2020-2024 AERMOD Meteorological Data

Technical Support Document

Alyssa Jensen and Brad Ashton

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Iowa Department of Natural Resources

Contents

Introduction

This document serves as a technical discussion of the methodology used to process the 2020-2024 meteorological data for AERMOD. It focuses on those portions of the process that are not described in the AERMET user guide, or where the instructions in the AERMET user guide were expanded upon. These topics include:

- Data acquisition
- Representativity analysis
- Filling missing data
- Use of AERMINUTE to process 1-minute wind data
- Land-use analysis
- Land cover data analysis
- Analysis of the expected changes in AERMOD predictions as a result of using the new meteorological data

For a detailed description of the methodology used to process meteorological data using EPA’s AERMET preprocessor, please refer to the AERMET user guide.

Data Acquisition

Meteorological Data - Hourly Surface

The 2020-2024 surface meteorological data were obtained from the National Oceanic and Atmospheric Administration (NOAA) National Centers for Environmental Information (NCEI) (1). The Integrated Surface Hourly (ISH) data was chosen because it is the most comprehensive format available that is compatible with AERMET. This dataset was downloaded as compressed files from the NCEI's online bulk download directory (2). A total of 118 surface observation stations in and around Iowa were extracted from the compressed files.

Meteorological Data - Upper Air

The 2020-2024 upper air data were obtained from the NCEI's online Integrated Global Radiosonde Archive (IGRA) data access site (3). The Forecast Systems Laboratory (FSL) format was discontinued and the IGRA is the only upper air available. The data are provided as a bulk download of all upper air soundings for all years and times (both 6Z and 12Z). The 2020-2024 soundings were extracted from the data for a total of four upper-air observation stations in and around Iowa (Davenport, IA; Lincoln, IL; Minneapolis, MN; and Omaha, NE).

Meteorological Data - 1-Minute Surface

The 2020-2024 1-minute wind data were obtained from the NCEI's online bulk download directory (4). This dataset was obtained as a series of text files. The data is not available for all locations. Of the 20 surface observation stations ultimately chosen for this round, 1-minute data was available and downloaded for 18 stations: KALO, KAMW, KBRL, KCID, KDBQ, KDSM, KDVN, KEST, KFSD, KIOW, KLWD, KMCW, KMIW, KMLI, KOMA, KOTM, KSPW and KSUX (1-minute data was not available at KHNR and KFOD).

Land Cover Data

Land cover data were obtained from the Multi-Resolution Land Characteristics (MRLC) Consortium (5). AERSURFACE has been updated to use the most recent land cover data. The land cover data are from the 2024 National Land Cover Dataset (NLCD 2024), and were obtained in GEOTIFF format to ensure compatibility with the AERSURFACE preprocessor (6).

Representativity Analysis

A representativity analysis was conducted in preparation for the processing of new meteorological data for use in the AERMOD dispersion model. The analysis was conducted to determine which surface and upper air measurement sites should represent the various areas of the state, and was conducted prior to processing the data for AERMOD. As such, the results of this analysis were also utilized as a guide when making decisions related to filling missing data.

As stated in the Guideline on Air Quality Models “the meteorological data used as input to a dispersion model should be selected on the basis of spatial and climatological (temporal) representativeness as well as the ability of the individual parameters selected to characterize the transport and dispersion conditions in the area of concern” (7). Furthermore, representativeness has been defined as “the extent to which a set of measurements taken in a space-time domain reflects the actual conditions in the same or different space-time domain taken on a scale appropriate for a specific application” (8). In other words, the goal of the meteorological dataset used in a model such as AERMOD is to provide a statistically suitable sample of the range of meteorological conditions that could occur within the modeling domain, and the frequency with which they tend to occur. The representativity of meteorological data is influenced by the following factors (7):

- Exposure of the instruments at the meteorological monitoring site
- Temporal proximity to the period being modeled
- Geographic features and land cover in the vicinity of the meteorological monitoring site
- Spatial proximity to the area being modeled

Instrument Exposure

All surface stations used in the development of the 2020-2024 AERMOD meteorological data were either ASOS (Automated Surface Observing System) or AWOS (Automated Weather Observing System), and all are located at airports in and around Iowa. Airport-based ASOS and AWOS stations are purposely sited with good exposure so that they provide accurate weather information for the aviation community, therefore instrument exposure would not affect the representativeness of this dataset.

Temporal Proximity

At the time that these data were obtained, 2024 was the most recent complete year available. Therefore, the years 2020-2024 were used in the processing of the AERMOD meteorological data sets.

Geographic Features, Land Cover, and Spatial Proximity

An objective technique using wind roses as a surrogate for the effects of local geographic features and land cover was developed to determine the best meteorological data to represent the various areas of the state. The premise of this technique is that similar wind roses from different locations are an indication that both sites are influenced by similar conditions attributable to the mesoscale flow, the geographic features, and land cover in the vicinity of each observation site. Therefore, meteorological observations made at one site would be considered representative of the other site.

Correlating Observations between Different Measurement Sites

Before the similarity of the wind roses can be determined it is first necessary to collect data from a large enough number of locations to provide adequate horizontal resolution of the wind patterns in the state. Ideally, there should be at least one observation site in each area for which representativeness will be determined. Historically, representativeness has been determined at the county level with the boundaries of the representative areas being defined by the county borders. Unfortunately, there is not a meteorological station located in every county in Iowa, so the focus was placed on finding the largest number of sites where data are collected in as similar a fashion as possible. This provides a reasonably large sample while also minimizing biases caused by siting or data collection differences. ASOS and AWOS sites are conveniently similar in both data availability and siting criteria. Therefore, wind roses were created for a total of 118 ASOS and AWOS sites in and around Iowa using Trinity Consultants’ BREEZE MetView program (9).

To avoid introducing biases, all wind roses were created from the raw ISH data for each site without filling gaps with data from surrounding locations. The wind roses were created using the joint frequency distribution of the wind data at each location. The wind rose joint frequency data show the percentages of time that the wind was observed for each combination of wind direction and speed. The similarity of each pair of wind roses was determined by calculating the correlation coefficient of the joint frequency data. A higher correlation indicates the wind roses are more similar in both shape and magnitude (frequency of wind direction and wind speed), whereas a lower correlation indicates they are more dissimilar.

For example, the wind roses in **Figure 1** are very similar, and have a correlation coefficient of 0.928. These are from Creston, IA (left) and Oskaloosa, IA (right).

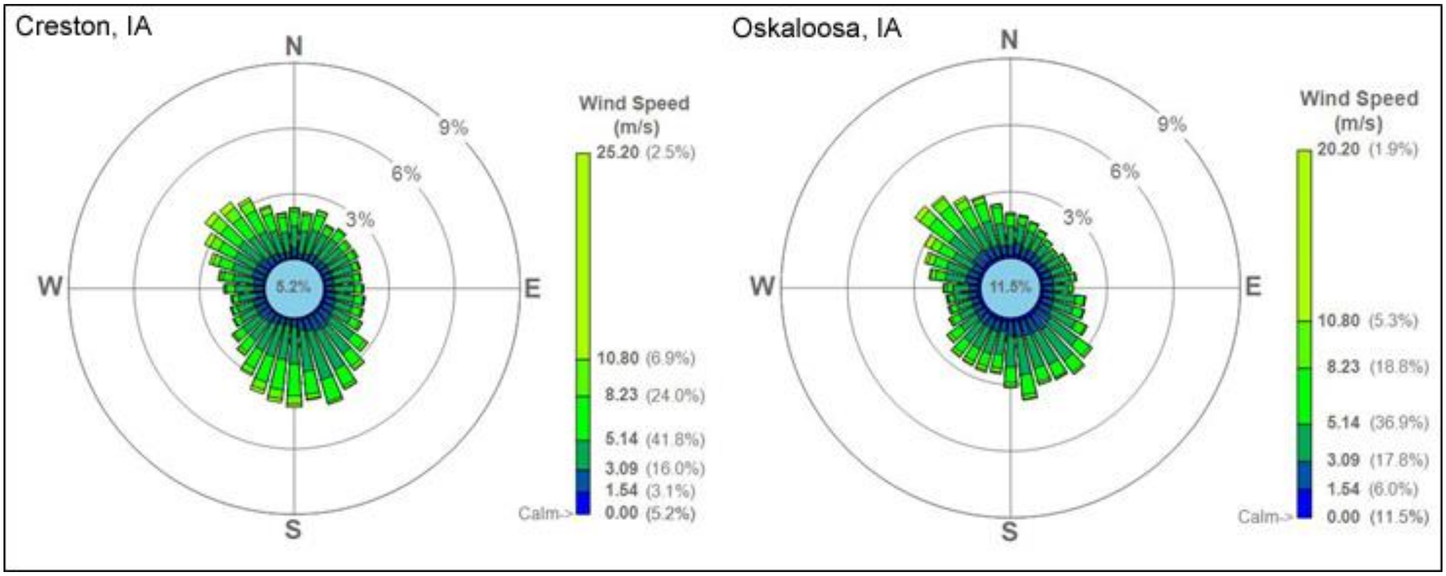


Figure 1. Wind Roses for Creston, IA (KCSQ) and Oskaloosa, IA (KOOA)

On the other hand, the wind roses in **Figure 2** are very dissimilar, and have a correlation coefficient of 0.27. These are from Clarion, IA (left) and Boscobel, WI (right).

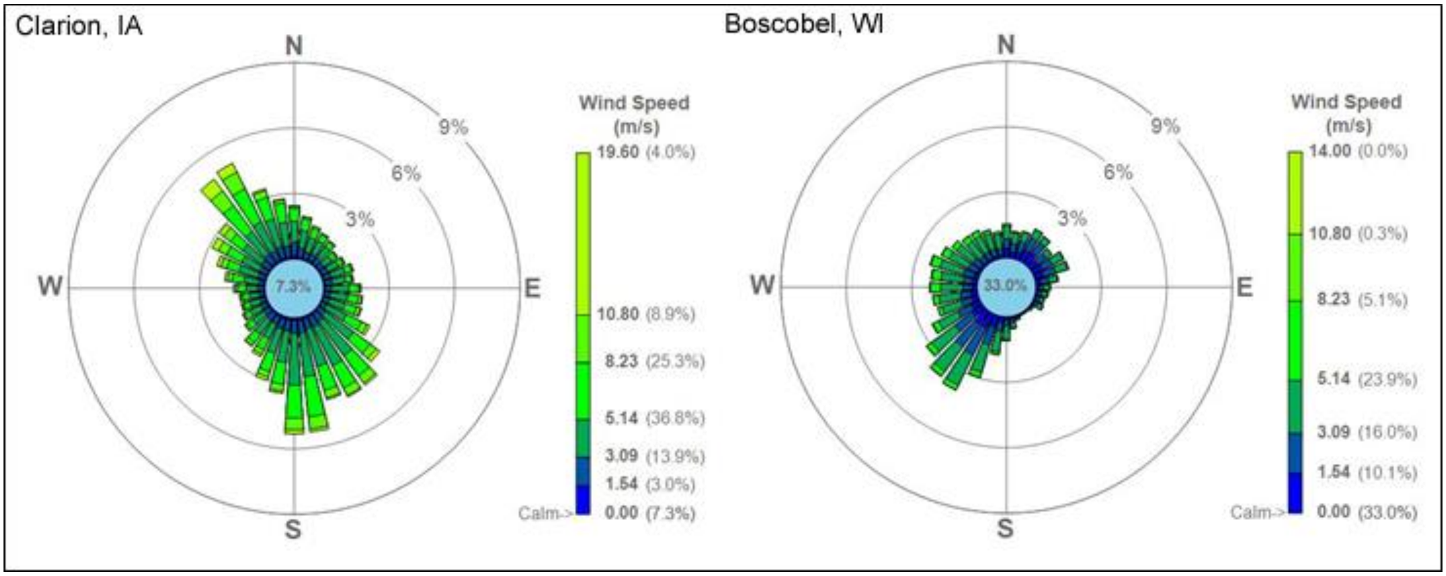


Figure 2. Wind Roses for Clarion, IA (KCAV) and Boscobel, WI (KOVS)

Generally, correlation coefficients of 0.9 or higher were observed when two wind roses were very similar, and 0.8 or higher when only mild differences were observed between two wind roses. The differences between wind roses became more evident when the correlation coefficient was less than 0.8. For these reasons, 0.9 and 0.8 were chosen as thresholds to indicate ideal and good similarity, respectively. These criteria were then used as a baseline for the remainder of this analysis.

Spatial proximity

Appendix A summarizes an analysis used to determine the effect of separation distance on the correlation of meteorological variables (temperature, pressure, and cloud cover). The analysis shows that the correlation of these variables between two sites will drop to 0.8 when the distance between them is approximately 284 km. This observation was used as a distance-weighted scaling factor in the representativity analysis. For more detailed information on the analysis please refer to appendix A.

Selection of AERMOD Meteorological Sites

For various reasons, only a portion of the 118 sites for which wind roses were created could be used to process data for use in AERMOD. The following factors were considered when determining which of the sites would be further analyzed for use in the model:

- Existence of concurrent 1-minute data.
- Fulfillment of the 90% data completeness criterion.
- Correlation of the wind roses.

Of the 118 sites, 20 were chosen for processing (see **Table 1**). These include one site not used in the 2015-2019 dataset (Harlan, IA), and two that are now being excluded (Blair, NE and Decorah, IA). Harlan did not meet the 90% completeness criterion for that previous five-year dataset, but does for the 2020-2024 timeframe. Additionally, Harlan replaces many of the Iowa counties previously represented by the Blair, NE site in the 2015-2019 dataset. Since Harlan is located in western Iowa it is more representative of the nearby counties in that area. The elimination of Decorah is a prudent decision given its limited historical use (once in the past five years, for a portable plant analysis) and the time savings gained by foregoing the data processing, gap-filling, and AERMOD analyses conducted for each representative site.

All but two of the chosen sites have 1-minute data available (KHNR and KFOD). For those two sites, sub-hourly ASOS wind data was obtained from the Iowa Environmental Mesonet (IEM). This data was processed manually to approximate the average wind conditions for each hour that would have been produced had 1-minute data been available.

For the 2020-2024 dataset there were many sites that were chosen but did not initially meet 90% completeness: KALO, KDBQ, KFOD, KMCW, KMIW, KMLI, KOMA, KOTM, KSPW and KSUX. This was a large increase from the last dataset. AERMET only pulls the last reading in an hour therefore if that reading is missing the whole hour is missing even if sub hourly readings were present in the raw data. The DNR created a tool to pull sub hourly data when the last reading was missing to get more accurate idea of the completeness of each data set. After each dataset was run through the tool the following sites still didn't meet the 90% completeness: KFOD, KMIW and KOTM. KFOD was not complete for the 2024 year for temperature and dew points, the Road Weather Information System (RWIS) site in Fort Dodge was used to supplement the missing data and the KFOD data and now meets 90% completeness. KMIW total observations for the 3rd quarter in 2020 was at 89.58%. KIFA (Iowa Falls) has a high correlation (92%) with KMIW and therefore KIFA data was used to fill in the missing data and now meets the 90% completeness. For KOTM, cloud cover and ceiling were only 86% complete in Q2 of 2022. KFFL (Fairfield) has a high correlation (95%) between with KOTM and was used to fill the missing data and now meets 90% completeness

Table 1. The 20 Surface Stations Used to Process Data for AERMOD

Station	Call Sign
Ames, IA	KAMW
Burlington, IA	KBRL
Cedar Rapids, IA	KCID
Davenport, IA	KDVN
Des Moines, IA	KDSM
Dubuque, IA	KDBQ
Estherville, IA	KEST
Fort Dodge, IA	KFOD
Harlan, IA	KHNR
Iowa City, IA	KIOW
Lamoni, IA	KLWD
Marshalltown, IA	KMIW
Mason City, IA	KMCW
Moline, IL	KMLI
Omaha, NE	KOMA
Ottumwa, IA	KOTM
Sioux City, IA	KSUX
Sioux Falls, SD	KFSD
Spencer, IA	KSPW
Waterloo, IA	KALO

Determination of the Areas Represented by Each Meteorological Site

The final step in the process was to use the distance-weighted correlation coefficients to determine those portions of the state for which each meteorological station listed in **Table 1** is representative. County borders are used as boundaries to determine which meteorological dataset to use for various areas of the state. However, research conducted by the Iowa DNR shows that parts of the Missouri and Mississippi River Valley need specific meteorological data.

In order to determine if a meteorological site is influenced by a river valley, an analysis was performed to find an objective method for determining when a site is influenced by river valley terrain. The wind patterns are quantified using a diurnal temperature in order to calculate an index value for every wind direction. This analysis shows a valley depth of 60 meters (or greater) tends to be influenced by the valley. The 60-meter depth threshold is used to identify the portions of the Mississippi and Missouri River valleys that are influenced by river valley terrain. Counties in Iowa affected by river valley wind channeling were subdivided into a portion of the county represented by a valley site and the remaining portion represented by a non-valley site.

In order to determine which areas of the state would be represented by each meteorological site the distance-weighted correlation coefficient data were input into Golden Software's Surfer program (10). Using this program, a grid was placed across the entire state with grid nodes in the center of each county. Surfer was then used to calculate the distance-weighted correlation coefficient at each grid point for each meteorological site listed in **Table 1**.

In most cases, the meteorological site with the highest distance-weighted correlation coefficient at each grid point was then assigned as the most representative site for that county. In some cases, there were two or more meteorological sites that were estimated to be similarly representative. When this occurred, the chosen site was often the location that would prevent a meteorological site from representing multiple non-contiguous areas of the state. The resulting representative areas are depicted in **Figure 3**.

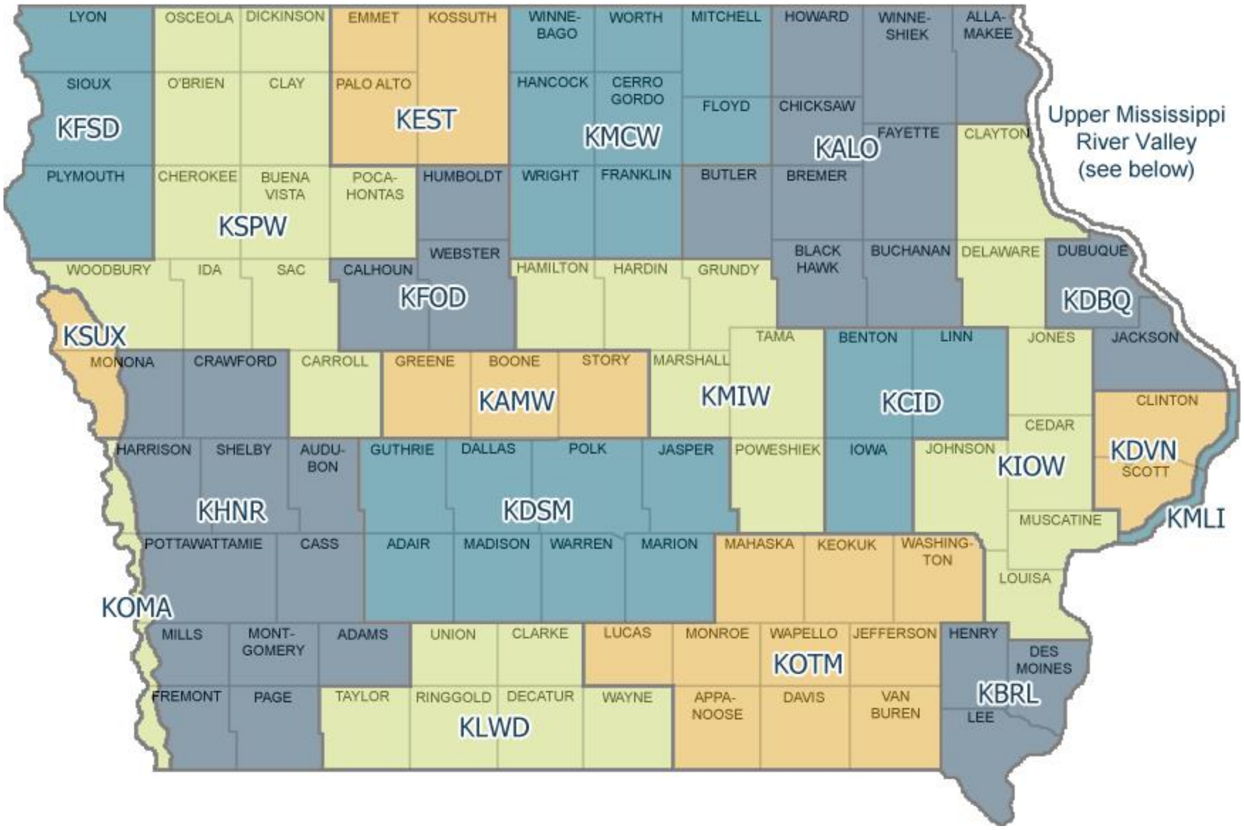


Figure 3. Representative Areas for the 2020-2024 AERMOD Meteorological Dataset

For those counties that were subdivided into valley and non-valley areas, the edge of the flood plain defines the border of the corresponding representative area. These meteorological stations in **Figure 3** are KMLI, KOMA, and KSUX. For areas on the map where the county is subdivided, a modeling analysis with sources located within the floodplain would use the meteorological data from the subdivision representing the river valley in that area, and an analysis with sources located anywhere other than the floodplain would use the meteorological data from the subdivision representing the remainder of the county. The abrupt increase in elevation adjacent to the floodplain used to define the boundary can be determined by inspecting topographic maps of the area.

Note, that there is no representative meteorological site for the Upper Mississippi River Valley (designated in **Figure 3**). For projects in this area the DNR recommends modeling all six sites closest to the upper Mississippi River Valley (KALO, KCID, KDBQ, KDVN, KIOW and KMLI) to produce a conservative estimate in lieu of a representative result. If an applicant would like to use different meteorological data than the six listed, please contact the DNR.

The distance-weighted correlation coefficient of the chosen representative site for each area is depicted in **Figure 4**. Areas where the distance-weighted correlation is 0.9 or greater are shaded in blue. Areas where the distance-weighted correlation is 0.8 or greater, but less than 0.9 are shaded in green. Areas where the distance weighted correlation is less than 0.8 are not shaded. The red dots represent the valley-based meteorological stations used to represent the portions of the Missouri and Mississippi River valleys where the wind patterns are significantly affected by those valleys, and the black dots represent the remaining meteorological stations.

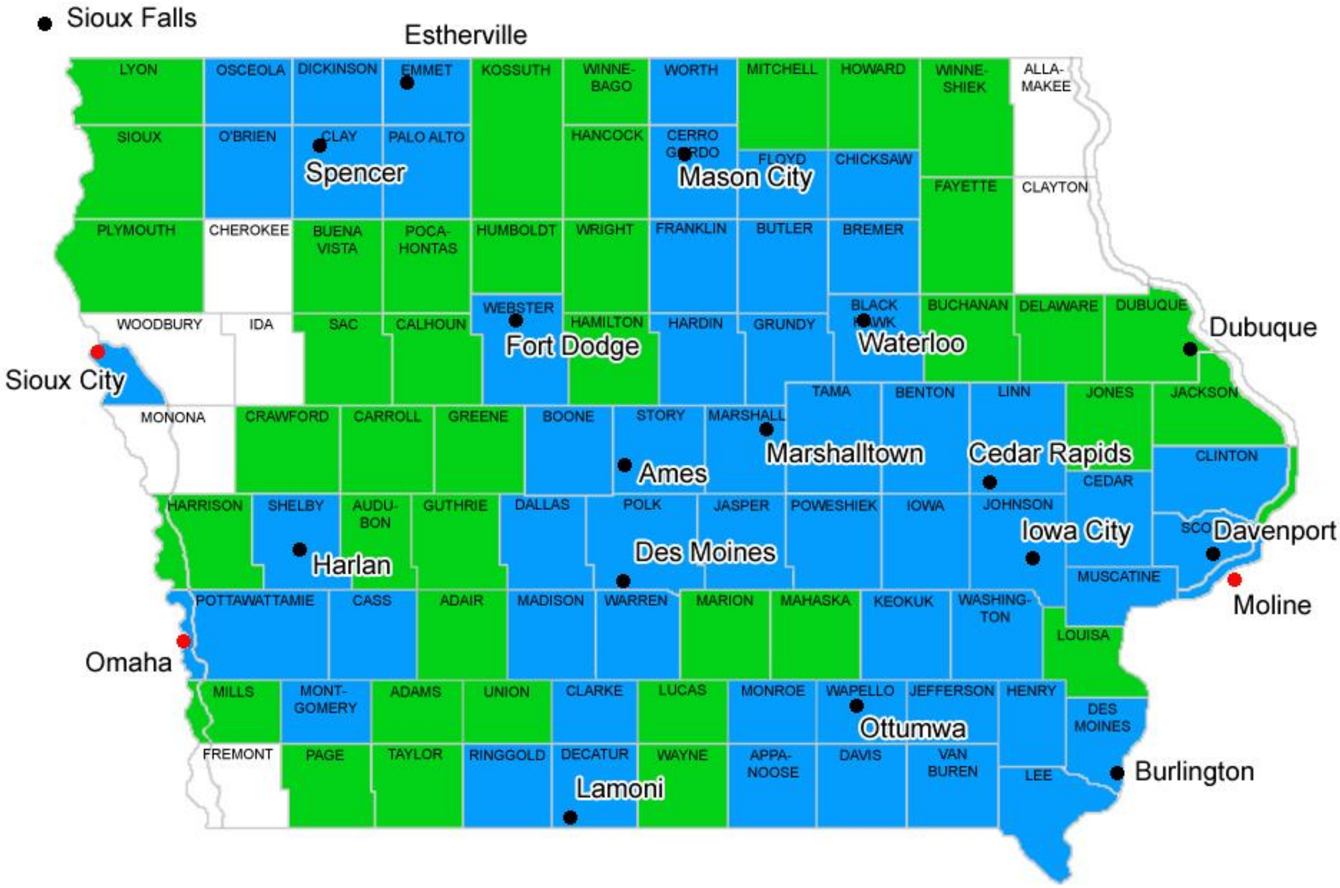


Figure 4. Distance-Weighted Correlation of Chosen Representative Sites

As shown by the map, approximately 92% of the state is represented by a meteorological station that is either ideally or well correlated (distance-weighted correlation coefficient greater than 0.9 or 0.8, respectively). Only about 8% is represented by less-correlated meteorological stations. This is mainly due to a lack of data in the NW portion of the state. The correlation in the NE portion of Iowa is below 0.8 because the DNR chose not to process Decorah, as discussed previously.

The representativeness of the upper air data was determined purely based on spatial proximity because the measurements are taken above the surface where local geographic features and land cover do not have an effect. The two nearest upper air sites are Omaha, NE and Davenport, IA. These data were applied to roughly the half of the state each is nearest to. The surface data from KAMW, KDSM, KEST, KFOD, KFSD, KHNR, KLWD, KMCW, KOMA, KSPW, and KSUX were paired with the Omaha upper air data. The surface data from KALO, KBRL, KCID, KDBQ, KDVN, KIOW, KMIW, KMLI, and KOTM were paired with the Davenport upper air data.

It should be noted that this representativity analysis is intended to provide a guide for general representativity only. The meteorological data assigned to each area of the state by this analysis is only representative to the extent that no local features would significantly alter the meteorological conditions in the area where it is to be applied. In this case, an alternative approach to meteorological data will need to be used. This could include on site data, using multiple different meteorological sets to ensure a conservative estimate or another approach.

Filling Missing Surface Data

Surface data were only filled for the 20 meteorological stations chosen during the representativity analysis (listed in **Table 1**). An Excel spreadsheet consisting of a series of embedded programs was used to fill all missing surface data. This program was developed in-house, and is called AERFILL.

The AERFILL program fills missing data using the recommendations in “Procedures for Substituting Values for Missing NWS Meteorological Data for Use in Regulatory Air Quality Models” by Dennis Atkinson and Russell F. Lee (11), and quality assures (QA) the results following the recommendations in EPA’s “Meteorological Monitoring Guidance for Regulatory Modeling Applications” document (12). Much of the data filling was performed automatically by AERFILL. Longer, or more problematic gaps, and most quality assurance related decisions, were addressed manually.

A new feature in AERFILL adds the ability to pull earlier readings within the hour. This is the first step before proceeding to other data filling methods, ranging from simple interpolations or persistence, to complicated spatially and temporally-weighted averages based on surrounding meteorological stations. In many instances, the data were filled based on the application of meteorological principles and techniques. Comments were included in the file indicating what method was used (one comment for each time the data were edited). The results of the representativity analysis were used to determine which alternate source of data was most likely to provide the best fit. Generally, data from the most representative station was available and was determined to be appropriate. If the data from the most representative neighboring station did not appear to fit or was also missing, the data from the next most representative station was evaluated. This process continued down the hierarchy of most representative stations until acceptable data were found.

After the data were completely filled, a QA procedure was executed. All QA flags were reviewed for relevance and importance. In most cases the flags did not signify inaccurate data, just extremes in the data due to the applicable weather conditions. The more questionable data were cross-checked with other sources of information including one or more of the following:

- The raw ISH data for the station in question.
- ASOS data from the IEM for the station in question.
- The raw ISH data for neighboring stations.
- ASOS data from the IEM for neighboring stations.
- AWOS/RWIS data from the IEM for neighboring stations.
- Weather Underground Past Data
- Iowa Mesonet Time Machine

If the data appeared to be meteorologically impossible or improbable, and could not be correlated with the cross-referenced sources, it was adjusted using data-filling schemes similar to those used to fill missing data. An example of this would be if the station pressure for five consecutive hours was 980.0 mb, 980.1 mb, 915.5 mb, 980.3 mb and 980.5 mb. In this case, it is clear that the third value is invalid, and would be replaced with a value of 980.2 mb.

If the data seemed to be meteorologically reasonable, or correlated with the cross-referenced sources, it was not modified. An example of this would be the occurrence of a cold front. A cold front could cause a rapid shift in pressure, temperature, wind, and cloud cover, all of which would be flagged by AERFILL’s QA routine, even though the data were valid.

After the QA was complete the data were exported from AERFILL in the format of an AERMET QA input file, ready to be merged with the 1-minute and upper air data.

Filling Missing Upper Air Data

The raw data from two sites (Davenport, IA and Omaha, NE) were processed using AERMET. The output from AERMET was then imported into Excel and sorted in order to create a list of available soundings at each location. The sounding inventory is summarized in **Table 2**.

Table 2. Morning Sounding Inventory

Station	Available Morning Soundings	Percentage
Davenport, IA	1,607	88%
Omaha, NE	1,808	99.0%

The DNR believes that Davenport did not meet the 90% completeness due to the helium shortage in 2021-2022, however it is the only upper air station in Iowa and Omaha was 99% complete and was used to fill most of the missing data at Davenport. Missing upper air data can cause an under-prediction bias in AERMOD. In cases where the data from only one of these locations was missing, the corresponding sounding from the other location was used to fill in the gap. There were two instances were both Omaha and Davenport were missing, 11/1/21-11/2/21 and 3/24/22-3/27/22. In both cases, Minneapolis data was used to fill.

These edited data were then reprocessed with AERMET to produce the files necessary to be merged with the surface and 1-minute data.

1-Minute Data (AERMINUTE)

The latest available version of AERMINUTE (dated 15272) was used to process the 1-minute data for each of the 18 meteorological stations processed for use in AERMOD. The 1-minute wind data were obtained from the NCEI's online bulk download directory (4). The downloaded data consists of text files; each text file contains monthly data for one station.

The 1-minute wind data consist of a running 2-minute average that are reported every minute at each ASOS station. The archived 1-minute wind data contained in the downloaded text files from the NCEI were used to calculate the hourly average wind speed and direction, which could then be used to supplement the standard archive of hourly observed winds in the surface data - reducing the number of calms, variable winds, and missing data.

The AERMINUTE preprocessor requires the user to indicate the start and end month and year of the data being processed as well as whether or not the station is part of the Ice Free Winds (IFW) group. The IFW group refers to ASOS sites that use sonic anemometers instead of cup and vane anemometers to measure winds. If the station is part of the IFW group during the data period being processed by AERMINUTE, then the IFW installation date must be entered into the program. The website indicated in section 3.1.2 of the AERMINUTE user guide (13) was used to determine if the stations were part of the IFW group and their respective installation dates.

AERMINUTE gives an option to include data files of standard NWS observations in order to compare the non-quality controlled 1-minute winds against the quality controlled standard observations. The raw ISH data for each of the 18 stations being processed was included in the AERMINUTE input file for comparison with each of these station's 1-minute raw data files.

The combination of the above described data was processed by AERMINUTE to produce the necessary output file for merging with the filled and edited surface and upper air data.

Two sites, Harlan (KHNR) and Fort Dodge (KFOD), do not have 1-minute data available. The methods used by AERMINUTE to determine the hourly average wind speed and direction was reproduced within a series of spreadsheets. Sub-hourly data from the IEM was then input into these spreadsheets and were used to replicate the average wind conditions for each hour that would have been produced had 1-minute data been available.

Even after processing the sub-hourly data for KHNR and KFOD these sites contained far more calms than any of the other data sets. The Harlan data contained 16.9% calms, and Fort Dodge 9.7%. For comparison, after processing the 1-minute data, the average amount of calms in all of the other data sets was 0.4%, with the highest being 1.5%. Initial sensitivity tests indicated that the higher number of calms at the sites without 1-minute data would create a bias towards low predictions.

Based on this information it seemed prudent to decrease the number of calms in these two datasets. Where possible, calm hours at KHNR and KFOD were filled with non-calm data taken from the highest correlated site. This decreased the calm percentage at KHNR to 9.6% and 6.4% at KFOD. This is still higher than the sites with 1-minute data, but updated sensitivity tests show that this change eliminates the bias towards low predictions.

Land Use Analysis

The latest available version of AERSURFACE (dated 24142) was used to conduct the land use analysis for each meteorological site. This version of AERSURFACE uses the 2024 land use, tree canopy and impervious surfaces data. While the data were processed in accordance with the guidance available in the AERSURFACE user guide (6), two additional levels of detail were added to this stage of processing. These include refinements to the snow cover and surface moisture condition estimates.

Snow Cover and Surface Moisture Conditions

The AERSURFACE preprocessor requires the user to indicate whether or not the site experiences continuous snow cover during the winter months, and if the area experienced below normal, above normal or average surface moisture conditions.

Daily snow cover maps from US. National Ice Center (USNIC) were analyzed for the entire 2020-2024 period (14). An example of a daily snow cover map is depicted in **Figure 5**.

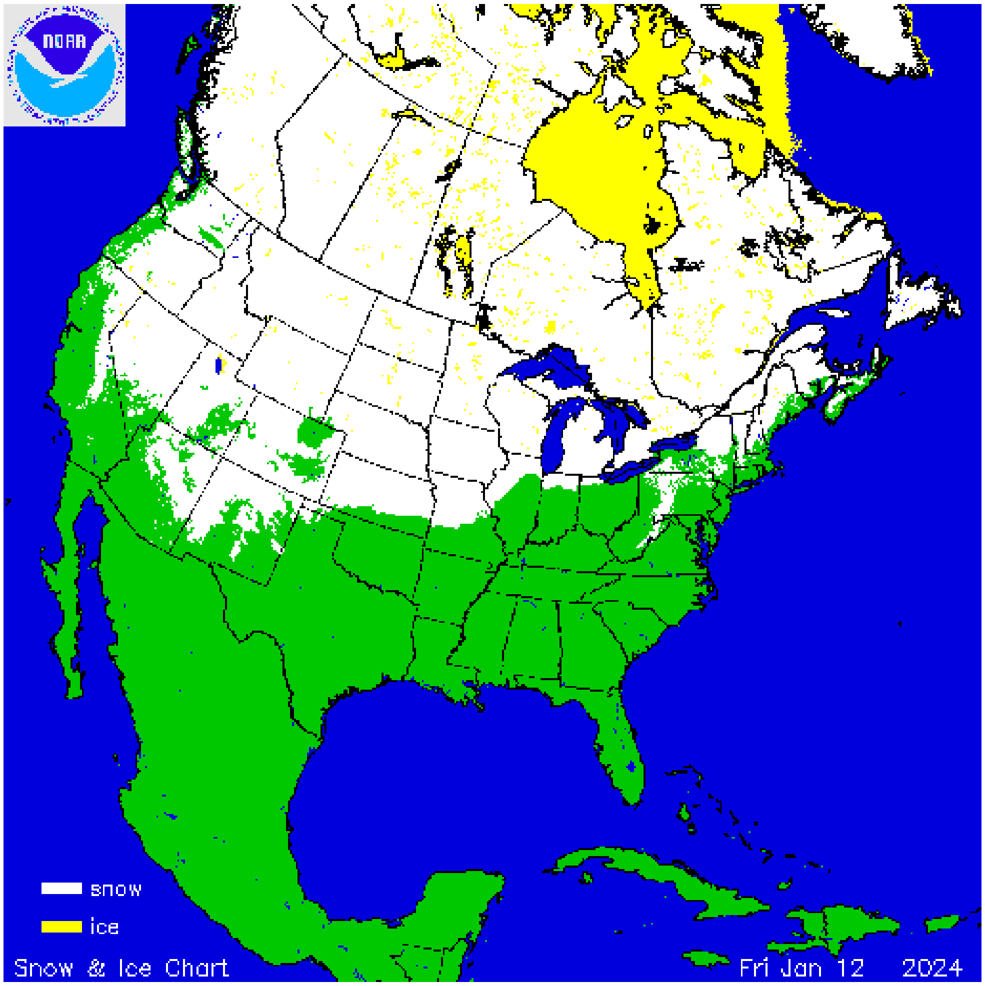


Figure 5. Example Daily Snow Cover Map

For each day of the period, a determination of whether or not snow cover was present at each meteorological station was made based on visual estimates of the proximity of snow cover shown on the maps to the stations being processed. These data were then combined to determine which months of the year should be considered as having continuous snow cover at each station. Continuous snow cover was assumed for each month if there was snow cover during at least half of the days in that month at that site

To determine the relative surface moisture conditions during each month of the period, monthly climatological divisional precipitation rank maps were analyzed (15). An example of a monthly climatological divisional precipitation rank map is depicted in **Figure 6**.

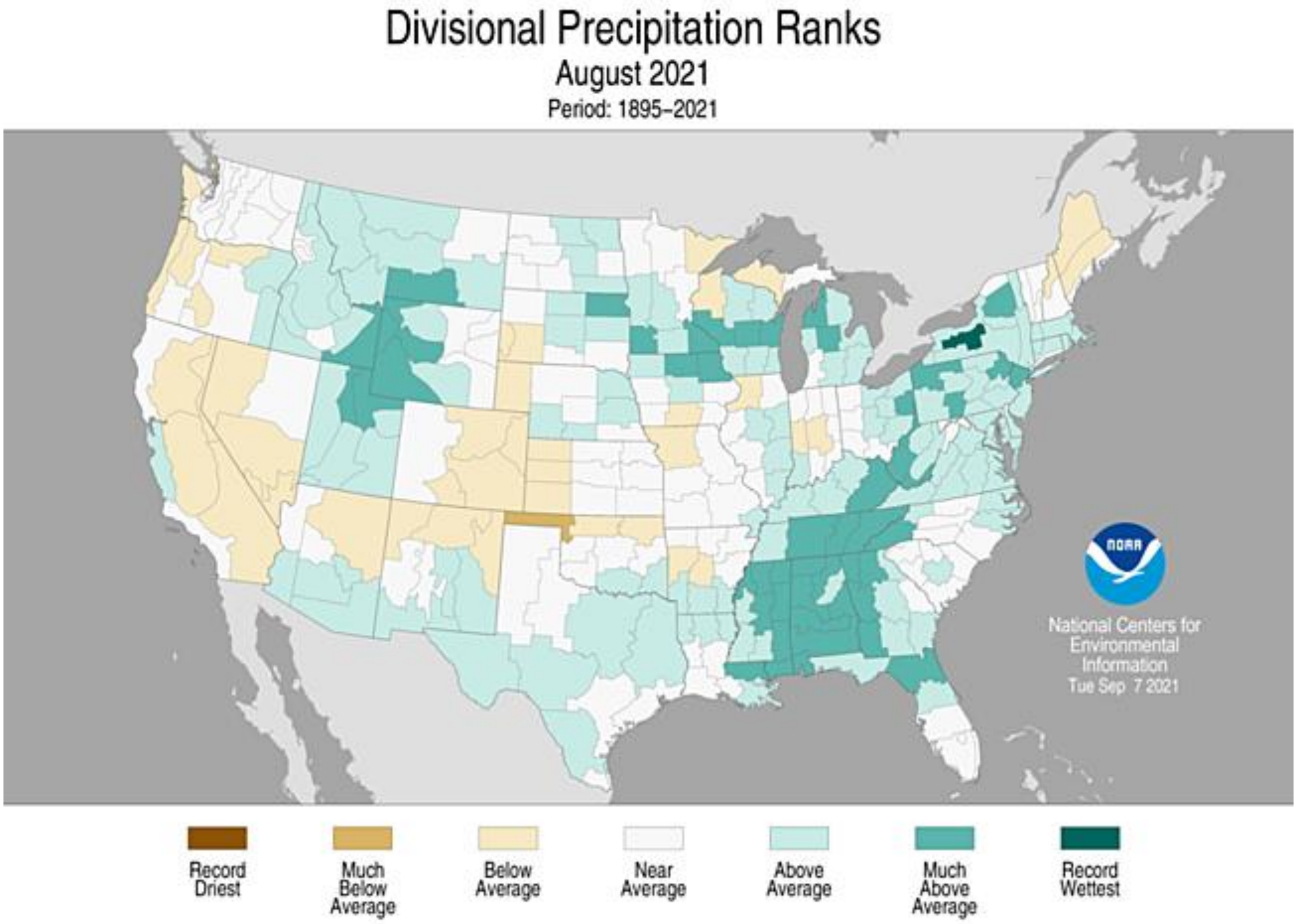


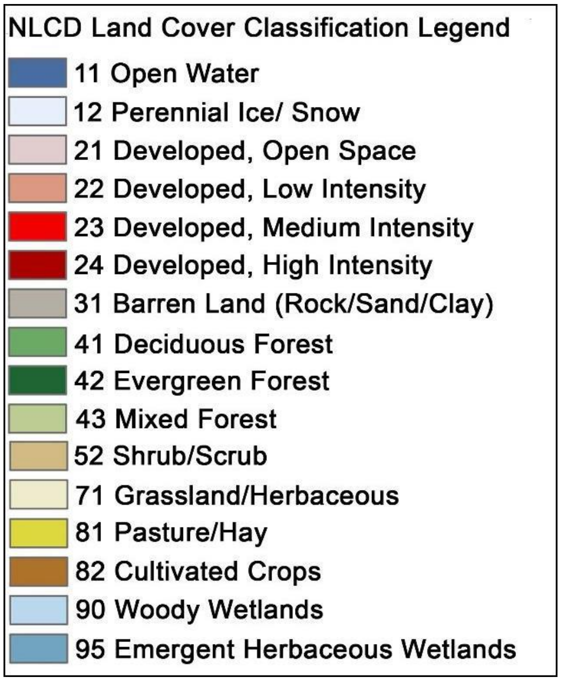
Figure 6. Example Monthly Climatological Divisional Precipitation Rank Map

Areas shown as “Record Driest” or “Much Below Normal” were categorized as being dry. Areas shown as “Below Normal”, “Near Normal”, or “Above Normal” were categorized as average. Areas shown as “Much Above Normal” or “Record Wettest” were categorized as wet. These categories approximate the guidance in section 2.2 of the AERSURFACE user guide (6):

> The surface moisture condition can be determined by comparing precipitation for the period of data to be processed to the 30-year climatological record, selecting “wet” conditions if precipitation is in the upper 30th-percentile, “dry” conditions if precipitation is in the lower 30th-percentile, and “average” conditions if precipitation is in the middle 40th-percentile.

Land Cover Data

The National Land Cover Dataset from 2024 (NLCD92) was chosen for this analysis because it was the most recent available at the time of processing. The land cover data were obtained from the Multi-Resolution Land Characteristics Consortium (5) in GEOTIFF format. The classifications included in this data are summarized in **Figure 7**.



NLCD Land Cover Classification Legend
11 Open Water
12 Perennial Ice/ Snow
21 Developed, Open Space
22 Developed, Low Intensity
23 Developed, Medium Intensity
24 Developed, High Intensity
31 Barren Land (Rock/Sand/Clay)
41 Deciduous Forest
42 Evergreen Forest
43 Mixed Forest
52 Shrub/Scrub
71 Grassland/Herbaceous
81 Pasture/Hay
82 Cultivated Crops
90 Woody Wetlands
95 Emergent Herbaceous Wetlands

Figure 7. 2024 National Land Cover Dataset Classification Summary

Processing Data in AERSURFACE

The first step in processing the land use data in AERSURFACE is to divide the area around each site into one or more sectors. The sectors were determined by examining the land use surrounding the site in all directions. Sites with little to no change in land use in any direction were processed using a single sector that encompassed the entire 360 degrees. Otherwise, areas with similar land use were grouped and the angular direction of each area was determined. For example, a site with a residential area along the eastern half and crops along the western half would be divided into two sectors with the boundaries of each at 0 degree and 180 degrees. A secondary consideration in defining the sectors was the type of “Developed” land cover in each sector. Each of the sites is located at an airport. Sectors that encompass portions of the airport need to be treated differently because the “Developed” land use categories do not distinguish between runways (low surface roughness) and areas with buildings (high surface roughness). AERSURFACE requires the user to input if each sector is low roughness or high roughness. AERSURFACE also has the ability to read and apply the percent impervious and percent tree canopy data to the “Developed” categories. These data were obtained for all sites and were used to supplement the land cover data.

Using the land cover and snow cover data described above, each site was processed three times (once each for “dry,” “average,” and “wet” surface moisture condition). The output for the individual months from these three runs were then manually combined into one output file for each site based on the monthly moisture conditions. These combined output files were then used in the final stage of AERMET.

Comparison of Model Results

The latest available version of AERMOD (dated 24124) was used to conduct a sensitivity analysis using both the 2015-2019 and 2020-2024 meteorological datasets. The goal of this analysis was to determine the expected change in model results due to the change in meteorological years and the change in the methods used to process the data. This section summarizes the results from this sensitivity analysis.

Point, capped, horizontal and downward sources were modeled using a range of stack heights from 20 to 200 feet with a temperature of 200°F, 37.4-inch diameter and 9,000 acfm flow rate. This encompasses most of the point source parameters seen across Iowa's facilities. Storage piles, haul roads, loadouts, and grain dryers were also evaluated. These sources were modeled using typical parameters seen at facilities in Iowa. Results for 1-hour, 24-hour and annual averaging periods were evaluated.

The concentrations predicted using the new meteorological data was divided by the concentrations predicted using the old meteorological data to determine the ratio of the difference in concentration caused by the change. Ratios greater than 1.0 indicate an expected increase in concentration while ratios less than 1.0 indicate an expected decrease. No changes are expected if the ratio equals 1.0.

On average the model results are predicted to increase slightly for all averaging periods modeled (1-hour, 24-hour, and annual) (**Figure 8**).

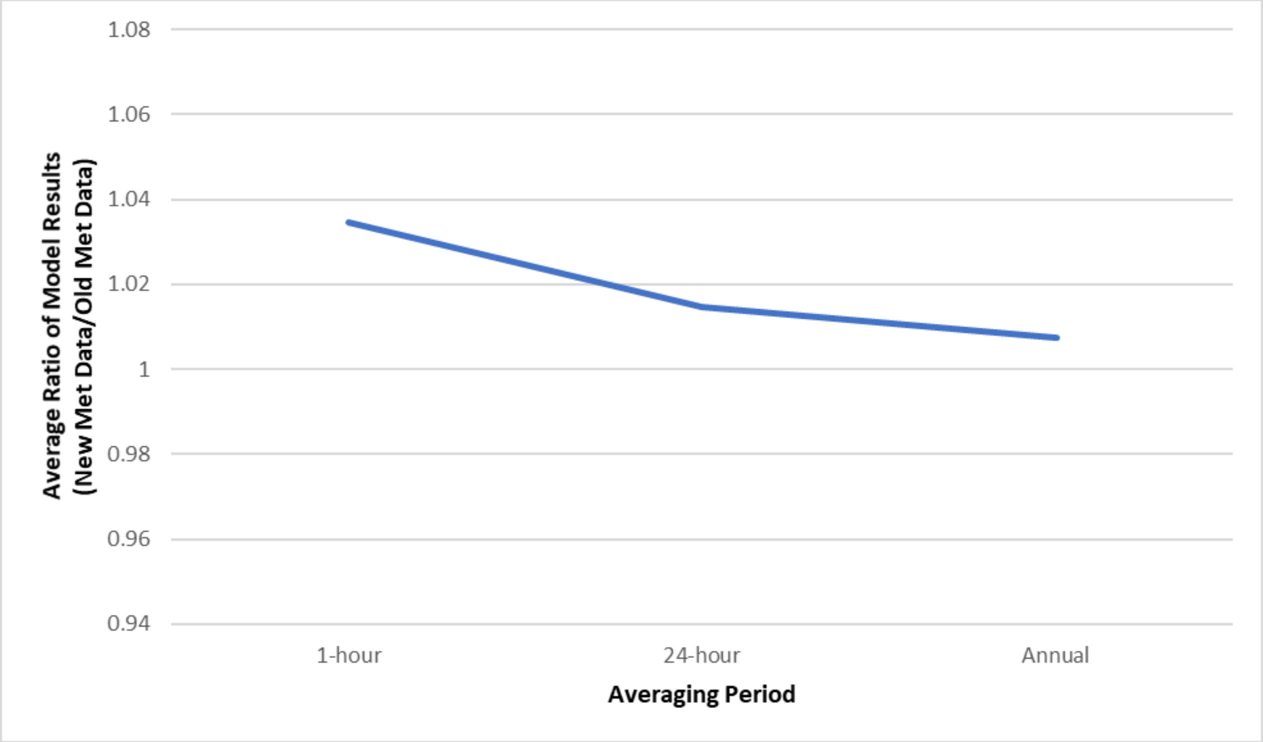


Figure 8. Average Ratio of New / Old Model Results by Averaging Period

The expected change in model results also varies by release height (**Figure 9**). On average the model results are expected to-decrease for 20-feet release heights and increase for all other release heights.

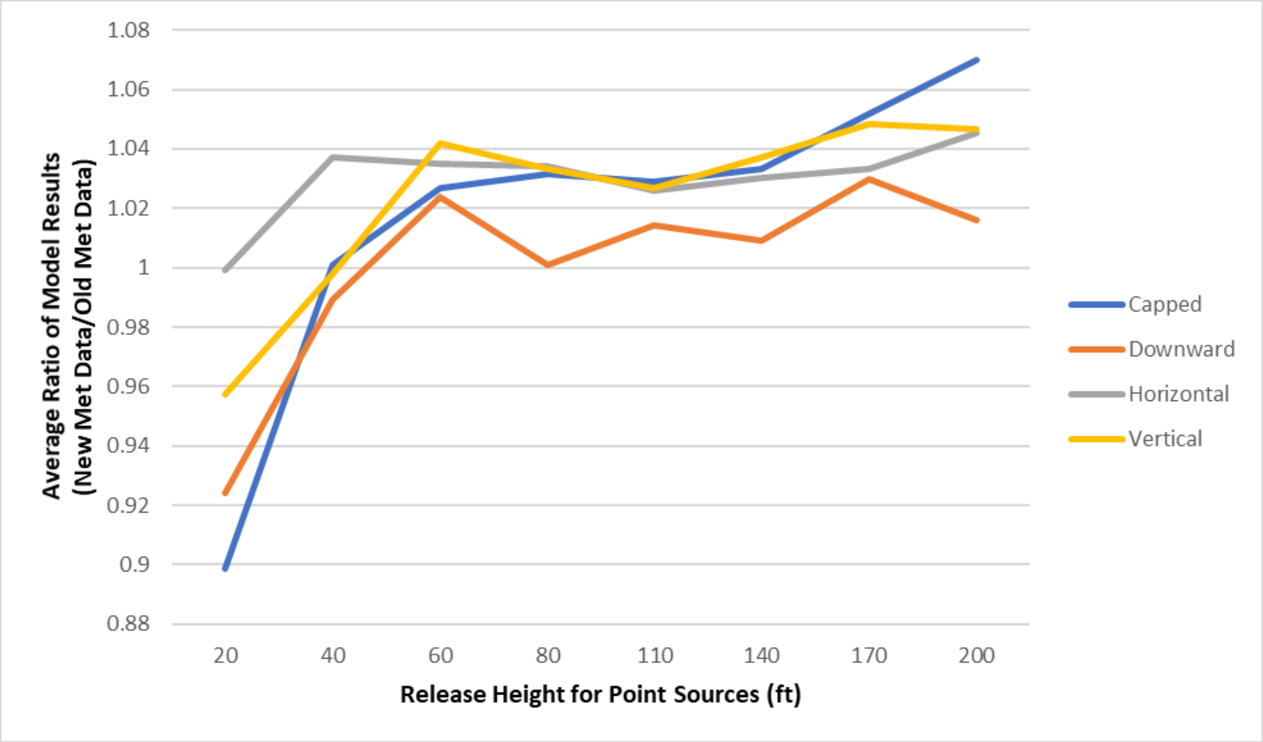


Figure 9. Average Ratio of New / Old Model Results by Release Height

The expected change in model results for each station varies (**Figure 10**). Overall, there is a 1.2% increase across all stations, however, six stations have an expected decrease while the rest have an expected slight increase in concentration. Results for KHNR are not shown here because it was not processed with the last dataset (2015-2019).

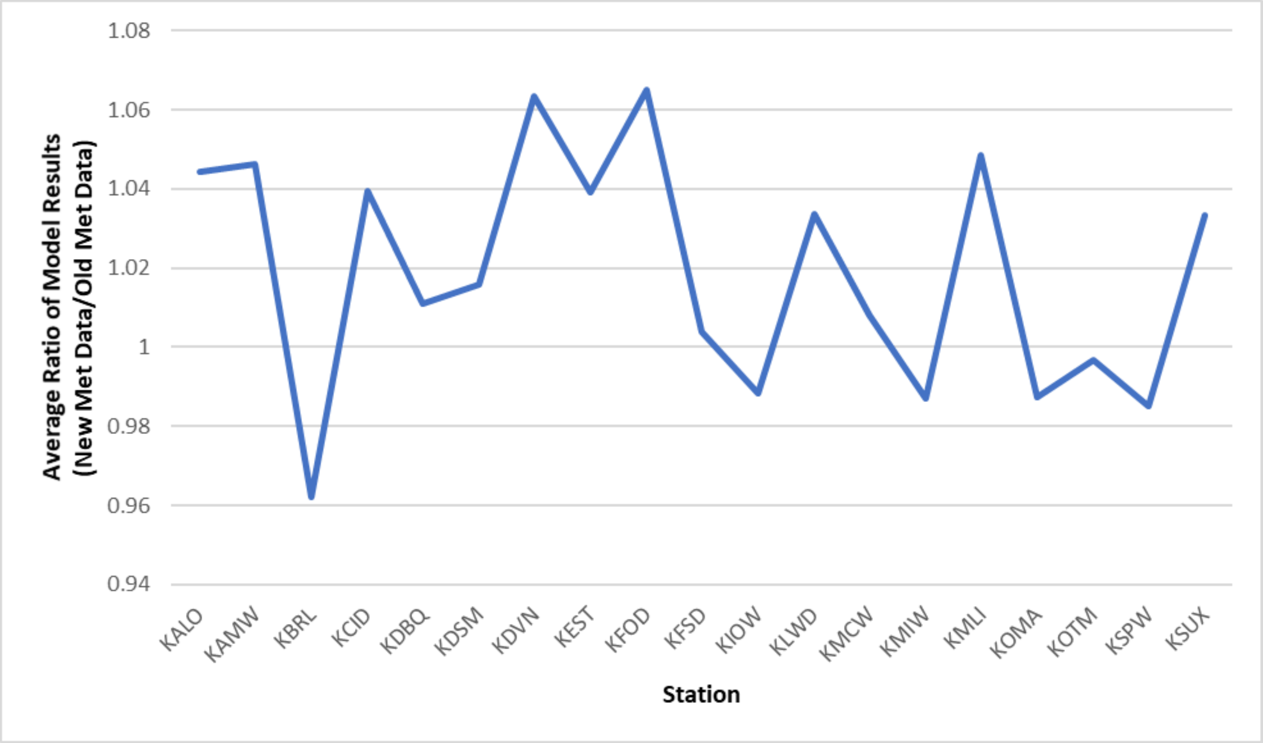


Figure 10. Average Ratio of New / Old Model Results by Station

For other source types, grain dryers should remain about the same and the haul roads, loadouts, and piles will have a slight increase in concentrations (**Figure 11**).

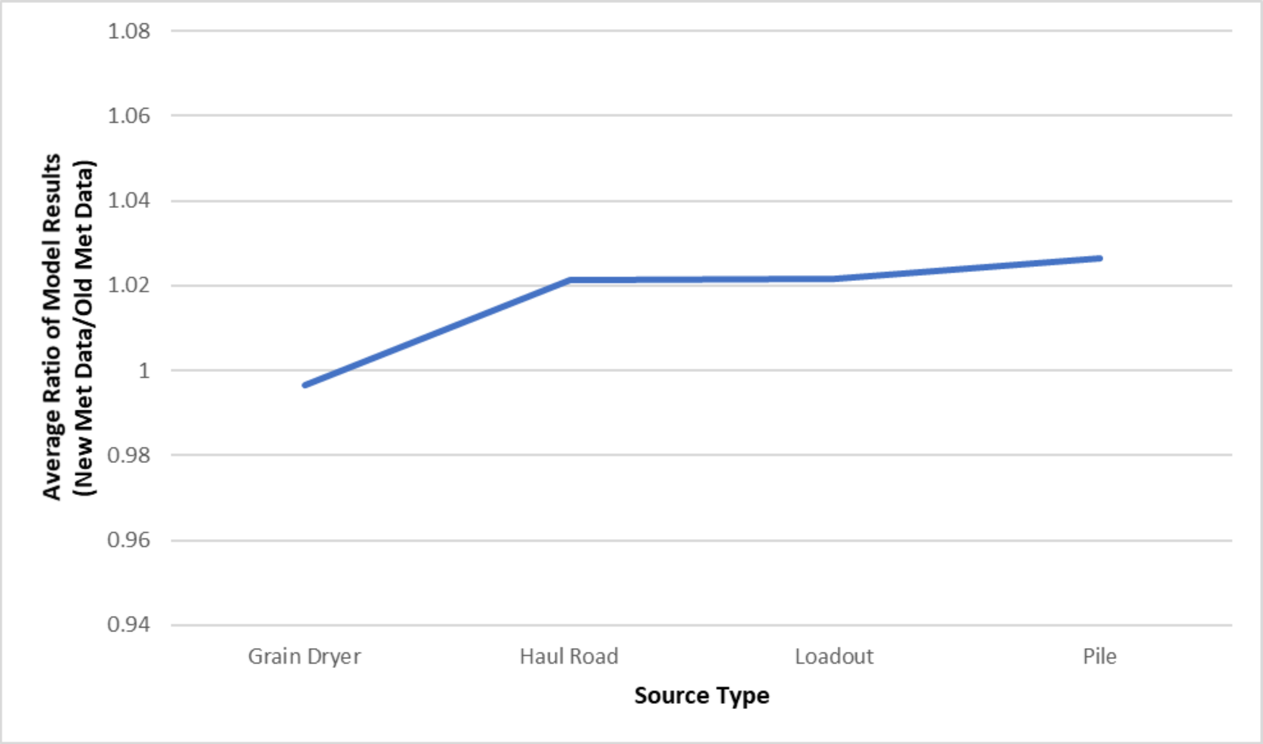


Figure 11. Average Ratio of New / Old Model Results by Source Type

Overall, a slight increase in concentration is expected for most averaging periods, release heights, source types and stations.

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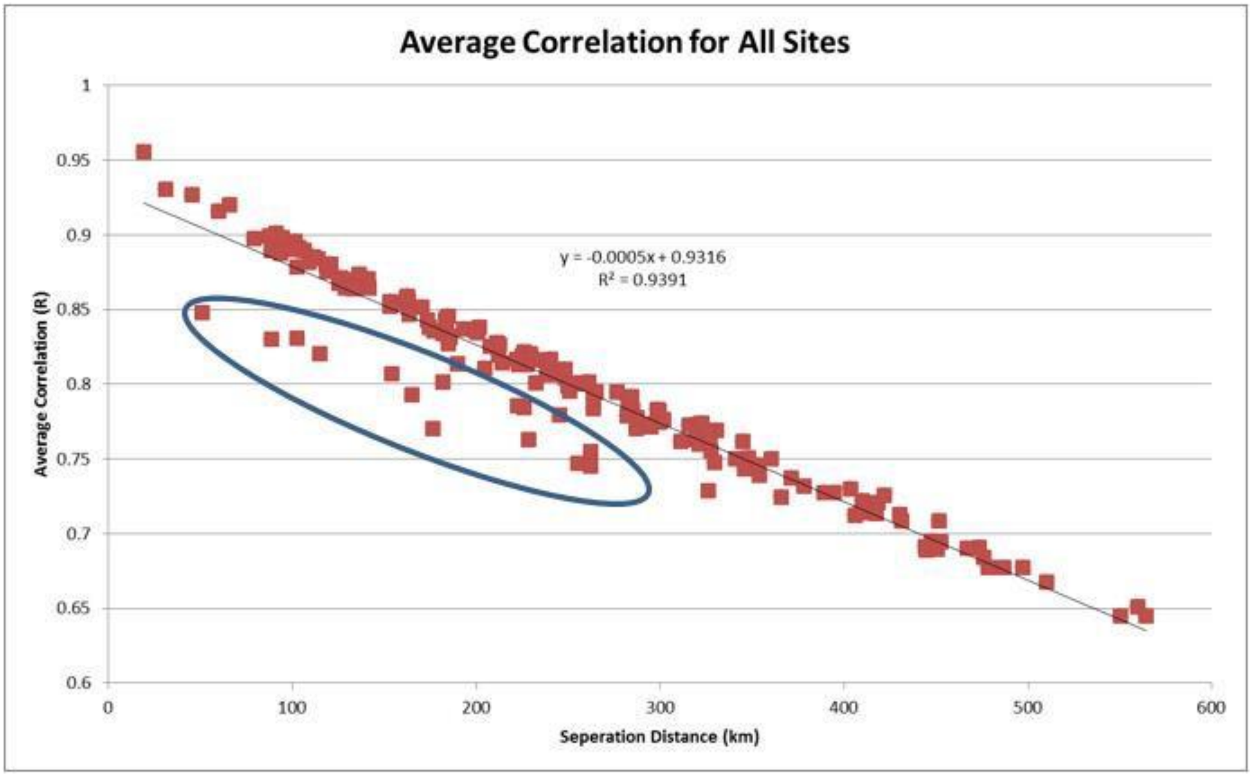
Appendix A

Determining the Effect of Separation Distance on Representativity

To account for spatial proximity, a distance-weighted scaling factor was applied to the wind correlation coefficient. Doing so serves to account for the potential differences caused purely by the distance between two points in the overlying mesoscale conditions, such as temperature, pressure, and cloud cover. A sensitivity analysis was conducted to evaluate the effect of separation distance on meteorological variables. This analysis was originally completed using the 2005-2009 dataset which was the most recent readily available dataset. This analysis is still valid therefore it will not be redone for future datasets.

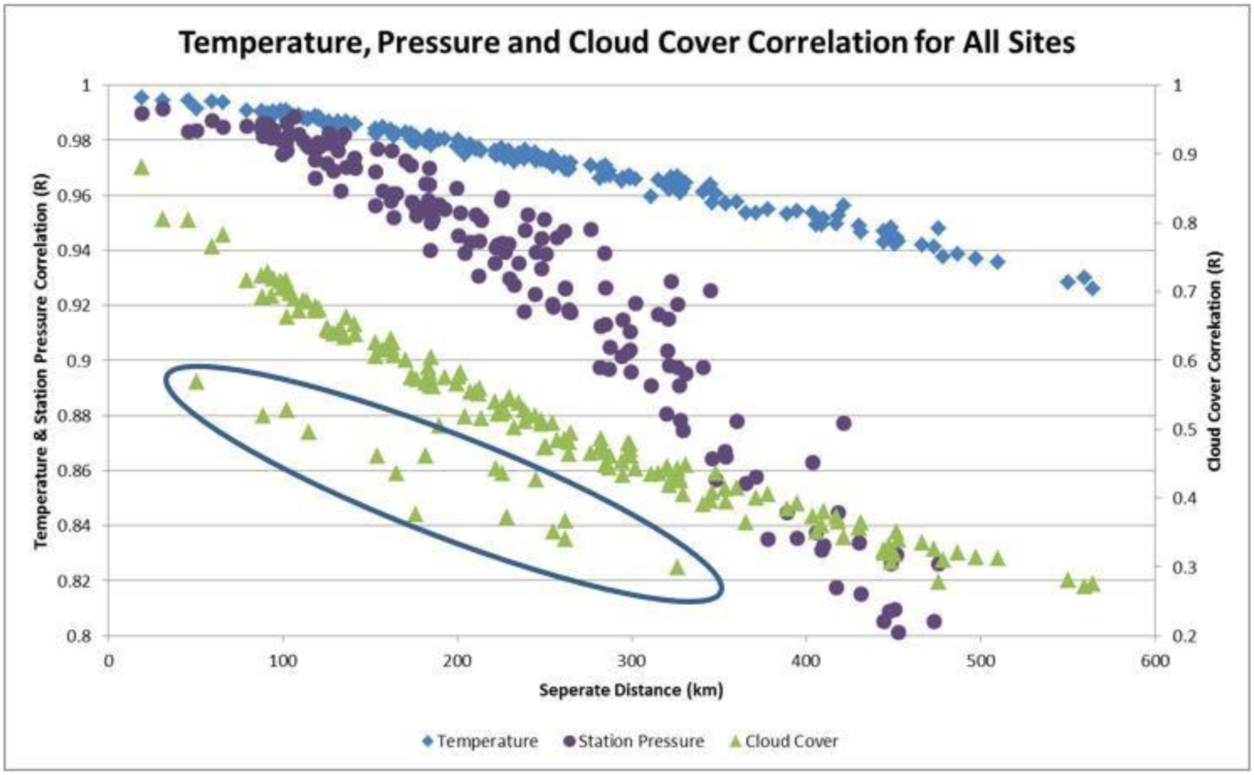
Nineteen ASOS sites across Iowa and surrounding states were used: Ames, Burlington, Cedar Rapids, Davenport, Des Moines, Dubuque, Estherville, Iowa City, La Crosse (WI), Lamoni, Marshalltown, Mason City, Moline (IL), Omaha (NE), Ottumwa, Sioux City, Sioux Falls (SD), Spencer and Waterloo. Hourly temperature, pressure and cloud cover observations from the 2005-2009 dataset were used. Temperature, pressure and cloud cover were chosen because those are the primary meteorological variables used in dispersion modeling (other than wind speed and direction). Wind data was not included because it can be affected by localized terrain influences, and is already considered in the wind correlation analysis described above.

First, the distance between each pair of meteorological sites was determined. Next, the correlation between the hourly data at each pair of meteorological sites was calculated for each of the three variables (temperature, pressure, and cloud cover). Finally, the correlations of the three variables for each pair of meteorological sites were averaged, resulting in a single correlation between each pair of sites. **Appendix Figure 1** shows how the average correlation varies with distance.



Appendix Figure 1. Average Correlation for All Nineteen Meteorological Sites

As expected, the average correlation decreases with distance. Unexpectedly, there were several site correlations (circled above) that appeared to be outliers. After further investigating the outliers, it was revealed that each included Des Moines as one of the sites. To determine what was causing the discrepancy each variable was plotted individually as shown in **Appendix Figure 2**.



Appendix Figure 2. Temperature, Pressure and Cloud Cover Correlation

The temperature and pressure correlation are plotted on the left axis and the cloud cover correlation is plotted on the right axis. The cloud cover has the same distinct group of outliers as in **Appendix Figure 1**.

The Des Moines cloud cover data were analyzed to determine the source of the correlation anomaly. AERMET breaks cloud cover into tenths. The numbers are based on sky coverage; no cloud coverage (0) - total cloud coverage (10). **Appendix Table 1** shows the hourly breakdown of the Des Moines cloud cover from 2005-2009.

Appendix Table 1. Des Moines Cloud Cover Count

Sky Coverage (tenths)	Number of Hours
0	9,580
1	0
2	28
3	6,077
4	19
5	4,303
6	0
7	35
8	1,135
9	5,404
10	17,243

The same method was performed for the Ames and La Crosse (WI) stations. Ames was analyzed because it is the closest site to Des Moines and therefore should have the most similar cloud cover. La Crosse (WI) was analyzed because it had the lowest cloud cover correlation with Des Moines. The hourly cloud cover breakdown for both sites is listed in **Appendix Table 2**.

Appendix Table 2. Ames and La Crosse, WI Cloud Cover Count

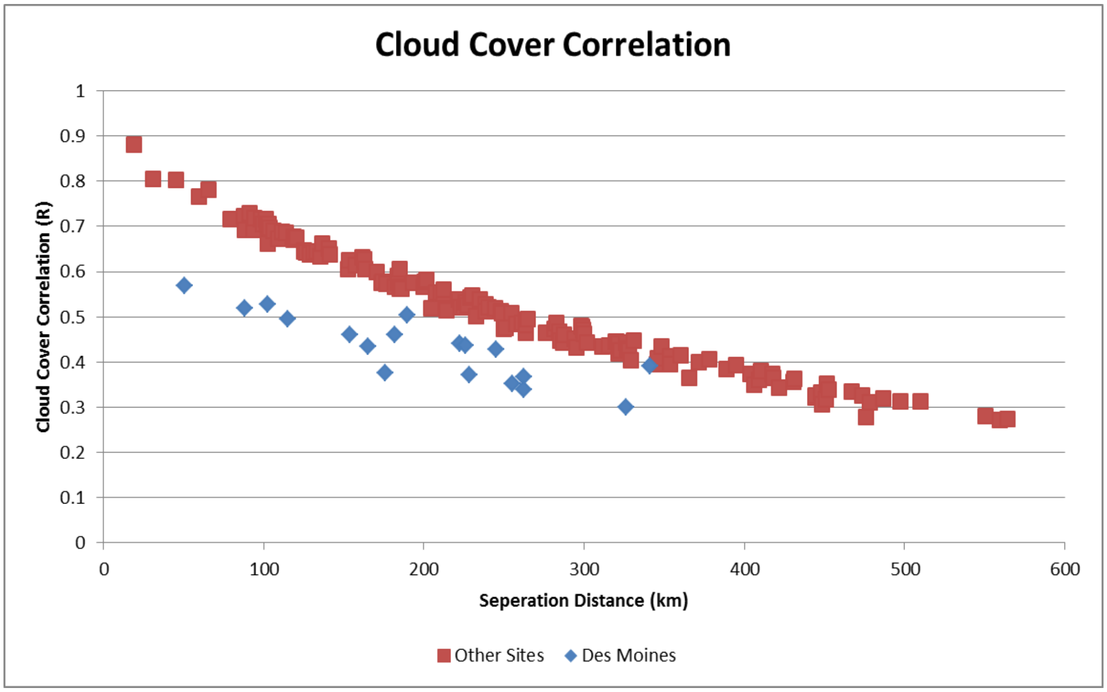
Sky Coverage (tenths)	Number of Hours Ames	Number of Hours La Crosse
0	22,573	22,058
1	0	0
2	0	5
3	4,183	2,192
4	0	6
5	1,966	1,539
6	0	0
7	0	5
8	53	0
9	3,209	3,017
10	11,840	15,002

In comparing the Des Moines breakdown to the other two sites it is clear that Des Moines is reporting greater numbers of cloudy hours and fewer clear hours then Ames and La Crosse (WI). The Des Moines National Weather Service Office was contacted and provided an explanation for this observation. The Des Moines International Airport records cloud cover above 12,000 feet due to its classification and contract with the Federal Aviation Administration (FAA). The Des Moines National Weather Service confirmed that all of the other meteorological sites used in this 2005-2009 representativity analysis do not report clouds above 12,000 feet. If no clouds are detected below 12,000 feet the hour is reported as clear, which translates into a zero for cloud cover, even if higher-altitude clouds were present. To ensure that this was indeed the reason for the group of outliers, the Des Moines cloud cover data was adjusted by changing all non-zero cloud cover observations above 12,000 feet into zeros. The revised data was then re-processed through AERMET. **Appendix Table 3** is the Des Moines cloud cover results with clear skies above 12,000 feet.

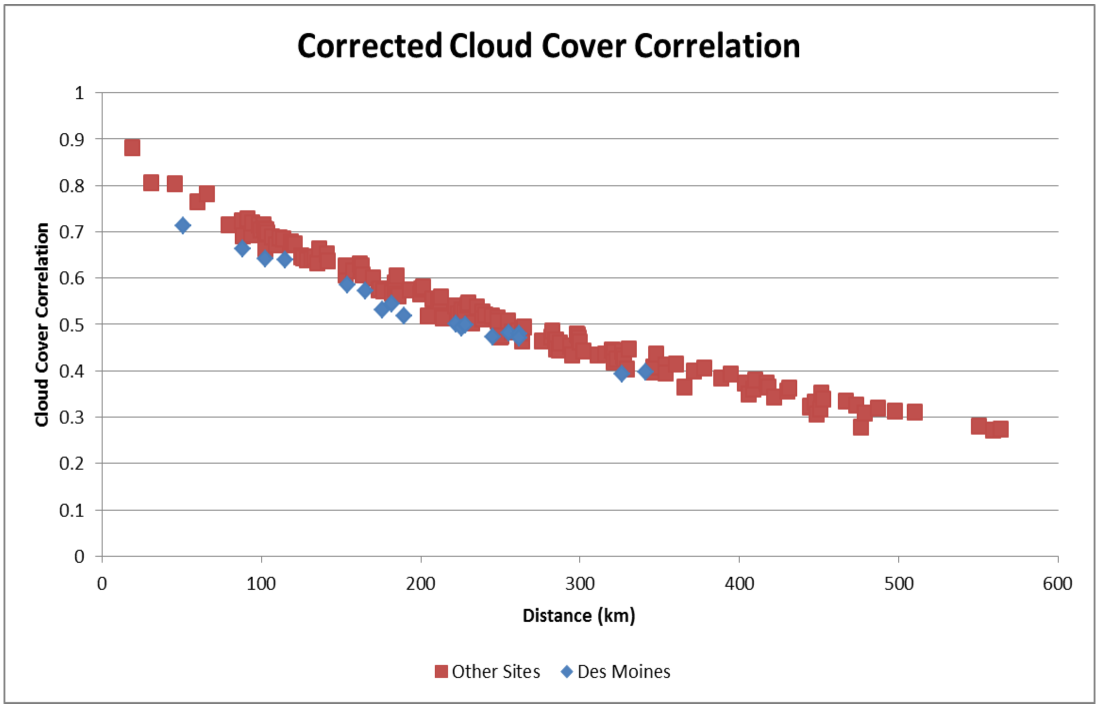
Appendix Table 3. Des Moines Clear Skies above 12,000 Feet

Sky Coverage (tenths)	Number of Hours
0	17,604
1	0
2	28
3	6,076
4	19
5	4,300
6	0
7	11
8	607
9	1,976
10	13,203

Appendix Figure 3 and **Appendix Figure 4** shows how the cloud cover correlation changed with the removal of cloudy skies above 12,000 feet in the Des Moines meteorological data.

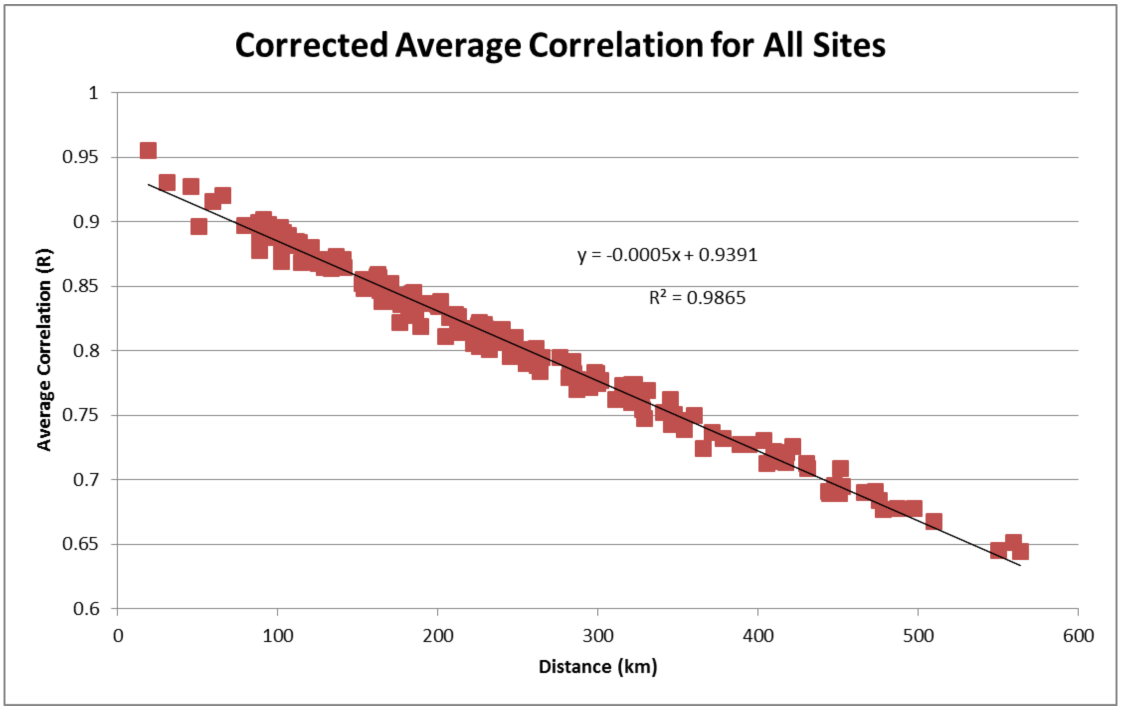


Appendix Figure 3. Original Cloud Cover Correlation



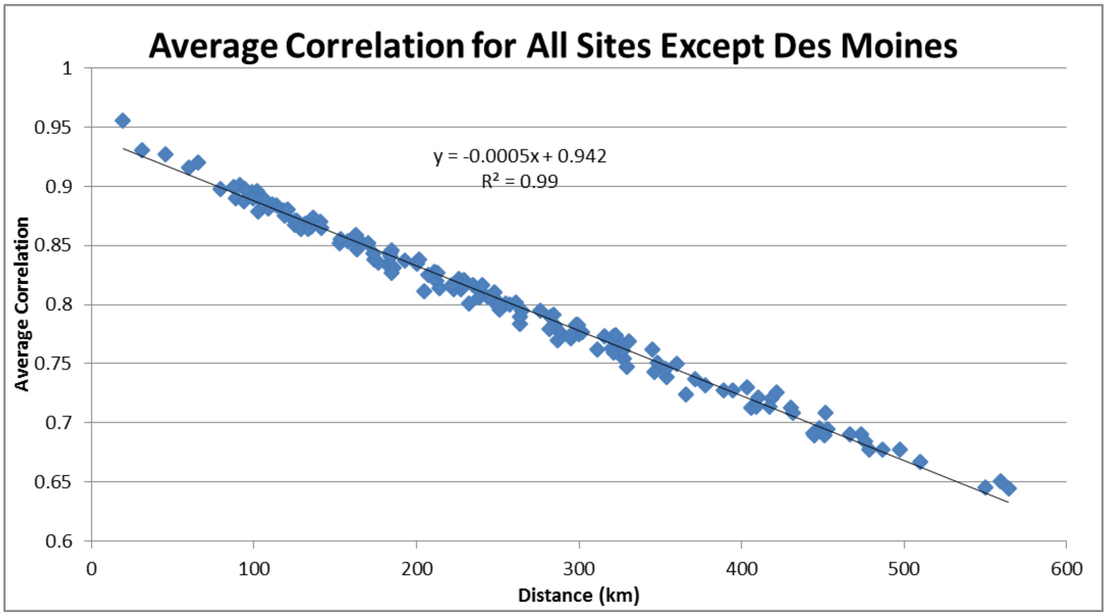
Appendix Figure 4. Corrected Cloud Cover Correlation

Replacing cloudy skies with sunny skies for cloud cover above 12,000 feet removed the outlier group; concluding that this discrepancy in ASOS reporting is the cause. Using the adjusted cloud cover correlation, the average correlation for all sites is re-plotted in **Appendix Figure 5**.



Appendix Figure 5. Adjusted Averaged Correlation

However, to find a distance cutoff the Des Moines data was excluded due to the discrepancy stated above. Since EPA does not have guidance on this reporting difference, the cloud cover above 12,000 feet was not removed from the Des Moines data. As shown previously in **Figure 1** this difference does affect the overall correlation and in order to get the correct distance cutoff the Des Moines data was removed (**Appendix Figure 6**).



Appendix Figure 6. Average Correlation without Des Moines Data

Removing the Des Moines data eliminates the outlier group and produces near perfect correlation between distance and cloud cover. In this analysis a 0.8 correlation is considered the minimum good fit correlation. Using the best fit equation and substituting 0.8 for "y", it is determined that a meteorological site could be separated from the application site by up to 284 km before this correlation coefficient falls below 0.8.

The relationship between correlation and separation distance was then converted into a function that could be used to apply a distance-weighted scaling factor to each wind correlation coefficient. This function was developed in such a way that the resulting scaling factor would not modify the wind correlation coefficient when there was no separation error, and would reduce the wind correlation coefficient between two perfectly correlated sites that are separated by up to 284 km to the minimum correlation considered a good fit (0.8).

This was accomplished using:

Equation 1

$$Q = 1 - (M \times D)$$

Where: Q = Distance-weighted scaling factor
M = Mesoscale coefficient
D = Distance (km)

The mesoscale coefficient is derived from the data in **Appendix Figure 6** using:

Equation 2

$$M = \frac{1 - RMin}{DMax}$$

Where: RMin = Minimum desired correlation
DMax = Maximum distance (km) at which RMIN is met

Substituting 0.8 for RMIN, and 284 km for DMAX in **Equation 2** results in M = 0.000704225. Thus, **Equation 1** becomes:

Equation 3

$$Q = 1 - (0.000704225 \times D)$$

Applying **Equation 3** to the correlation coefficients of every pair of wind roses results in a distance-weighted correlation coefficient. Using two perfectly correlated (correlation coefficient = 1.0) wind roses as an example:

- If the wind roses are from collocated sites (D = 0), **Equation 3** becomes: Q = 1 - (0.000704225 *0) = 1 - 0 = 1.0. The correlation coefficient (1.0) for the two identical wind roses from collocated sites would be multiplied by 1, and therefore remain perfectly correlated (1.0).
- If the wind roses are from sites separated by 284 kilometers (D = 284), **Equation 3** becomes: Q = 1 - (0.000704225 * 284) ≈ 1 - 0.2 = 0.8. The correlation coefficient (1.0) for the two identical wind roses from sites separated by a distance of 284 kilometers would be multiplied by 0.8, and therefore be reduced to the minimum correlation previously defined as being a good fit (0.8).

A distance-weighting factor was calculated as described above for every possible combination of measurement site, and then applied to the corresponding correlation coefficients for those combinations.