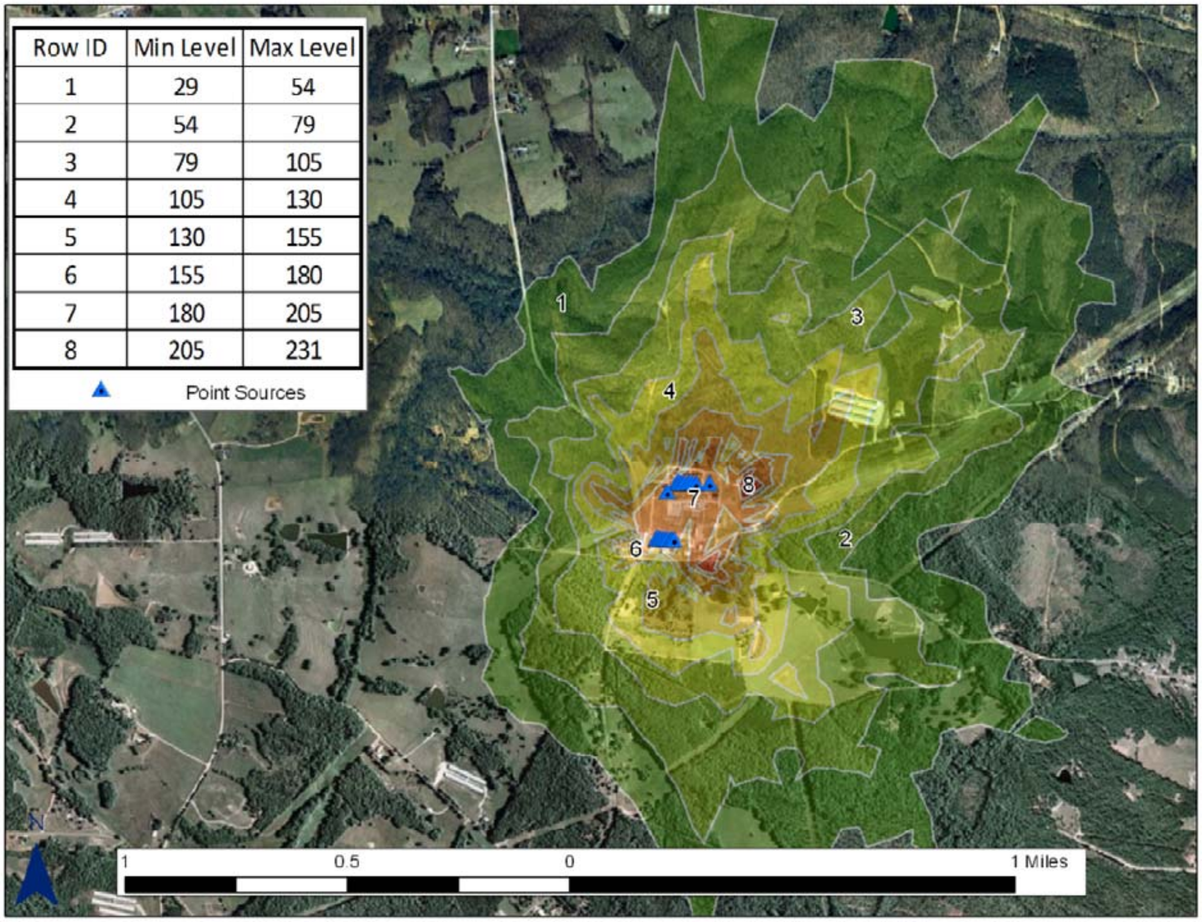


Figure 5: Maximum 24-hour Formaldehyde Concentrations (μg/m³)

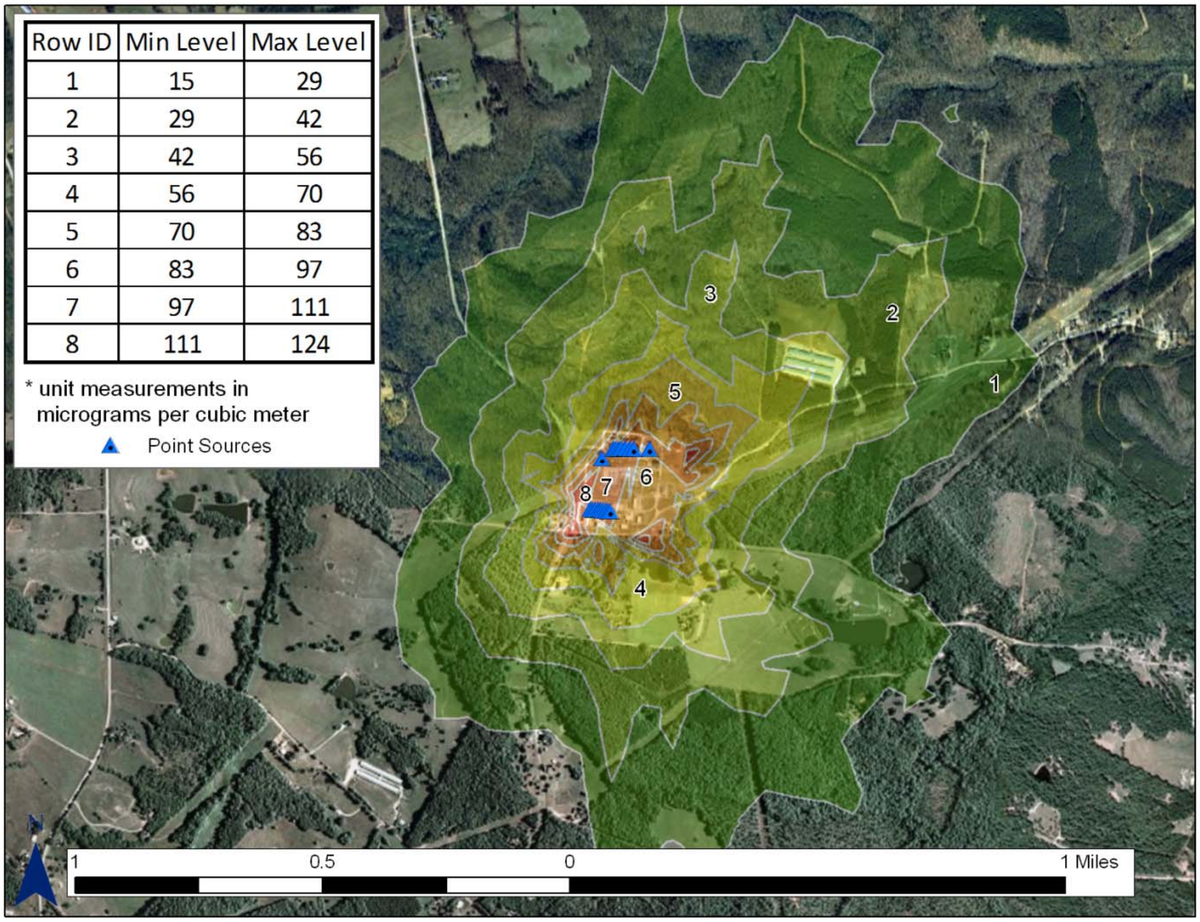
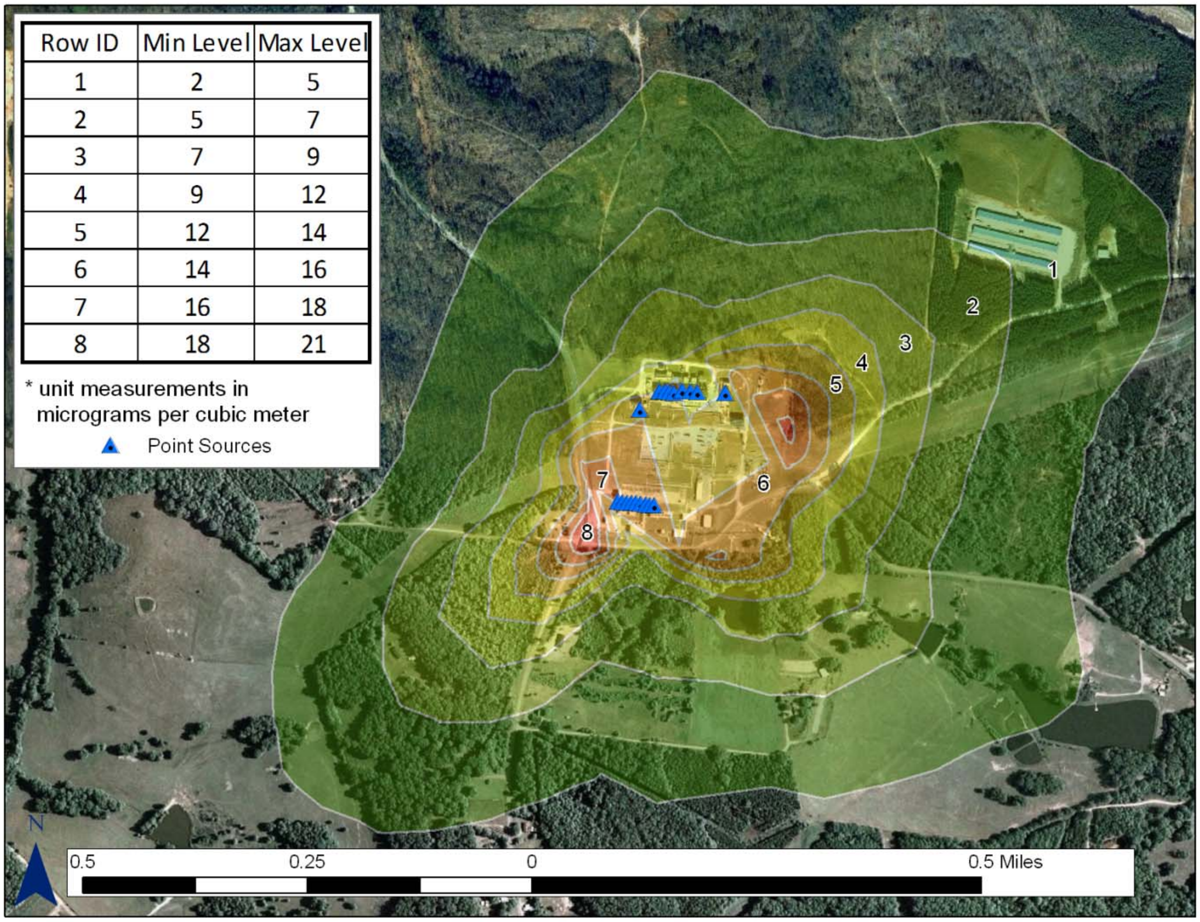


Figure 6: 5-Year Average Formaldehyde Concentrations (µg/m^3)



The maximum predicted hourly, 8-hour, 24-hour, and 5 year formaldehyde concentrations on the facility were as follows:

Table 4. Maximum Predicted Formaldehyde Concentrations at the Facility

Time Average	Formaldehyde Concentration (ug/m^3)[1]	Row ID in Figure
1 hour	447	Figure 3, Row 8
8 hour	231	Figure 4, Row 8
24 hour	124	Figure 5, Row 8
5 year	21	Figure 6, Row 8

[+] micrograms per cubic meter

Discussion

Formaldehyde

Formaldehyde is ubiquitous in the environment, found as a natural component of fruits, vegetables, meats and fish, and in the air primarily from by-products of combustion of fossil fuels (e.g., coal, oil, wood, and natural gas). Cars are the largest contributor to ambient formaldehyde air levels. Cigarette smoke is also a source of airborne exposure [Sullivan 2001].

Formaldehyde is a colorless, highly toxic, and flammable gas at room temperature that is slightly heavier than air. It has a pungent, highly irritating odor that is detectable at low concentrations. Formaldehyde has a short half-life in the environment because it is removed from the air by photochemical processes, precipitation and biodegradation. Its half-life in air is 6 to 19 hours [ATSDR 1999].

Comparison Values

In this modeling effort, we chose the highest permitted formaldehyde discharge level to ambient air; 185 tons/year. For acute exposures (1 day to 2 weeks), ATSDR compared the maximum 24 hour predicted concentrations – between 56 and 70 $\mu g/m^3$ – in the nearest residential area of the community to acute health comparison values. For chronic exposure (1 year or greater), ATSDR compared the 5-year average predicted exposure, which was between 5 and 7 $\mu g/m^3$ in the residential area of the community to chronic health comparison values.

Formaldehyde has health comparison, regulatory, and advisory values for inhalation. The health comparison values (HCV) are toxicological numbers from animal and human testing. The regulatory values have been incorporated in government regulations, while advisory values are non-regulatory usually provided by the government or other groups as advice. Also, because formaldehyde is ubiquitous in the environment, there are typical indoor and outdoor values. We discuss here some of those values and the relevance to a residential outdoor air exposures like those predicted for the areas surrounding Transcontinental Pipeline in Comer, Georgia.

Minimal Risk Levels (MRL)

ATSDR has developed a chronic MRL as a health comparison value. MRLs are estimates of exposure levels *posing minimal risk to humans*. They are an estimate of daily human exposure to a substance that is likely to be without an appreciable risk of adverse effects (non-carcinogenic) over a specified duration of exposure. These substance specific estimates are intended to serve as screening levels and do not imply adverse risk above those levels. ATSDR's chronic inhalation MRL for formaldehyde is 10 µg/m^3 or 8 parts per billion (ppb). It is based on one of the Lowest-Observed-Adverse-Effect Levels (LOAELs) of 294.5 µg/m^3 or 240 ppb and a 30-fold safety factor. That LOAEL comes from a 1988 occupational study. In that study, histological changes in nasal specimens of two groups of workers with well-defined exposure to formaldehyde and to formaldehyde and wood dust were compared with a control group [Holmstrom et al., 1989]. "Significant changes were found in the formaldehyde group but not in the group exposed to both formaldehyde and wood dust. No correlation was found between histological changes and duration of exposure, doses of exposure, or smoking habits" [Holmstrom et al., 1989].

Typical Outdoor (Ambient) Formaldehyde Levels

Formaldehyde is present in air primarily from by-products of combustion of fossil fuels (e.g., coal, oil, wood, and natural gas) with cars being the largest contributor. Typical ambient formaldehyde levels range from 12 to 37 µg/m^3 (0.01 to 0.03 ppm) [Sullivan 2001].

As part of the state of Georgia's Ambient Monitoring Program, they compiled formaldehyde data for four cities in the state. Between 2005 and 2009, the average formaldehyde levels were between 12 and 23 µg/m^3. In 2009, the closest rural monitor to Comer was in Dawsonville, Georgia had a mean formaldehyde concentration of 2.08 µg/m^3 [GADNR 2009].

EPA's National-Scale Air Toxics Assessment (NATA) modeled 180 of the 187 Clean Air Act air toxics (including formaldehyde) plus diesel particulate matter (PM) [EPA 2002]. We compared the Dawsonville NATA data with Georgia's Ambient Monitoring Program data and the results were similar. Using the NATA data, we estimate that the background formaldehyde level in Corner's outdoor air to be approximately 1.5 µg/m^3.

Typical Indoor Formaldehyde Levels

The highest formaldehyde air levels are typically detected in indoors. Formaldehyde is released from various consumer products (e.g., building materials and home furnishings). Higher levels have been found in newly manufactured or mobile homes than in older conventional homes [EPA 2010c].

Formaldehyde concentrations in mobile and other home environments can typically range from 123 to 612 µg/m^3 (0.1 to 0.5 ppm) with a level in the average standard home of 86 µg/m^3 (0.070 ppm) [Sullivan 2001]. One survey reported formaldehyde levels in homes as high as 4,540 µg/m^3 (3.7 ppm) [EPA 2010c]. Airborne exposure from cigarette smoke can reportedly contain up to 49,080 µg/m^3 (40 ppm) formaldehyde [Sullivan 2001].

Formaldehyde Irritation Levels

Some people experienced eye irritation when exposed to 612 µg/m^3 (0.5 ppm); many people will at 1,224 µg/m^3 (1 ppm). The odor threshold is between 612 to 1,224 µg/m^3 (0.5 and 1 ppm) [ATSDR 1999].

EPA has set an (Interim) Acute Exposure Guideline Level (AEGL-1) of 1,100 µg/m^3 (0.9 ppm) for exposures up to 8 hours. This is based on a No-Observed-Adverse-Effect Level (NOAEL) for eye irritation among sensitive human subjects [EPA 2008].

AEGLs represent threshold exposure limits for the general public and are applicable to emergency exposure periods ranging from 10 minutes to 8 hours.. AEGL-1 is the airborne concentration, expressed as parts per million or milligrams per cubic meter (ppm or mg/m3) of a substance above which it is predicted that the general population, including susceptible individuals, could experience notable discomfort, irritation, or certain asymptomatic nonsensory effects. However, the effects are not disabling and are transient and reversible upon cessation of exposure [EPA 2008].

Formaldehyde Occupational Levels (Regulatory)

The Occupational Safety and Health Administration (OSHA) set a Permissible Exposure Limit (PEL) for workers of 918 µg/m^3 (0.75 ppm) measured as an 8-hour time-weighted average (TWA).[6] The standard includes a second PEL in the form of a short-term exposure limit (STEL) of 2,454 µg/m^3 (2 ppm) that is the maximum exposure allowed during a 15-minute (work) period [OSHA 2010].

Adjusting the PEL for exposures lasting more than 40 hours per week would result in the following (for persons without respiratory maladies, young children or the elderly) [GADNR 1998]:

$$24 \text{ hours/day} \times 7 \text{ day/week} = 168 \text{ hour/week}$$
$$918\ \mu g/m^3 \times 40/168 \text{ week} = 219\ \mu g/m^3$$

Intolerable Levels

Most people cannot tolerate prolonged formaldehyde exposures of 4,906 to 6,135 µg/m^3 (4 to 5 ppm) [NIOSH 1995, Sullivan 2001]. Exposure to 12,245 to 24,490 µg/m^3 (10 to 20 ppm) produces almost immediate eye irritation and a sharp burning sensation of the nose and throat. At those levels, people may sneeze, have difficulty in taking a deep breath, and cough; recovery is prompt from these transient effects once they are removed from the exposure [NIOSH 1995].

Cancer Levels

Nasal tumors have been seen in animal studies. Because formaldehyde is so highly reactive and rapidly metabolized/detoxified by the tissues of the nasal passages, cancers from inhalation are unlikely to result at other (cancer) sites [EPA 2008].

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[6] TWA is the employee's average airborne exposure in any 8-hour work shift of a 40-hour work week which shall not be exceeded. The employer shall assure that no employee is exposed to an airborne concentration of formaldehyde which exceeds 0.75 parts formaldehyde per million parts of air (0.75 ppm) as an 8-hour TWA.

More than 60 epidemiology studies examined the potential for occupational formaldehyde exposure to cause cancer in humans. Although some of the epidemiological studies have found some evidence for extra-respiratory site cancers in groups of formaldehyde-exposed workers, the data are not consistent across studies, and adjustment for potential confounding cancer risk factors has not often been possible [ATSDR 2010].

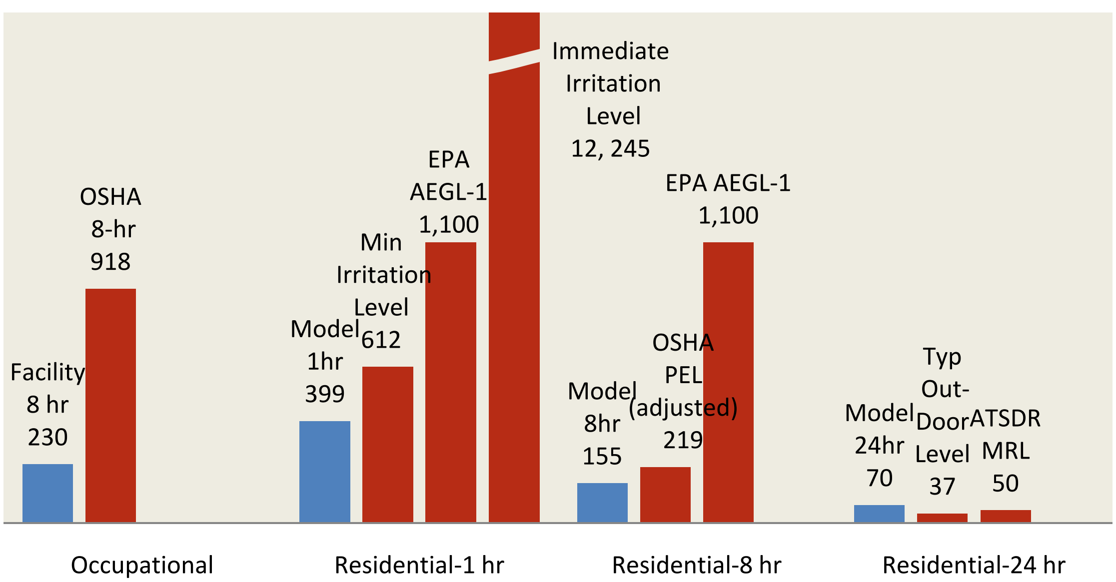
Although the human carcinogenicity data is limited, EPA considers formaldehyde a probable human carcinogen. Some human data showed associations between site-specific respiratory neoplasms and exposure to formaldehyde or formaldehyde-containing products [EPA 2010d]. The National Toxicology Program (NTP) considers formaldehyde to be reasonably anticipated to be a human carcinogen and IARC says there is sufficient evidence of carcinogenicity in humans [NTP 2010, IARC 2006]

The EPA unit inhalation risk for formaldehyde in 1.3E-05 (-µg/m^3). Exposure to 5-7 µg/m^3 is within the EPA acceptable risk range of $10^{-6} – 10^{-4}$.

A summary of the formaldehyde inhalation comparison values is listed in Appendix E, Table E1.

Figure 7 shows the formaldehyde acute inhalation comparison values and the maximum predicted acute model levels.

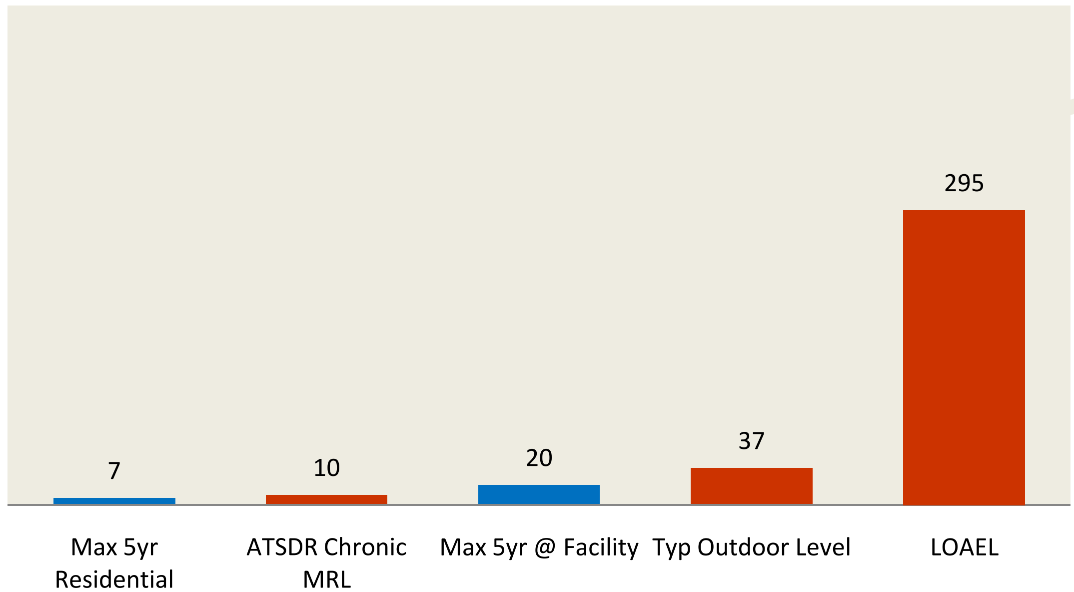
Figure 7. Estimated Formaldehyde Air Levels at Compressor Station #130 and Acute Inhalation Comparison Values (µg/m³)



Blue are modeled levels

Figure 8 shows the formaldehyde chronic inhalation comparison values and the maximum predicted chronic model levels.

Figure 8. Estimated Formaldehyde Air Levels for Compressor Station #130 and Chronic Inhalation Comparison Values (µg/m³)



Blue are modeled levels

Toxicological Evaluation

Formaldehyde is a normal metabolic product of animal metabolism, with varying endogenous[7] levels present at all times. It is rapidly metabolized and storage is not a factor in its toxicity. As a result, formaldehyde-induced health effects are restricted to the route of exposure [ATSDR 1999]. Levels of endogenous formaldehyde in the blood of unexposed humans range from about 2 to 3 µg/g (i.e., 2-3 ppm), and similar levels have been found in rats (2.24 µg/g or 2.4 ppm) and monkeys (2.04 µg/g or 2.04 ppm) [Heck et al., 1985; Casanova et al., 1988]. Blood levels of formaldehyde remained *unchanged* in human studies where subjects were exposed to 2,327 ug/m^3 (1.9 ppm) formaldehyde for 40 minutes [Heck et al., 1985]. Exogenous formaldehyde is rapidly and nearly completely absorbed following exposure by inhalation routes [Collins et al., 2001].

[7] Endogenous substances are those that originate from within an organism, tissue, or cell

The predicted formaldehyde outdoor air levels near Transcontinental Pipeline Compressor Station #130 were at or near the acute exposure guidelines or the minimal risk levels for non-cancer health effects. Those predicted highest chronic levels are also at or within the range of levels typical found in outdoor air in this area.

Community Concerns

According to GDPH, the community contacted them with concerns about:

- rates for cancer cases and cancer deaths,
- reports of children living near pipeline facilities recently diagnosed with leukemia, and
- the number of miscarriages.

In 2008, Georgia Public Health, Northwest Health District conducted a door-to-door community health assessment of residents living within a one-mile radius of the facility to determine if the level of mortality/morbidity in this area was higher than that of other similar populations. A survey was developed to measure the amount of environmental exposure in relation to the amount of disease in the identified community. The 40- question survey tool included self-reported comprehensive questions, sub-questions, and history charts that included health topics including, but not limited to: behavioral/environmental exposure, demographics, maternal/child exposure, medical history, occupational exposure, and tobacco exposure. Fifty-nine residences were identified during the survey process. Sixty-four percent of those households voluntarily completed a health assessment survey interview. Of the 36% that did not participate, nineteen families refused and two properties were not physically accessible. The total sample population was 97 residents.

The survey findings were as follows: [GDPH 2008]

1. Cancer morbidity rates were not higher-than expected given the ages and confounding risk behaviors of the respondents. The identified skin cancers were highly correlated with outdoor sun exposure.
2. The occurrence of adverse respiratory conditions, cardiovascular conditions, and neoplasms were not elevated compared to similar populations.
3. An analysis of cancer in this zip code by the State of Georgia Cancer Registry showed no unusual cancer levels.
4. Twenty four percent of female respondents responded “yes” to “Have had a miscarriage”. Studies reveal that anywhere from 10-25% of all clinically recognized pregnancies will end in miscarriage [APA 2007].
5. The need for further assessment of this area is not indicated by the results of this study.

Limitations

The results of this model prediction have limitations. First, we do not have actual stack sampling data for formaldehyde. Although we used the predicted permit discharge levels which we believe might be an overestimate, we have no actual community samples to verify the model predictions.

Second, the model assumes that all of the formaldehyde is released at a steady state when in reality, the engines turn on and off based on demand for natural gas. The sporadic discharge may make the predicted maximums higher for shorter periods of time. Next, the more recent meteorological data for a 5- year period could produce uncertainty in the model created by how the data is processed. We used meteorological data for 1986-1990; more recent meteorology produced levels similar (but lower) than the 1986-1990 period. Finally, we only considered formaldehyde and not other chemicals released from the facility nor other chemicals that people may be exposed to in their homes.

Conclusions

ATSDR used the measured data points, estimated emissions levels, and area-specific meteorological data in a computer model to predict the formaldehyde concentrations that might be present over various durations of time in the air in residential areas near Transcontinental Pipeline, Compressor Station #130, Comer, Georgia. ATSDR then compared the predicted modeled values with various health and regulatory values to determine if harmful health effects are indicated at those predicted values.

Based on the formaldehyde air modeling and state health survey results, ATSDR concludes that formaldehyde emissions from this facility are not expected to harm people's health. The predicted concentrations, frequencies, and durations of exposure were constructed based on conservative inputs to the model.

- **Highest Predicted Levels:** The highest predicted formaldehyde air concentrations in the closest residential areas to Transcontinental Pipeline, Compressor Station #130, Comer, Georgia are 1-hour averages and range between 350 and 399 µg/m^3**.** This is well below the U.S. Environmental Protection Agency (EPA) Acute Exposure Guideline Level (AEGL) of 1,100 µg/m^3 (AEGL-1) and below irritation and odor threshold levels (612 ug/m^3). Predicted hourly formaldehyde levels at the nearest residential property ranged from 0.00017 to 394 µg/m^3. The predicted hourly median concentration was 01.8 µg/m^3 and the 75th percentile was 2.83 µg/m^3. Additionally, hourly levels at the closest residential area are predicted to have exceeded 50 µg/m^3 no more than 5% of the time over a 5 year period.

- **Acute Exposure (24 hours to 2 weeks):** The highest 24-hour predicted formaldehyde air levels in the closest residential areas are between 56 and 70 µg/m^3. Comparing that range to ATSDR's acute (24 hours to 2 week exposure) minimal risk l**ev**el (MRL) of 50 µg/m^3– the level posing minimal risk to humans – the predicted level is slightly higher. Although this maximum level is slightly higher, the 24-hour averages (including adding an estimated background concentration of 1.5 µg/m^3) only exceeded the acute MRL at the closest residential area 5 days over the 5 year period. The predicted 24-hr median concentration was 3.35 µg/m^3 and the 75th percentile was 11.56 µg/m^3. Additionally, the highest predicted 24-hour air level is 4 times lower that the Lowest-Observed-Adverse-Effect Levels (LOAELs) (295 µg/m^3 for histological changes in nasal specimens). Therefore acute non-cancer health effects are not likely from the predicted formaldehyde emissions.

- **Chronic Exposure (more than one year):** The predicted residential chronic formaldehyde air levels (between 5 and 7 $\mu g/m^3$) are lower than ATSDR's 10 $\mu g/m^3$ chronic MRL. That level is also 12 times lower than typical indoor air levels (86 $\mu g/m^3$)**.** Therefore chronic non-cancer health effects are not expected from formaldehyde emissions.

- **Cancer Concerns:** The Environmental Protection Agency (EPA), the National Toxicology Program (NTP), and the International Agency for Research on Cancer (IARC) all consider formaldehyde a probable human carcinogen, however, the predicted residential chronic levels including background are within the EPA acceptable risk range. That background formaldehyde level in Comer is well below the typical ambient outdoor levels in Georgia and the country even after adding the modeled predicted maximum level of 7 $\mu g/m^3$. Additionally, in 2008, Georgia Public Health, Northwest Health District conducted a door-to-door community health assessment of residents living within a one-mile radius of the facility to determine if the level of mortality/morbidity in this area was higher than that of other similar populations. They determined that the cancer morbidity rates were not found to be at unexpected levels given the ages and confounding risk behaviors of the respondents. An analysis of cancer in this zip code by the State of Georgia Cancer Registry showed no unusual cancer levels. Therefore, cancer health effects are not likely from predicted formaldehyde emissions from Transcontinental Pipeline, Compressor Station #130, Comer, Georgia. This conclusion is based on the low overall background level, the small predicted increase to that level from the facility emissions, the health outcome data collected and reviewed by the State of Georgia, and that the predicted concentrations are within the acceptable risk level.

Recommendations

1. Because a general review of available information and predictive models include a level of uncertainty, the information provided in this consultation cannot be used to determine the health impacts of a specific individual particularly those with pre-existing respiratory or immune compromised systems. Those persons should consult with their own physicians about their health concerns.

2. Re-evaluate the formaldehyde emissions from this facility if any of the following takes place:

    - Additional stack testing is done at this facility
    - Engines are added, replaced, or modified or usage changes that would increase emissions substantially.

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Appendices

for

The Review of Formaldehyde Emissions from Transcontinental Pipeline, Compressor Station #130, Comer, GA

Appendix A. Station 130 Summary of Formaldehyde Emissions

Transcontinental Gas Pipe Line Company, LLC
Station 130 - Comer, Georgia

Summary of Formaldehyde Emissions [1,2]

Unit No.	Manufacturer/ Model	HP	Btu Rating (MMBtu/hr)	Potential Hours Operated	1) Potential Formaldehyde Emissions [1] (Assumed % of VOC Emissions)				2) Potential Formaldehyde Emissions [2] (Based on AP-42 Emission Factor)		
					VOC Emission Rate (lb/hr)	VOC Emission Percentage	Formaldehyde Rate (lb/hr)	Formaldehyde (tons/year)	Formaldehyde Rate (lb/MMBtu)	Formaldehyde Rate (lb/hr)	Formaldehyde Emissions (Tons/yr)
ML01	Clark BA-8T	2,050	15.4	8,760	6.14	46%	2.82	12.3726	5.52E-02	0.85	3.7234
ML02	Clark BA-8T	2,050	15.4	8,760	6.14	46%	2.82	12.3726	5.52E-02	0.85	3.7234
ML03	Clark BA-8T	2,050	15.4	8,760	6.14	46%	2.82	12.3726	5.52E-02	0.85	3.7234
ML04	Clark BA-8T	2,050	15.4	8,760	6.14	46%	2.82	12.3726	5.52E-02	0.85	3.7234
ML05	Clark BA-8T	2,050	15.4	8,760	6.14	46%	2.82	12.3726	5.52E-02	0.85	3.7234
ML06	Clark BA-8T	2,050	15.4	8,760	6.14	46%	2.82	12.3726	5.52E-02	0.85	3.7234
ML07	Clark BA-8T	2,050	15.4	8,760	6.14	46%	2.82	12.3726	5.52E-02	0.85	3.7234
ML08	Clark HBA-8T	2,050	16.4	8,760	5.71	46%	2.63	11.5117	5.52E-02	0.91	3.9651
ML09	Clark HBA-8T	2,050	16.4	8,760	5.71	46%	2.63	11.5117	5.52E-02	0.91	3.9651
ML10	Clark TLA-6	2,100	14.7	8,760	3.93	46%	1.81	7.9158	5.52E-02	0.81	3.5541
ML11	Clark TLA-6	2,100	14.7	8,760	3.93	46%	1.81	7.9158	5.52E-02	0.81	3.5541
ML12	Clark TLA-6	2,100	14.7	8,760	3.93	46%	1.81	7.9158	5.52E-02	0.81	3.5541
ML13	Clark TLA-6	2,100	14.7	8,760	3.93	46%	1.81	7.9158	5.52E-02	0.81	3.5541
ML14	Clark TCV-12	4,000	27.4	8,760	4.21	46%	1.94	8.4841	5.52E-02	1.51	6.6247
ML15	Clark TCV-12	4,000	27.4	8,760	4.21	46%	1.94	8.4841	5.52E-02	1.51	6.6247
ML16	Clark TCV-16	5,500	37.7	8,760	11.96	46%	5.50	24.1038	5.52E-02	2.08	9.1150
ML17 (T1)	Solar Centaur	3,735	37.7	8,760	0.22	34%	0.08	0.3306	7.10E-04	0.03	0.1172
ML18 (G1)	Solar Mars T15000S	13,851	108.3	8,760	1.28	34%	0.44	1.9077	7.10E-04	0.08	0.3368
AUX1	Ingersoll Rand PVG-8	370	2.8	200	0.37	69%	0.25	0.0253	2.05E-02	0.06	0.0057
AUX2	Ingersoll Rand PVG-8	370	2.8	200	0.37	69%	0.25	0.0253	2.05E-02	0.06	0.0057
AUX3	Ingersoll Rand PVG-8	370	2.8	200	0.37	69%	0.25	0.0253	2.05E-02	0.06	0.0057
AC01	Waukesha F817G	100	0.8	8,760	0.02	69%	0.02	0.0716	2.05E-02	0.02	0.0718
AC02	Waukesha F817G	100	0.8	8,760	0.02	69%	0.02	0.0716	2.05E-02	0.02	0.0718
TOTAL EMISSIONS								184.82			71.19

[1] For each emission source, total VOC emissions are multiplied by the estimated formaldehyde contribution percentage to determine formaldehyde emissions.
[2] Formaldehyde emission factors from EPA AP-42 Section 3.1 (April 2000) and Section 3.2 (July 2000).

Appendix B. Station 130 Exhaust Parameters

Transcontinental Gas Pipe Line Company LLC
Station 130 - Comer, GA

Station 130 - Exhaust Parameters for Mainline Compression Sources

Unit No.	Manufacturer/Model	Equipment Description	Horsepower	Stack Parameters			
				Height (ft)	Diameter (ft)	Exit Velocity [1] (ft/sec)	Exit Temp [1] (° F)
ML01	Clark BA-8T	2SLB NG Fired IC Engine	2,050	22.0	2.0	90.9	798
ML02	Clark BA-8T	2SLB NG Fired IC Engine	2,050	22.0	2.0	90.9	798
ML03	Clark BA-8T	2SLB NG Fired IC Engine	2,050	22.0	2.0	90.9	798
ML04	Clark BA-8T	2SLB NG Fired IC Engine	2,050	22.0	2.0	90.9	798
ML05	Clark BA-8T	2SLB NG Fired IC Engine	2,050	22.0	2.0	90.9	798
ML06	Clark BA-8T	2SLB NG Fired IC Engine	2,050	22.0	2.0	90.9	798
ML07	Clark BA-8T	2SLB NG Fired IC Engine	2,050	22.0	2.0	90.9	798
ML08	Clark HBA-8T	2SLB NG Fired IC Engine	2,050	22.0	2.0	90.4	876
ML09	Clark HBA-8T	2SLB NG Fired IC Engine	2,050	22.0	2.0	90.4	876
ML10	Clark TLA-6	2SLB NG Fired IC Engine	2,100	25.0	2.0	82.2	820
ML11	Clark TLA-6	2SLB NG Fired IC Engine	2,100	25.0	2.0	82.2	820
ML12	Clark TLA-6	2SLB NG Fired IC Engine	2,100	25.0	2.0	82.2	820
ML13	Clark TLA-6	2SLB NG Fired IC Engine	2,100	25.0	2.0	82.2	820
ML14	Clark TCV-12	2SLB NG Fired IC Engine	4,000	31.3	2.5	94.4	741
ML15	Clark TCV-12	2SLB NG Fired IC Engine	4,000	31.3	2.5	94.4	741
ML16	Clark TCV-16	2SLB NG Fired IC Engine	5,500	49.5	4.0	65.4	637
ML17	Solar Centaur	NG Fired Turbine	3830 ISO	32.5	3.3	137.0	872
ML18	Solar Mars T15000S	NG Fired Turbine	15000 ISO	43.0	7.5 [2]	52.8	870

[1] Exhaust parameters from 1992 emission test events; data representative of operations at those test conditions.
[2] Equivalent diameter

Appendix C: AERMOD Model Inputs

Table C1: Stack Location Information, Transcontinental Pipeline

Source	Type	X coordinate (m)	Y Coordinate (m)	Ground Elevation of Base (m)
STACK1	POINT	302343	3780953	222.99
STACK2	POINT	302351	3780952	222.52
STACK3	POINT	302359	3780951	222.12
STACK4	POINT	302367	3780950	221.89
STACK5	POINT	302375	3780950	221.62
STACK6	POINT	302383	3780949	221.39
STACK7	POINT	302392	3780948	221.07
STACK8	POINT	302399	3780947	220.79
STACK9	POINT	302407	3780946	220.45
STACK10	POINT	302417	3781151	219
STACK11	POINT	302426	3781151	219
STACK12	POINT	302434	3781150	219
STACK13	POINT	302443	3781149	219
STACK14	POINT	302458	3781153	219
STACK15	POINT	302472	3781151	219
STACK16	POINT	302381	3781119	219
STACK17	POINT	302485	3781150	218.88
STACK18	POINT	302535	3781149	217.65

Table C2: Formaldehyde Emissions Data for Transcontinental Pipeline

Source	Emission Rate (g/s)	Stack Height (m)	Gas Exit Temperature (K)	Gas Exit Velocity (m/s)	Stack Inside Diameter (m)
STACK1	0.36	6.9	698.7	28.4	0.6
STACK2	0.36	6.9	698.7	28.4	0.6
STACK3	0.36	6.9	698.7	28.4	0.6
STACK4	0.36	6.9	698.7	28.4	0.6
STACK5	0.36	6.9	698.7	28.4	0.6
STACK6	0.36	6.9	698.7	28.4	0.6
STACK7	0.36	6.9	698.7	28.4	0.6
STACK8	0.33	6.9	698.7	28.4	0.6
STACK9	0.33	6.9	742	28.25	0.6
STACK10	0.23	7.8	710.9	25.69	0.6
STACK11	0.23	7.8	710.9	25.69	0.6
STACK12	0.23	7.8	710.9	25.69	0.6
STACK13	0.23	7.8	710.9	25.69	0.6
STACK14	0.24	9.8	667	29.5	0.8
STACK15	0.24	9.8	667	29.5	0.8
STACK16	0.69	10.2	739.8	42.8	1
STACK17	0.01	13.5	739.7	16.5	2.3
STACK18	0.05	15.5	609.3	20.4	1.3

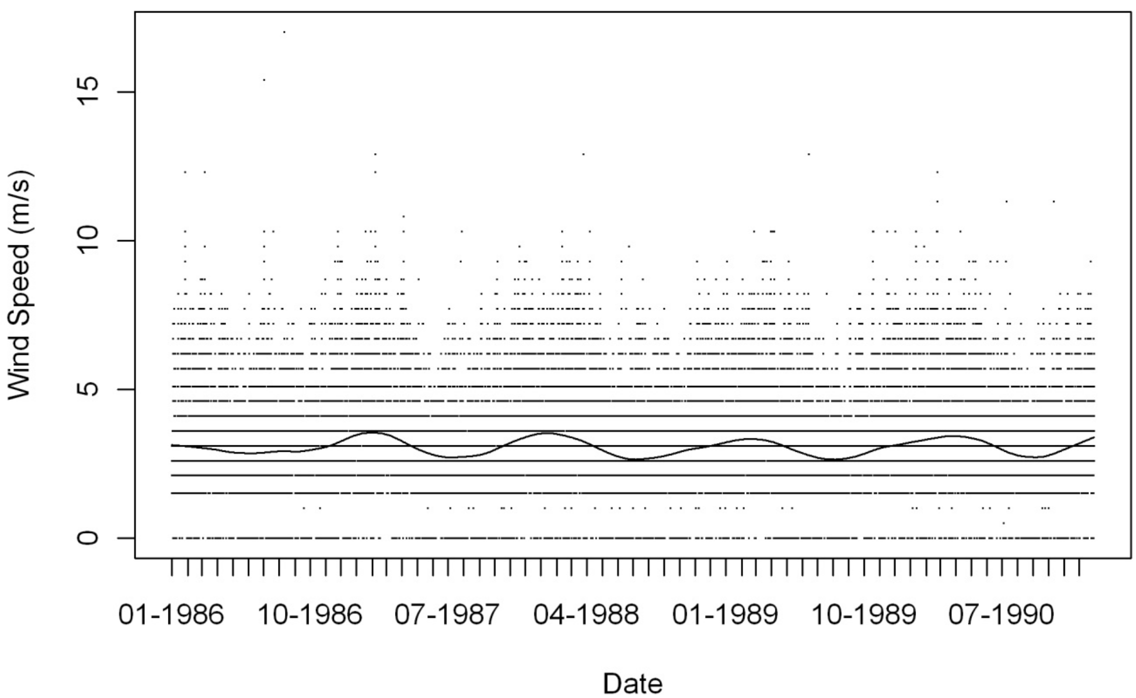
Table C3: Building Data for Transcontinental Pipeline

Building	Southwest Corner (UTM)	Length (meters)	Width (meters)	Height above Ground Level (meters)	Angle (degrees)
COMP. A	302339.93E x 3780957.05	76.8	13.4	9.8	355
COMP B. (OLD)	302405.24E x 3781131.95	47.9	13.7	9.8	358
COMP B(NEW)	302499.15E x 3781128.53N	19.2	46.3	13.4	88
COMP C.	302369.54E x 3781112.34	14.6	11.3	9.1	355
COMP. D	302526.41E x 3781145.86	18.3	11.3	9.4	359

Appendix D– Resultant AERMOD Model Outputs Using Two Different Meteorological Profiles (1986-1990& 2005-2010)

ATSDR considered both 1986-1990 and 2005-2010 meteorological data. ATSDR ultimately selected the 1986-1990 because the more recent data would come from an ASOS converted meteorological stations. These stations do not process calms and those gaps could be interpreted by the model as insufficient data and create more uncertainty. Utilizing the more recent meteorological data resulted in only slightly *lower* concentrations than the 1986-1990 data, but would not have altered any conclusions reached by the public health interpretation of the model. The following figures are plots of the two meteorological surface files and profile files generated by AERMET.

Figure D1. Surface File Wind Speeds



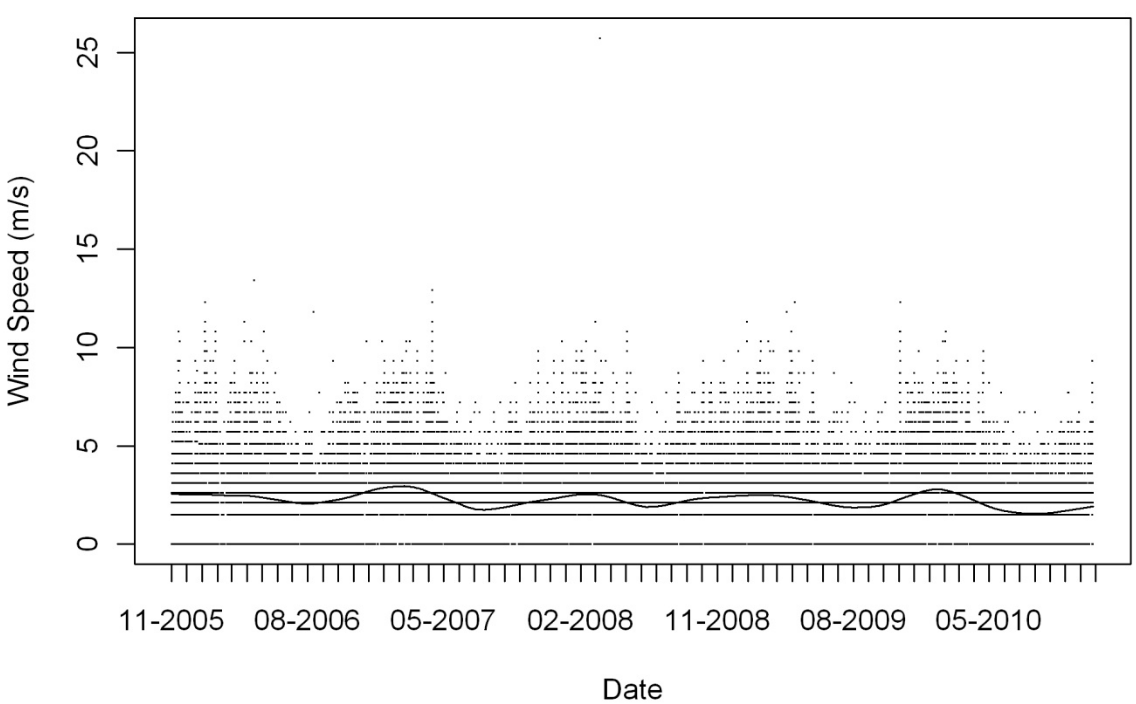
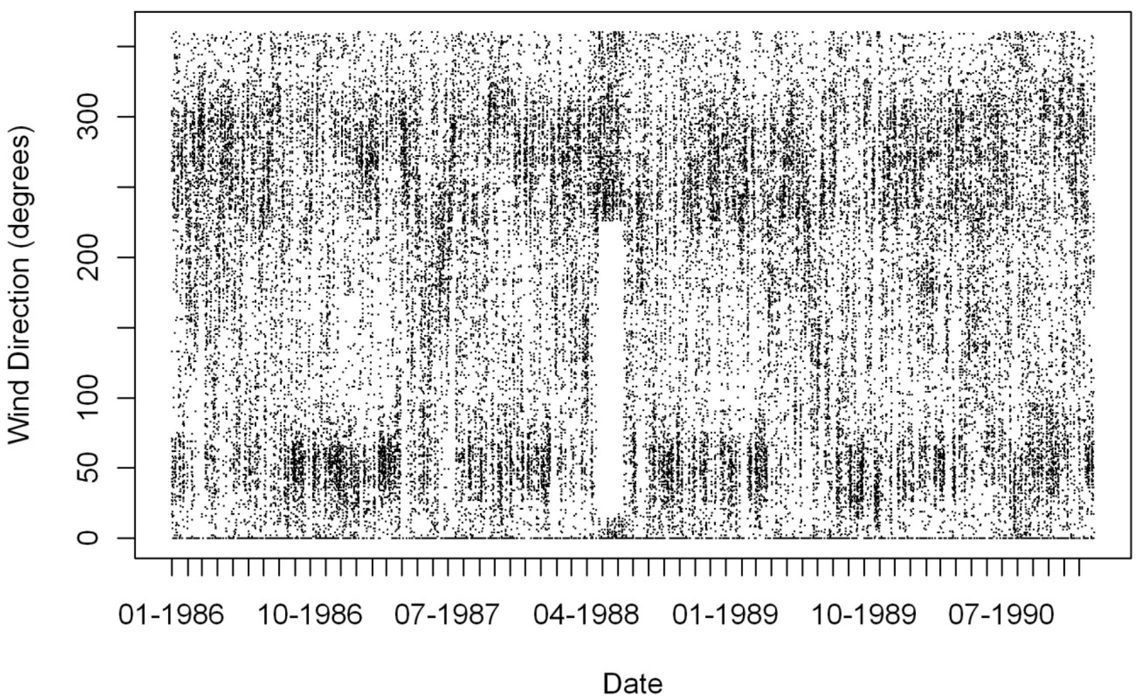


Figure D2. Surface File Wind Direction



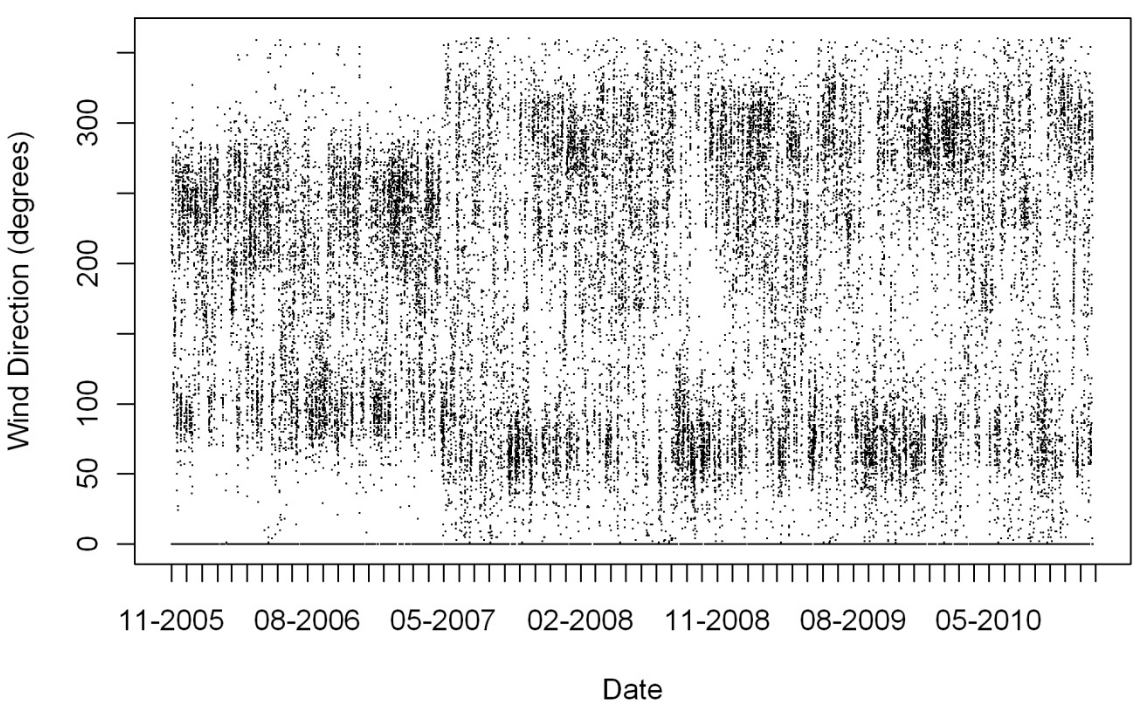
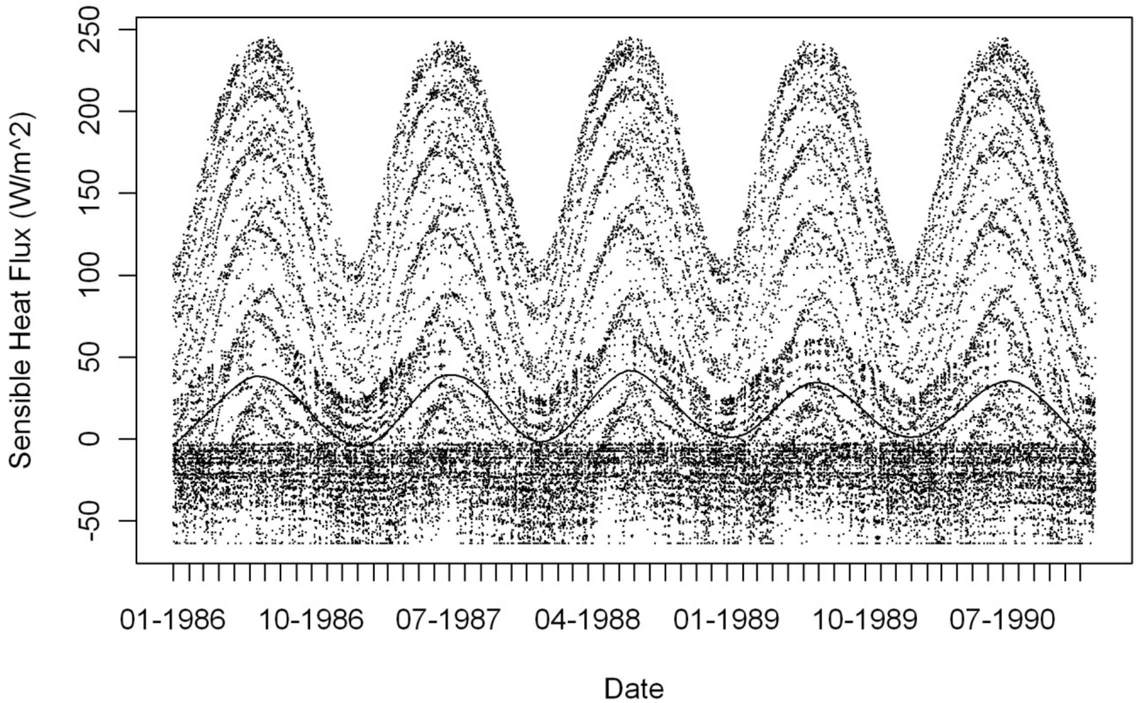
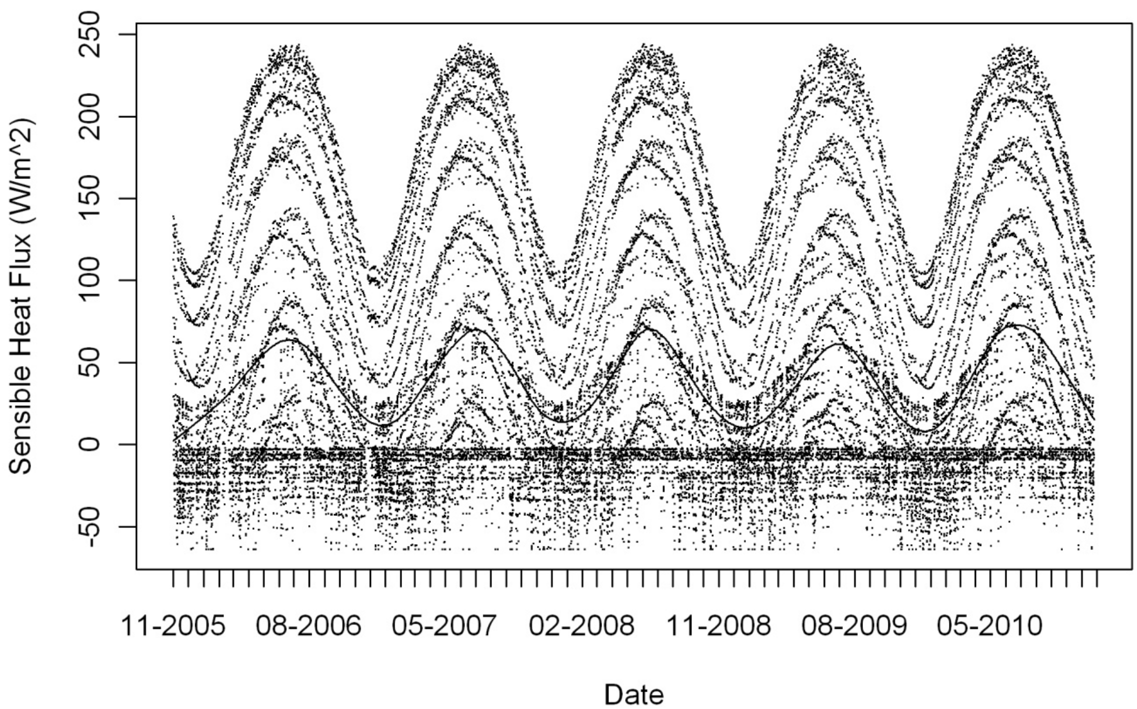


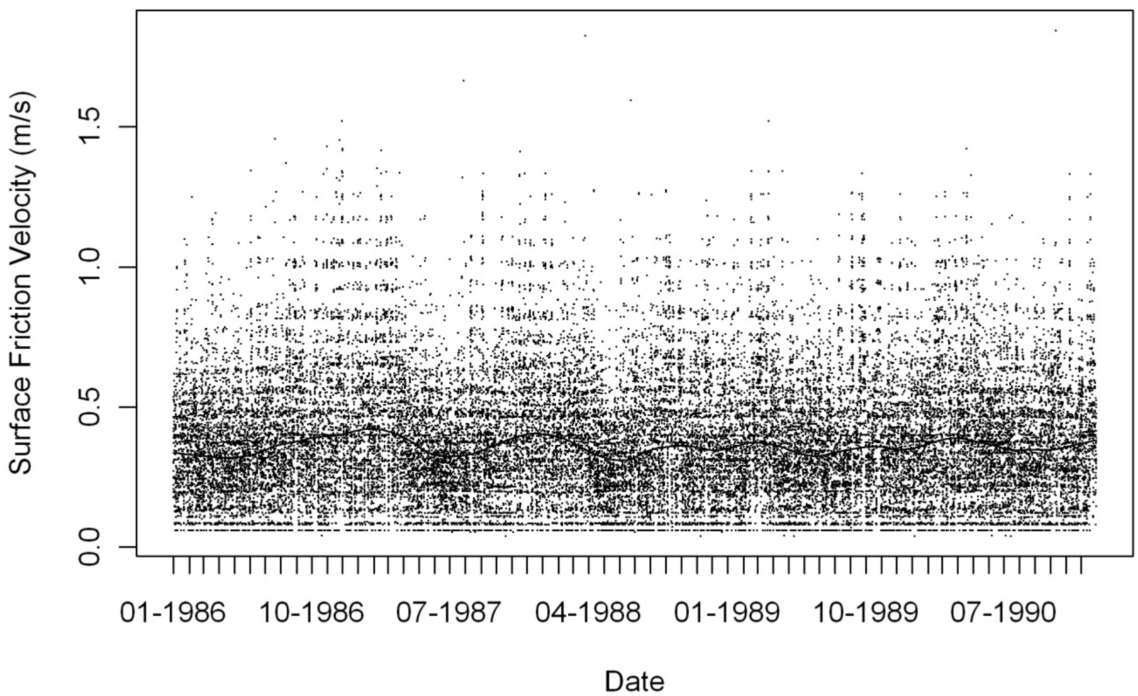
Figure D3. Sensible Heat Flux





Date

Figure D4. Surface Friction Velocity



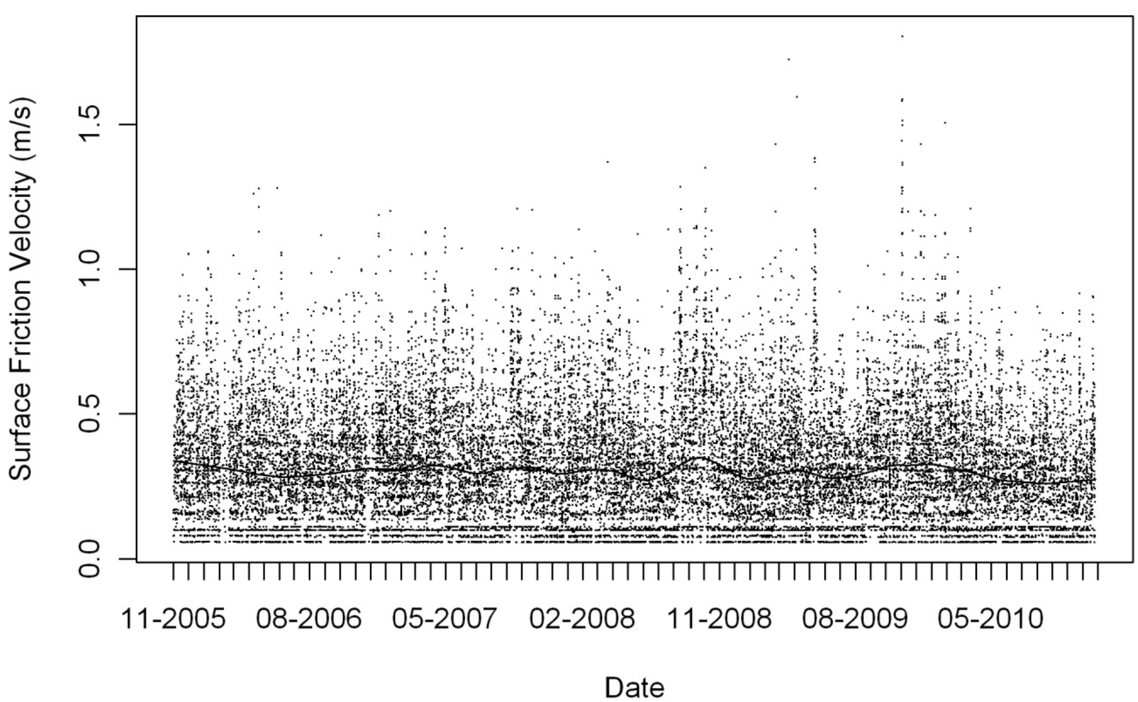
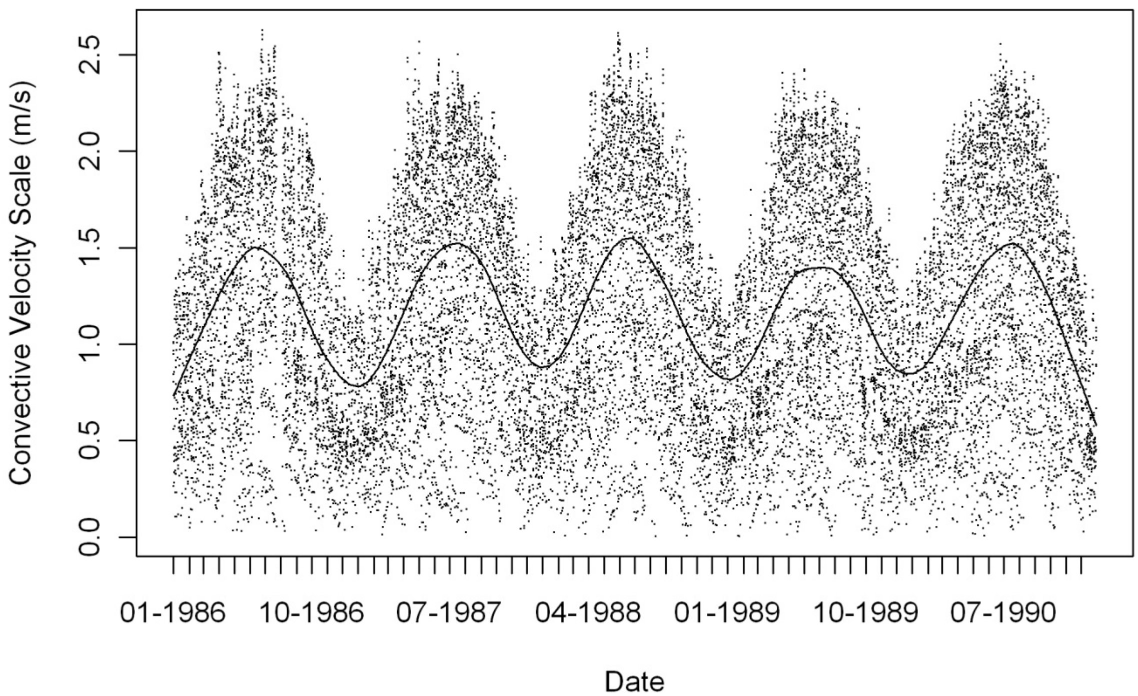
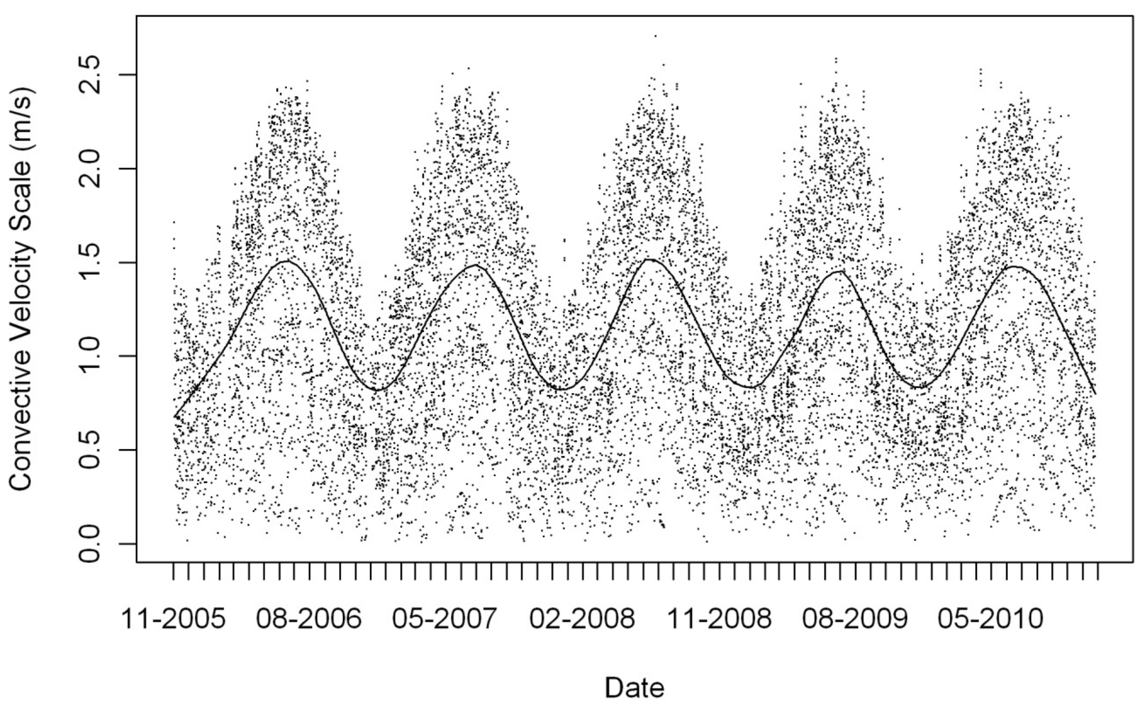


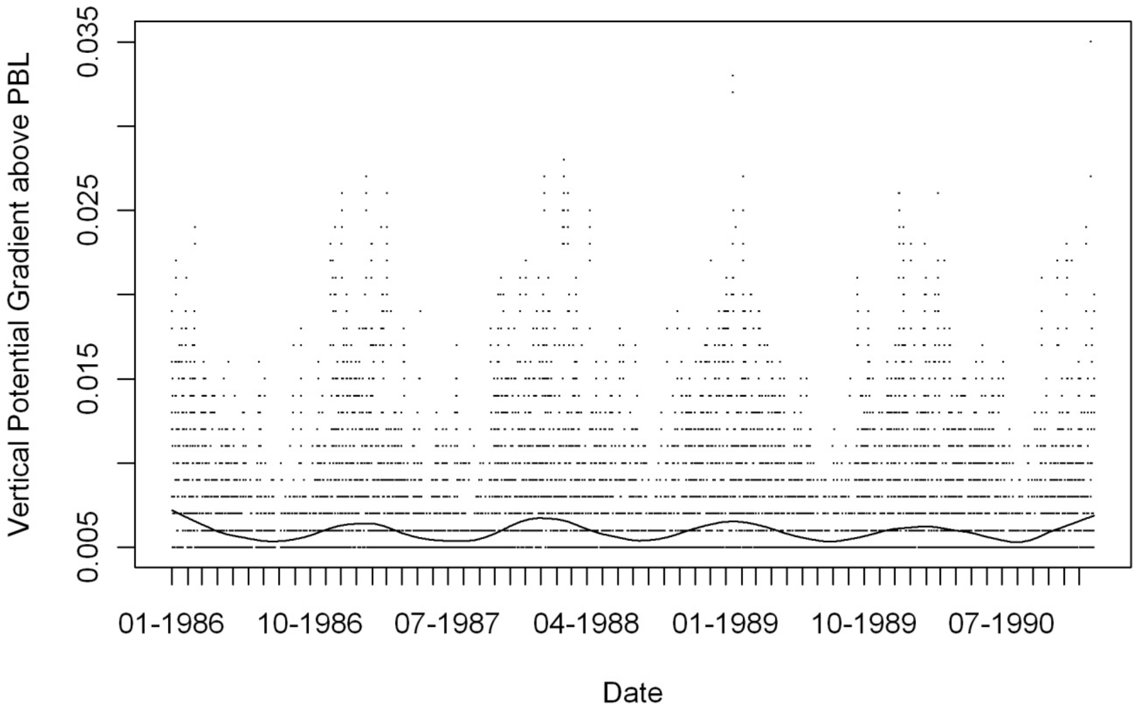
Figure D5. Convective Velocity Scale





Date

Figure D6. Vertical Potential Temperature



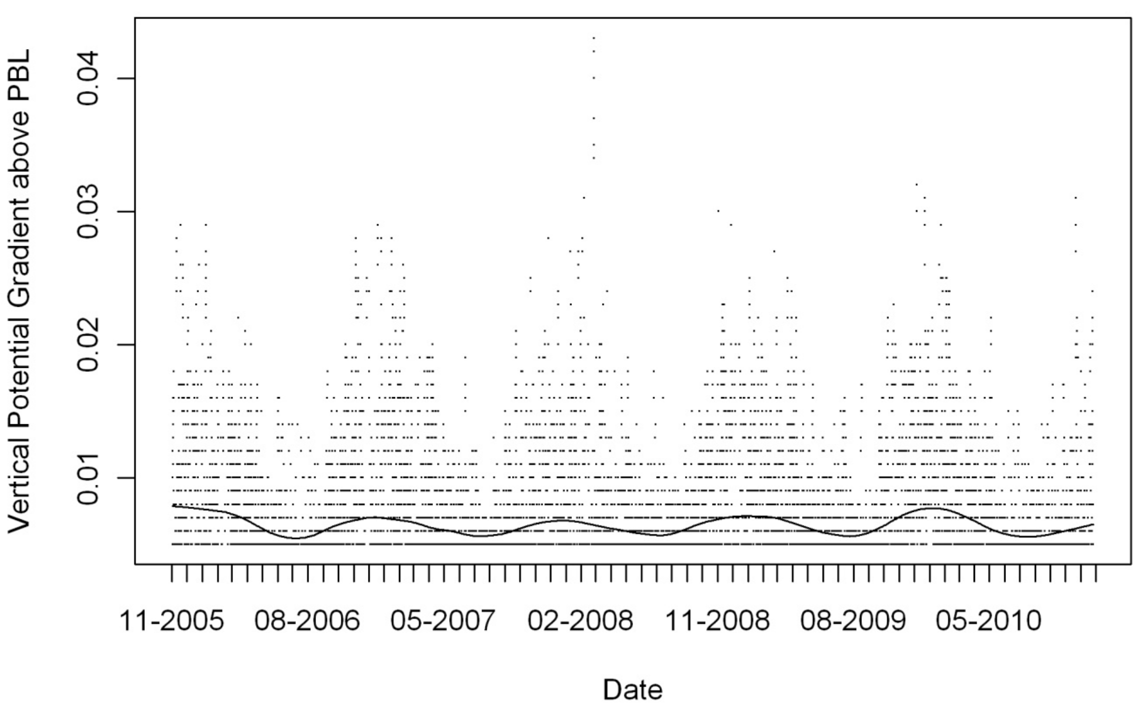
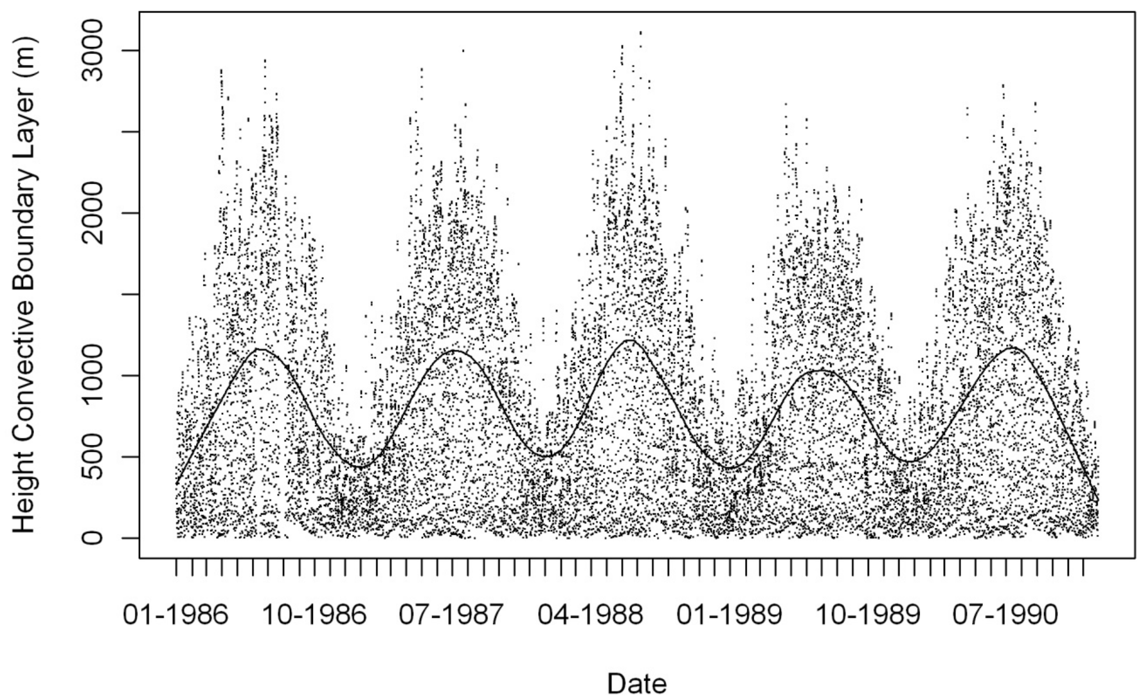


Figure D7. Height of Convectively Generated Boundary Layer



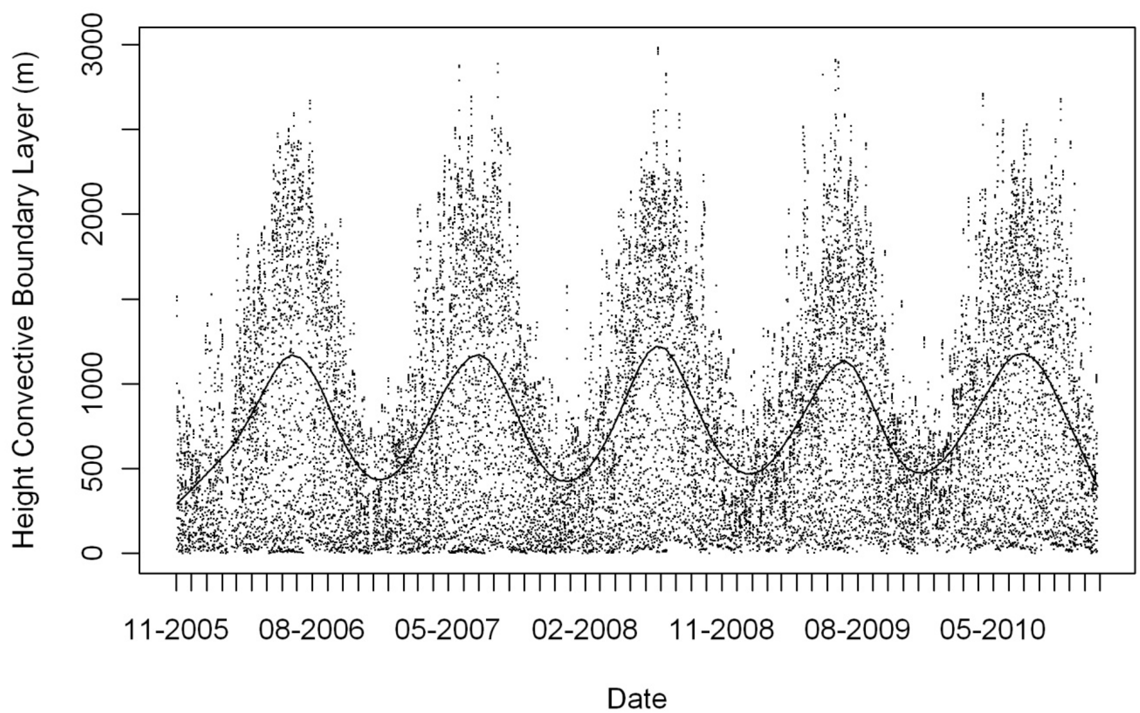
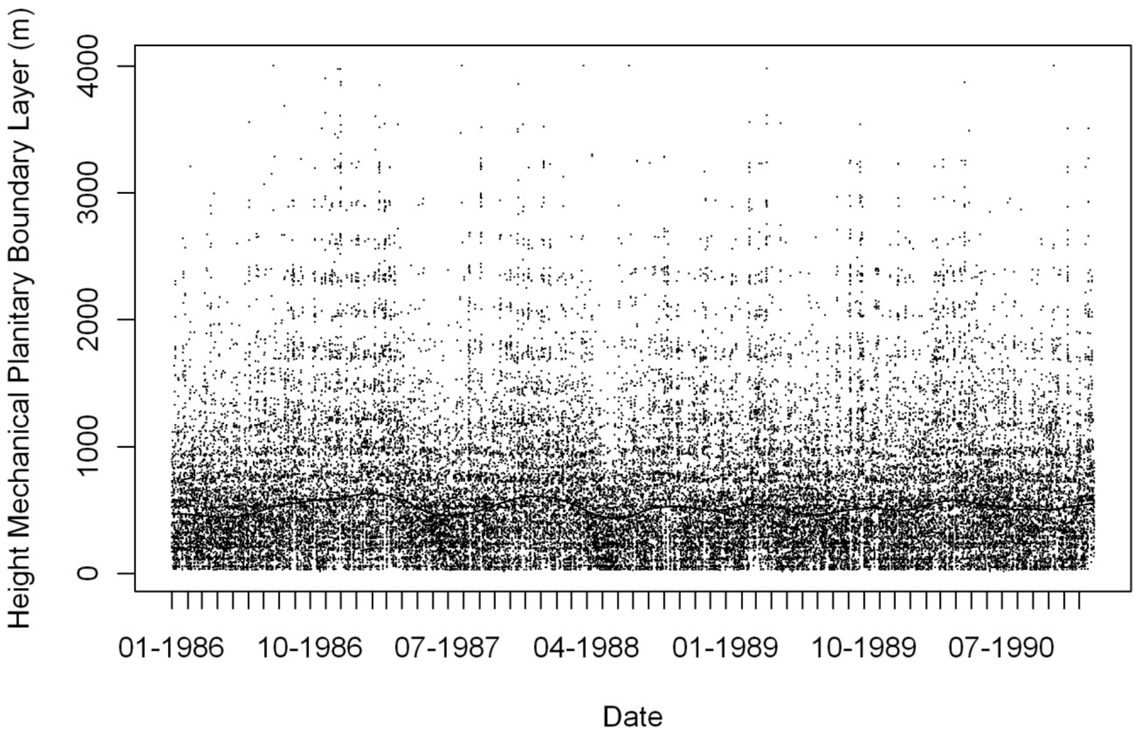


Figure D8. Height of Mechanically Generated Boundary Layer



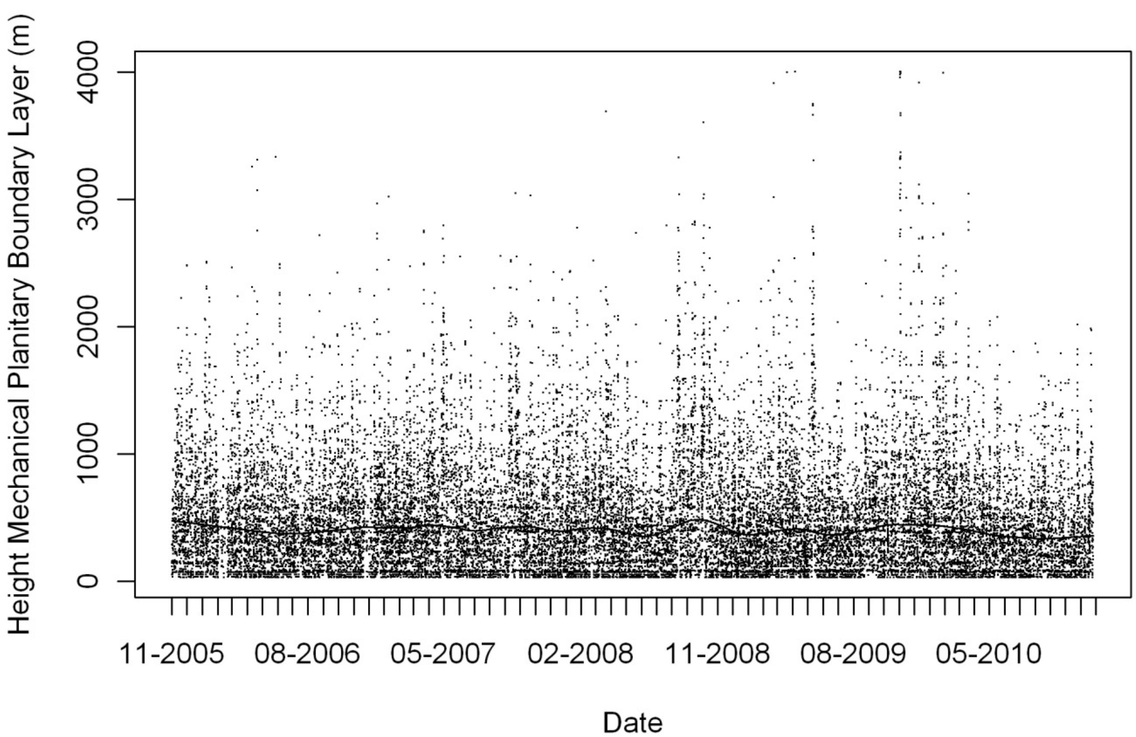
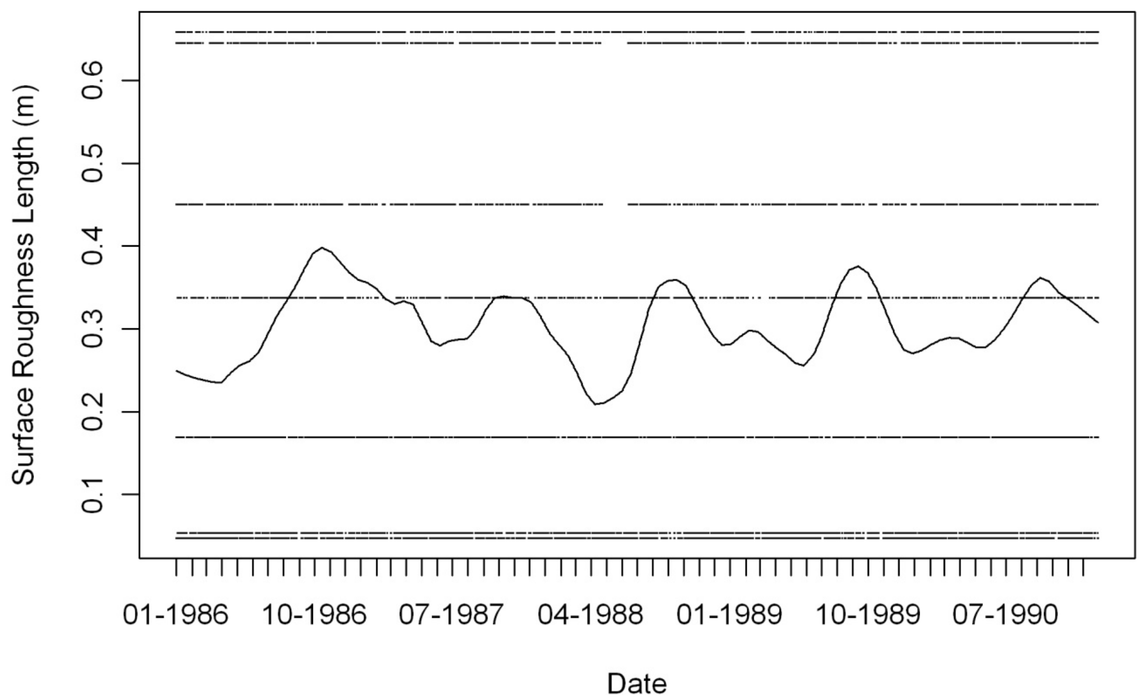


Figure D9. Surface Roughness Length



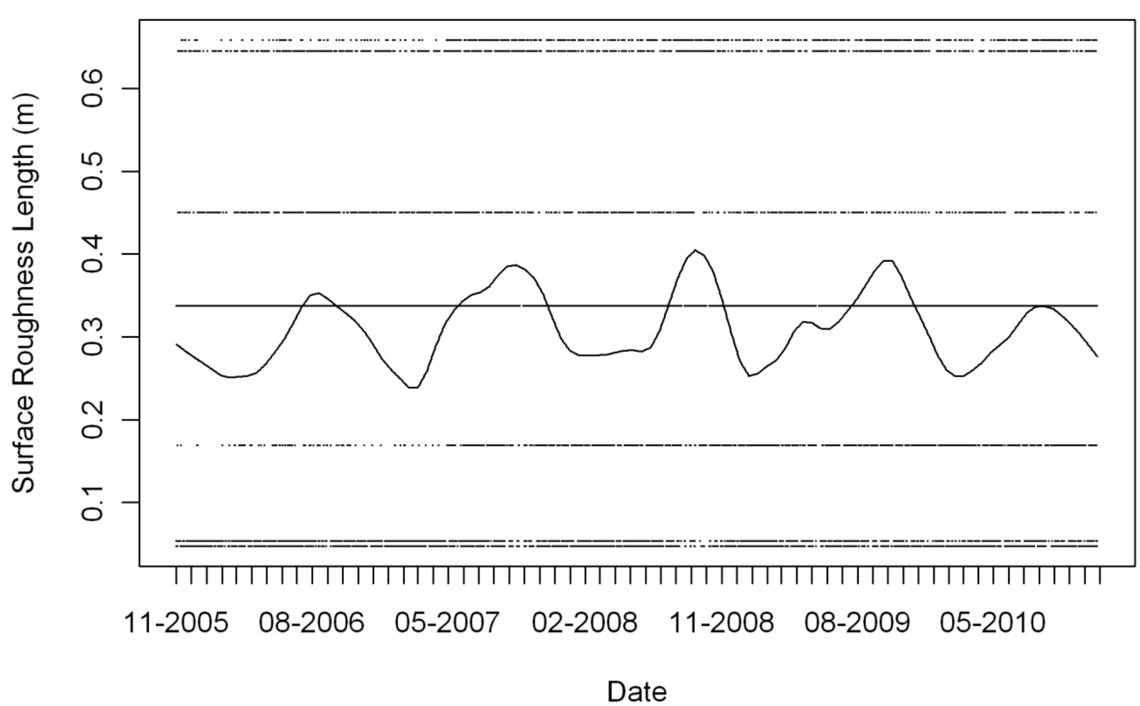


Figure D10. Monin-Obukhov Length by Hour and Month

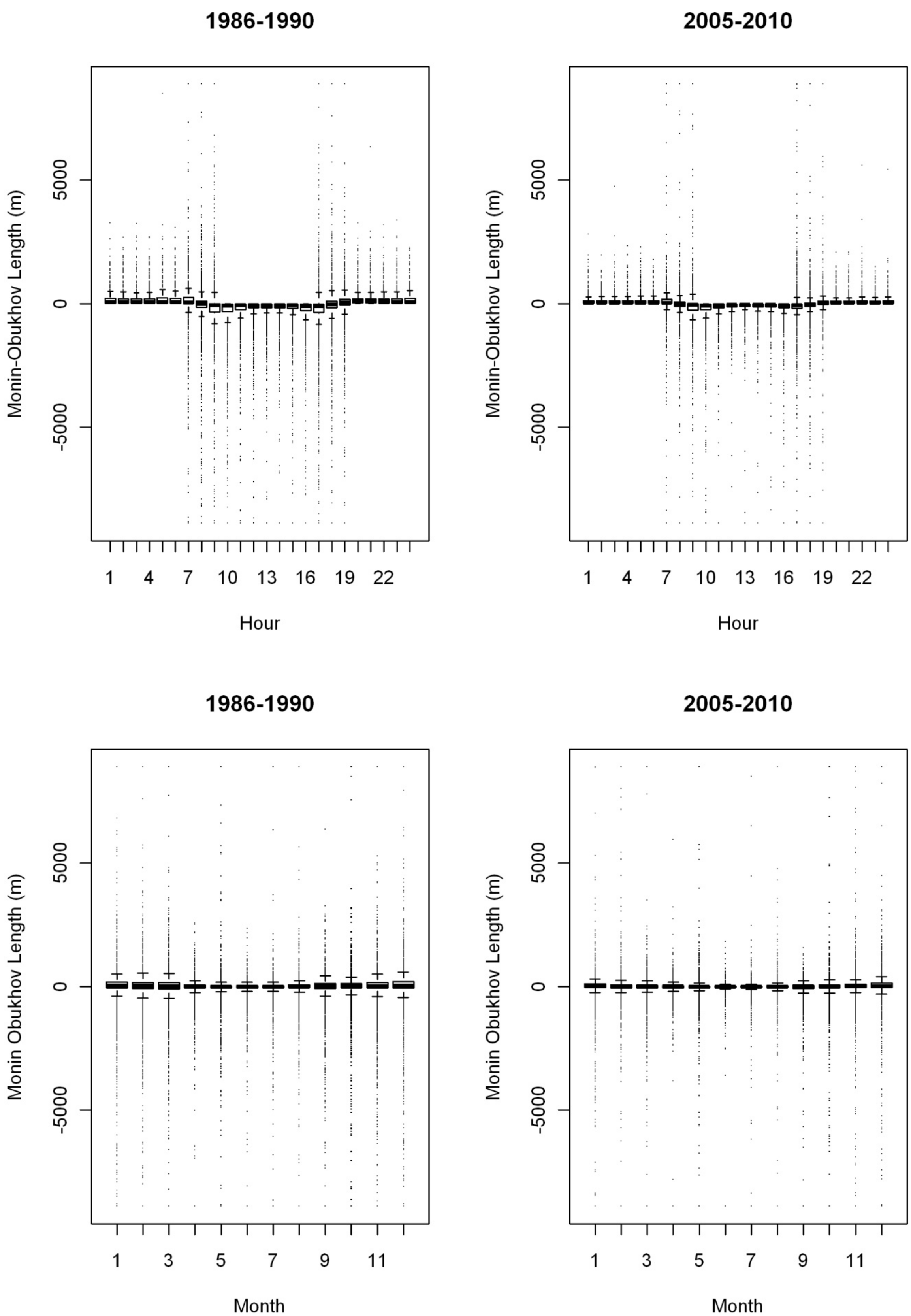
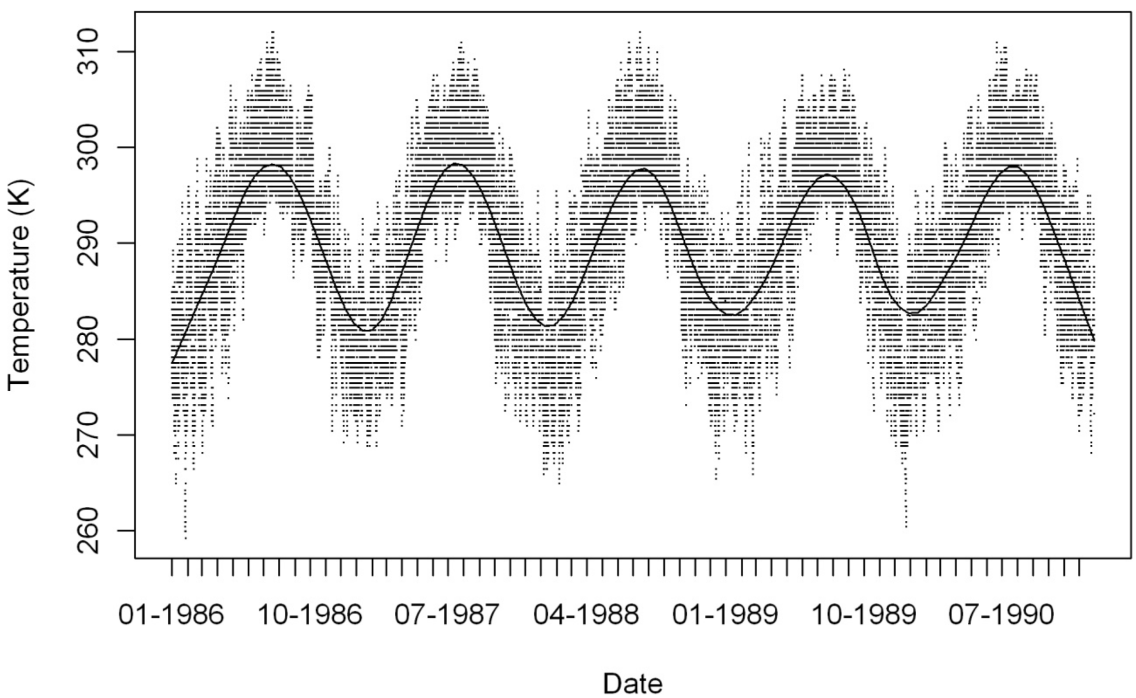


Figure D11. Temperature



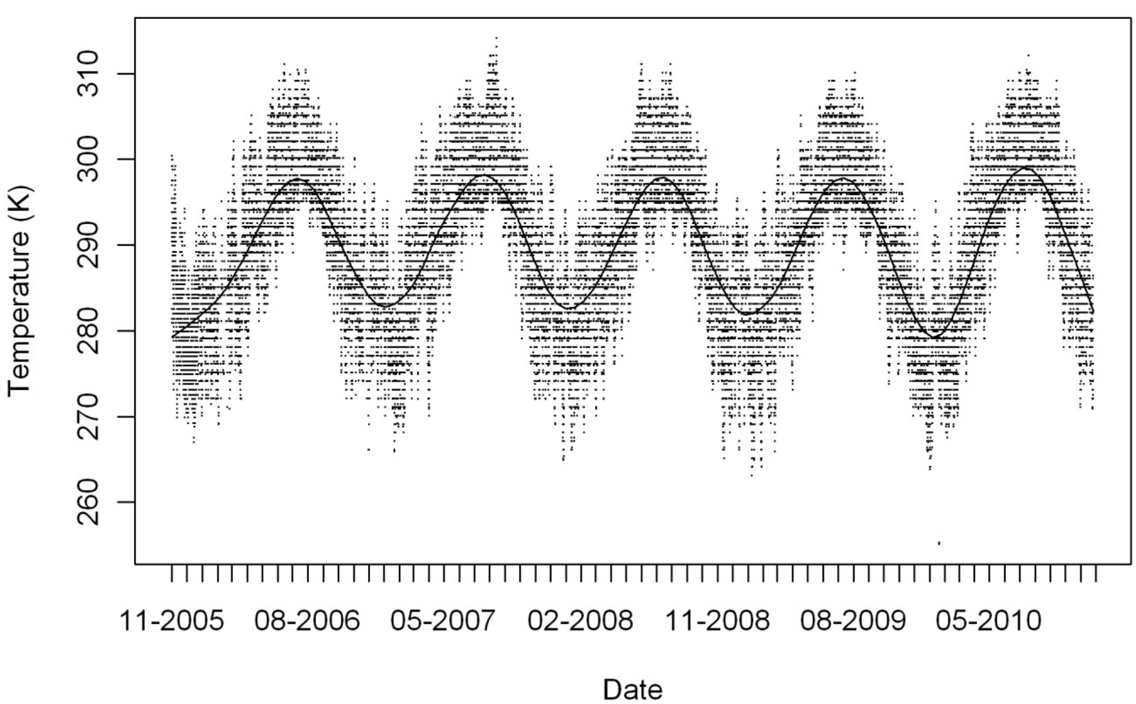
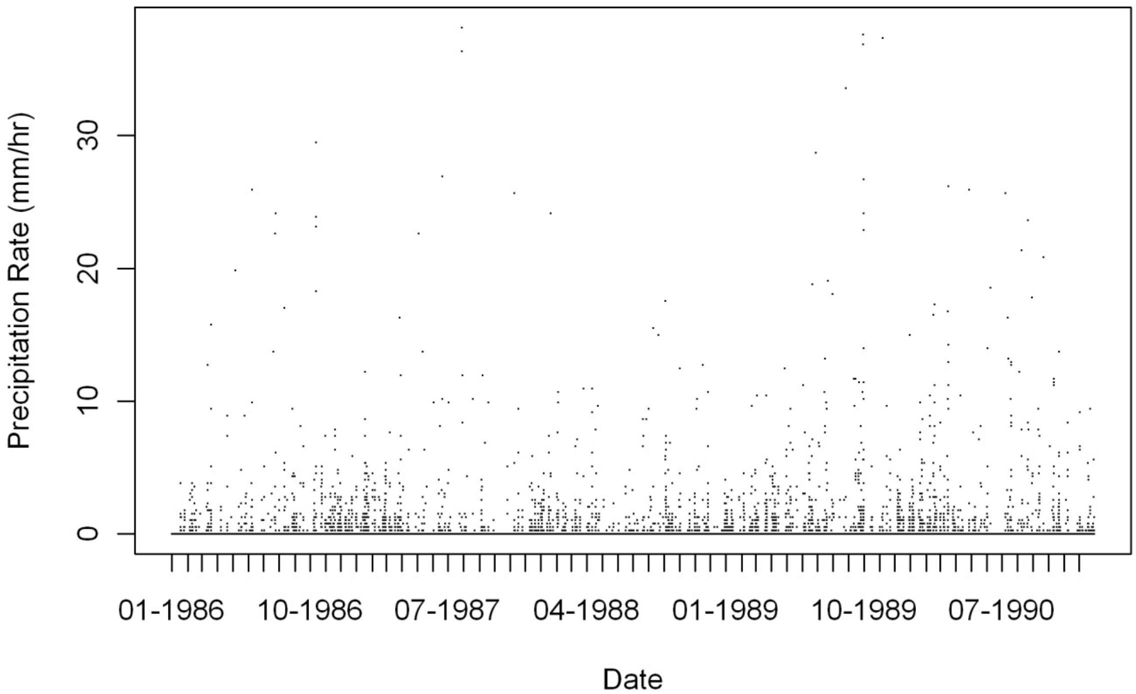


Figure D12. Precipitation Rate



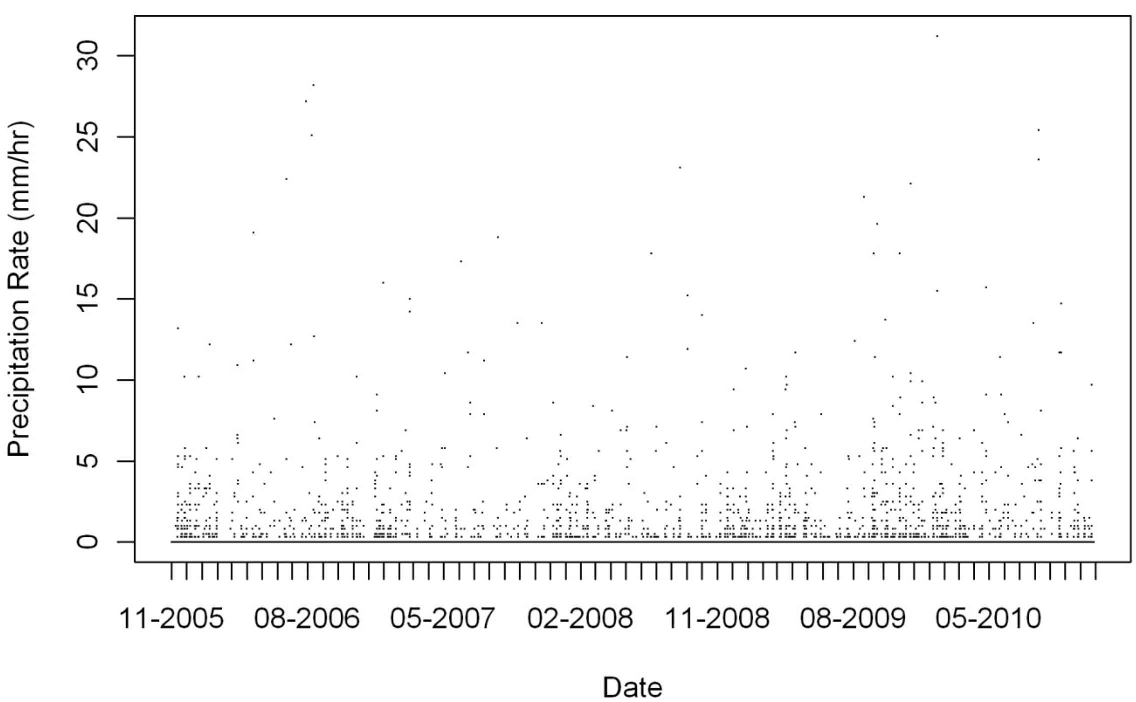
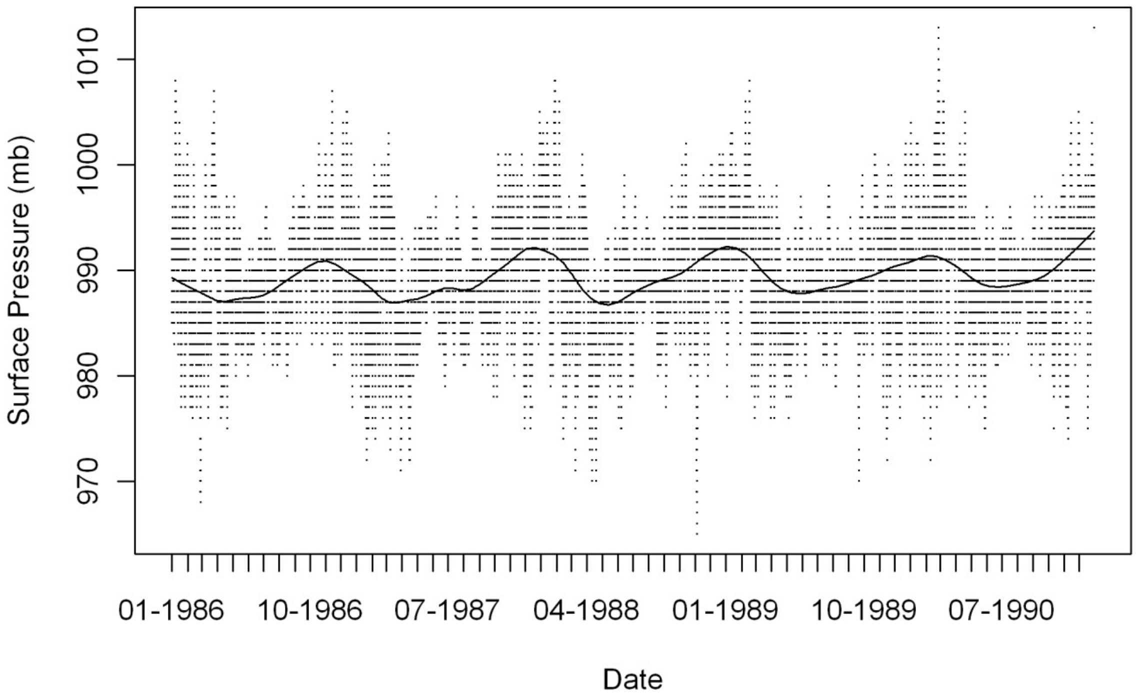


Figure D13. Pressure



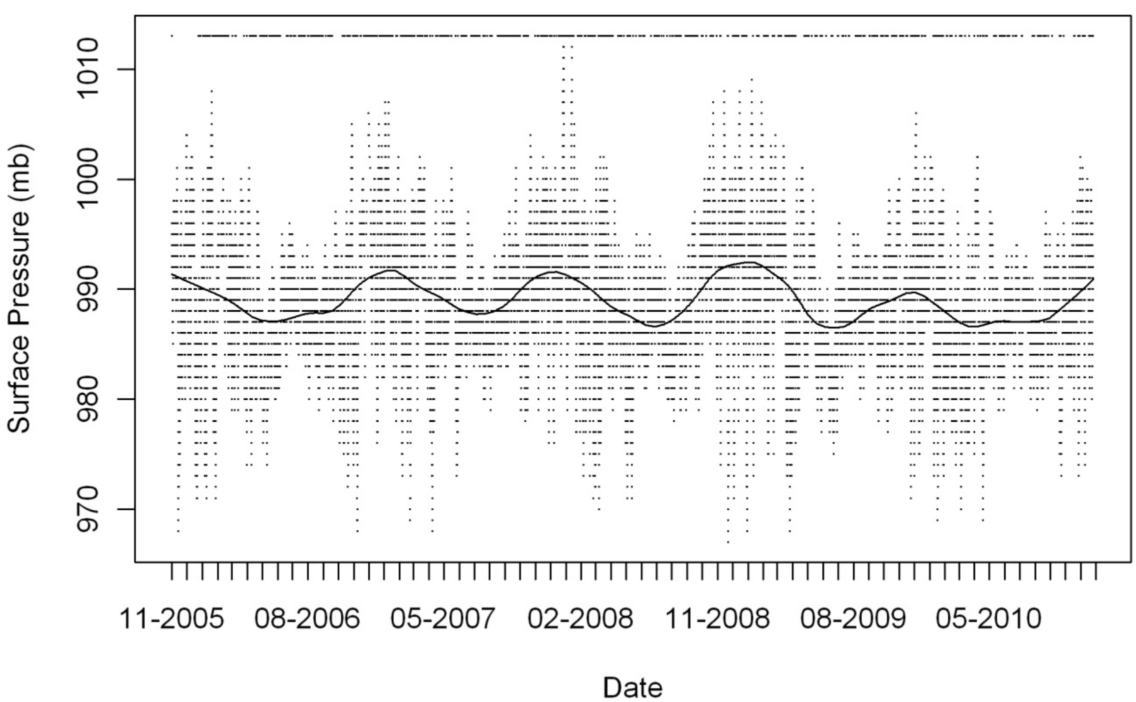
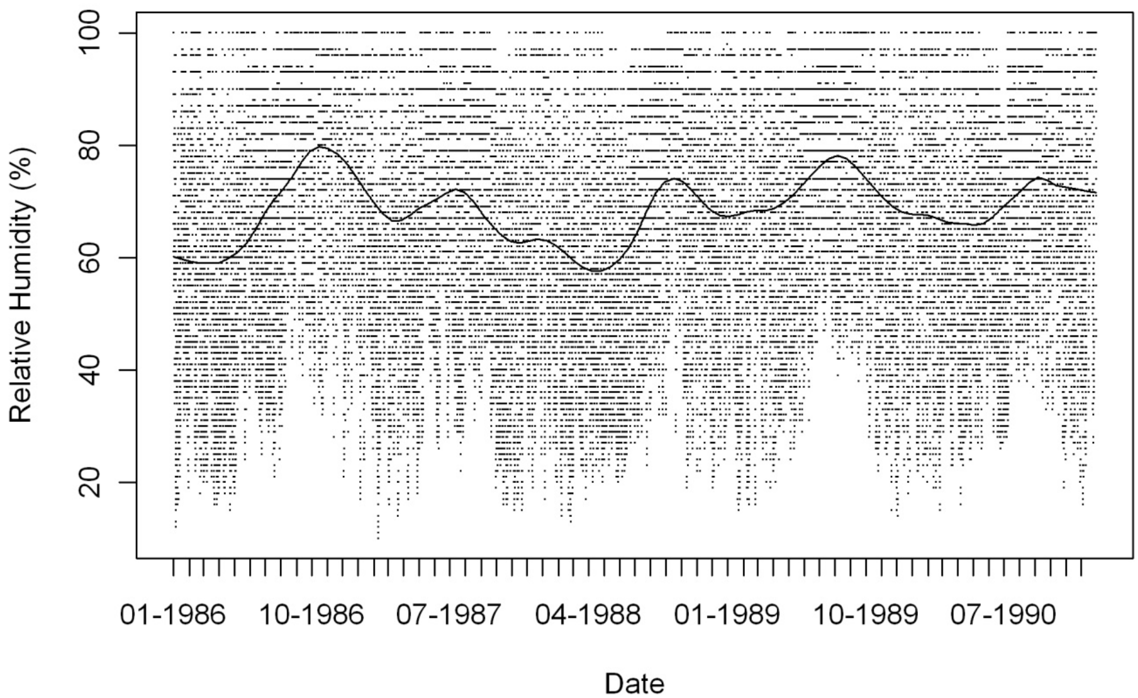
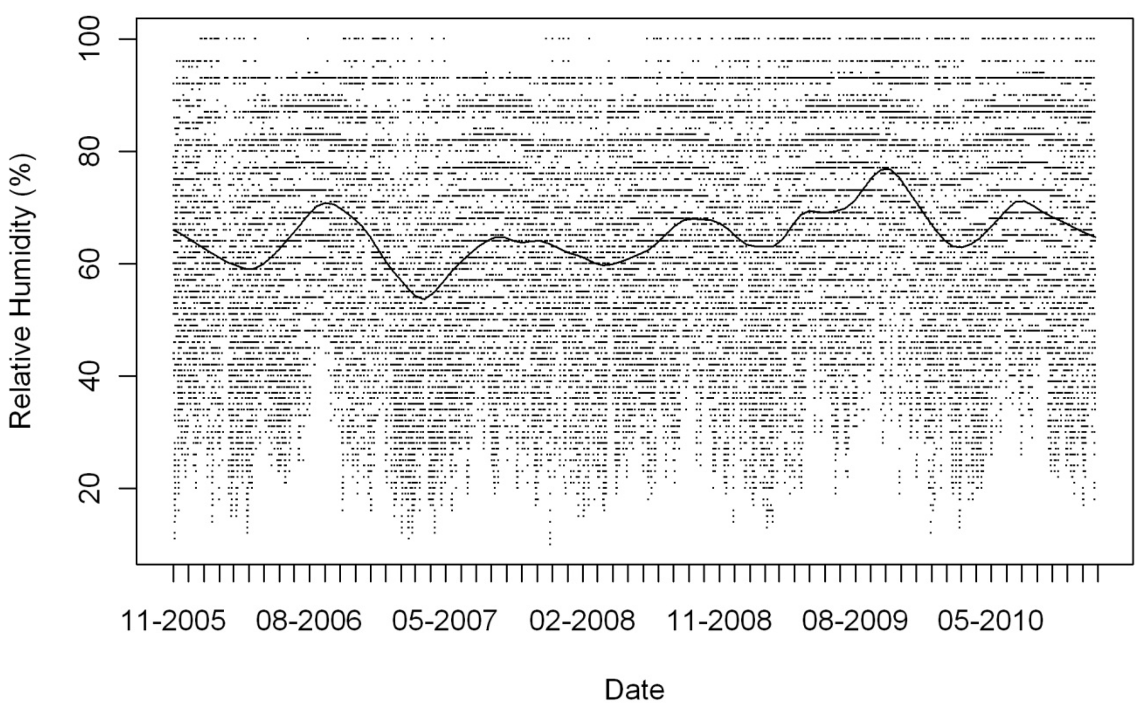


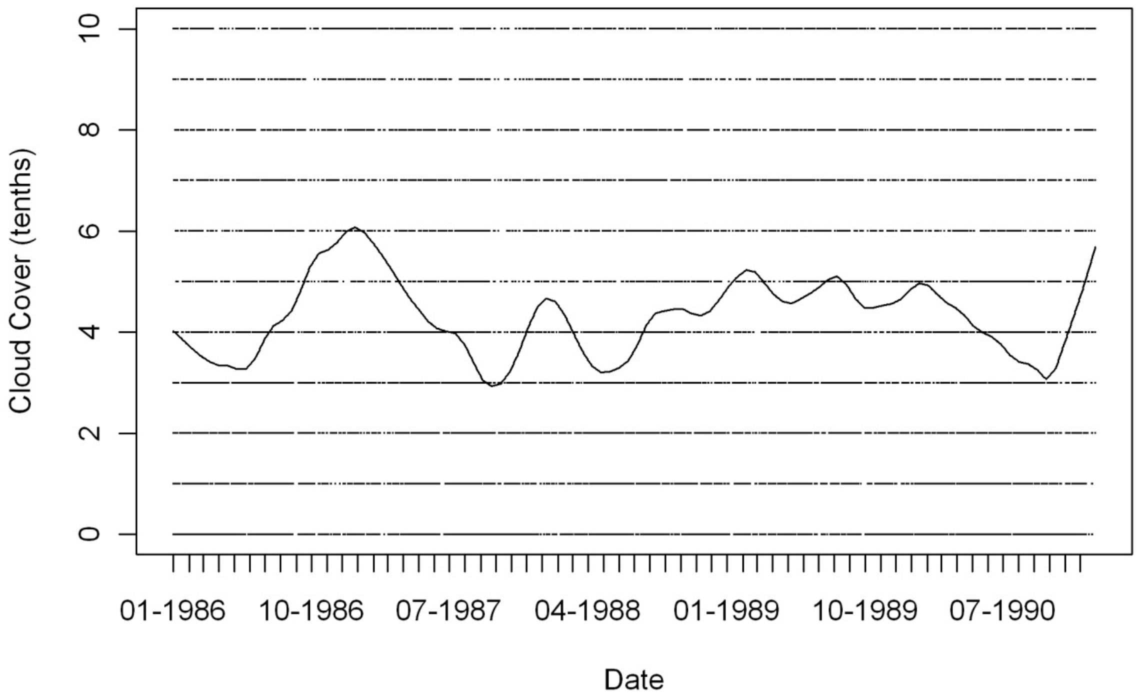
Figure D14. Relative Humidity

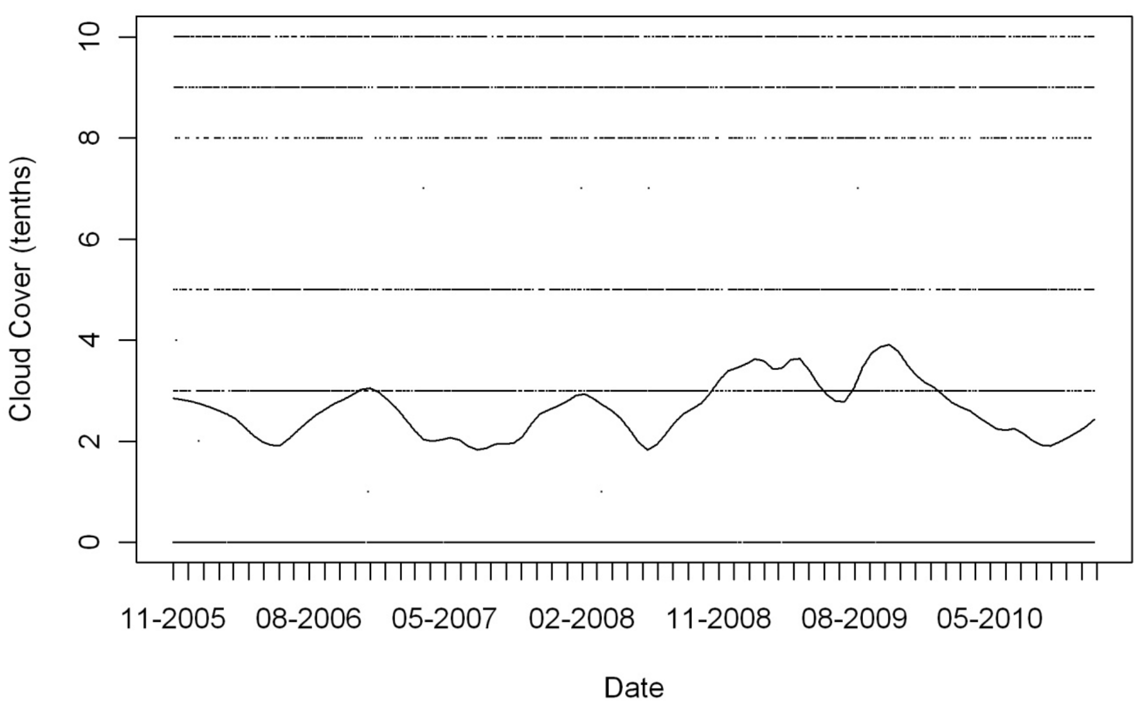




Date

Figure D15. Cloud Cover





Date

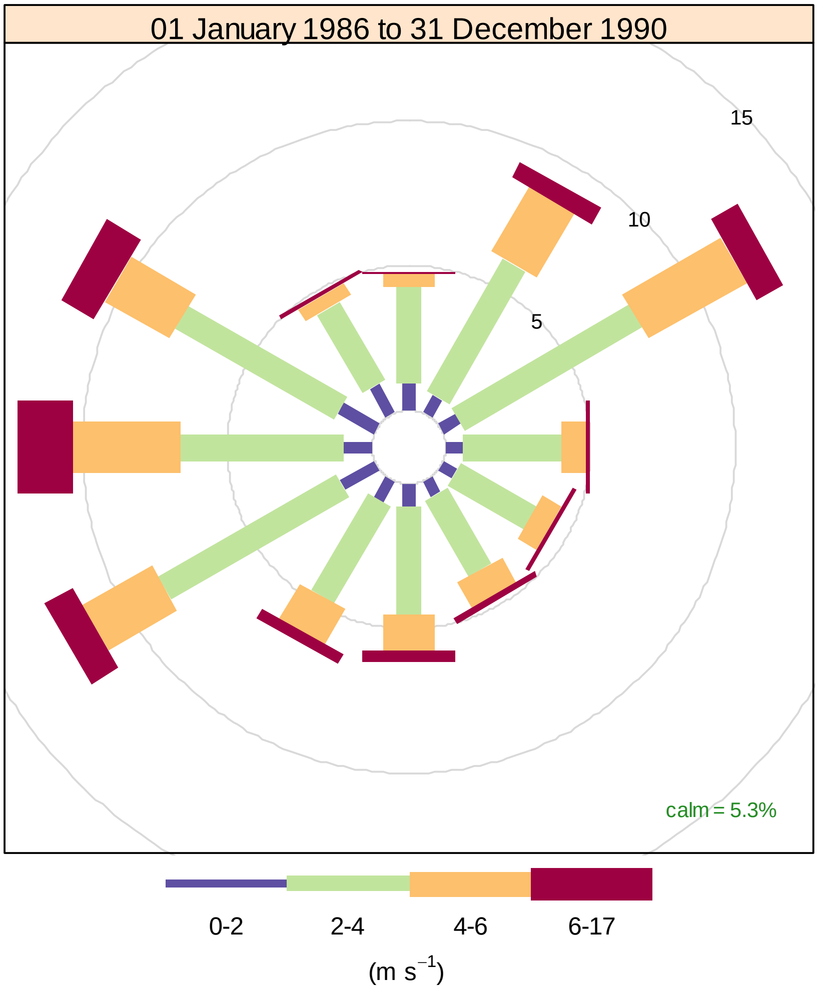


Figure D16. Windrose Jan 1, 1986 to December 31, 1990

Surface Station: Athens/Ben-Epps Airport
Upper Air Station: Peachtree City, GA
Period: 2005-2010

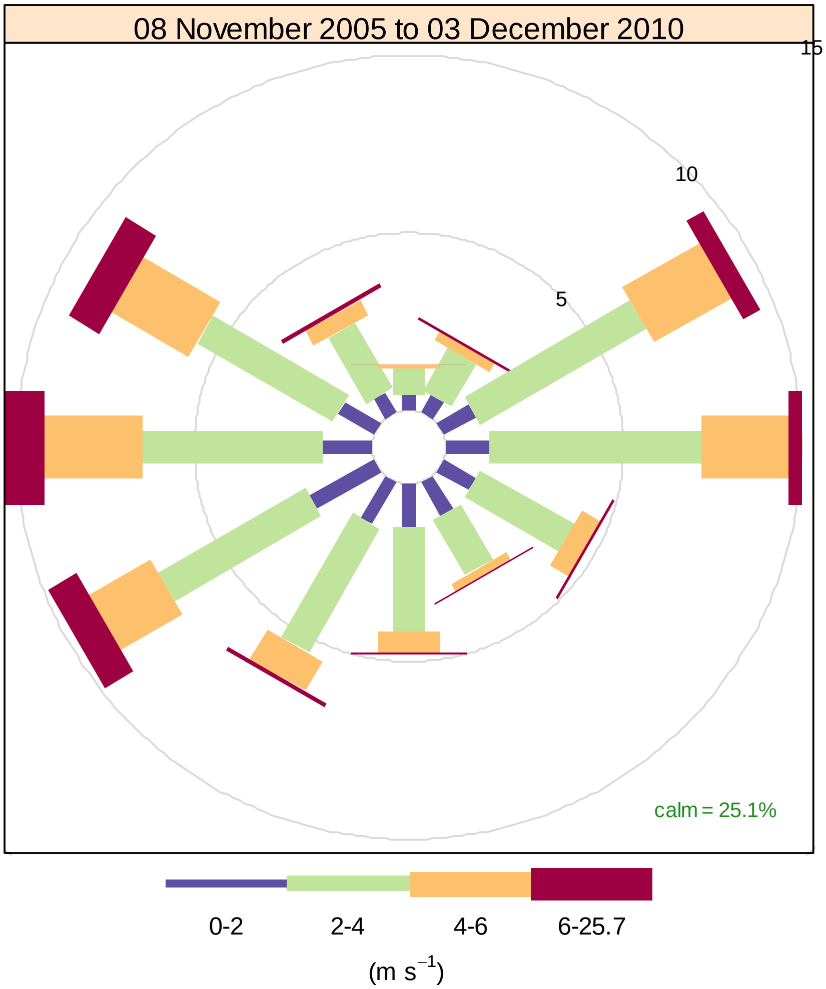


Figure D17. Windrose November 8, 2005 to December 3, 2010

Surface Station: Athens/Ben-Epps Airport
Upper Air Station: Peachtree City, GA
Period: 2005-2010

Figure D18. Maximum 24-hour Formaldehyde Concentrations (μg/m^3) using 2005 to 2010 Meteorological Data

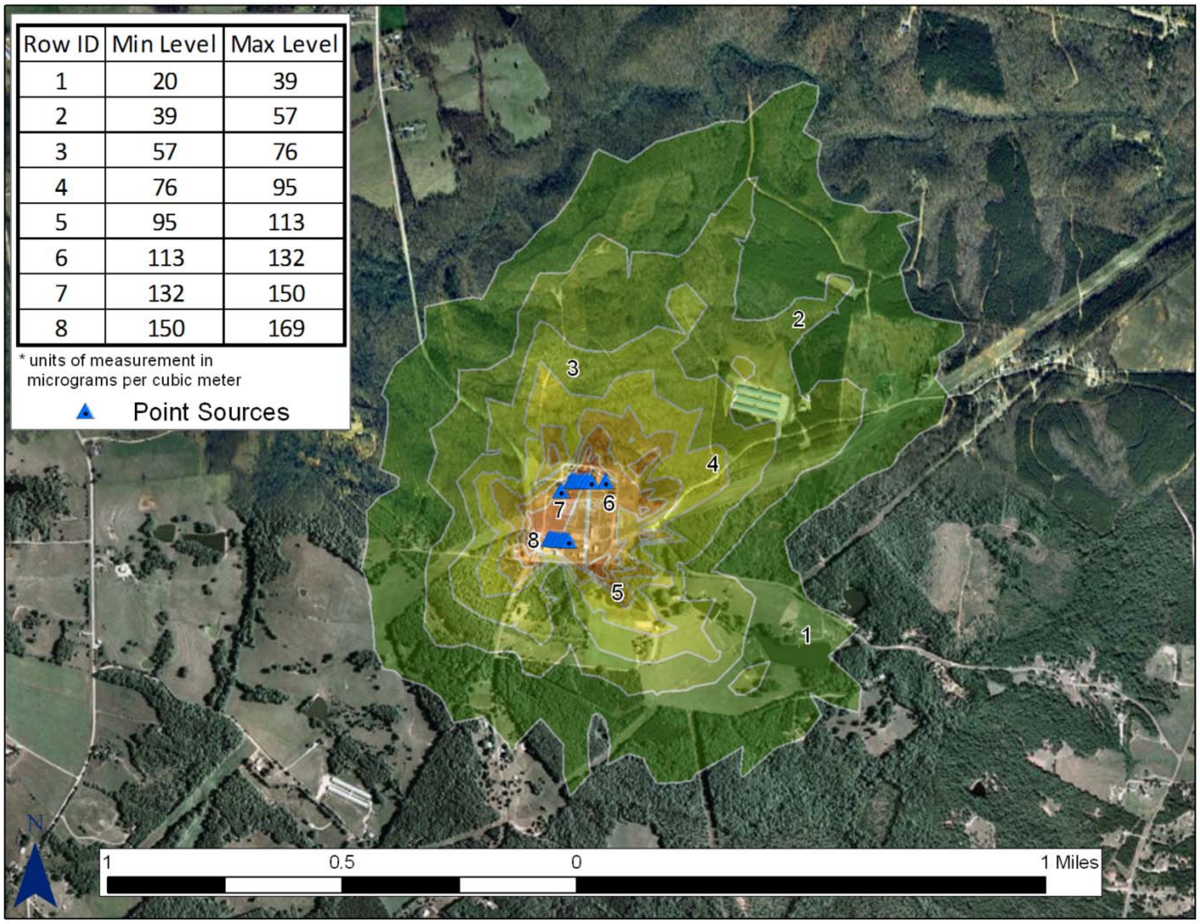
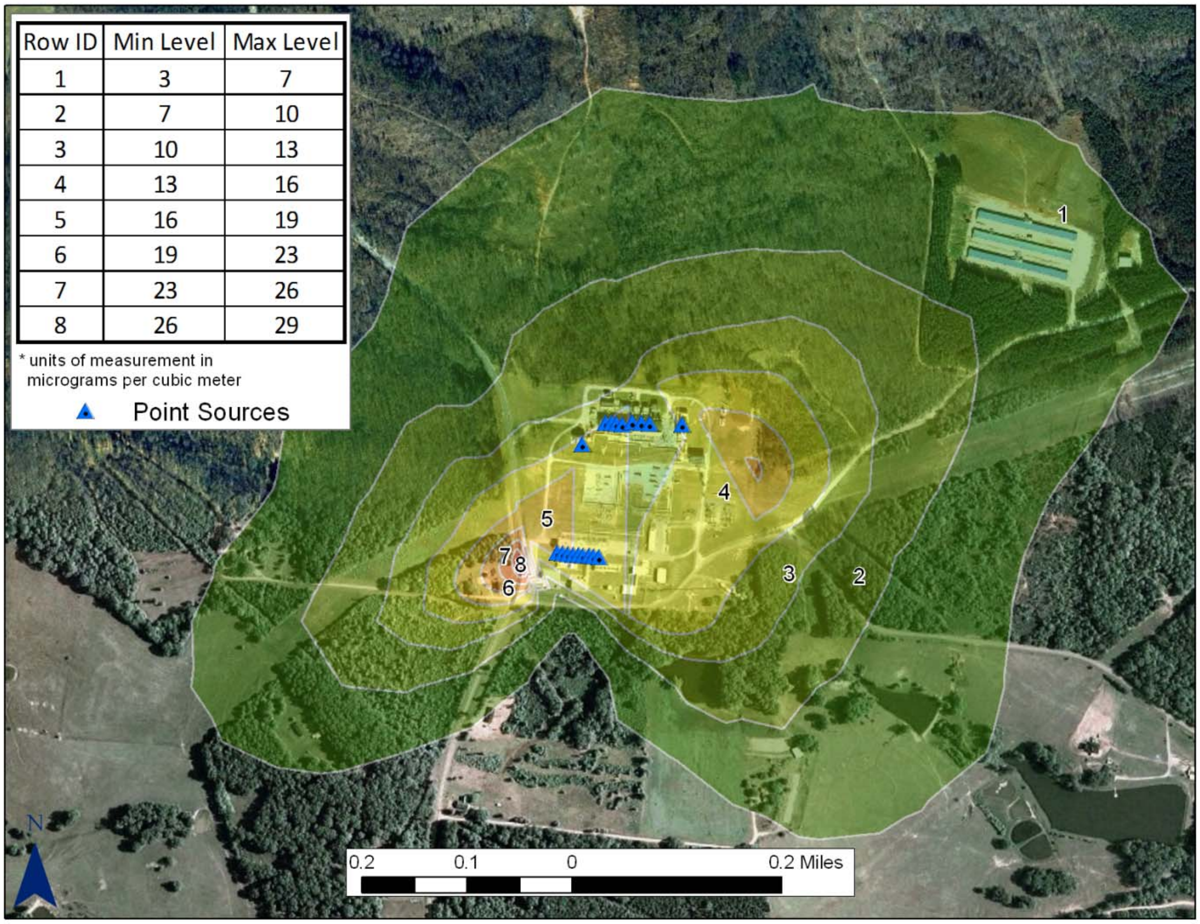


Figure D19. 5-Year Average Formaldehyde Concentrations (μg/m³) using 2005 to 2010 Meteorological Data



Appendix E. Table of Formaldehyde Inhalation Comparison Values

Table E1. Formaldehyde Inhalation Comparison Levels		
Inhalation Comparison	**Level**	**Reference**
Acute		
ATSDR Acute MRL (1 day to 2 weeks)	50 ug/m^3 (0.04 ppm)	ATSDR 1999
OSHA Permissible Exposure Limit (PEL) Adjusted for Residential Exposure	219 µg/m^3 (0.18 ppm)	GADNR 1998
OSHA PEL (TWA, 8 hr) (Worker Exposure)	918 ug/m^3 (0.75 ppm)	OSHA 2010
Odor Threshold	612 to 1,224 ug/m^3 (0.5 to 1 ppm)	ATSDR 1999
Irritation Level	612 to 1,224 ug/m^3 (0.5 to 1 ppm)	ATSDR 1999
Acute Exposure Guideline Level (AEGL-1) (Exposures up to 8 hours)	1,100 µg/m^3 (0.9 ppm)	EPA 20008
OSHA Short Term Exposure Limit (STEL) (15 min) (Worker Exposure)	2,454 ug/m^3 (2 ppm)	OSHA 2010
Immediate Irritation Level	12,245 to 24,490 µg/m^3 (10 to 20 ppm)	NIOSH 1996 Sullivan 2001
Chronic		
ATSDR Chronic MRL (LOAEL plus a safety factor of 30)	10 ug/m^3 (0.008 ppm)	ATSDR 1999
Ambient (Outdoor) Air Levels (Georgia)	17 and 24 µg/m^3 (0.014 to 0.02 ppm)	GADNR 2008
Ambient (Outdoor) Air Levels (U.S.)	12 to 37 ug/m^3 (0.01 to 0.03 ppm)	Sullivan 2001
Indoor Air Levels (U.S.)	123 to 612 ug/m^3 (0.1 to 0.5 ppm) Average standard home of 86 ug/m^3 (0.07 ppm)	Sullivan 2001
Lowest-Observed-Adverse-Effect Levels (LOAEL)	295 ug/m^3 (0.24 ppm)	ATSDR 1999
Cancer Effect Level	12,270 ug/m^3 (10 ppm)	ATSDR 1999

Appendix F – Exposure Profile Frequency of a Populated Receptor

To better understand the frequency of model predicted formaldehyde exposures, the AERMOD model was re-run with a single receptor located at the nearest residential property. A threshold table was generated where any hourly exposure greater than zero was recorded. This table was merged with the surface file in R [R Development Core Team 2010]. Calendar plots showing 24 hour concentrations (Figures F-1 through F-5) and time series showing the hourly (Figure F-6) and daily average (Figure F-7) formaldehyde concentrations were generated using the Open Air package in R [Carslaw, D, Ropkins, K 2010].

AERMOD formaldehyde maximum air levels at the nearest residential property averaged 7 µg/m^{3}over the five year period modeled (1986-1990). Although the average concentration of formaldehyde was below the chronic ATSDR Minimal Risk Level (MRL), the 24-hour average exceeded the acute MRL of 50 µg/m^3 on 5 days over the 5 year period (including the background concentration of 1.5 µg/m^3). The predicted 24-hr median concentration was 3.35 µg/m^3 and the 75th percentile was 11.56 µg/m^3(including the background concentration of 1.5 µg/m^3).

Hourly levels at the nearest residential property ranged from 0.00017 to 394 µg/m^3 and exceeded 50 µg/m^3 on 2,226 hours over the 5 year modeling period (no more than 5% of the time). The predicted hourly median concentration was 1.8 µg/m^3 and the 75th percentile was 2.83 µg/m^3 (including the background concentration of 1.5 µg/m^3).

Using the time variation function in Open Air, we analyzed for monthly, diurnal, and day of the week trends (Figure F8). This analysis shows that AERMOD predicted concentrations, on average, tended strongly to be higher in the morning period and seasonal variation favored higher concentrations in August, September, and October.

Figure F1

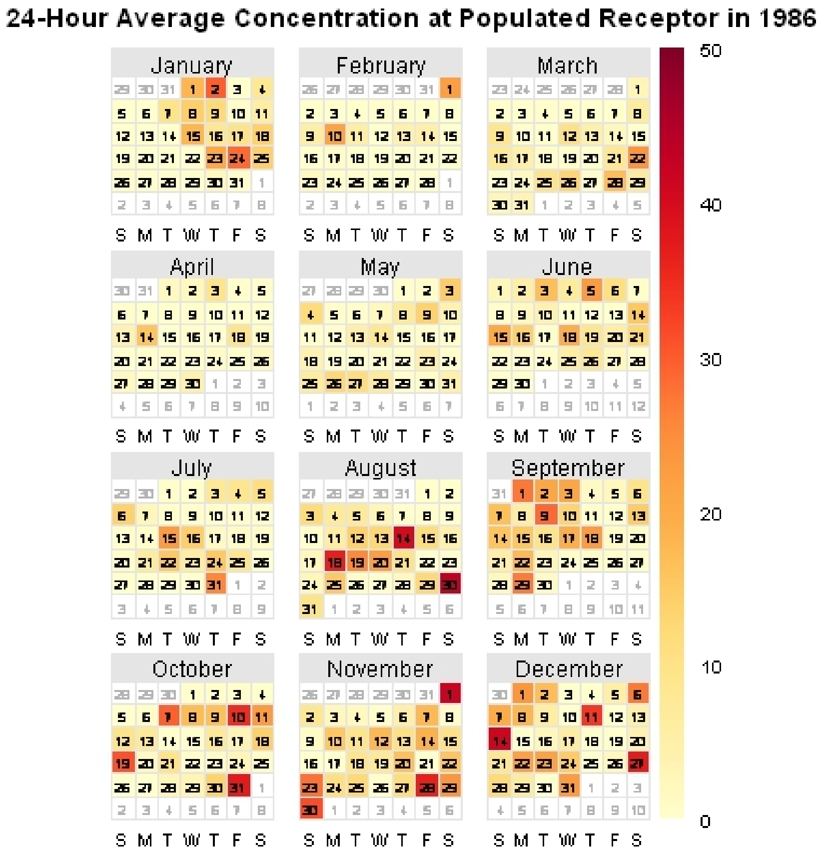


Figure F2

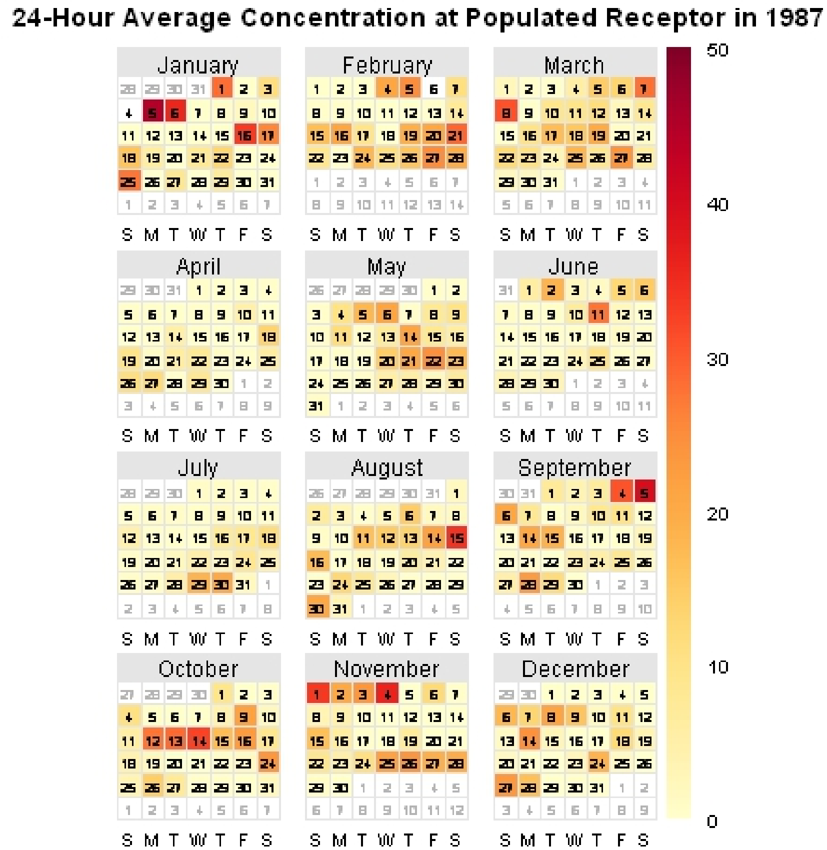


Figure F3

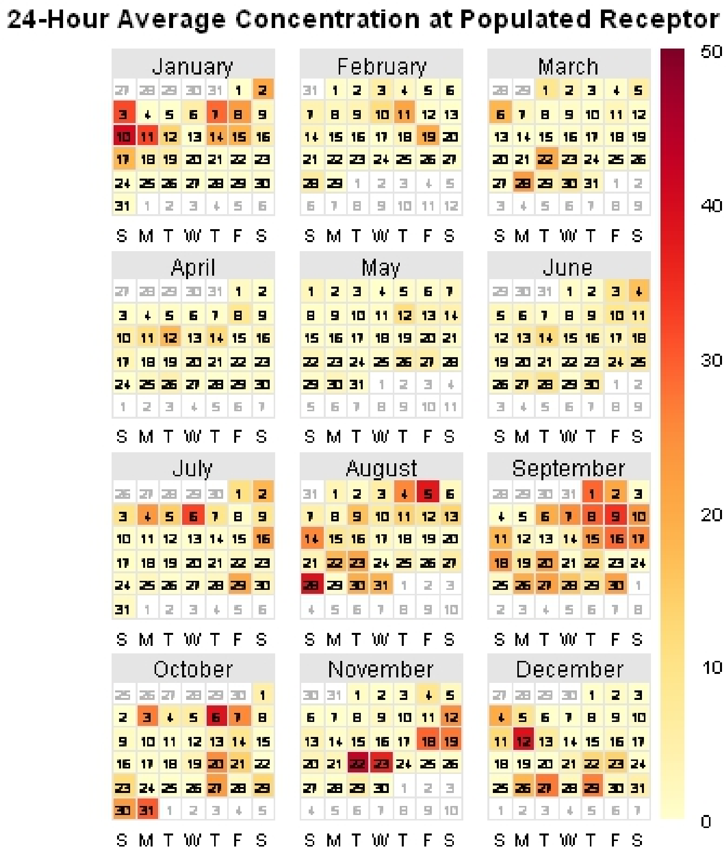


Figure F4

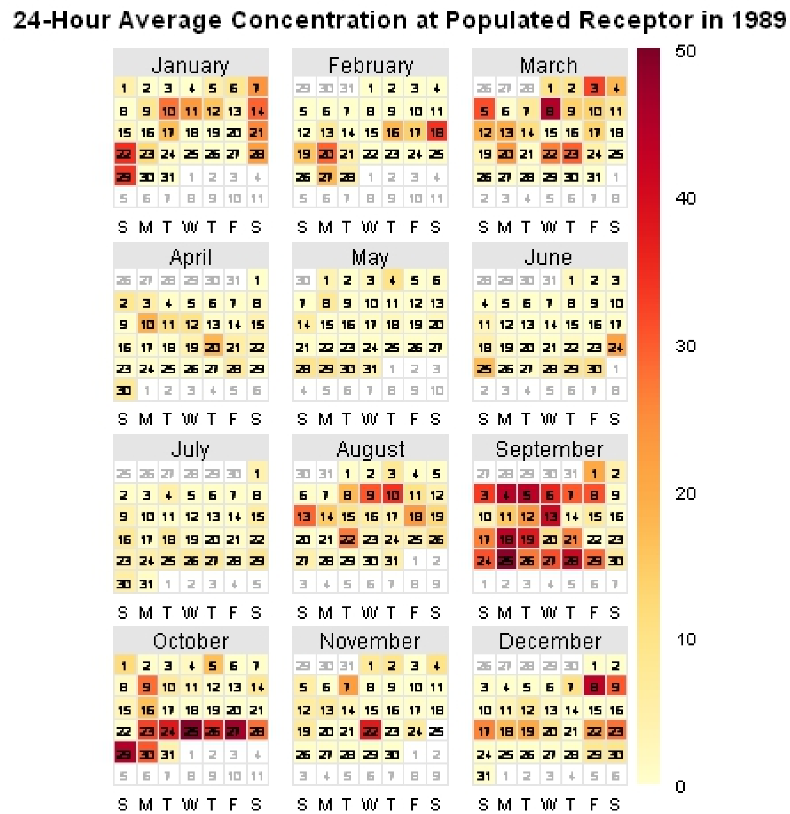


Figure F-5

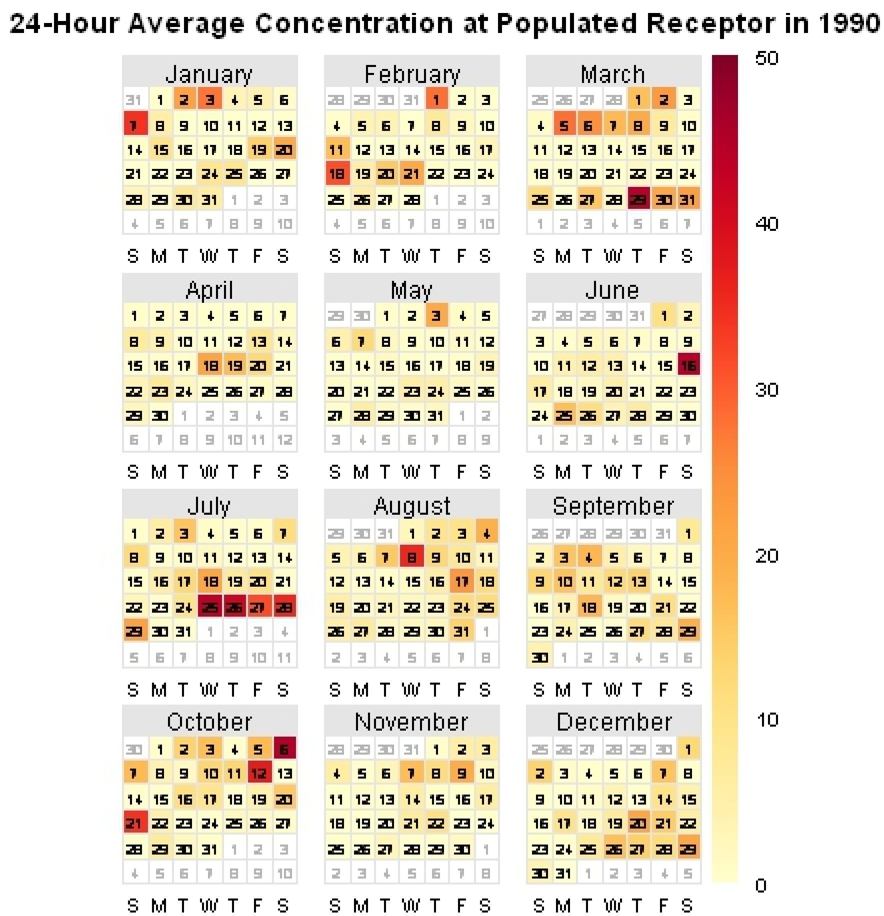

24-Hour Average Concentration at Populated Receptor in 1990
January
February
March
April
May
June
July
August
September
October
November
December
S M T W T F S
50
40
30
20
10
0

Figure F6. Hourly Formaldehyde Air Concentrations at Closed Populated Receptor (μg/m³)

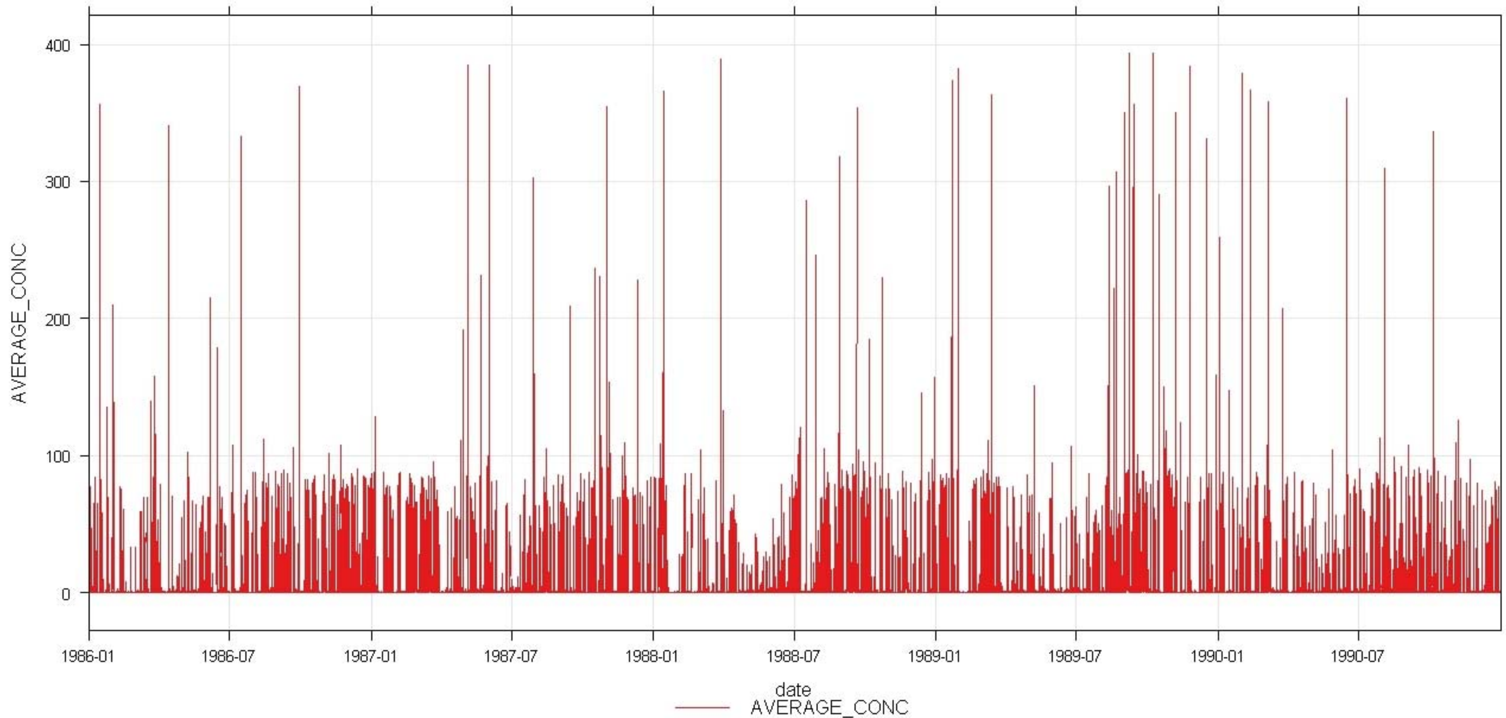


Figure F7. Daily (24 hour) Formaldehyde Air Concentrations at Closed Populated Receptor ($\mu g/m^3$)

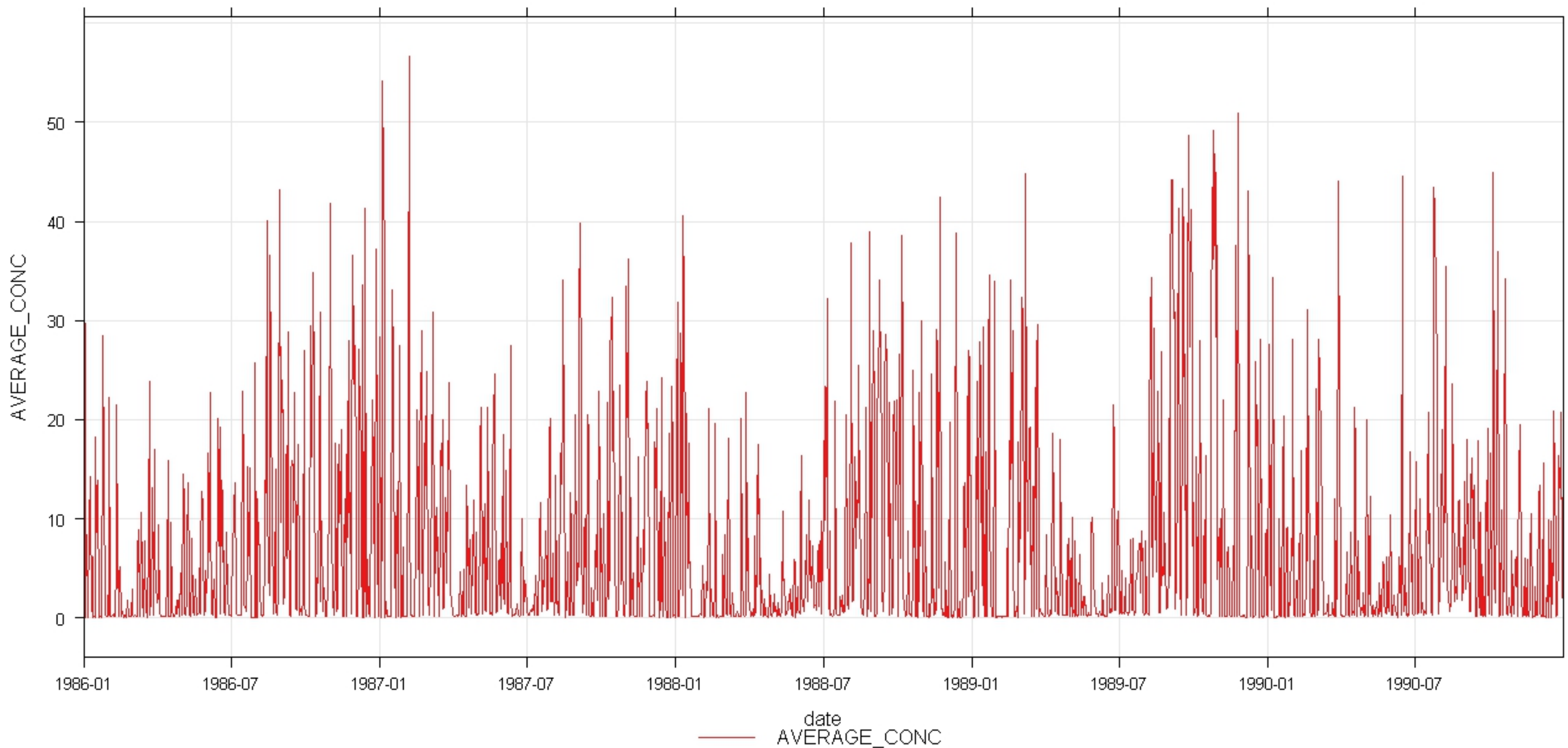


Figure F8: Model Predicted Average Formaldehyde Concentrations – Time Variation Analysis