2015-2019 AERMOD Meteorological Data

Technical Support Document

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Contents

Introduction

This document serves as a technical discussion of the methodology used to process the 2015-2019 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
- Representivity analysis
- Filling missing data
- Use of AERMINUTE to process 1-minute wind data
- Land-use 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 2015-2019 surface meteorological data were obtained from the National Climatic Data Center (NCDC) (1). The TD-3505, or 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 NCDC's online file transfer protocol (ftp) directory (2). A total of 93 surface observation stations in and around Iowa were extracted from the compressed files. The sites are listed in Appendix A – Meteorological Observation Station Information.

Meteorological Data – Upper Air

The 2015-2019 upper air data were obtained from the online National Oceanic and Atmospheric Association Earth System Research Laboratory (NOAA/ESRL) Radiosonde Database (3). The Forecast Systems Laboratory (FSL) format was chosen because it is the only format available from this website that is compatible with AERMET. This dataset was obtained as a series of text files. Data were obtained 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 2015-2019 1-minute wind data were obtained from the NCDC's online ftp directory (4). The 1-minute data are divided into two datasets: 6405 and 6406. The 6405 dataset contains primarily wind data (5) whereas the 6406 dataset contains temperature, dew point, precipitation and pressure (6). The AERMINUTE preprocessor only uses the wind data, so only the 6405 dataset was downloaded. This dataset was obtained as a series of text files. The data is not available for all locations. Of the 93 surface observation stations, 1-minute data was available and downloaded for 25 stations (as indicated in Table 12 in Appendix A – Meteorological Observation Station Information).

Land Cover Data

Land cover data were obtained from the Multi-Resolution Land Characteristics (MRLC) Consortium (7). AERSURFACE has been updated to use the most recent land cover data. The land cover data are from the 2016 National Land Cover Dataset (NLCD 2016), and were obtained in GEOTIFF format to ensure compatibility with the AERSURFACE preprocessor.

Locations and Elevations

There is some uncertainty regarding the accuracy of the location information provided with the Automated Surface Observing System (ASOS) data. The location provided for many of the ASOS stations can be off by several hundred meters or more (8) (9). This uncertainty necessitates use of an alternate method for determining the actual location of each site.

Online sources of aerial imagery, such as Google Earth (10), Bing Maps (11) and the Iowa Geographic Map Server (12) were used to visually locate the instrument towers. Most ASOS sites near major cities are easily identifiable because these locations are generally covered by high-resolution images. The tower is not as easily identifiable in lower resolution images, but the tower location at airports is consistently near the main runway(s). This knowledge was useful in deciphering which object in low resolution images could be the meteorological instrument tower. In a few cases, the actual location was confirmed via physical inspection of the site. The locations of the upper-air sites were based on the observed location of the rawinsonde balloon inflation shelter/radiotheodolite radome at each site. The shelter and associated radome are easily identifiable in even low-resolution images. Once each location was found visually, the coordinates and elevation of that location were determined using Google Earth. The aerial images used to locate each site are shown in Appendix A – Meteorological Observation Station Information.

The elevation above ground of the anemometer at each location was determined using the data available on the National Weather Service's (NWS) website (13).

Representivity Analysis

A representivity 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" (14). 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" (15). 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 representivity of meteorological data is influenced by the following (14):

- 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

More detail on each of these items follows.

Instrument Exposure

Instrument exposure refers to the ability of the instruments to measure meteorological conditions without the influence of manmade or natural obstructions. If obstructions are present, they can influence the measurements of the meteorological monitoring site. For example, a tree located a few dozen feet away from an instrument tower could alter the speed and direction of the wind at the instrument. These effects may be useful in defining the microscale atmospheric conditions in the immediate vicinity of the obstruction, but would be inappropriate if applied over an entire modeling domain. Any instrument affected by such local-scale influences should not be used to develop meteorological data for use in a dispersion model.

All surface stations used in the development of the 2015-2019 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. It is stated that "the NWS will follow the guidelines documented in the Federal Standard for Siting Meteorological Sensors at Airports" when siting ASOS and AWOS stations (16). These standards include siting and exposure requirements that limit the effects of any obstructions within 1000 feet of the anemometer (17). For these reasons it was determined that instrument exposure would not affect the representativeness of any data obtained from airport-based ASOS and AWOS stations.

Instrument exposure is not a concern with upper air data because the observations occur above the surface of the earth, away from any obstructions that could affect them.

Temporal Proximity

"Consecutive years from the most recent, readily available 5-year period are preferred" for use with regulatory air dispersion modeling analyses (14). At the time that these data were obtained, 2019 was the most recent complete year available. Therefore, the years 2015-2019 were used in the processing of the AERMOD meteorological data sets. The data observed at all surface and upper air stations were considered temporally representative of all locations in Iowa for the purposes of this analysis.

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.

When the wind fields observed at a significant number of sites are compared to one another, patterns emerge from the data that reveal clues about the geographic features and land cover at each site. For instance, the wind direction at a site that is located within a river valley may be aligned with the direction of the river valley instead of the predominant wind directions seen at a nearby site that is not within the valley. Similarly, due to the higher surface roughness, the average wind speed observed at a site surrounded by forests may be lower than the wind speed observed at a site surrounded by grassland. Taking these examples, a step further, the geographic features and land use that exist around the measurement site will affect the shape and magnitude of the wind rose for that site. Assuming no differences in overlying mesoscale conditions and adequate instrument exposure, it can be concluded that two sites whose wind roses are similar either have similar surrounding geographic features and land cover, or the geographic features and land cover surrounding both sites have little or similar effect. In either case the 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 provided 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 93 ASOS and AWOS sites in and around Iowa using Trinity Consultants' BREEZE MetView program (18).

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. Table 1 depicts an example of wind rose joint frequency data for one location. The wind directions are shown along the vertical axis and the wind speeds (knots) along the horizontal axis. The values shown within the body of the table are the percentages of time that the wind was observed for each combination of wind direction and speed at that location. The similarity of each pair of wind roses was determined by calculating the correlation coefficient of the joint frequency data outlined in red from the corresponding table for each site. 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.

Table 1. Example Joint Frequency Table of wind direction and wind speed

Dir \ Spd	≤ 3knots	≤ 6 knots	≤ 10 knots	≤ 16 knots	≤ 21 knots	> 21 knots	Total
0.0	0.11%	0.53%	1.37%	0.83%	0.12%	0.03%	2.98%
10.0	0.08%	0.50%	0.99%	0.47%	0.05%	0.01%	2.10%
20.0	0.06%	0.41%	1.04%	0.59%	0.17%	0.08%	2.34%
30.0	0.09%	0.31%	0.91%	0.46%	0.13%	0.07%	1.96%
40.0	0.09%	0.35%	0.79%	0.47%	0.09%	0.02%	1.81%
50.0	0.07%	0.30%	0.61%	0.30%	0.08%	0.03%	1.40%
60.0	0.08%	0.22%	0.54%	0.25%	0.07%	0.03%	1.19%
70.0	0.05%	0.28%	0.50%	0.24%	0.05%	0.02%	1.14%
80.0	0.05%	0.23%	0.51%	0.23%	0.06%	0.01%	1.08%
90.0	0.05%	0.23%	0.58%	0.22%	0.05%	0.03%	1.16%
100.0	0.05%	0.21%	0.60%	0.26%	0.05%	0.01%	1.19%
110.0	0.05%	0.30%	0.67%	0.46%	0.06%	0.01%	1.56%
120.0	0.08%	0.34%	0.97%	0.48%	0.10%	0.04%	2.01%
130.0	0.12%	0.63%	1.54%	0.76%	0.17%	0.02%	3.25%
140.0	0.10%	0.56%	1.55%	0.96%	0.17%	0.04%	3.38%
150.0	0.11%	0.42%	1.74%	1.48%	0.28%	0.04%	4.06%
160.0	0.08%	0.32%	1.61%	1.73%	0.41%	0.06%	4.21%
170.0	0.08%	0.29%	1.61%	1.71%	0.42%	0.08%	4.19%
180.0	0.07%	0.37%	1.95%	1.82%	0.55%	0.17%	4.93%
190.0	0.09%	0.40%	1.67%	1.48%	0.45%	0.16%	4.24%
200.0	0.08%	0.37%	1.41%	0.93%	0.34%	0.08%	3.22%
210.0	0.06%	0.33%	1.29%	0.69%	0.16%	0.02%	2.54%
220.0	0.08%	0.29%	0.94%	0.57%	0.15%	0.04%	2.07%
230.0	0.07%	0.27%	0.97%	0.53%	0.09%	0.03%	1.96%
240.0	0.07%	0.23%	0.76%	0.30%	0.10%	0.04%	1.49%
250.0	0.06%	0.27%	0.68%	0.29%	0.07%	0.03%	1.41%
260.0	0.05%	0.25%	0.77%	0.33%	0.10%	0.08%	1.57%
270.0	0.03%	0.23%	0.89%	0.50%	0.13%	0.07%	1.84%
280.0	0.05%	0.23%	0.90%	0.59%	0.21%	0.08%	2.07%
290.0	0.05%	0.35%	1.03%	0.65%	0.22%	0.08%	2.38%
300.0	0.07%	0.42%	0.86%	0.59%	0.17%	0.05%	2.16%
310.0	0.09%	0.44%	1.40%	0.93%	0.36%	0.13%	3.35%
320.0	0.08%	0.60%	1.68%	1.14%	0.49%	0.16%	4.14%
330.0	0.05%	0.42%	1.56%	1.52%	0.75%	0.31%	4.62%
340.0	0.10%	0.50%	1.27%	1.17%	0.36%	0.10%	3.49%
350.0	0.11%	0.50%	1.36%	1.12%	0.28%	0.07%	3.45%
Total	2.65%	12.90%	39.52%	27.04%	7.48%	2.33%	91.92%
Calms							5.52%
Missing							2.56%
Total							100%

For example, the wind roses from Charles City, IA (Figure 1) and Oelwein, IA (Figure 2) are very similar, and have a correlation coefficient of 0.933.

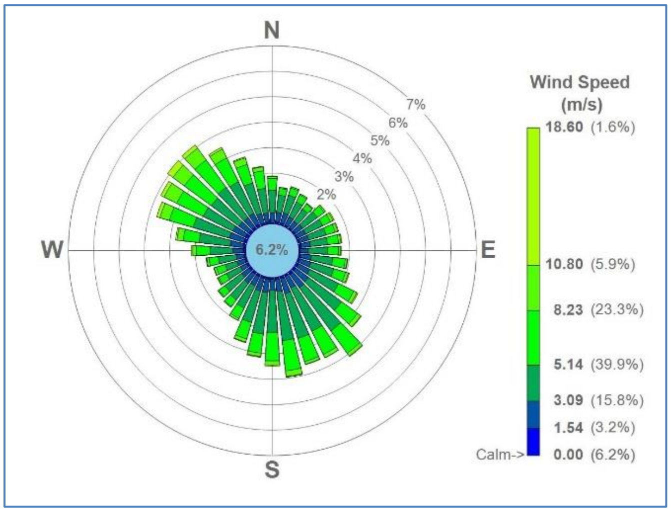


Figure 1. Wind Rose for Charles City, IA (KCCY)

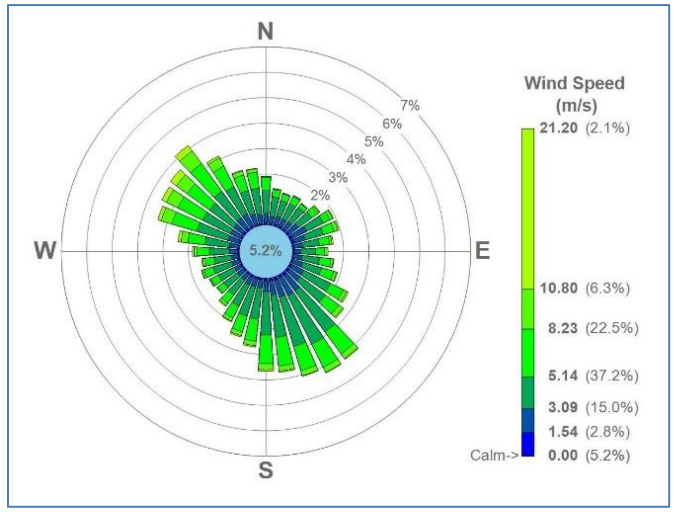


Figure 2. Wind Rose for Oelwein, IA (KOLZ)

On the other hand, the wind roses from Omaha, NE (Figure 3) and Boscobel, WI (Figure 4) are very dissimilar, and have a correlation coefficient of 0.036.

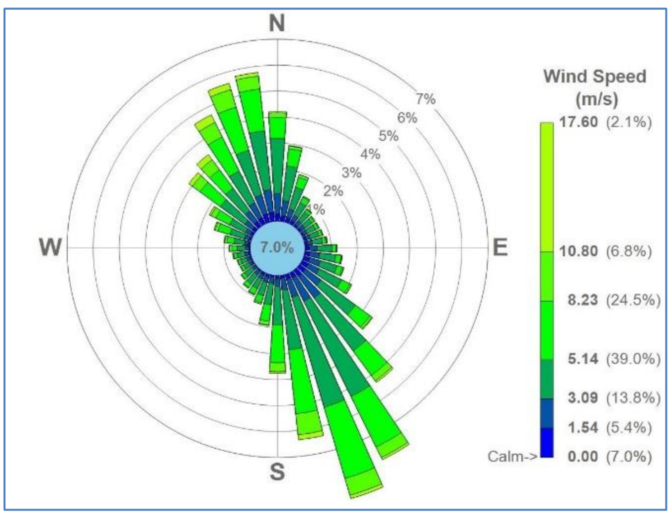


Figure 3. Wind Rose for Omaha, NE (KOMA)

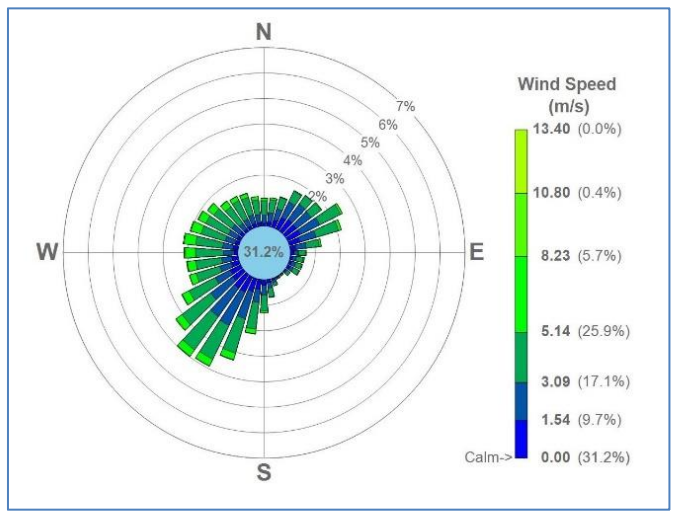


Figure 4. Wind Rose for Boscobel, WI (KOVS)

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.

Determining the Effect of Separation Distance on Representivity

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 completed using the 2005-2009 dataset which was the most recent readily available dataset. This analysis is still valid therefore it was no redone with the 2010-2014 dataset.

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 existing 2005-2009 dataset was used. Using these data allowed the sensitivity analysis to be conducted prior to the processing of the 2015-2019 data for which the results would be 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. Figure 5 shows how the average correlation varies with distance.

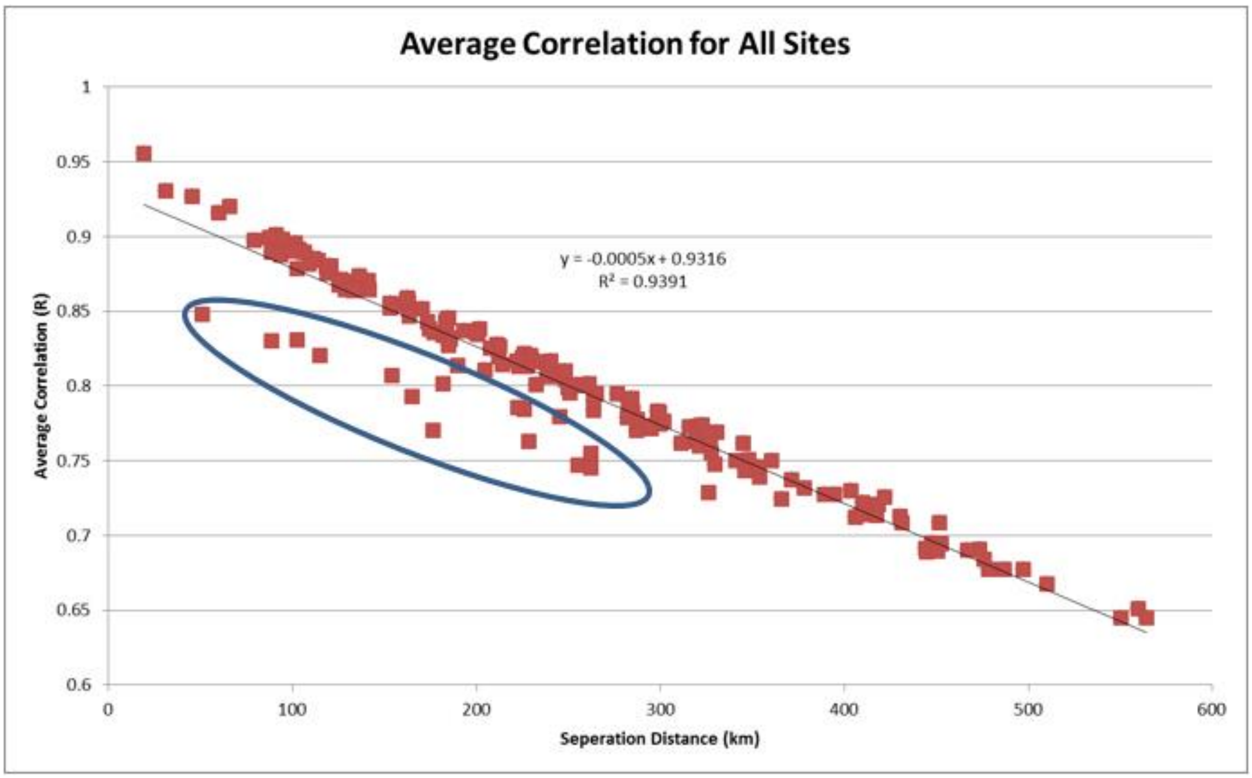


Figure 5. Average Correlation for All Nineteen Meteorological Sites

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 Figure 6.

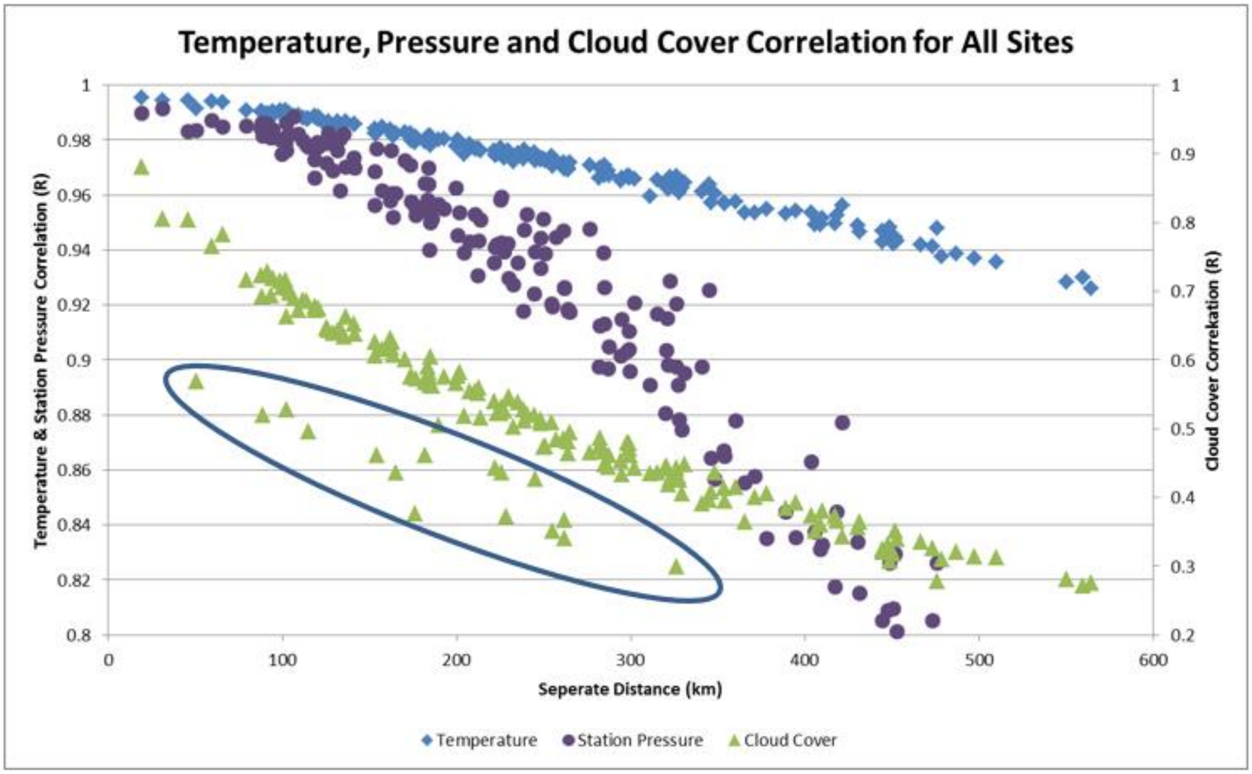


Figure 6. Temperature, Pressure and Cloud Cover Correlation

The temperature and pressure correlation are plotted on the left and the cloud cover correlation is plotted on the right. The cloud cover has the same distinct group of outliers as Figure 5.

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). Table 2 shows the hourly breakdown of the Des Moines cloud cover from 2005-2009.

Table 2. 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 Table 3.

Table 3. 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 (19) 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 18 meteorological sites used in this representivity 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. Table 4 is the Des Moines cloud cover results with clear skies above 12,000 feet.

Table 4. 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

Figure 7 and Figure 8 shows how the cloud cover correlation changed with the removal of cloudy skies above 12,000 feet in the Des Moines meteorological data.

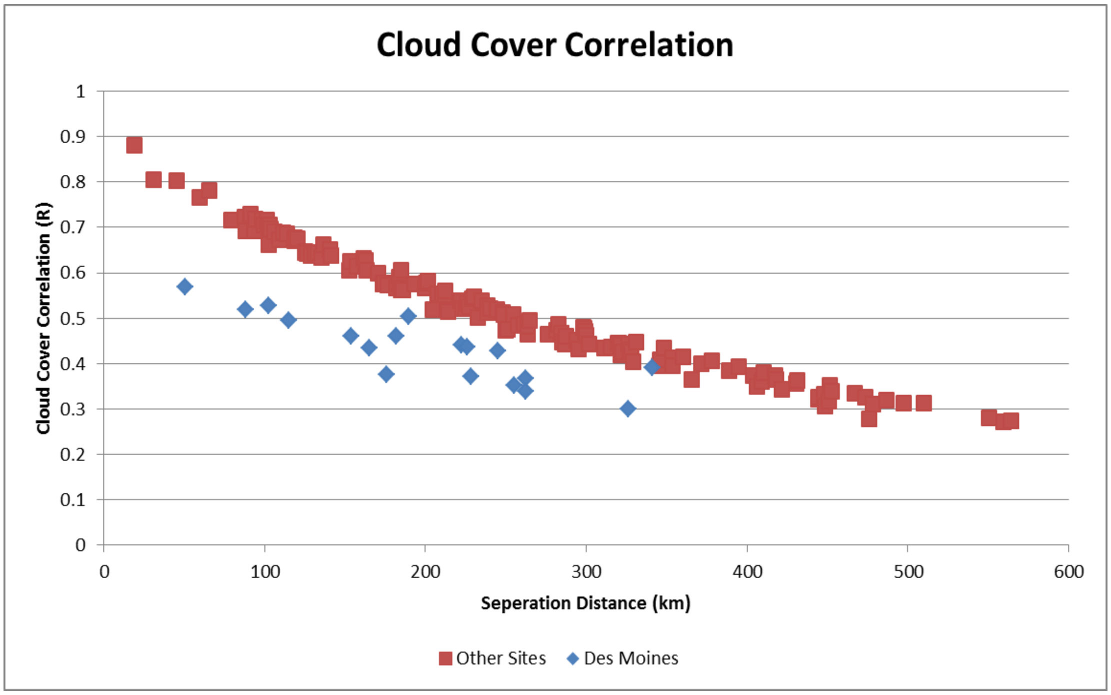


Figure 7. Original Cloud Cover Correlation

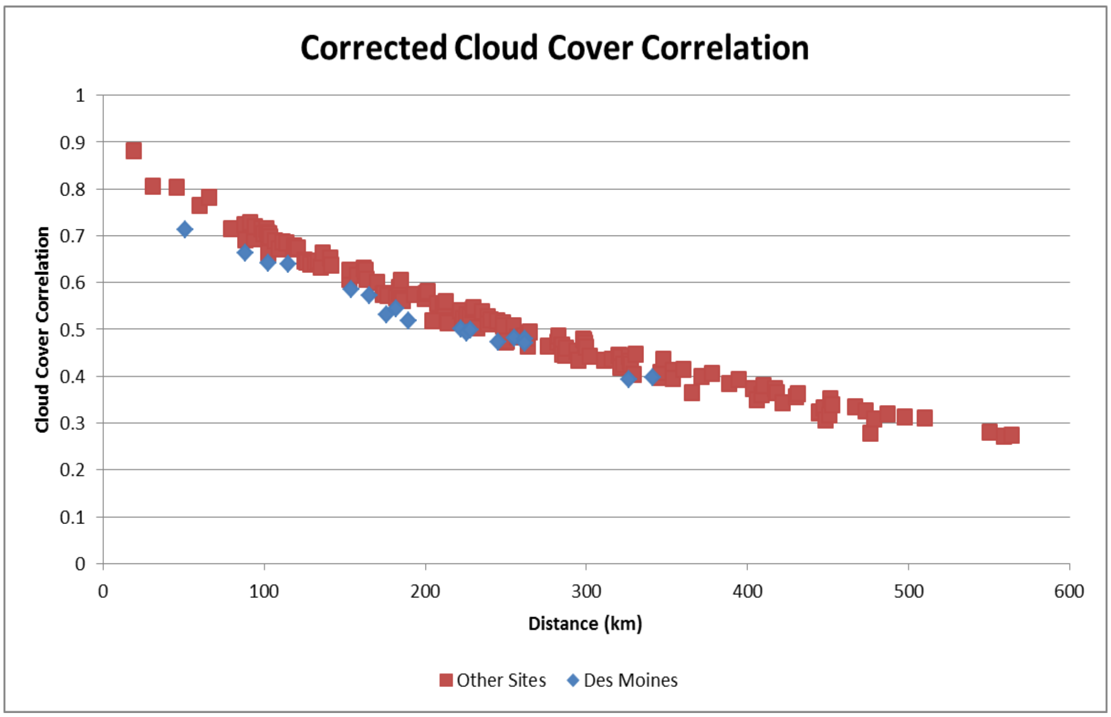


Figure 8. Corrected Cloud Cover Correlation

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 Figure 9.

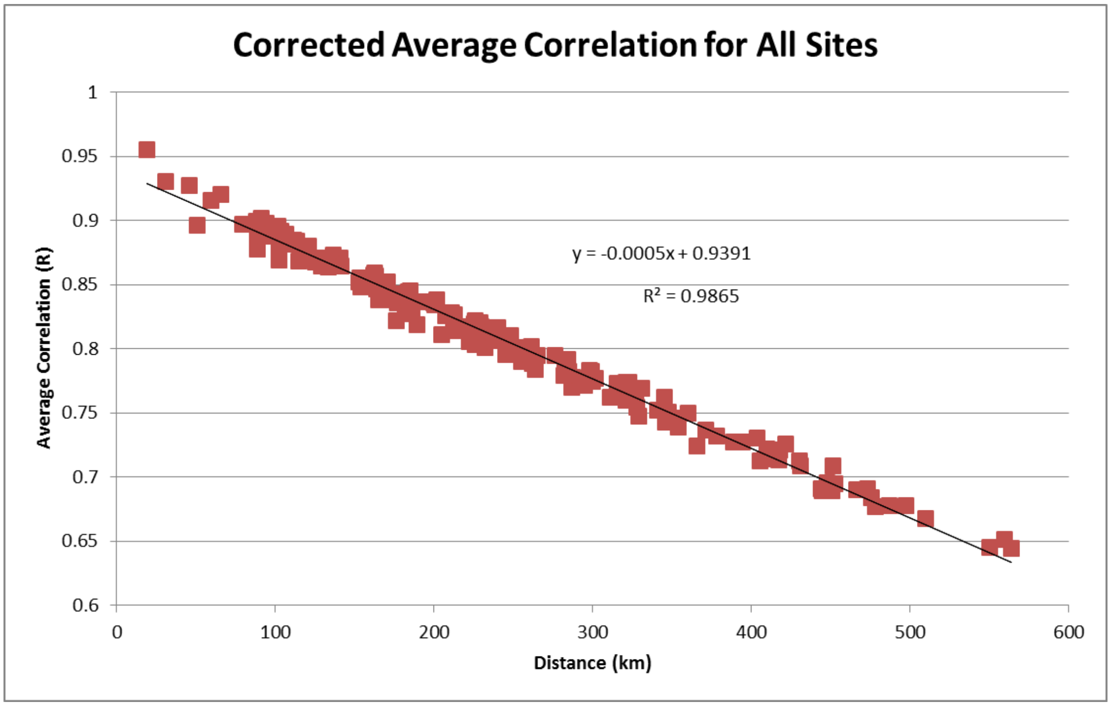


Figure 9. Adjusted Averaged Correlation

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 5 this difference does affect the overall correlation and in order to get the correct distance cutoff the Des Moines data was removed (Figure 10).

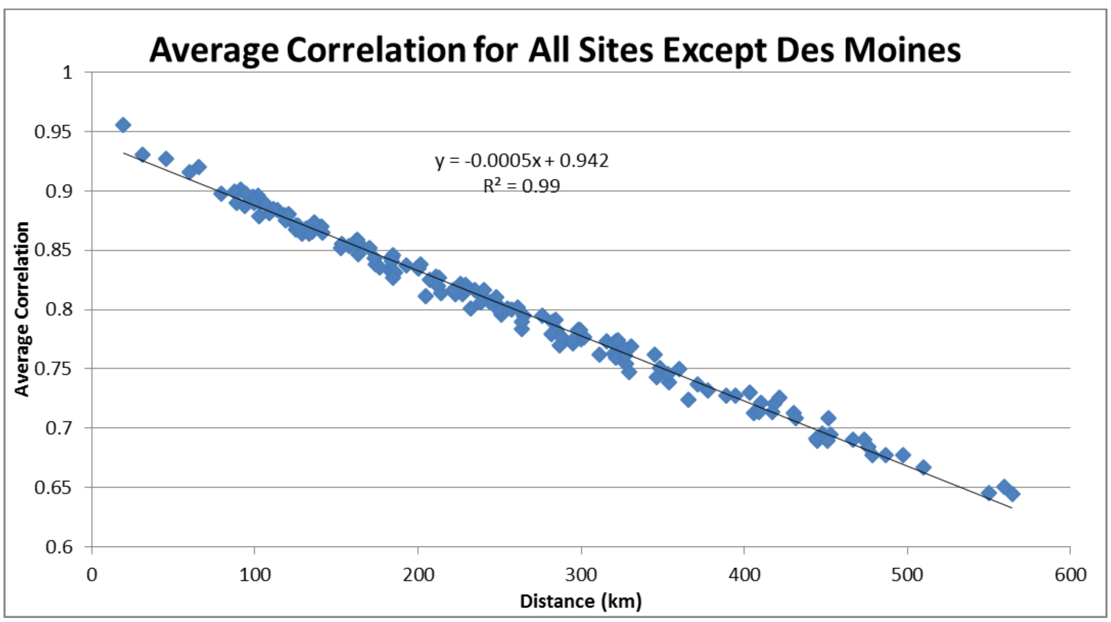


Figure 10. Average Correlation without Des Moines Data

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:

Equation 1

$$Q = 1 - (M * D)$$

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

The mesoscale coefficient is derived from the data in Figure 10 using Equation 2:

Equation 2

$$M = \frac{(1 - R_{Min})}{D_{Max}}$$

Where: R_{Min} = Minimum desired correlation
D_{Max} = Maximum distance (km) at which R_{MIN} is met

Substituting 0.8 for R_{MIN}, and 284 km for D_{MAX} results in M = 0.000704225. Thus, Equation 1 becomes:

Equation 3

$$Q = 1 - (0.000704225 * D)$$

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 sites, and then applied to the corresponding correlation coefficients for those combinations.

Selection of AERMOD Meteorological Sites

For various reasons, only a portion of the 93 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 93 sites, 21 were chosen for processing (see Table 5). These include three sites not used in the 2010-2014 dataset (Blair, NE; Decorah, IA; and Fort Dodge, IA). The addition of these sites significantly improves the coverage of representative meteorological data. One site from the 2010-2014 dataset has been removed (La Crosse, WI). Previously, this site was used in the upper Mississippi River Valley. The DNR has since determined that this site is not representative of many sections of the river valley and has decided not to process it for use in the model. All but three of the chosen sites have 1-minute data available. For those three sites, sub-hourly ASOS wind data was obtained from the Iowa Environmental Mesonet (IEM). This data was processed manually to replicate the average wind conditions for each hour that would have been produced had 1-minute data been available.

The data for Decorah did not meet the 90% completeness criterion during the third quarter of 2015 (~82%) and the third quarter of 2016 (~86%). The EPA Region 7 office approved the use of this data set because it is more representative of the far northeast corner of the state than any of the alternatives that meet the 90% criterion. The expectation being that the Iowa DNR would fill in the missing data using sub-hourly data from the Decorah site obtained from the IEM.

Table 5. The 21 Surface Stations Used to Process Data for AERMOD

Station	Call Sign
Ames, IA	KAMW
Blair, NE	KBTA
Burlington, IA	KBRL
Cedar Rapids, IA	KCID
Davenport, IA	KDVN
Decorah, IA	KDEH
Des Moines, IA	KDSM
Dubuque, IA	KDBQ
Estherville, IA	KEST
Fort Dodge, IA	KFOD
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

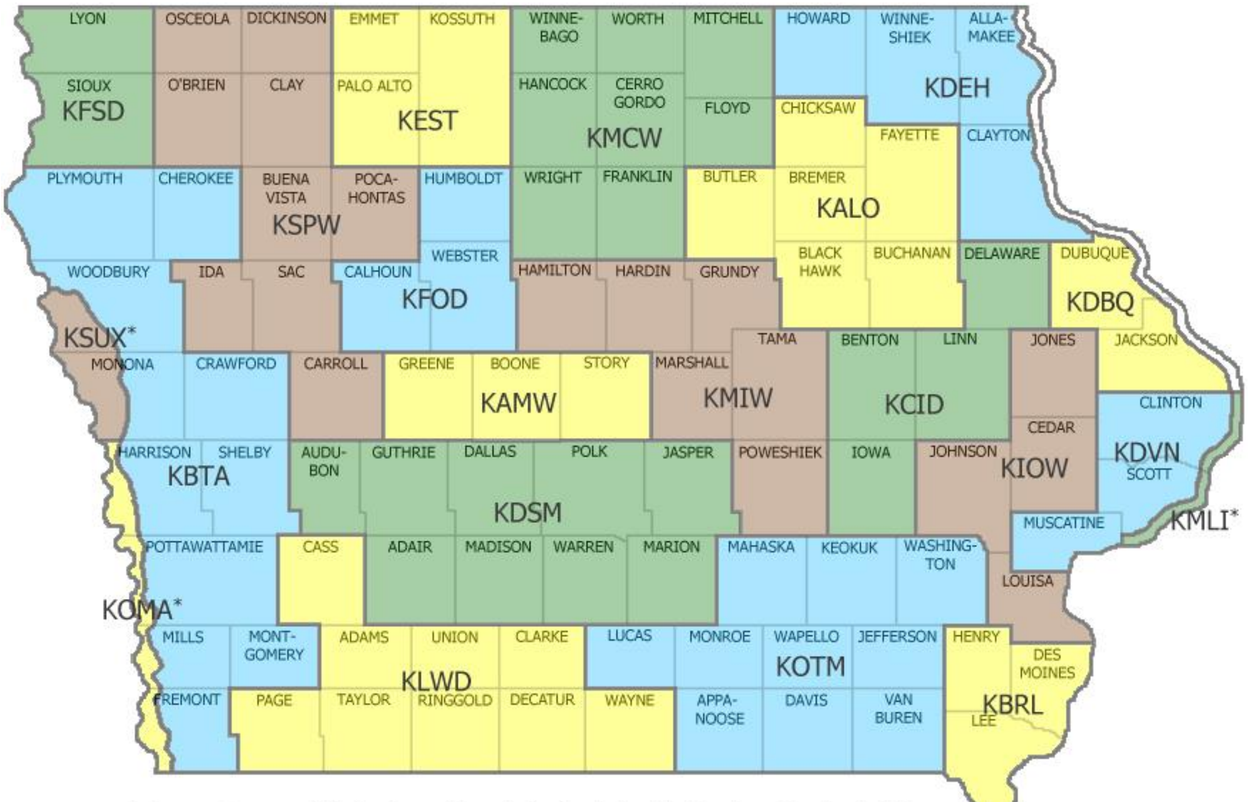
The final step in the process was to use the distance-weighted correlation coefficients to determine those portions of the state for which each meteorological station listed in Table 5 is representative. Traditionally, county borders have been used as convenient boundaries that can be easily referenced to determine which meteorological dataset to use for various areas of the state. However, research conducted by the Iowa DNR shows that there are areas of the state where meteorological representivity may vary within a county, specifically: areas affected by portions of the Missouri or Mississippi River valleys. Figure 3 provides an example of such an area.

The Omaha, NE meteorological measurement site is located within the Missouri River valley. Its wind rose is most correlated with the wind rose from Tekamah, NE, which is also located in the Missouri River valley approximately 50 km N-NW of the Omaha, NE site, but it is far less correlated with the wind rose from Council Bluffs, IA, which is located only 8 km to the east of the Omaha, NE site, but is situated on the bluff above the Missouri River valley. This is an obvious indication that the Missouri River valley effects the overlying mesoscale flow along this stretch of the river. Similar effects can be seen along the remainder of the Missouri River valley bordering Iowa, and along the stretch of the Mississippi River valley upstream from Moline, IL.

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. An index value of 0.0023 was used as a cutoff. Only sites with a terrain index value above this cutoff are considered to be influenced by river valley terrain. This index value cutoff corresponds to a valley depth of 60 meters (or greater). 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 (20). 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 5.

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 11.



* Represents areas within the river valley only (border defined by the edge of the flood plain).

Figure 11. Representative Areas for the 2015 – 2019 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. 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.

A major change from the 2010-2014 dataset is the removal of the La Crosse, WI data for the Upper Mississippi River Valley. The meteorological conditions in this stretch of the river are highly influenced by the orientation of the valley at any specific location, as can be seen in the wind data for La Crosse, WI and Prairie Du Chien, WI. As such, the DNR has determined that the La Crosse, WI data is not representative of many sections of the valley. In addition, there are only a small number of facilities located in this section of the valley. For these reasons **the DNR has decided to treat projects in portions of the Mississippi River Valley north of Clinton County on a case-by-case basis. Applicants located in this section of the Mississippi River Valley should contact the DNR for guidance prior to conducting modeling.**[1]

In Muscatine County, the two highest-correlated sites were Iowa City (0.91) and Davenport (0.88). The majority of modeling conducted in the county occurs in the $PM_{2.5}$ and SO_2 SIP areas (generally located on the southeastern edge of the county). When the distance-weighted correlation coefficients are calculated based on the location of the SIP areas

[1] In some cases, it may be appropriate for applicants in this area of the State to conservatively estimate model results by using a large sample of less representative data. The DNR evaluated model results for multiple facilities located within the upper Mississippi River valley using data from all 2010-2014 meteorological data sites. The highest ranked results were captured using data from a combination meteorological sites nearest to the upper Mississippi River valley (excluding La Crosse, WI). Therefore, future modeling projects that are evaluated using all seven sites in the 2015-2019 data set nearest to the valley (KALO, KCID, KDBQ, KDEH, KDVN, KIOW, and KMLI) would be expected to produce a conservative estimate. Use of the meteorological data in this way should not be confused with “representivity.” If an approach like this is approved for a project it will be considered a conservative estimate and not a representative result. Any conservative approach may result in permit limits that are more stringent than would otherwise be required if representative data were used. However, there may be projects where a conservative estimate is acceptable to the applicant and thus the DNR is providing this as one possible approach to conducting a modeling analysis in this area.

they become 0.89 for both the Iowa City and Davenport data. In this case, Davenport was chosen as the representative site because a thorough representivity analysis has already been conducted as part of several modeling analyses conducted in Muscatine.

The distance-weighted correlation coefficient of the chosen representative site for each area is depicted in Figure 12. 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.

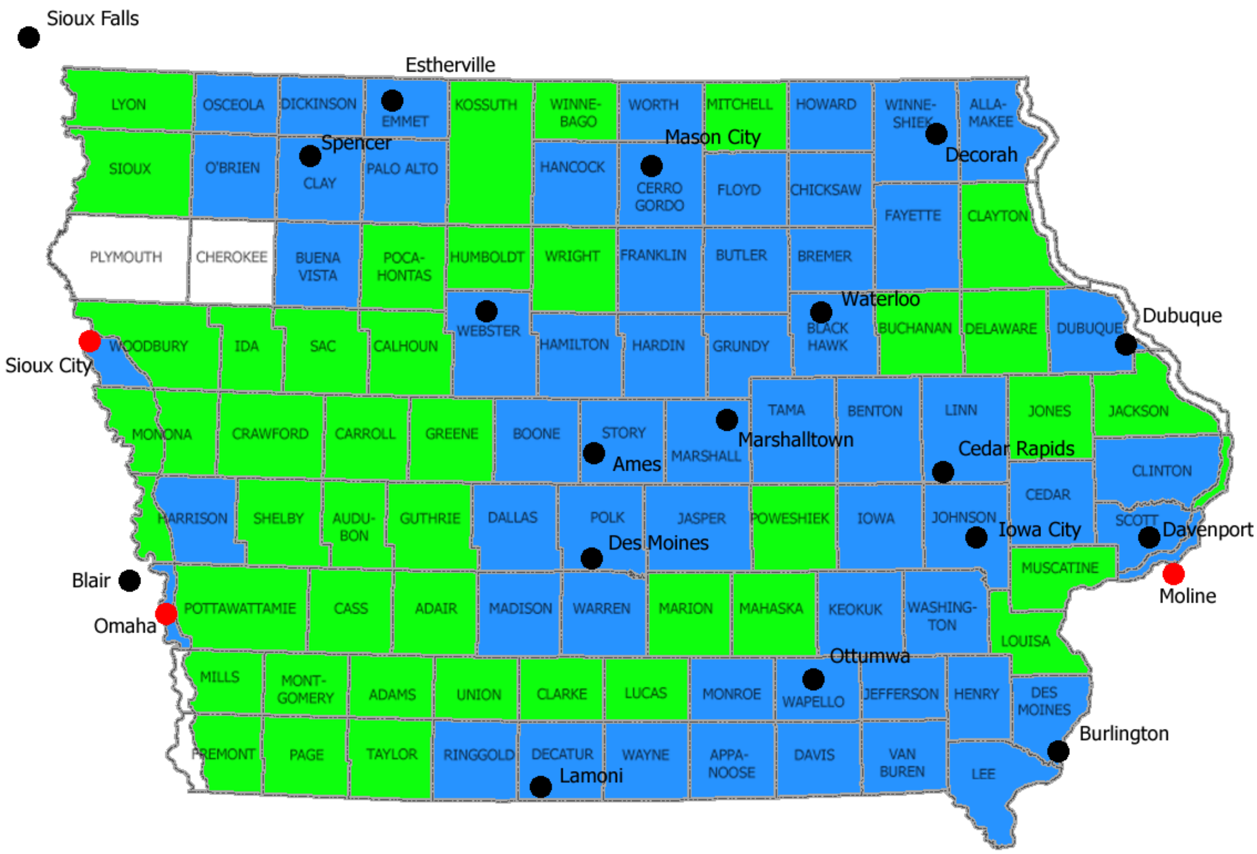


Figure 12. Distance-Weighted Correlation of Chosen Representative Sites

As shown by the map, approximately 98% 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 2% is represented by less-correlated meteorological stations. This is mainly due to a lack of data in these areas of the state.

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, KBTA, KDSM, KEST, KFOD, KFSD, KLWD, KMCW, KOMA, KSPW, and KSUX were paired with the Omaha upper air data. The surface data from KALO, KBRL, KCID, KDBQ, KDEH, KDVN, KIOW, KMIW, KMLI, and KOTM were paired with the Davenport upper air data.

It should be noted that this representivity analysis is intended to provide a guide for general representivity 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.

Filling Missing Surface Data

Surface data were only filled for the 21 meteorological stations chosen during the representivity analysis (listed in Table 5). 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 (21), and quality assures (QA) the results following the recommendations in EPA’s “Meteorological Monitoring Guidance for Regulatory Modeling Applications” document (22). Much of the data filling was performed automatically by AERFILL. Longer, or more problematic gaps, and most quality assurance related decisions, were addressed manually.

The data were filled using various techniques, 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 representivity 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 was 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 (23) for the station in question.
- The raw ISH data for neighboring stations.
- ASOS data from the IEM for neighboring stations.
- AWOS/RWIS (Road Weather Information System) 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 have been 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

Missing upper air data can cause an under-prediction bias in AERMOD. This effect, and procedures for filling missing upper air data, are outlined in the document "A Method for Filling AERMET Upper Air Data" (24). The procedures described in that document were used to fill the missing data.

The raw data from four sites (Davenport, IA; Lincoln, IL; Minneapolis, MN; 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 morning soundings at each location. Evening soundings are not currently used by AERMET, and were therefore not evaluated. The morning sounding inventory is summarized in Table 6.

Table 6. Morning Sounding Inventory

Station	Available Morning Soundings	Percentage
Davenport, IA	1,810	99.1%
Lincoln, IL	1,818	99.6%
Minneapolis, MN	1,801	98.6%
Omaha, NE	1,807	99.0%

Using this information, the raw data were edited to fill in the missing morning soundings. Only data from the two nearest sites (Davenport and Omaha) were used to process data for AERMOD, so only those data were filled. 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 no instances where the sounding was missing from both Davenport and Omaha.

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 version of AERMINUTE available at the time of processing (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 was obtained from the NCDC's online ftp directory (4) in the 6405 format, which is compatible with the AERMINUTE program. The downloaded data consists of text files; each text file contains data for one station-month.

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 NCDC 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 (25) 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 eighteen stations being processed was included in the AERMINUTE input file for comparison with each of these stations 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.

Three sites (Blair, NE (KBTA); Decorah (KDEH), 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. Also, January of 2018 for the Omaha, NE (KOMA) site did not have 1-minute data available, therefore sub-hourly data was used.

Even after processing the sub-hourly data for KBTA, KDEH and KFOD these sites contained far more calms than any of the other data sets. The Decorah data contained 9% calms, Fort Dodge 6%, and Blair 3%. 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%. 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 three datasets. Each calm hour within one hour of a non-calm record at these three sites was filled using a wind speed of 1 m/s and the same wind direction as the nearest non-calm hour. This method of filling calms is the same that was used in the DNR's 2000-2004 meteorological data sets (prior to the availability of 1-minute data). After this was accomplished the average percentage of calms for these three sites was reduced from 6% to 2%, with the highest percentage for any one year being 3% (Decorah). 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.

The method used to fill calms is similar to the way calms used to be treated before calms processing routines were developed. Before calms processing, a "calm" was defined as an hour with a wind speed of 1.0 m/s and a wind direction that was equal to the previous hour. This method produced conservative estimates and avoided division by zero in the dispersion equations of earlier models. Since then, calms processing routines have been built into the models to modify the averages during periods in which calms are present. Filling all calms that occur within one hour of a non-calm hour is a hybrid of the two techniques. In other words, calms are filled via persistence to a certain extent, but left intact for the calms processing routines to handle during longer periods.

Land Use Analysis

The latest version of AERSURFACE (dated 19191) was used to conduct the land use analysis for each meteorological site. This version of AERSURFACE uses the 2016 land use, tree canopy and impervious surfaces data. While the data were processed in accordance with the guidance available in the AERSURFACE user guide (9), 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 NCDC were analyzed for the entire 2015-2019 period (26). An example of a daily snow cover map is depicted in Figure 13.

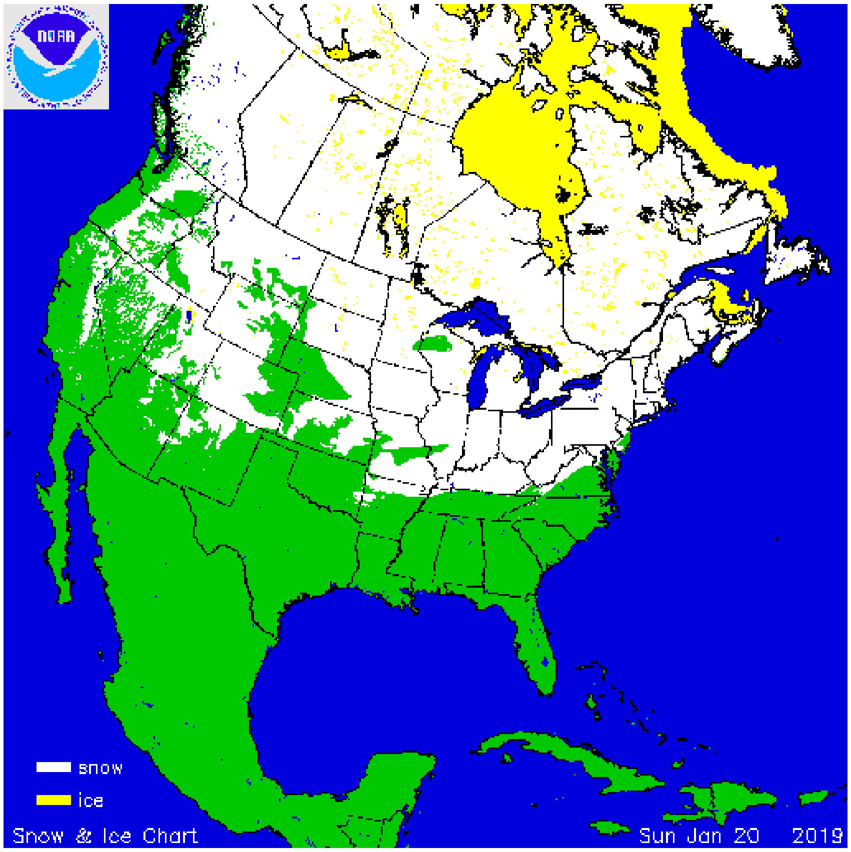


Figure 13. Example Daily Snow Cover Map

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 during which there was snow cover during at least half of the days in that month at that site (marked by the letter “X” in Tables Table 7-Table 11).

To determine the relative surface moisture conditions during each month of the period, monthly climatological divisional precipitation rank maps were analyzed (27). An example of a monthly climatological divisional precipitation rank map is depicted in Figure 14.

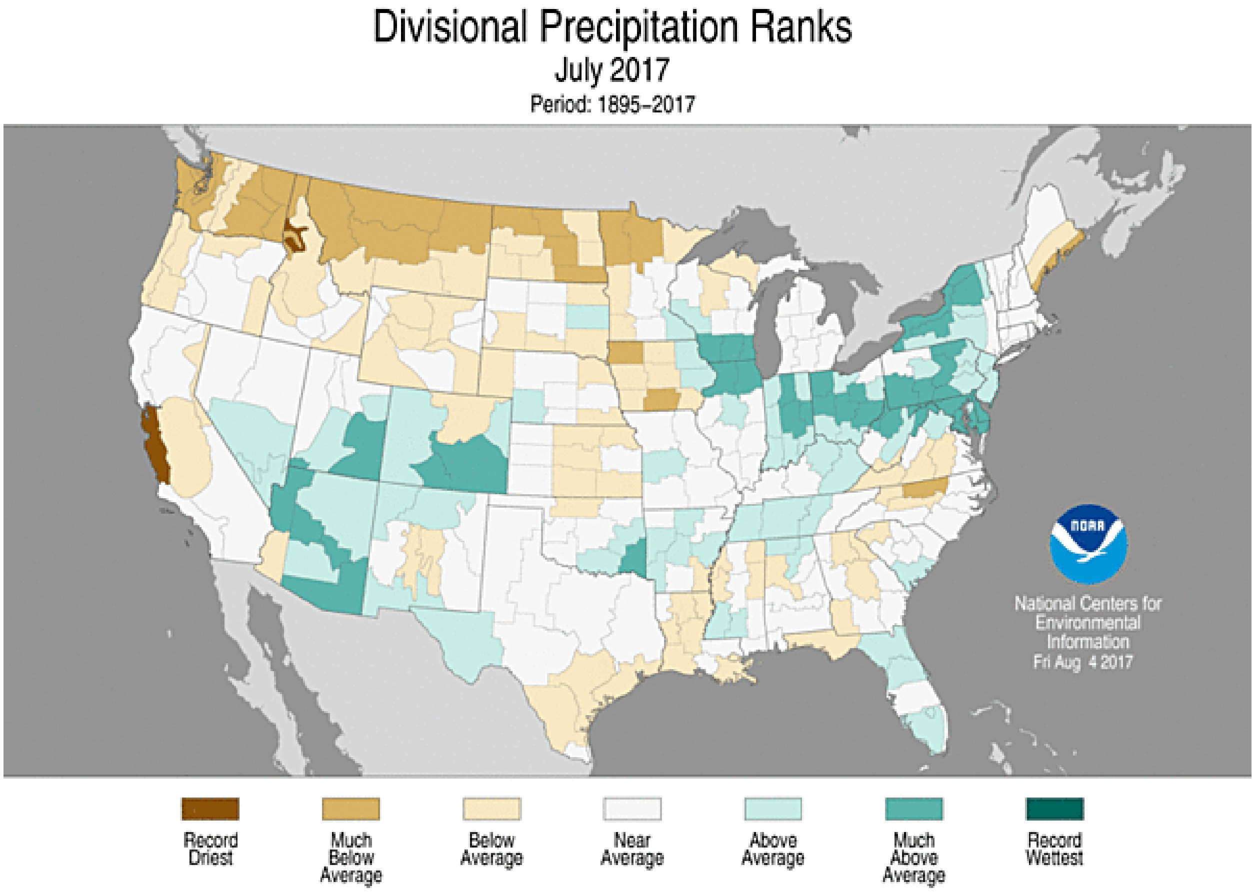


Figure 14. Example Monthly Climatological Divisional Precipitation Rank Map

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 (9):

> *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.*

Dry conditions are represented in Tables Table 7-Table 11 with orange-shaded cells, wet conditions are represented with blue-shaded cells and average conditions are not shaded.

Table 7. Snow Cover and Moisture Conditions – 2015

Station	January	February	March	April	May	June	July	August	September	October	November	December
KALO (Waterloo)	X	X										
KAMW (Ames)		X										
KBRL (Burlington)	X	X										
KBTA (Blair NE)	X	X										
KCID (Cedar Rapids)	X	X										
KDBQ (Dubuque)	X	X										
KDEH (Decorah)	X	X	X									
KDSM (Des Moines)		X										
KDVN (Davenport)	X	X										
KEST (Estherville)	X	X										X
KFOD (Fort Dodge)	X	X										
KFSD (Sioux Falls SD)	X	X										X
KIOW (Iowa City)	X	X										
KLWD (Lamoni)		X										
KMCW (Mason City)	X	X										
KMIW (Marshalltown)	X	X										
KMLI (Moline IL)	X	X										
KOMA (Omaha NE)	X	X										
KOTM (Ottumwa)		X										
KSPW (Spencer)	X	X										X
KSUX (City City)	X	X										X

Table 8. Snow Cover and Moisture Conditions - 2016

Station	January	February	March	April	May	June	July	August	September	October	November	December
KALO (Waterloo)	X	X										X
KAMW (Ames)	X	X										X
KBRL (Burlington)	X											
KBTA (Blair NE)	X	X										
KCID (Cedar Rapids)	X	X										X
KDBQ (Dubuque)	X	X										X
KDEH (Decorah)	X	X										X
KDSM (Des Moines)	X	X										
KDVN (Davenport)	X											X
KEST (Estherville)	X	X										X
KFOD (Fort Dodge)	X	X										X
KFSD (Sioux Falls SD)	X	X										X

Station	January	February	March	April	May	June	July	August	September	October	November	December
KIOW (Iowa City)	X	X										X
KLWD (Lamoni)	X	X										
KMCW (Mason City)	X	X										X
KMIW (Marshalltown)	X	X										X
KMLI (Moline IL)	X	X										X
KOMA (Omaha NE)	X	X										
KOTM (Ottumwa)	X	X										
KSPW (Spencer)	X	X										X
KSUX (Sioux City)	X	X										

Table 9. Snow Cover and Moisture Conditions – 2017

Station	January	February	March	April	May	June	July	August	September	October	November	December
KALO (Waterloo)	X	X										
KAMW (Ames)	X											
KBRL (Burlington)												
KBTA (Blair NE)												
KCID (Cedar Rapids)												
KDBQ (Dubuque)	X											
KDEH (Decorah)	X	X										
KDSM (Des Moines)												
KDVN (Davenport)												
KEST (Estherville)	X	X										
KFOD (Fort Dodge)	X											
KFSD (Sioux Falls SD)	X											X
KIOW (Iowa City)												
KLWD (Lamoni)												
KMCW (Mason City)	X	X										
KMIW (Marshalltown)												
KMLI (Moline IL)												
KOMA (Omaha NE)												
KOTM (Ottumwa)												
KSPW (Spencer)	X	X										X
KSUX (Sioux City)		X										

Table 10. Snow Cover and Moisture Conditions – 2018

Station	January	February	March	April	May	June	July	August	September	October	November	December
KALO (Waterloo)	X	X										
KAMW (Ames)	X	X										
KBRL (Burlington)		X										
KBTA (Blair NE)	X	X										X
KCID (Cedar Rapids)	X	X										
KDBQ (Dubuque)	X	X										
KDEH (Decorah)	X	X		X								X
KDSM (Des Moines)	X	X										
KDVN (Davenport)	X	X										
KEST (Estherville)	X	X	X	X								X
KFOD (Fort Dodge)	X	X										X
KFSD (Sioux Falls SD)	X	X	X	X								X
KIOW (Iowa City)		X										
KLWD (Lamoni)	X											
KMCW(Mason City)	X	X	X	X								X
KMIW (Marshalltown)	X	X										
KMLI (Moline IL)	X	X										
KOMA (Omaha NE)	X	X										X
KOTM (Ottumwa)		X										
KSPW (Spencer)	X	X	X	X								X
KSUX (Sioux City)	X	X	X									X

Table 11. Snow Cover and Moisture Conditions – 2019

Station	January	February	March	April	May	June	July	August	September	October	November	December
KALO (Waterloo)	X	X										
KAMW (Ames)	X	X										
KBRL (Burlington)	X	X										
KBTA (Blair NE)	X	X										
KCID (Cedar Rapids)	X	X										
KDBQ (Dubuque)	X	X										
KDEH (Decorah)	X	X	X								X	
KDSM (Des Moines)	X	X										
KDVN (Davenport)	X	X										
KEST (Estherville)		X										X
KFOD (Fort Dodge)	X	X										
KFSD (Sioux Falls SD)	X	X	X									X

Station	January	February	March	April	May	June	July	August	September	October	November	December
KIOW (Iowa City)	X	X										
KLWD (Lamoni)	X	X										
KMCW (Mason City)	X	X	X									X
KMIW (Marshalltown)	X	X										
KMLI (Moline IL)	X	X										
KOMA (Omaha NE)	X	X										
KOTM (Ottumwa)	X	X										
KSPW (Spencer)	X	X	X									X
KSUX (Sioux City)		X										X

Land Cover Data

The National Land Cover Dataset from 2016 (NLCD92) was chosen for this analysis because the AERSURFACE preprocessor had been updated to use the 2016 land cover data, the most recent available. The land cover data were obtained from the Multi-Resolution Land Characteristics Consortium (7) in GEOTIFF format. The classifications included in this data are summarized in Figure 15.

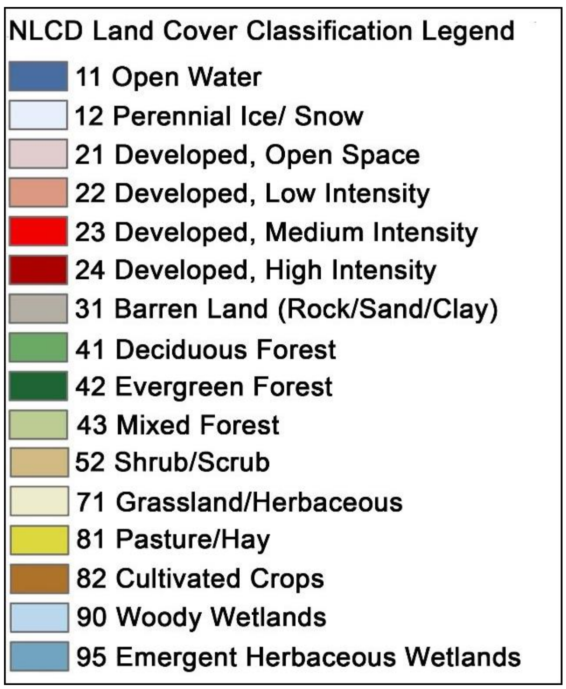


Figure 15. 2016 National Land Cover Dataset Classification Summary

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 distinguishes between these different land uses, but it requires the user to input what type of area each sector is. In order to account for this it was also necessary to define if the sector was “at an airport” or not. Even though all sites are at airports, the distinction here is the roughness elements that will be present. In some cases the sectors were further refined so that this distinction could be made and then each sector was labeled as either airport or non-airport. 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 moisture conditions determined for each month in Tables 7 – 11. These combined output files were then used in the final stage of AERMET.

Appendix B – AERSURFACE sectorscontains the land cover around each of the 21 surface stations. There are four figures per station. The first figure (upper left) for each site shows an aerial photograph along with a circle which depicts the 1 km upwind fetch used by AERSURFACE to calculate the surface roughness. It also shows the sectors (if applicable) that were used for input into AERSURFACE. Sectors were chosen based on similar land use, impervious data and canopy data. If the surface station has similar land use, canopy data and impervious data in all directions the figure will show one sector. The remaining three figures for each station are zoomed out to show the 10 km by 10 km domain used by AERSURFACE to calculate the Bowen Ratio and Albedo for each site. The circle in the middle of each of these is the same 1 km circle depicted in the first figure. The second figure (upper right) for each station shows the land use by category (see Figure 15). The third figure (lower left) shows the percentage of the area covered by impervious material (brighter reds and purple are higher percentages). The fourth figure (lower right) shows the percentage of the area covered by tree canopy (darker greens are higher percentages).

Comparison of Model Results

The latest version of AERMOD available at the time (dated 19191) was used to conduct a sensitivity analysis using both the 2010-2014 and 2015-2019 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.

A series of point, volume and area sources were modeled with varying release heights between zero and 65 meters above ground, with release heights set at every 5 meters. Two types of each source were modeled at each release height – one with characteristics resulting in more initial dispersion, the other with characteristics resulting in less. The less disperse point sources were modeled with an ambient exhaust temperature (varies with and is the same as the atmospheric temperature) and horizontally-oriented release, whereas the more disperse point sources were modeled with a bouyant exhaust temperature of 100° C and vertically-oriented release. The less disperse volume sources were modeled with 1-meter horizontal and vertical dimensions, whereas the more disperse volume sources were modeled with 10-meter horizontal and vertical dimensions. The less disperse area sources were modeled with no initial vertical dimension, whereas the more disperse area sources were modeled with a 10-meter initial vertical dimension. This variety of sources were modeled for 1-hour, 3-hour, 8-hour, 24-hour, and annual averaging periods using both sets of meteorological data.

The concentrations predicted using the new meteorological data were then 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.

In the interest of consistency, and in an effort to retain data that would be helpful in explaining any potential biases or patterns in the data, all combinations of source types, release heights and averaging periods were modeled, even though several of those combinations have little or no real-world relevance:

- Point sources are generally used to represent smokestacks or vents, and normally do not exhaust at ground level.
- Area sources are most commonly used to represent storage piles or other broad ground-based sources, and are almost never applied to sources released higher than ten meters above the ground.
- Volume sources are most commonly used to represent sources of emissions that have already been dispersed to some degree before being released into the general atmospheric flow, such as emissions from haul roads or emissions vented into a building that seep out various points in the structure. These types of sources are generally released within 20 meters of the ground.
- Both area and volume sources are almost always used to represent particulate emissions, to which only the 24-hour and annual averaging periods are important (with respect to the current NAAQS).

The data presented in this summary were filtered to exclude all such non-realistic data in order to provide a more real-world depiction of the expected change in model results. A detailed comparison that includes all possible combinations of source types, release heights and averaging periods can be found in Appendix C – Comparison of Model Results by Location.

On average the model results are predicted to decrease slightly for all averaging periods modeled (1-hour, 3-hour, 8-hour, 24-hour, and annual) (Figure 16).

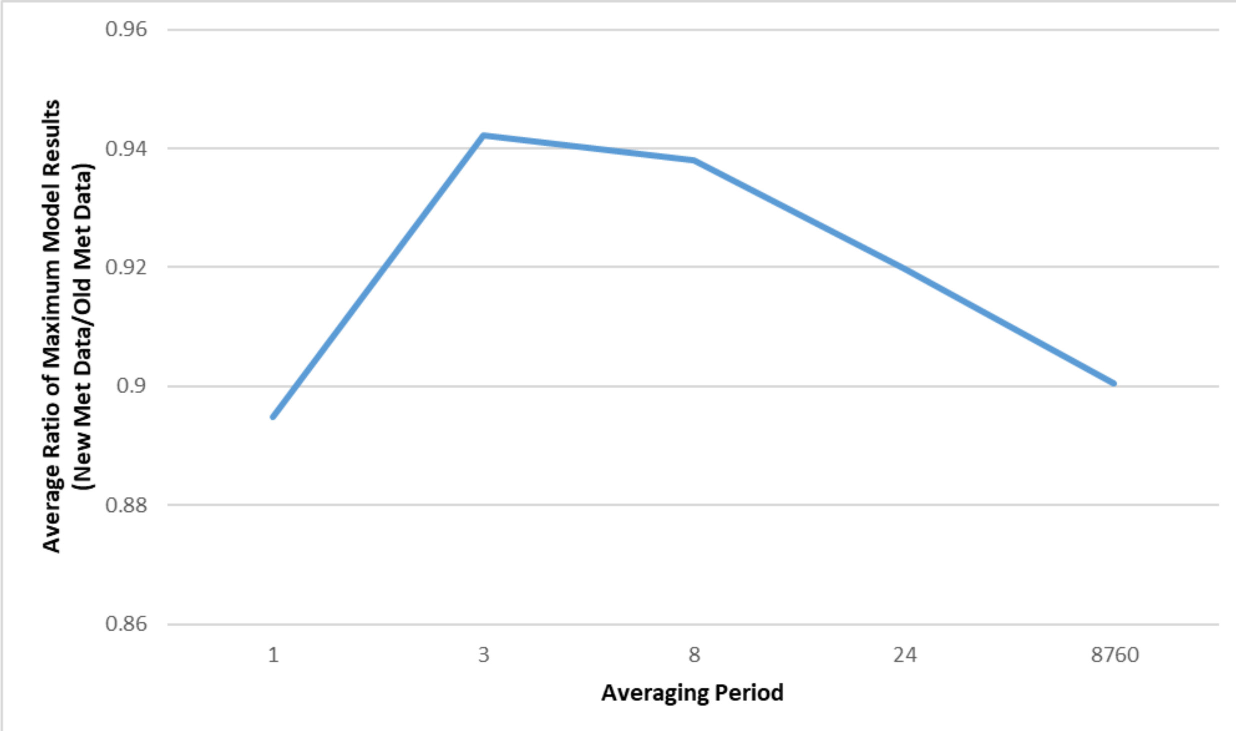


Figure 16. Average Ratio of New / Old Model Results by Averaging Period

The expected change in model results also varies by release height (Figure 17). On average the model results are expected to increase for ground-level releases and decrease for all other release height.

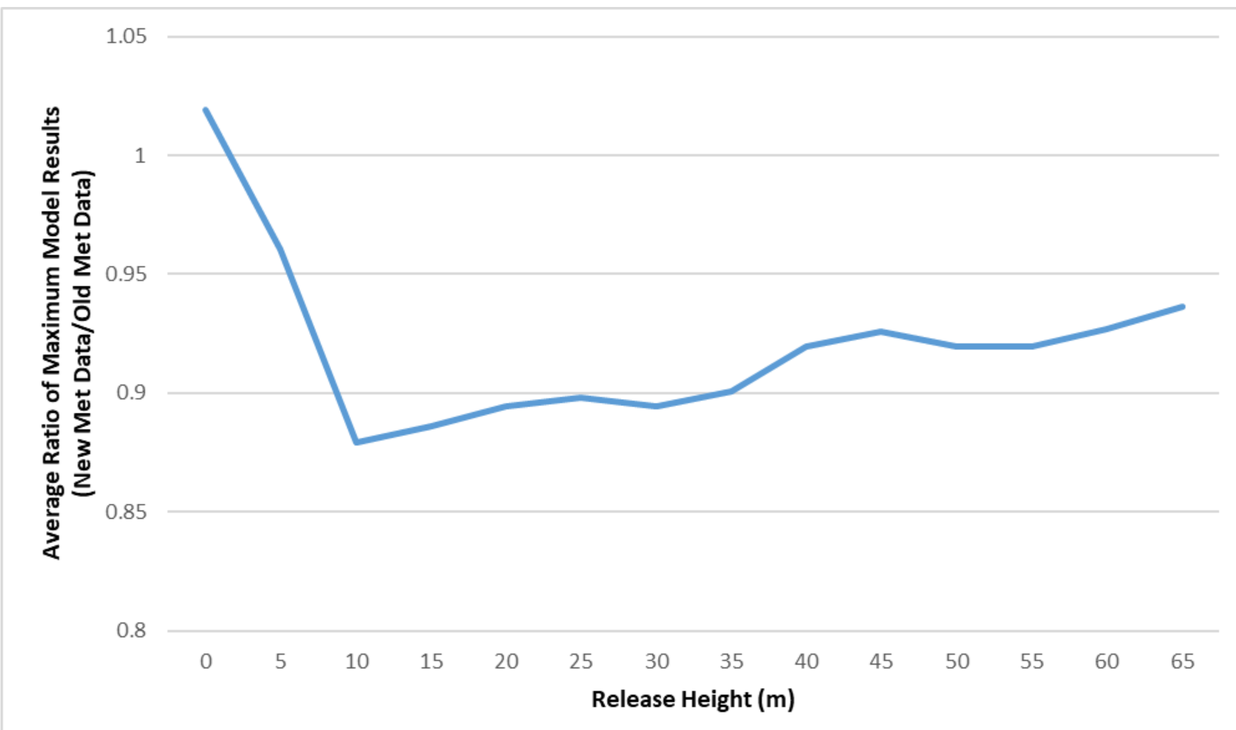


Figure 17. Average Ratio of New / Old Model Results by Release Height

All results depicted up to this point are averages of all maximum concentrations regardless of source type. As multiple types of sources were modeled, it is also worthwhile to analyze the expected change in results based on source type. Figures Figure 18-Figure 23 depict the expected change in model concentration by averaging period for the various combinations of source types and characteristics (averaged across all applicable release heights). Figures Figure 24-

Figure 29 depict the expected change in model concentration by release height for the various combinations of source types and characteristics (averaged across all applicable averaging periods).

One of the most important results to note applies to the “more disperse” point source category (Figure 21 and Figure 27). These are stacks with a vertical exhaust that is hotter than the surrounding air (generators, boilers, combustion turbines, etc.). This type of source constitutes a large percentage of modeled sources and the model concentrations are expected to decrease for all averaging periods and release heights.

Overall, there is expected to be a slight decrease in concentration, on average, for most averaging periods and release heights. Only the low non-disperse releases (0-5 meters) show a slight increase in concentration.

Average Ratio of Maximum Model Results – by Averaging Period

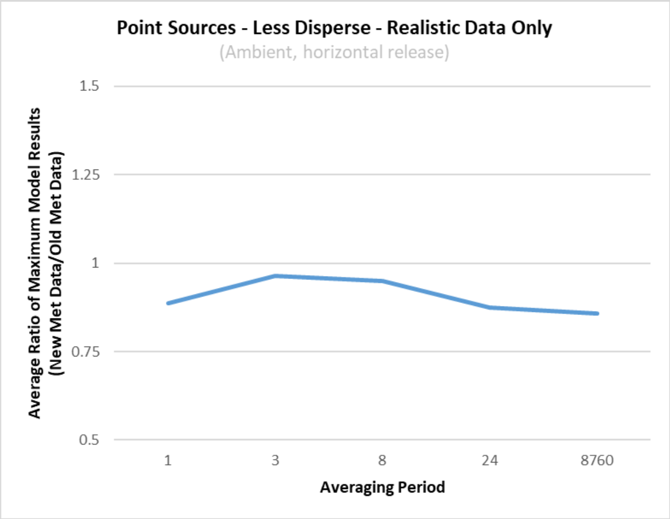


Figure 18. Less Disperse Point Sources

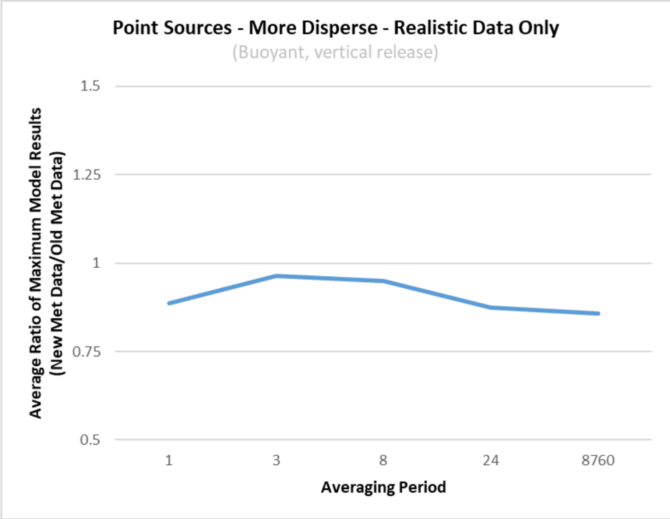


Figure 21. More Disperse Point Sources

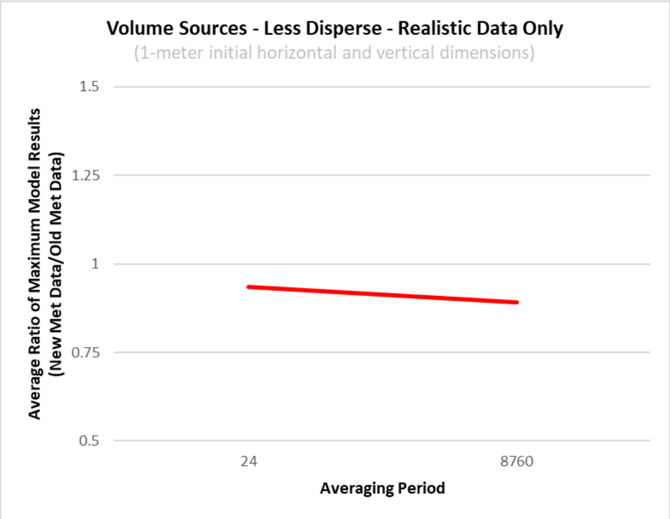


Figure 19. Less Disperse Volume Sources

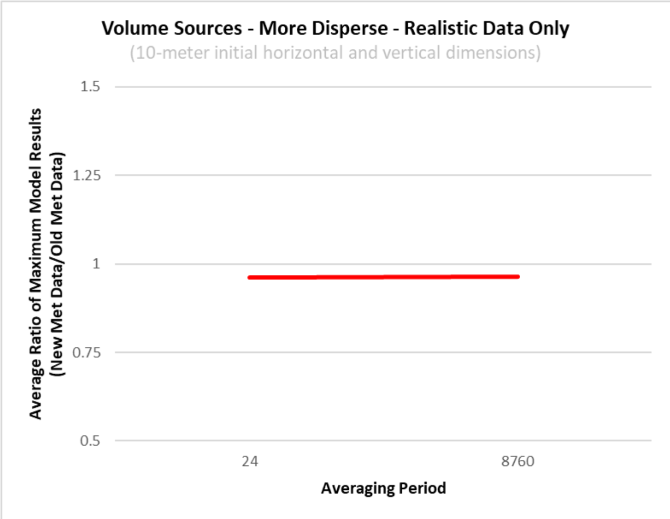


Figure 22. More Disperse Volume Sources

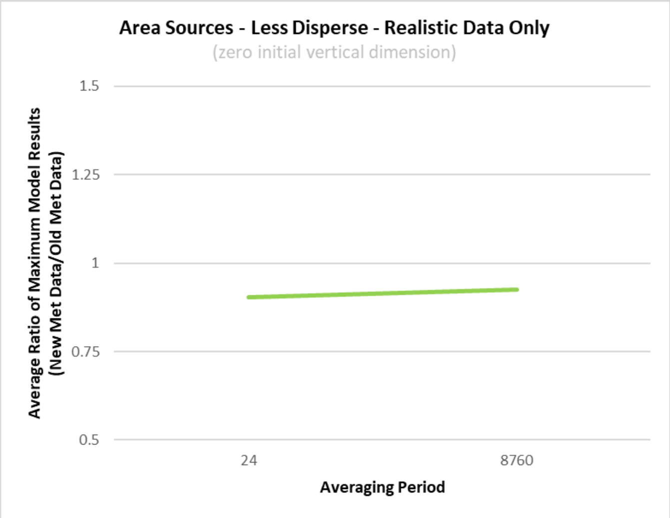


Figure 20. Less Disperse Area Sources

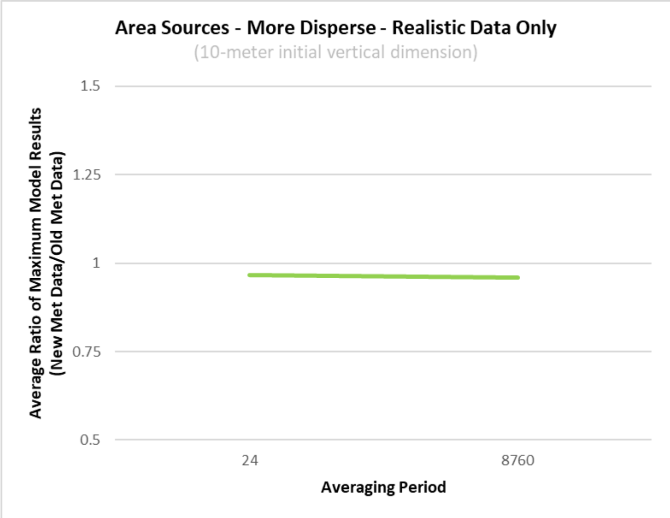


Figure 23. More Disperse Area Sources

Average Ratio of Maximum Model Results – by Release Height

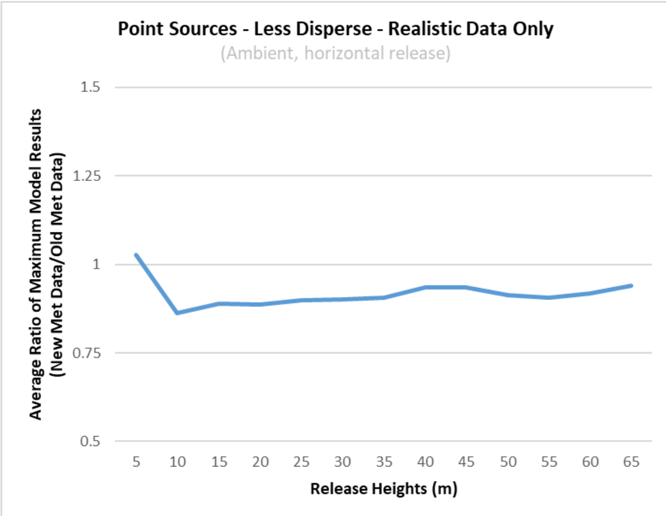


Figure 24. Less Disperse Point Sources

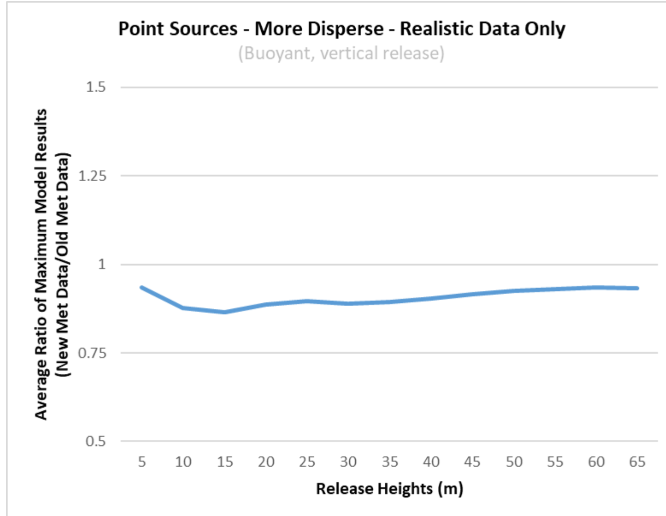


Figure 27. More Disperse Point Sources

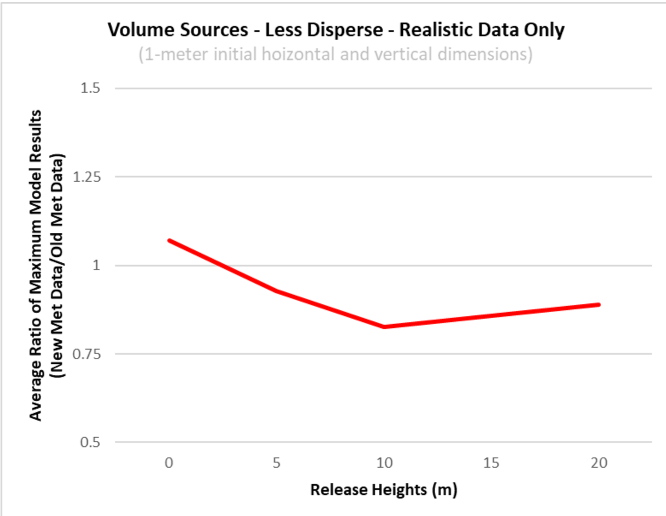


Figure 25. Less Disperse Volume Sources

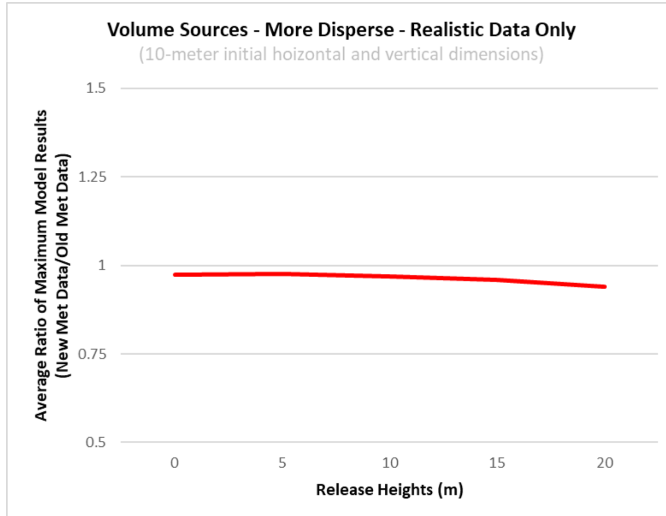


Figure 28. More Disperse Volume Sources

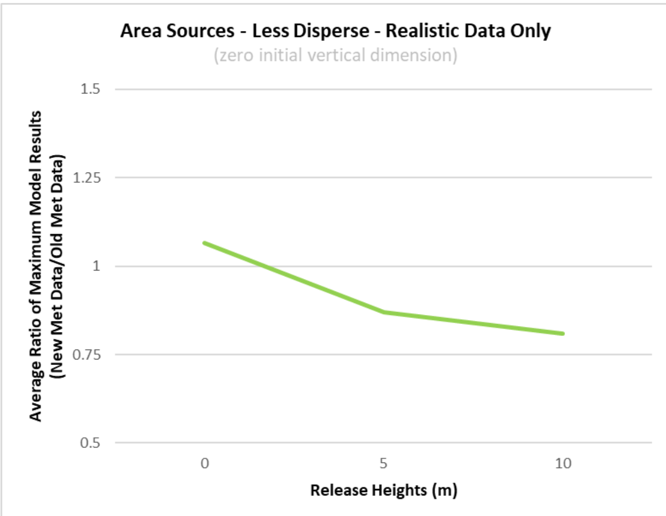


Figure 26. Less Disperse Area Sources

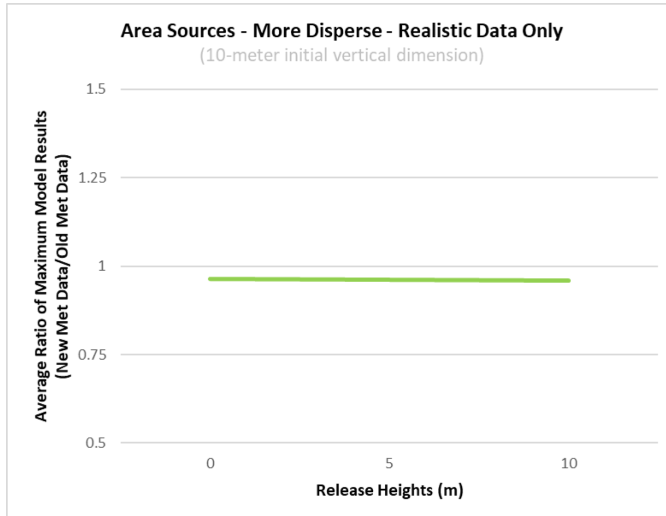


Figure 29. More Disperse Area Sources

The comparisons described above were conducted by pairing the results using the 2010-2014 meteorological data from one site to the model results using the 2015-2019 meteorological data from the same site. These comparisons depict the expected change in model results due to the change in model years and processing methodology. A more detailed comparison of model results was conducted using all 21 meteorological sites that includes the expected change in concentration due to a change in representative site. The results of this analysis are presented in Appendix C – Comparison of Model Results by Location. In addition, the data in Appendix C – Comparison of Model Results by Location have not been filtered to exclude the unrealistic source type/release height/averaging period combinations.

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Appendix A – Meteorological Observation Station Information

This appendix contains information about the locations of the meteorological observation stations used in the processing of the meteorological data for AERMOD. Table 12. Surface Observation Stations provides a summary of the surface observation stations by call sign and city.

Two maps are provided depicting the locations of all of the surface stations used in the representivity analysis and the processing of the AERMOD meteorological data. Figure 30. Surface Station Location Map – Counties includes county names while Figure 31. Surface Station Location Map – Terrain includes terrain elevations for the state of Iowa. On Figure 31. Surface Station Location Map – Terrain, the sites where the wind observations were determined to be influenced by the terrain are highlighted. The aerial imagery used to determine the locations of all surface and upper air sites used in the processing of the AERMOD meteorological data are depicted in Figures Figure 32. Ames, IA (KAMW) Overview through Figure 77. Omaha, NE (KOAX) Close-up.

Table 12. Surface Observation Stations

Call Sign	City	WBAN	WMO	Anemometer Height	1-Min Data Available	Latitude	Longitude
KAEL	Albert Lea	94968	726589	Unknown	No	43.6823	-93.3722
KAXA	Algona	04904	725457	Unknown	No	43.0798	-94.2741
KAMW	Ames	94989	725472	10.0 m	Yes	41.9904	-93.6185
KIKV	Ankeny	04938	725466	Unknown	No	41.6878	-93.5695
KAIO	Atlantic	14930	725453	Unknown	No	41.4046	-95.0476
KADU	Audubon	94998	725498	Unknown	No	41.701	-94.9205
KAUM	Austin	04902	727566	Unknown	No	43.6688	-92.9321
KBTA	Blair	00436	720405	Unknown	No	41.4116	-96.1087
KBNW	Boone	04906	725486	Unknown	No	42.0486	-93.8486
KOVS	Boscobel	94994	726438	10.0 m	Yes	43.1561	-90.6775
KBRL	Burlington	14931	725420	10.0 m	Yes	40.7728	-91.1254
KCIN	Carroll	04910	725468	Unknown	No	42.0444	-94.7889
KCID	Cedar Rapids	14990	725450	7.9 m	Yes	41.8829	-91.7246
KTVK	Centerville	54939	722274	Unknown	No	40.6832	-92.8984
KCNC	Chariton	04913	725469	Unknown	No	41.0184	-93.3608
KCCY	Charles City	14966	725463	Unknown	No	43.073	-92.6132
KCKP	Cherokee	54920	720344	Unknown	No	42.7304	-95.5538
KICL	Clarinda	04937	725479	Unknown	No	40.7242	-95.0223
KCAV	Clarion	04907	725458	Unknown	No	42.743	-93.7592
KCWI	Clinton	94979	725473	Unknown	No	41.8295	-90.3328
KCBF	Council Bluffs	04908	725497	Unknown	No	41.2557	-95.7598
KCSQ	Creston	04915	725474	Unknown	No	41.0188	-94.3608
KDVN	Davenport	94982	744550	10.0 m	Yes	41.6133	-90.5949
KDEH	Decorah	04916	725476	Unknown	No	43.2755	-91.7433
KDNS	Denison	04917	725477	Unknown	No	41.9842	-95.38
KDSM	Des Moines	14933	725460	10.0 m	Yes	41.534	-93.6531
KDBQ	Dubuque	94908	725470	10.0 m	Yes	42.3983	-90.7091
KEST	Estherville	94971	726499	10.0 m	Yes	43.4009	-94.7476
KFFL	Fairfield	04925	726498	Unknown	No	41.0521	-91.9834
KFRM	Fairmont	94948	726586	Unknown	No	43.6455	-94.4168

Call Sign	City	WBAN	WMO	Anemometer Height	1-Min Data Available	Latitude	Longitude
KFXY	Forest City	54940	720643	Unknown	No	43.2323	-93.6237
KFOD	Fort Dodge	94933	725490	Unknown	No	42.5496	-94.2033
KFSW	Fort Madison	04930	725483	Unknown	No	40.6615	-91.3267
KFEP	Freeport	04876	722082	Unknown	No	42.2475	-89.581
KGBG	Galesburg	94959	722089	Unknown	No	40.9328	-90.4335
KGGI	Grinnell	14976	725292	Unknown	No	41.7097	-92.7333
KHNR	Harlan	04936	722097	Unknown	No	41.5842	-95.3358
KIIB	Independence	04989	720293	Unknown	No	42.4544	-91.9504
KIOW	Iowa City	14937	725462	10.0 m	Yes	41.6394	-91.5445
KIFA	Iowa Falls	54941	722331	Unknown	No	42.4691	-93.2651
KMJQ	Jackson	04946	726593	Unknown	No	43.6496	-94.9885
KEOK	Keokuk	04921	725456	Unknown	No	40.4615	-91.4275
KIRK	Kirksville	14938	724455	10.0 m	Yes	40.0966	-92.547
KOXV	Knoxville	04962	725493	Unknown	No	41.2984	-93.1114
KLSE	La Crosse	14920	726430	10.0 m	Yes	43.8792	-91.253
KLWD	Lamoni	94991	725499	10.0 m	Yes	40.6306	-93.9004
KLRJ	Le Mars	04942	725484	Unknown	No	42.7748	-96.1924
KLYV	Luverne	54926	722006	Unknown	No	43.617	-96.214
KMQB	Macomb	04949	722157	Unknown	No	40.5176	-90.6481
KMIW	Marshalltown	94988	725461	10.0 m	Yes	42.1106	-92.9163
KEVU	Maryville	99999	720475	Unknown	No	40.3524	-94.9137
KMCW	Mason City	14940	725485	10.0 m	Yes	43.1543	-93.3262
KMLE	Millard	04992	720308	Unknown	No	41.1981	-96.113
KMLI	Moline	14923	725440	10.0 m	Yes	41.4514	-90.5147
KMXO	Monticello	04953	725475	Unknown	No	42.2204	-91.1605
KMPZ	Mount Pleasant	04947	720309	Unknown	No	40.9452	-91.5122
KMUT	Muscatine	04950	725487	Unknown	No	41.367	-91.1406
KAFK	Nebraska City	04993	725541	Unknown	No	40.6065	-95.8635
KTNU	Newton	04977	725464	Unknown	No	41.6701	-93.0191
KOLZ	Oelwein	04955	725488	Unknown	No	42.6832	-91.9762
KOFF	Offutt	14949	725540	Unknown	No	41.1149	-95.8985
KOMA	Omaha (Eppley)	14942	725500	10.0 m	Yes	41.3119	-95.9018
KORC	Orange City	04959	725489	Unknown	No	42.9895	-96.0606
KI75	Osceola	54942	720701	Unknown	No	41.0472	-93.6876
KOOA	Oskaloosa	54919	720351	Unknown	No	41.2273	-92.4919
KOTM	Ottumwa	14950	725465	10.0 m	Yes	41.1008	-92.4445
KPEA	Pella	04964	720312	Unknown	No	41.3989	-92.9431
KPRO	Perry	54943	720412	Unknown	No	41.8278	-94.1638
KPVB	Platteville	00183	720586	Unknown	No	42.6909	-90.4413
KPMV	Plattsmouth	00470	722291	Unknown	No	40.9446	-95.9124
KPDC	Prairie Du Chien	04963	726444	Unknown	No	43.0193	-91.1211
KFKA	Preston	04927	720283	Unknown	No	43.677	-92.1743

Call Sign	City	WBAN	WMO	Anemometer Height	1-Min Data Available	Latitude	Longitude
KUIN	Quincy	93989	724430	7.9 m	Yes	39.9387	-91.198
KRDK	Red Oak	04966	725494	Unknown	No	41.0107	-95.2622
KRST	Rochester	14925	726440	10.0 m	Yes	43.904	-92.4921
KSFY	Savanna	04996	722204	Unknown	No	42.0455	-90.1101
KSHL	Sheldon	04975	725495	Unknown	No	43.2082	-95.8354
KSDA	Shenandoah	04973	725467	Unknown	No	40.7533	-95.4112
KSUX	Sioux City	14943	725570	10.0 m	Yes	42.3917	-96.3795
KFSD	Sioux Falls	14944	726510	10.0 m	Yes	43.5775	-96.7539
KSPW	Spencer	14972	726500	10.0 m	Yes	43.1682	-95.2101
KSTJ	St. Joseph	13993	724490	10.0 m	Yes	39.7683	-94.9095
KSQI	Sterling	04894	725326	Unknown	No	41.7432	-89.6654
KSLB	Storm Lake	04976	725496	Unknown	No	42.5972	-95.2399
KTQE	Tekamah	94978	725527	10.0 m	Yes	41.7631	-96.1798
KVTI	Vinton	04981	720326	Unknown	No	42.2176	-92.0248
KAWG	Washington	04903	725454	Unknown	No	41.272	-91.6745
KALO	Waterloo	94910	725480	10.0 m	Yes	42.5544	-92.4013
KEBS	Webster City	04920	725478	Unknown	No	42.4392	-93.8691
KONA	Winona	04956	726588	Unknown	No	44.0783	-91.7065
KOTG	Worthington	94927	726587	Unknown	No	43.6525	-95.5758
KYKN	Yankton	94911	726525	Unknown	No	42.9142	-97.3805

Figure 30. Surface Station Location Map – Counties

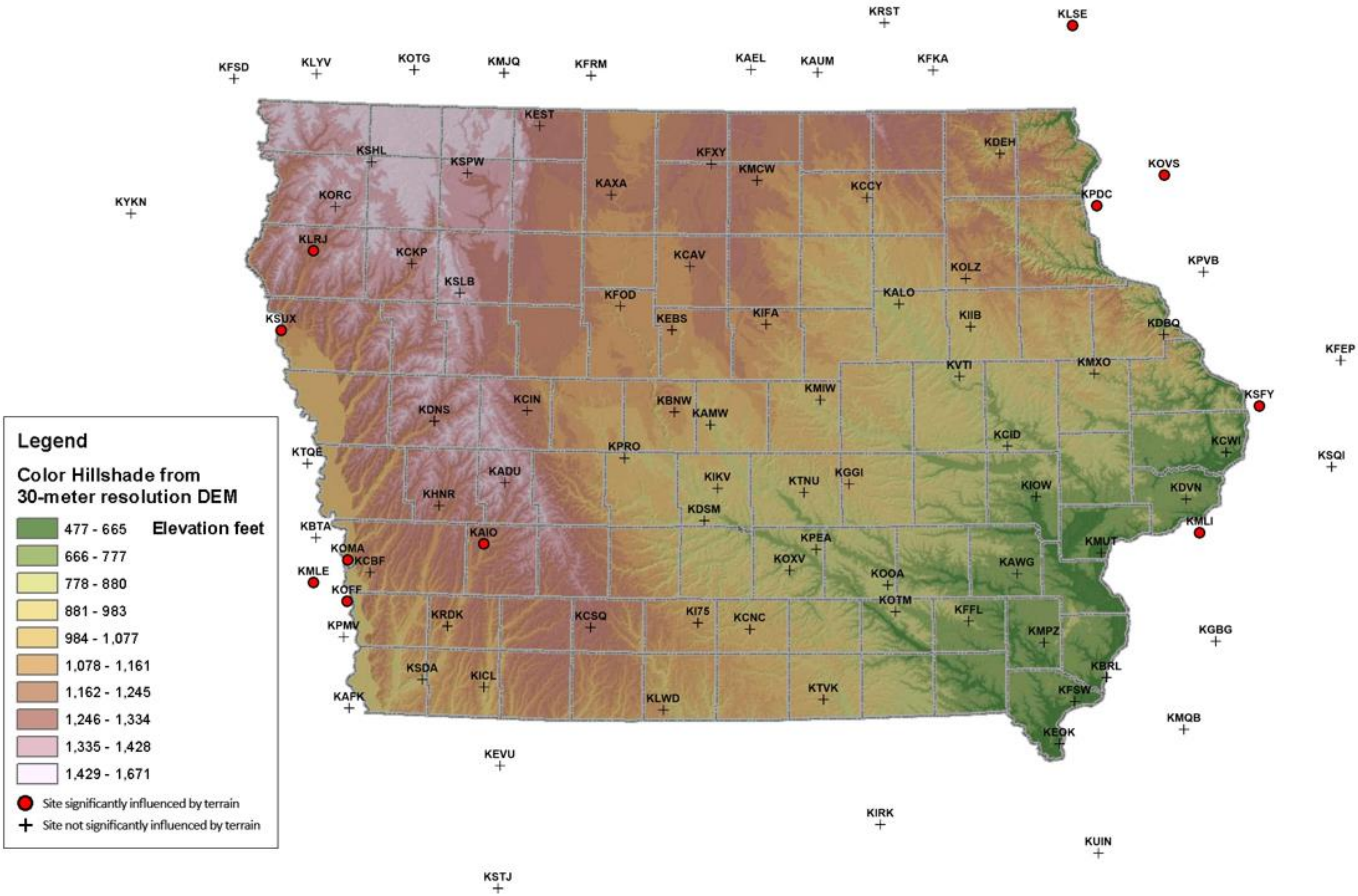

Figure 31. Surface Station Location Map – Terrain

Aerial Photographs – Surface Observation Stations

Figure 32. Ames, IA (KAMW) Overview

Figure 33. Ames, IA (KAMW) Close-up

Figure 34. Blair, NE (KBTA) Overview

Figure 35. Blair, NE (KBTA) Close-up

Figure 36. Burlington, IA (KBRL) Overview

Figure 37. Burlington, IA (KBRL) Close-up

Figure 38. Cedar Rapids, IA (KCID) Overview

Figure 39. Cedar Rapids, IA (KCID) Close-up

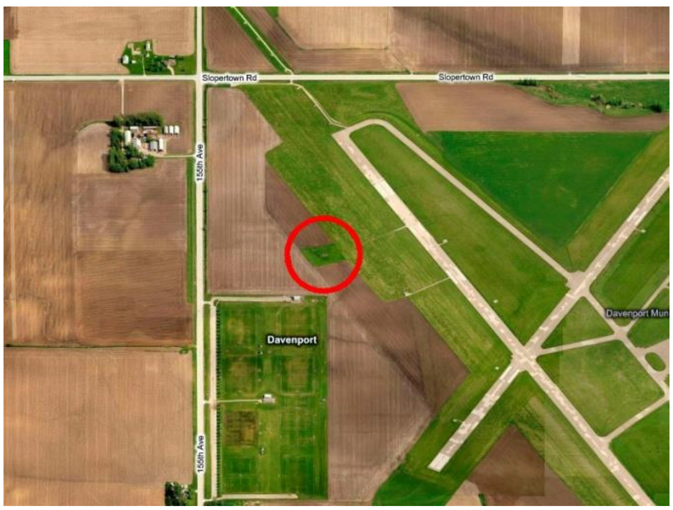

Figure 40. Davenport, IA (KDVN) Overview

Figure 41. Davenport, IA (KDVN) Overview

Figure 42. Decorah, IA (KDEH) Overview

Figure 43. Decorah, IA (KDEH) Close-up

Figure 44. Des Moines, IA (KDSM) Overview


Figure 45. Des Moines, IA (KDSM) Close-up

Figure 46. Dubuque, IA (KDBQ) Overview

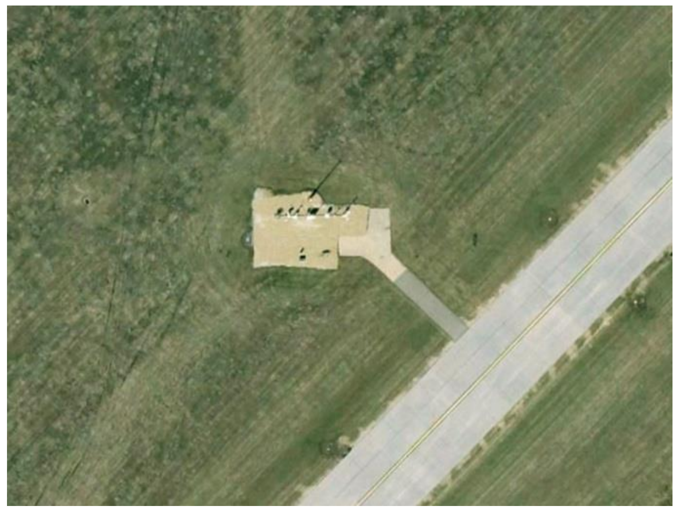
Figure 47. Dubuque, IA (KDBQ) Close-up

Figure 48. Estherville, IA (KEST) Overview


Figure 49. Estherville, IA (KEST) Close-up

Figure 50. Fort Dodge, IA (KFOD) Overview

Figure 51. Fort Dodge, IA (KFOD) Close-up

Figure 52. Iowa City, IA (KIOW) Overview

Figure 53. Iowa City, IA (KIOW) Close-up

Figure 54. Lamoni, IA (KLWD) Overview

Figure 55. Lamoni, IA (KLWD) Close-up

Figure 56. Marshalltown, IA (KMIW) Overview

Figure 57. Marshalltown, IA (KMIW) Close-up

Figure 58. Mason City, IA (KMCW) Overview

Figure 59. Mason City, IA (KMCW) Close-up

Figure 60. Moline, IL (KMLI) Overview

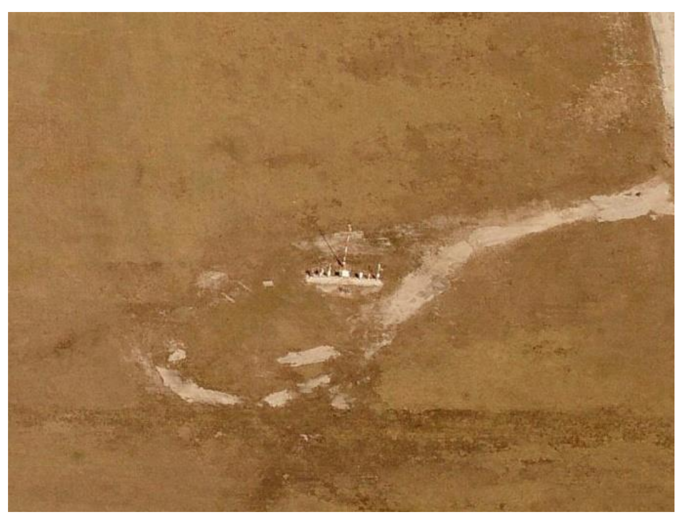

Figure 61. Moline, IL (KMLI) Close-up

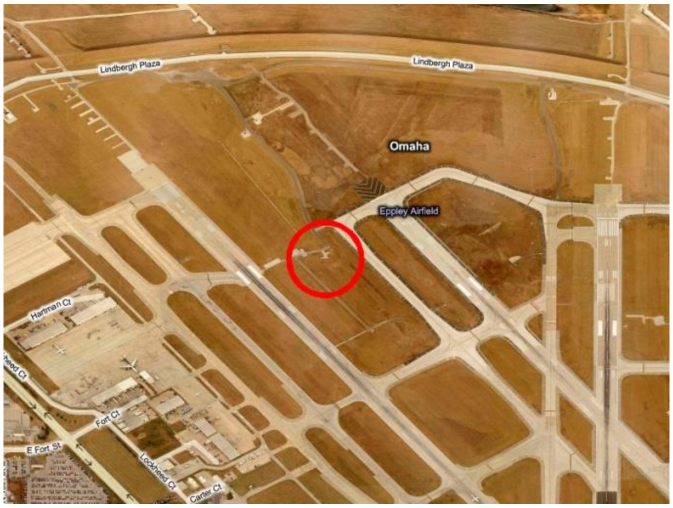

Figure 62. Omaha, NE (KOMA) Overview

Figure 63. Omaha, NE (KOMA) Close-up

Figure 64. Ottumwa, IA (KOTM) Overview

Figure 65. Ottumwa, IA (KOTM) Close-up

Figure 66. Sioux City, IA (KSUX) Overview

Figure 67. Sioux City, IA (KSUX) Close-up

Figure 68. Sioux Falls, SD (KFSD) Overview

Figure 69. Sioux Falls, SD (KFSD) Close-up

Figure 70. Spencer, IA (KSPW) Overview

Figure 71. Spencer, IA (KSPW) Close-up

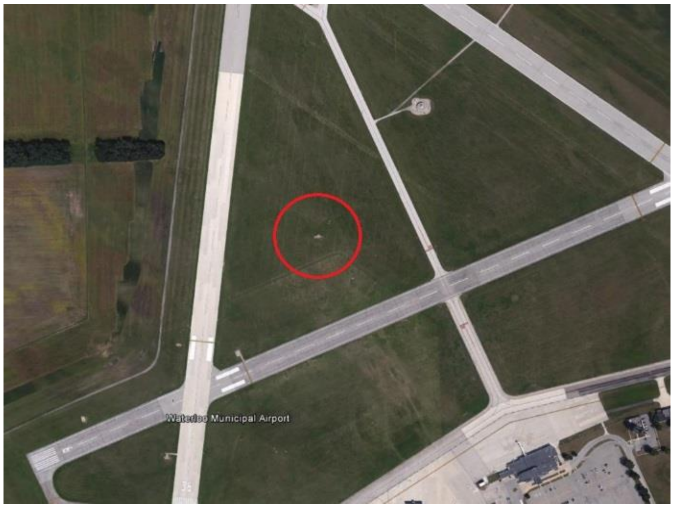

Figure 72. Waterloo, IA (KALO) Overview

Figure 73. Waterloo, IA (KALO) Close-up

Aerial Photographs – Upper Air Observation Stations

Figure 74. Davenport, IA (KDVN) Overview

Figure 75. Davenport, IA (KDVN) Close-up

Figure 76. Omaha, NE (KOAX) Overview

Figure 77. Omaha, NE (KOAX) Close-up

Appendix B – AERSURFACE sectors

Surface Characteristics Data for KALO (Waterloo, IA)

Figure 78. Aerial Photograph with Sectors – KALO

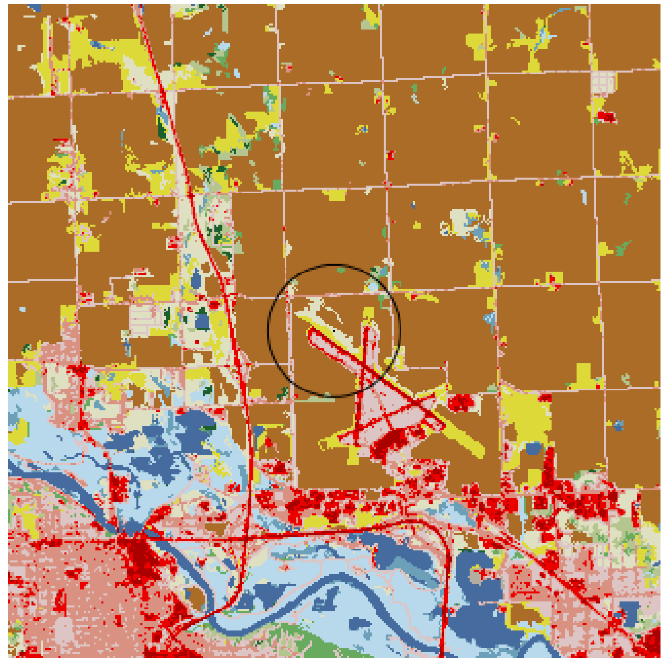

Figure 79. Land Use Data – KALO

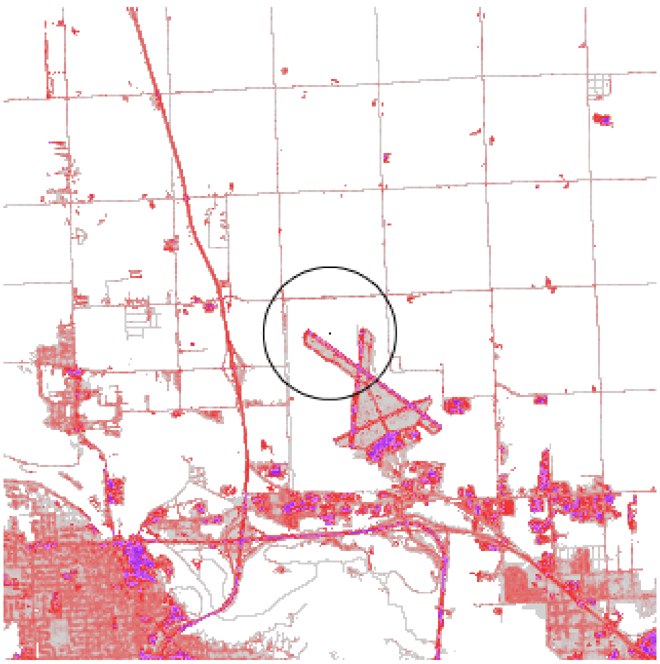

Figure 80. Impervious Data – KALO

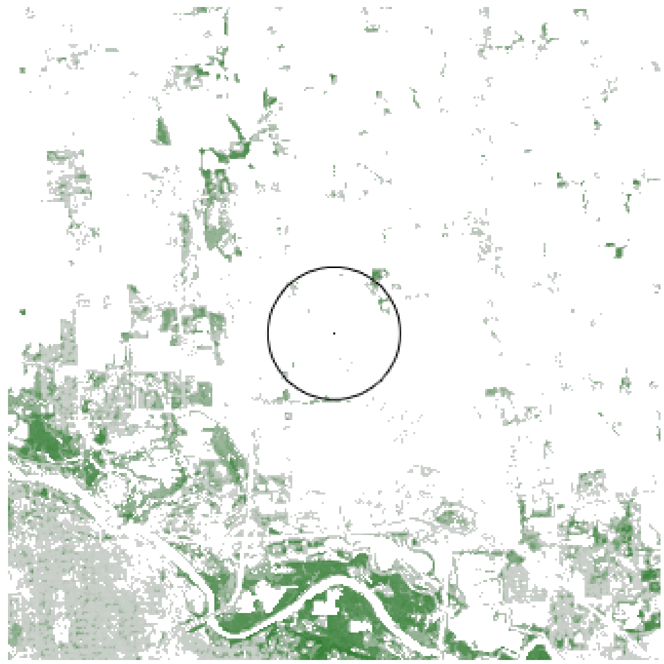

Figure 81. Canopy Data – KALO

Surface Characteristics Data for KAMW (Ames, IA)

Figure 82. Aerial Photograph with Sectors – KAMW

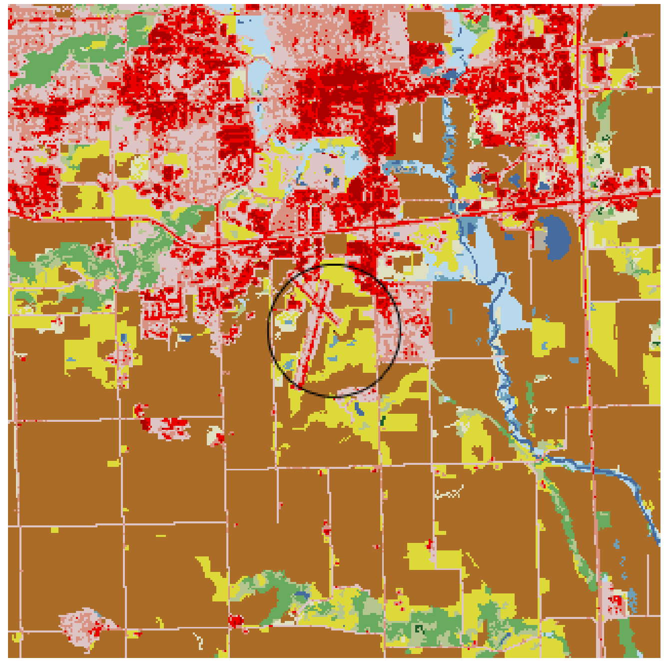

Figure 83. Land Use Data – KAMW

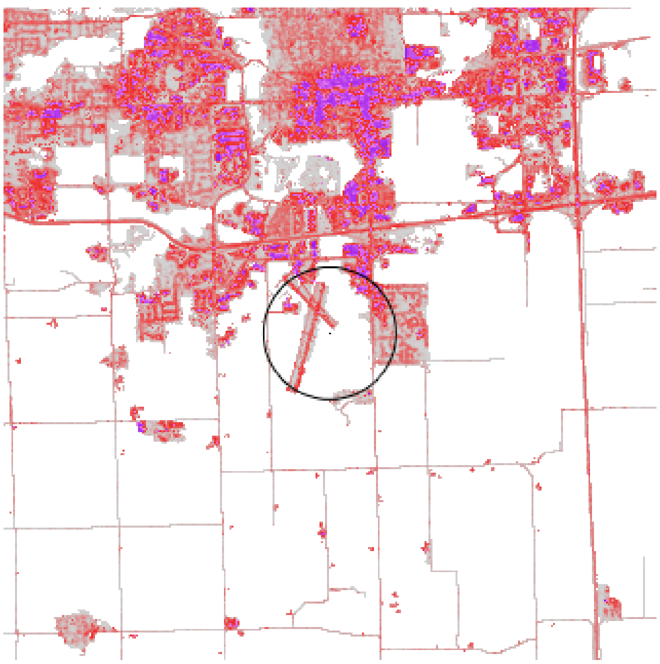

Figure 84. Impervious Data – KAMW

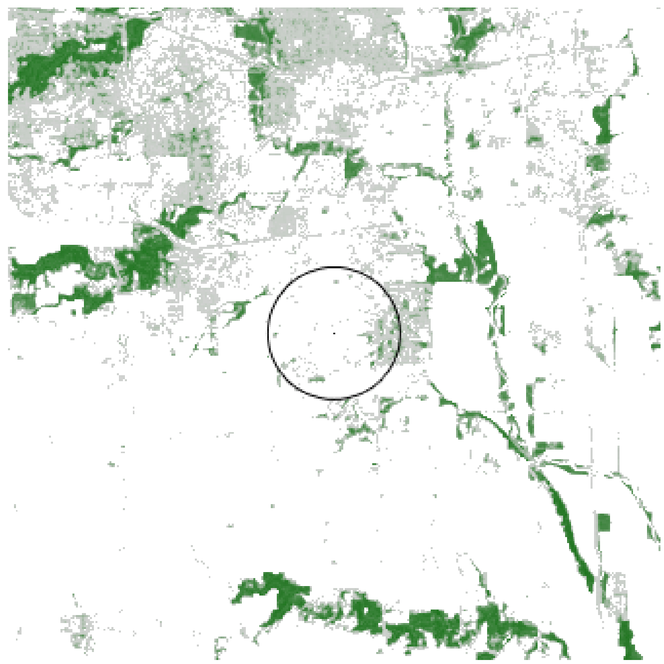

Figure 85. Canopy Data – KAMW

Surface Characteristics Data for KBRL (Burlington, IA)

Figure 86. Aerial Photograph with Sectors – KBRL

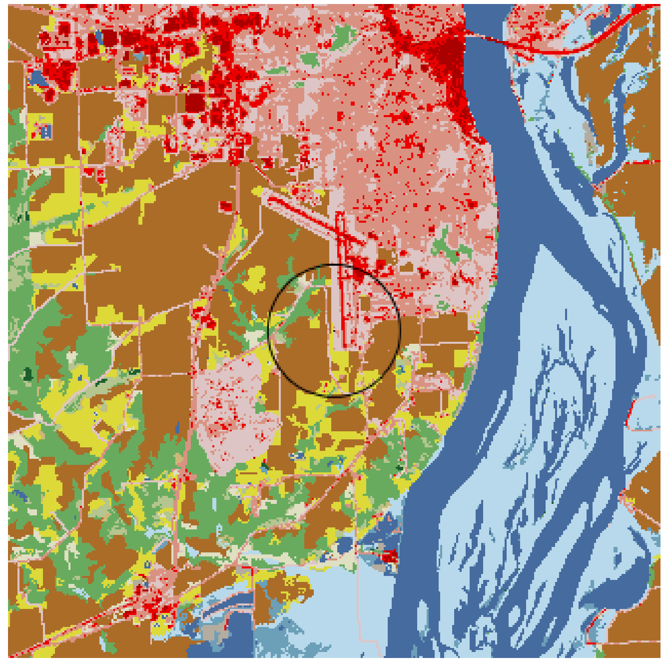

Figure 87. Land Use Data – KBRL

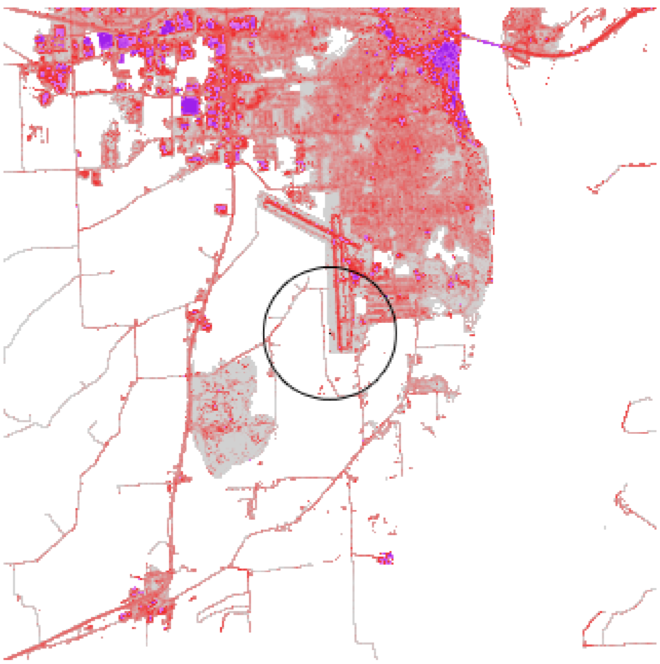

Figure 88. Impervious Data – KBRL

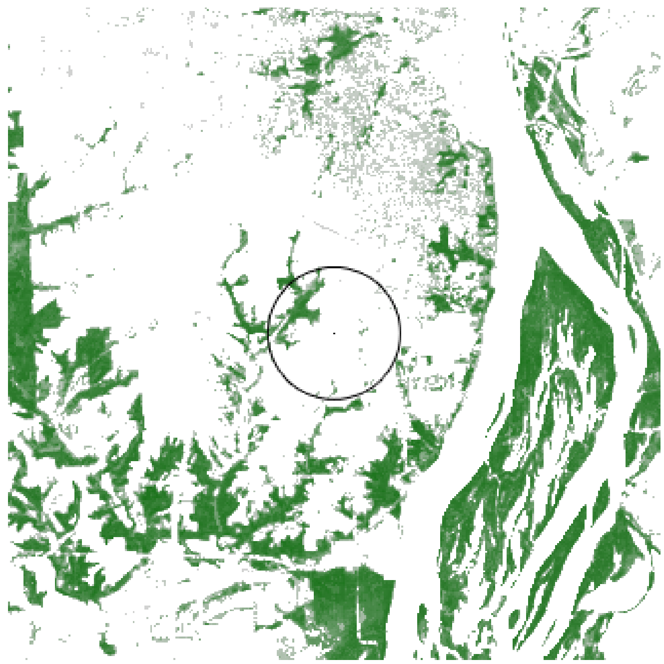

Figure 89. Canopy Data – KBRL

Surface Characteristics Data for KBTA (Blair, NE)

Figure 90. Aerial Photograph with Sectors – KBTA

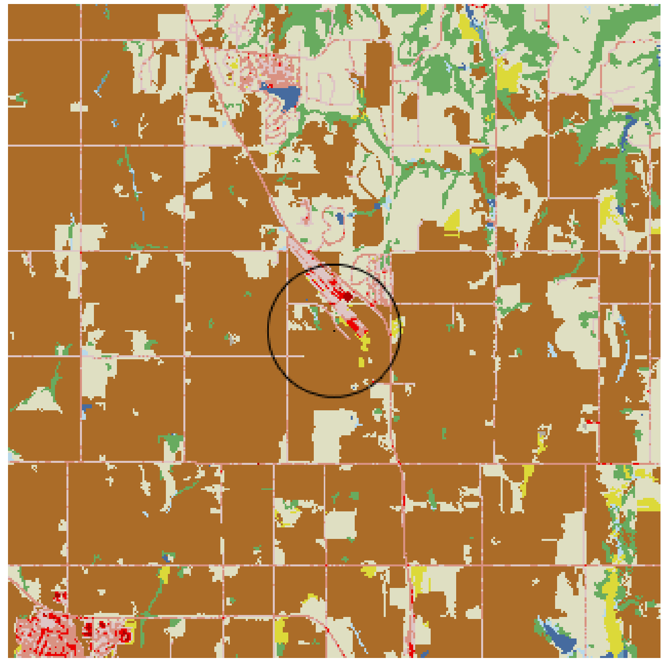

Figure 91. Land Use Data – KBTA

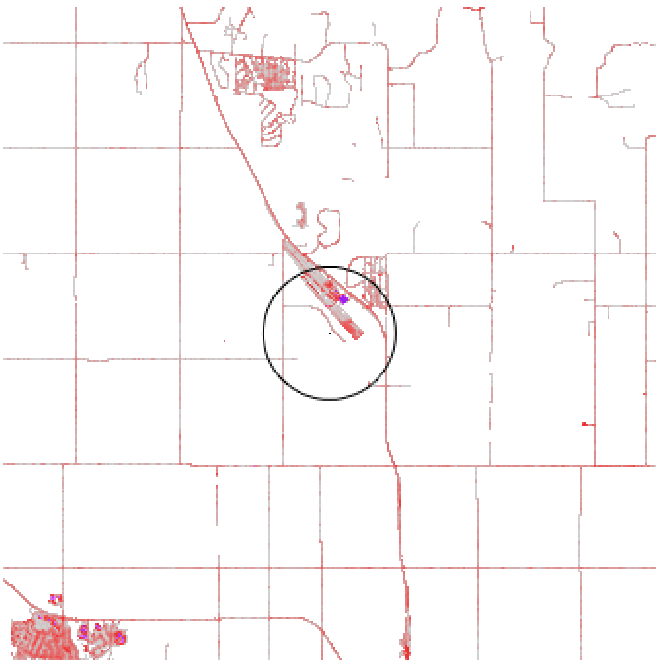

Figure 92. Impervious Data – KBTA

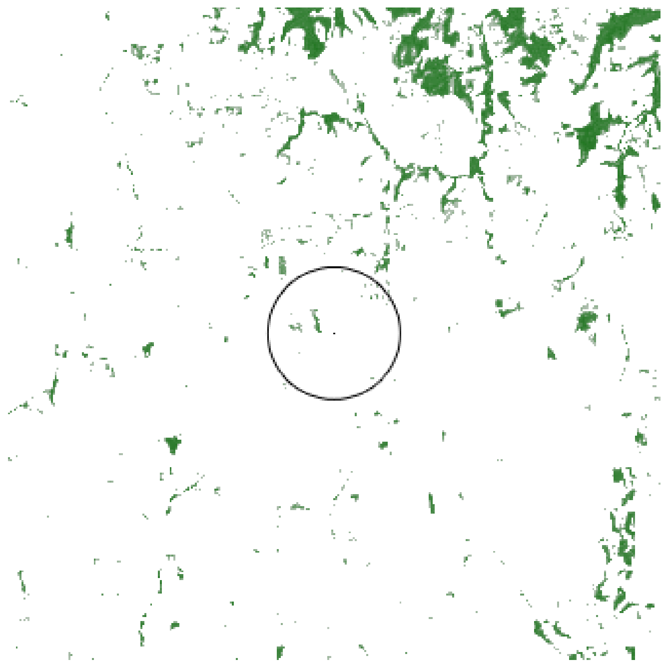

Figure 93. Canopy Data – KBTA

Surface Characteristics Data for KCID (Cedar Rapids, IA)

Figure 94. Aerial Photograph with Sectors – KCID

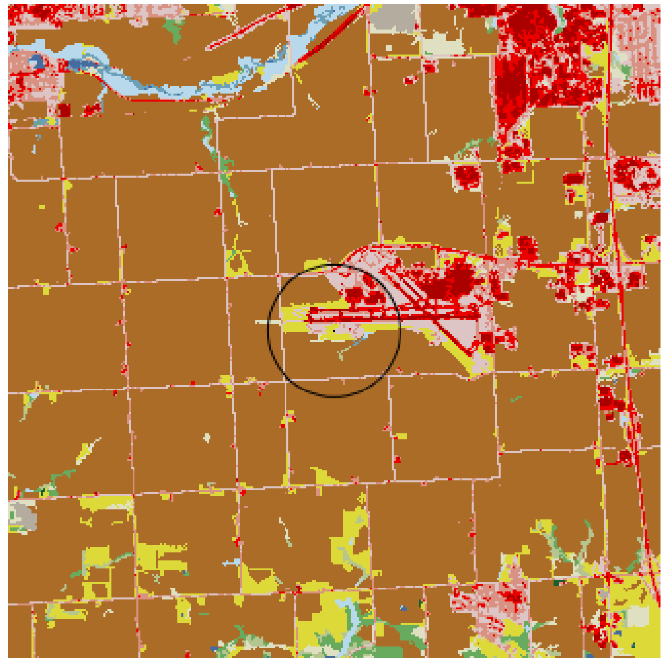

Figure 95. Land Use Data – KCID

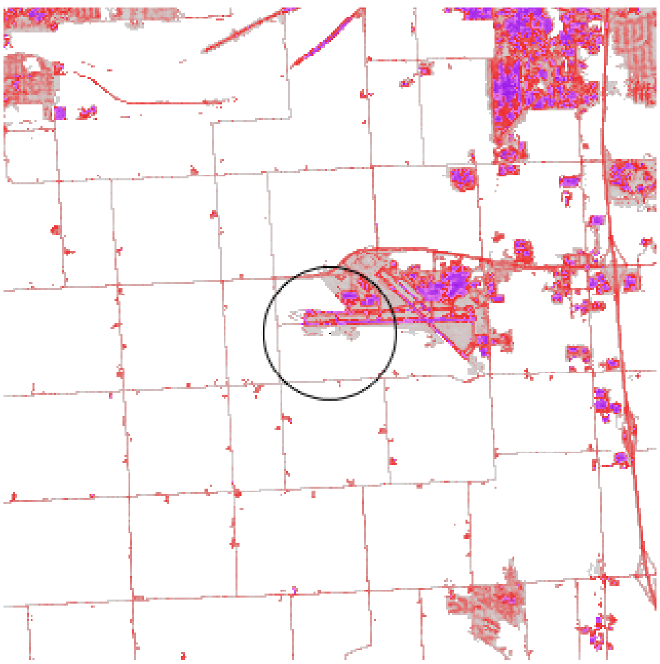

Figure 96. Impervious Data – KCID

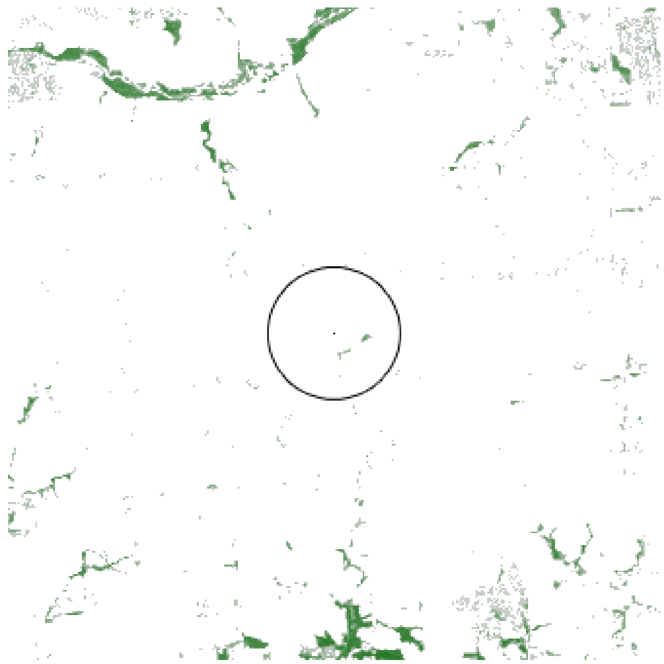

Figure 97. Canopy Data – KCID

Surface Characteristics Data for KDBQ (Dubuque, IA)

Figure 98. Aerial Photograph with Sectors – KDBQ

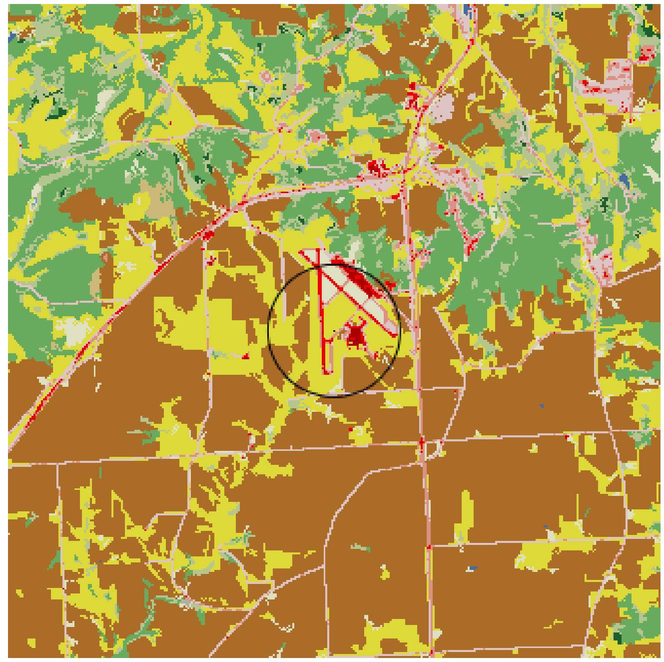

Figure 99. Land Use Data – KDBQ

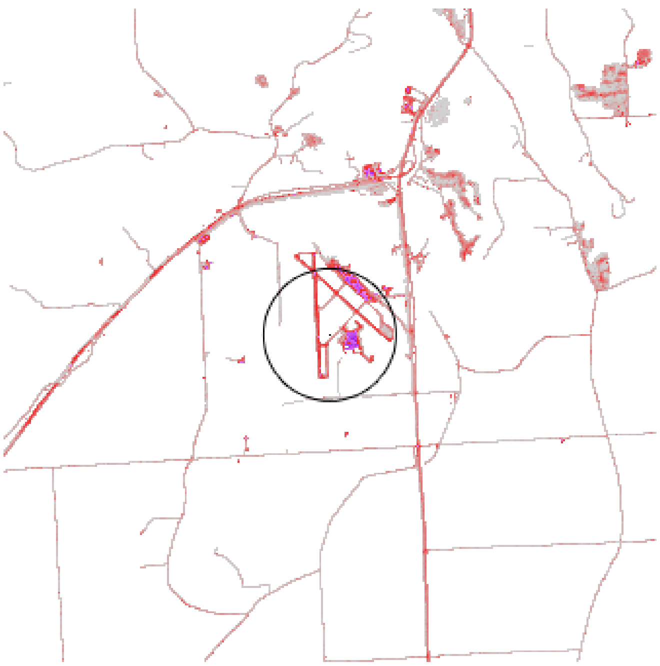

Figure 100. Impervious Data – KDBQ

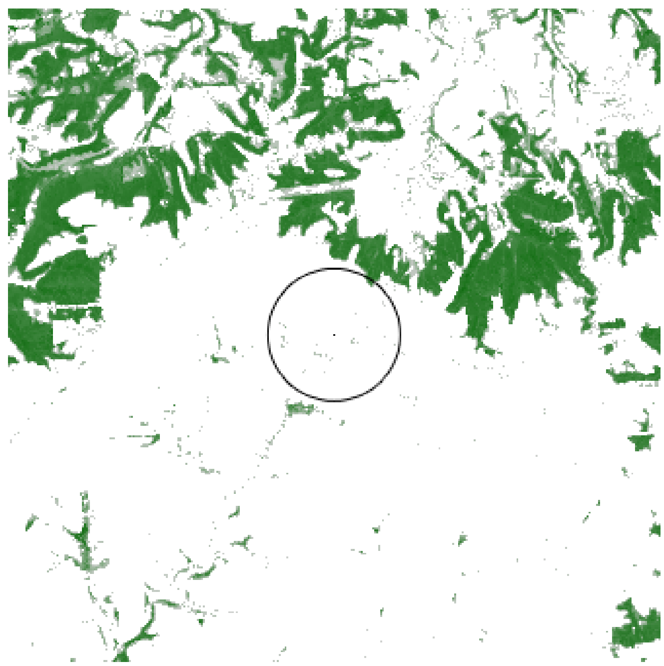

Figure 101. Canopy Data – KDBQ

Surface Characteristics Data for KDEH (Decorah, IA)

Figure 102. Aerial Photograph with Sectors – KDEH

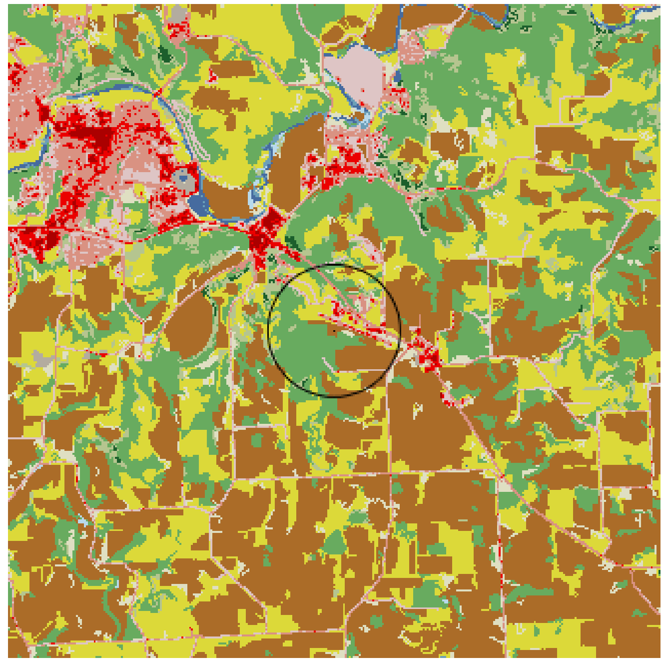

Figure 103. Land Use Data – KDEH

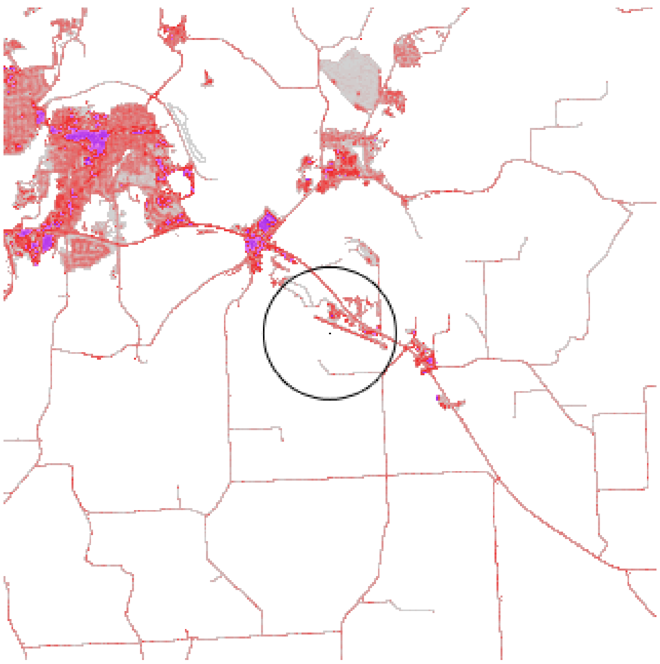

Figure 104. Impervious Data – KDEH

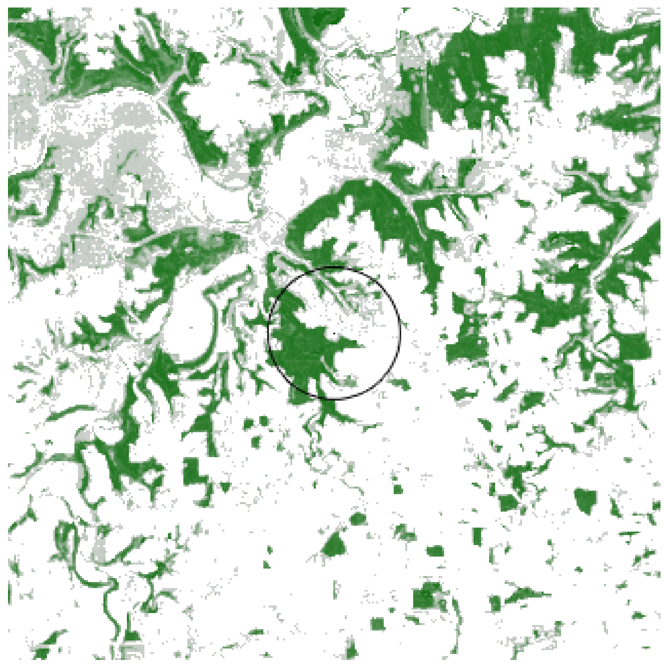

Figure 105. Canopy Data – KDEH

Surface Characteristics Data for KDSM (Des Moines, IA)

Figure 106. Aerial Photograph with Sectors – KDSM

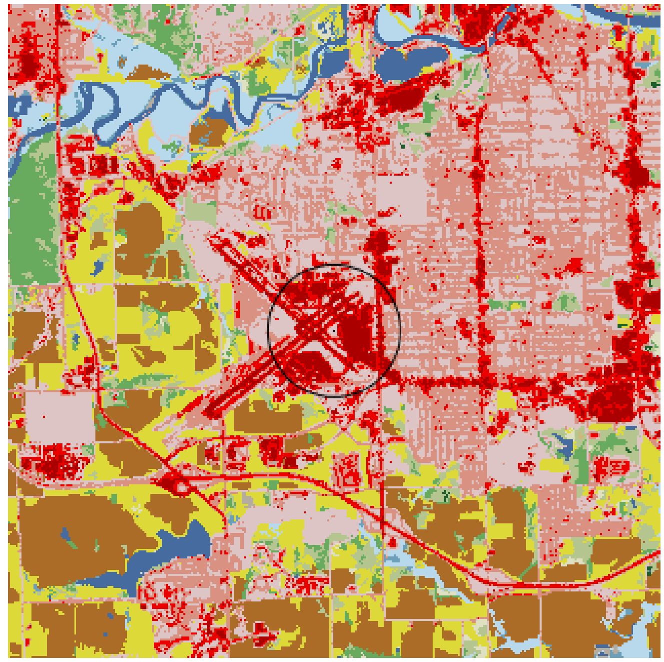

Figure 107. Land Use Data – KDSM

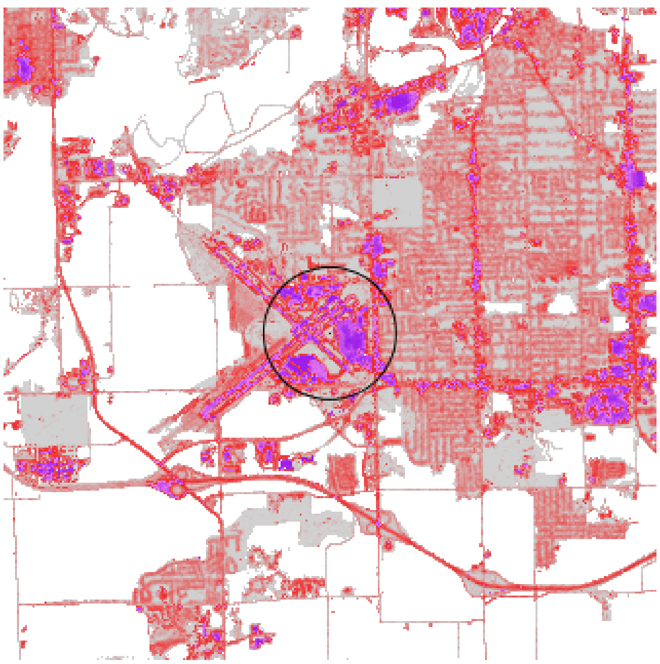

Figure 108. Impervious Data – KDSM

Figure 109. Canopy Data – KDSM

Surface Characteristics Data for KDVN (Davenport, IA)

Figure 110. Aerial Photograph with Sectors – KDVN

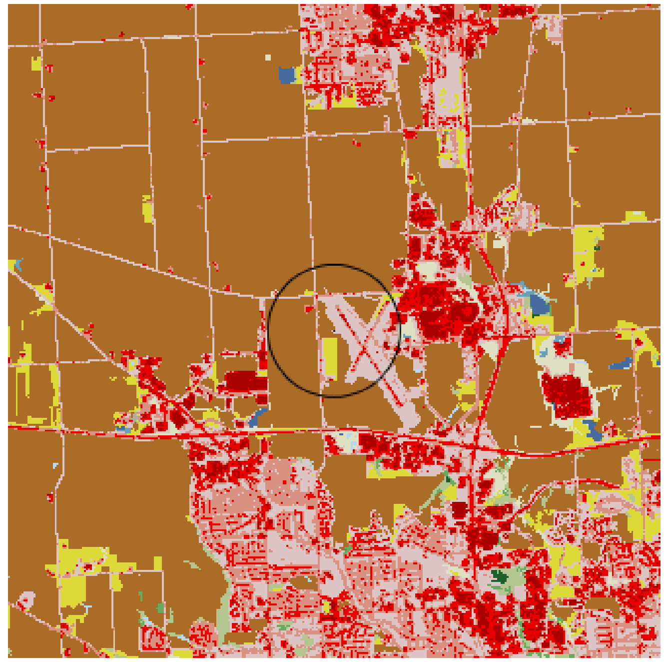

Figure 111. Land Use Data – KDVN

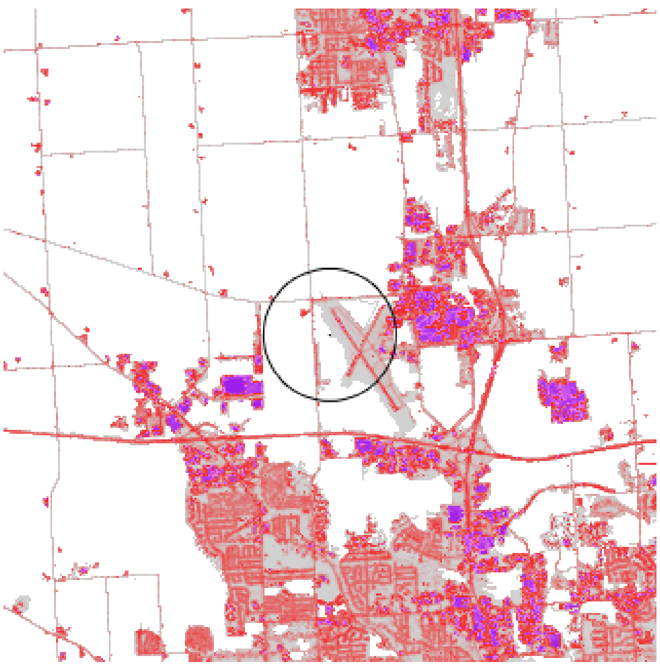

Figure 112. Impervious Data – KDVN

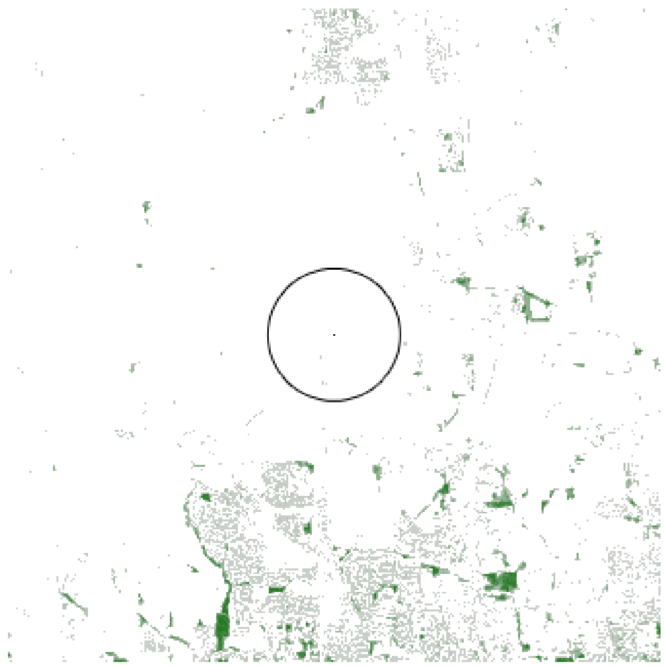

Figure 113. Canopy Data – KDVN

Surface Characteristics Data for KEST (Estherville, IA)

Figure 114. Aerial Photograph with Sectors – KEST

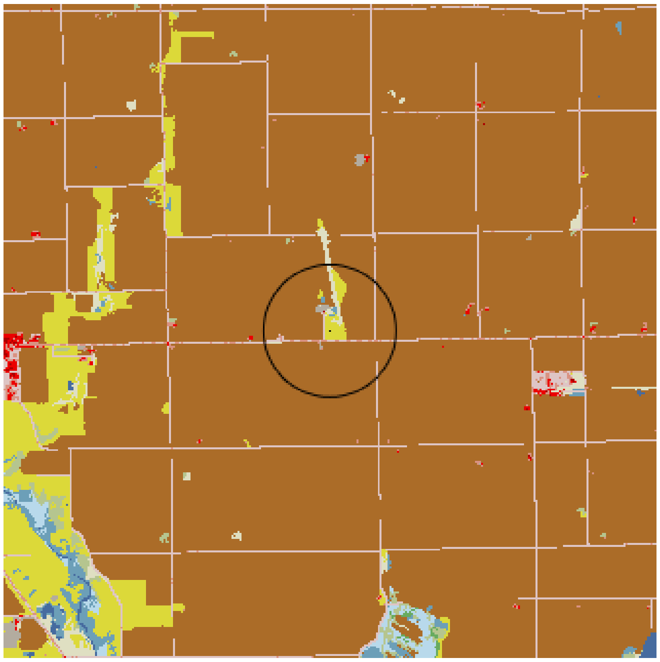

Figure 115. Land Use Data – KEST

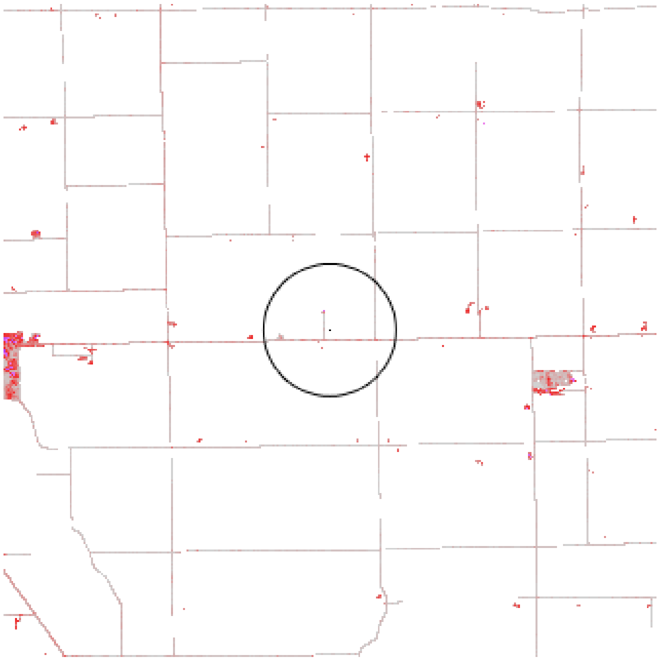

Figure 116. Impervious Data – KEST

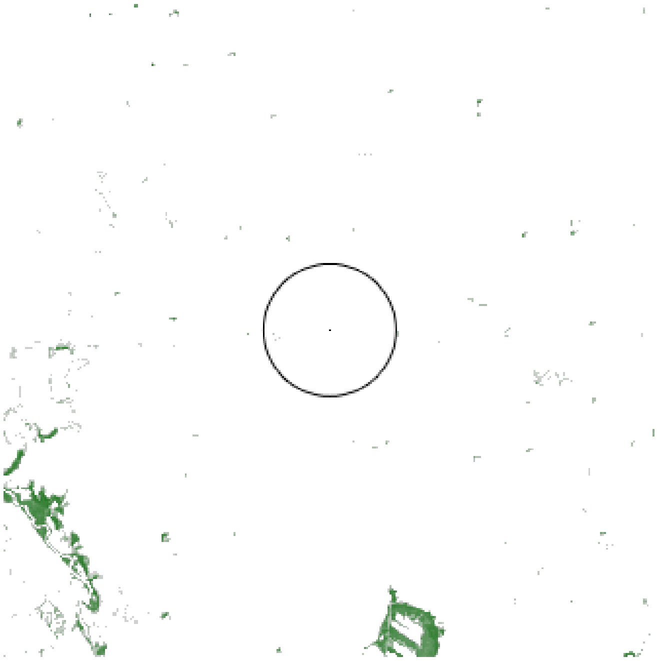

Figure 117. Canopy Data – KEST

Surface Characteristics Data for KFOD (Fort Dodge, IA)

Figure 118. Aerial Photograph with Sectors – KFOD

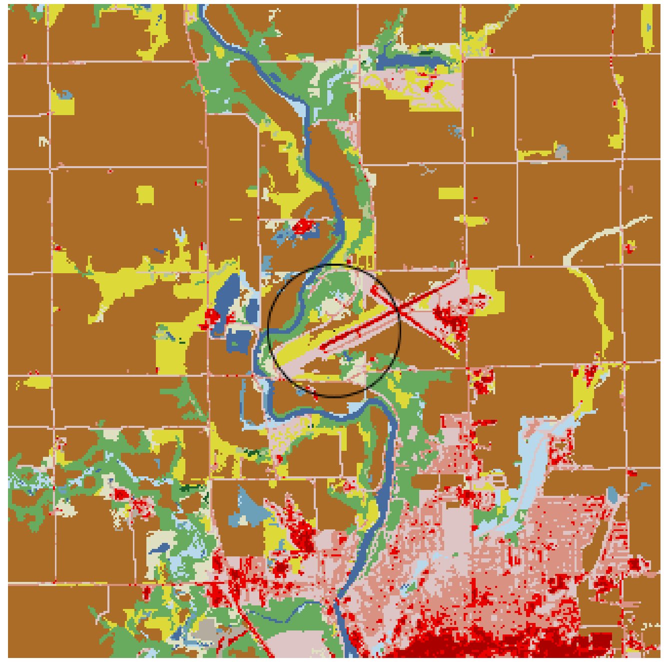

Figure 119. Land Use Data – KFOD

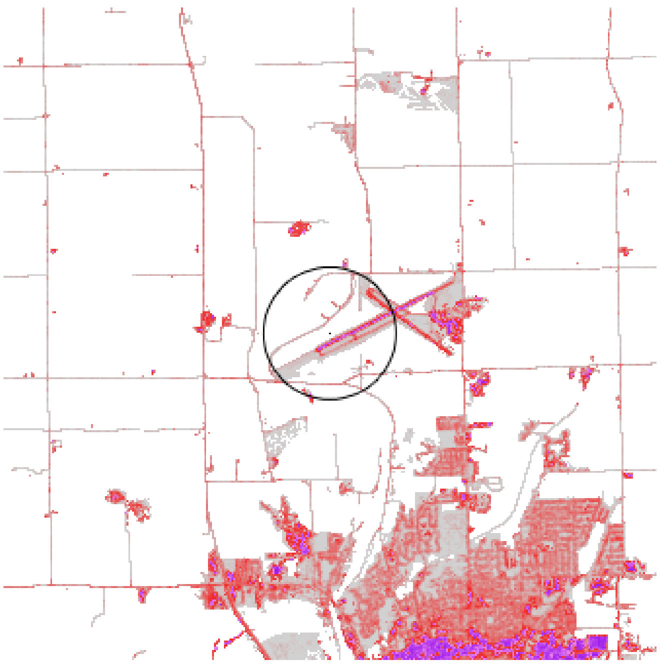

Figure 120. Impervious Data – KFOD

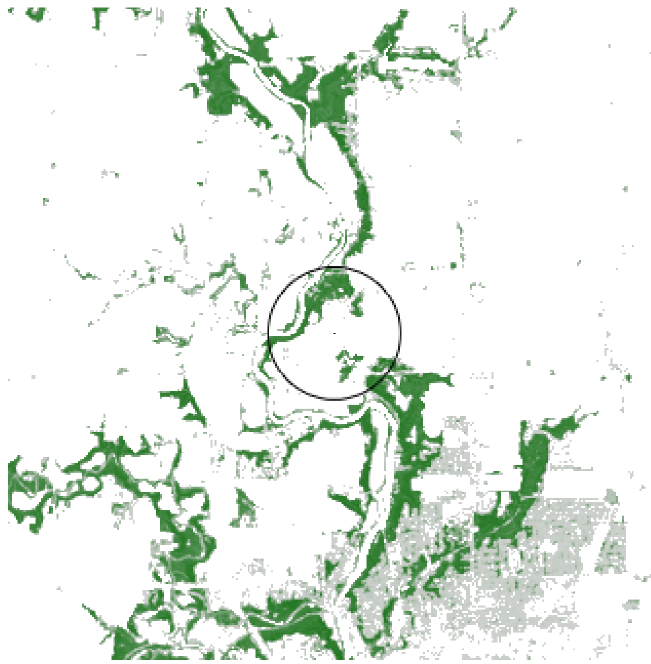

Figure 121. Canopy Data – KFOD

Surface Characteristics Data for KFSD (Sioux Falls, SD)

Figure 122. Aerial Photograph with Sectors – KFSD

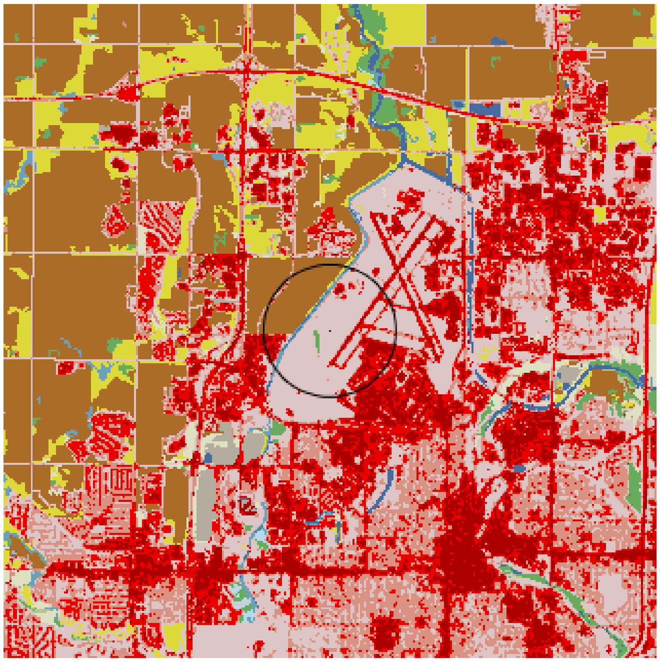

Figure 123. Land Use Data – KFSD

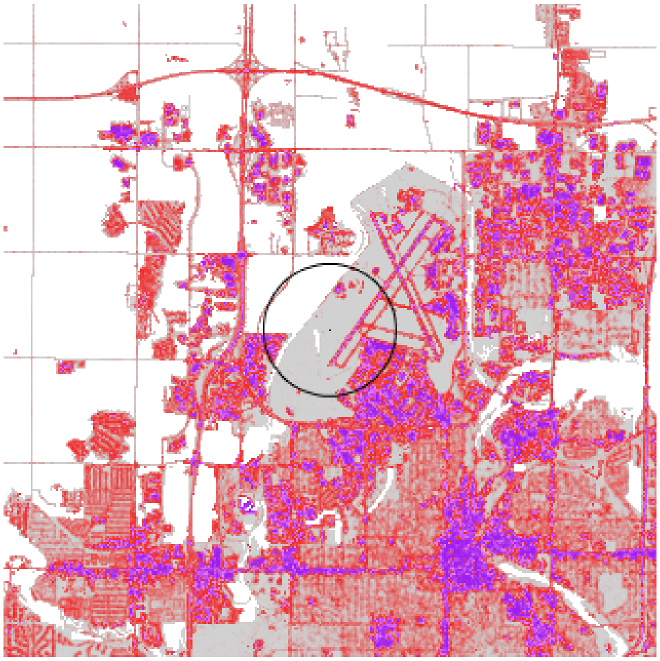

Figure 124. Impervious Data – KFSD

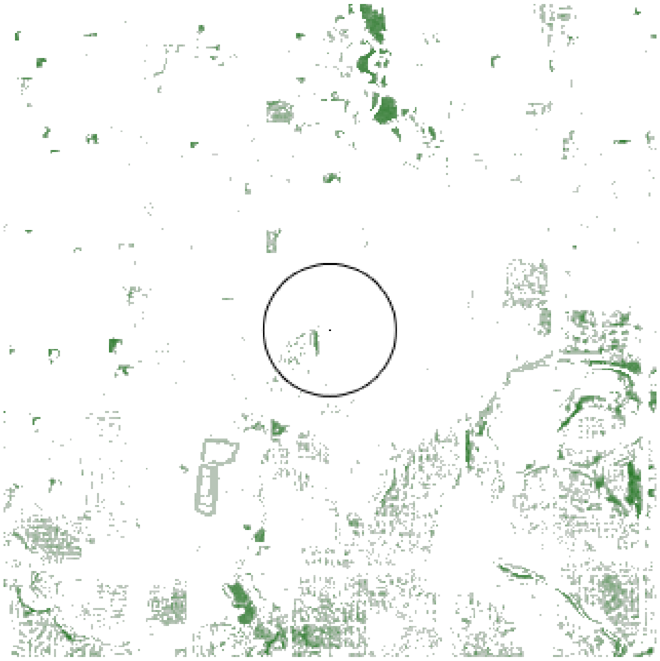

Figure 125. Canopy Data – KFSD

Surface Characteristics Data for KIOW (Iowa City, IA)

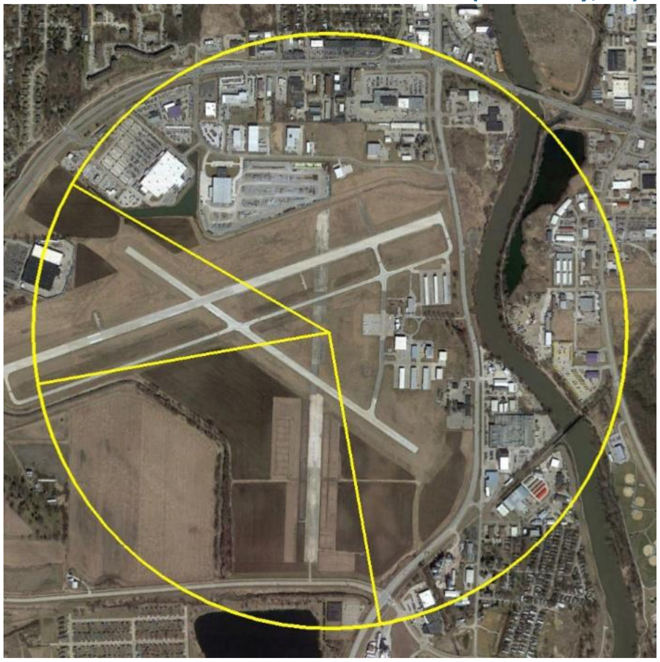

Figure 126. Aerial Photograph with Sectors – KIOW

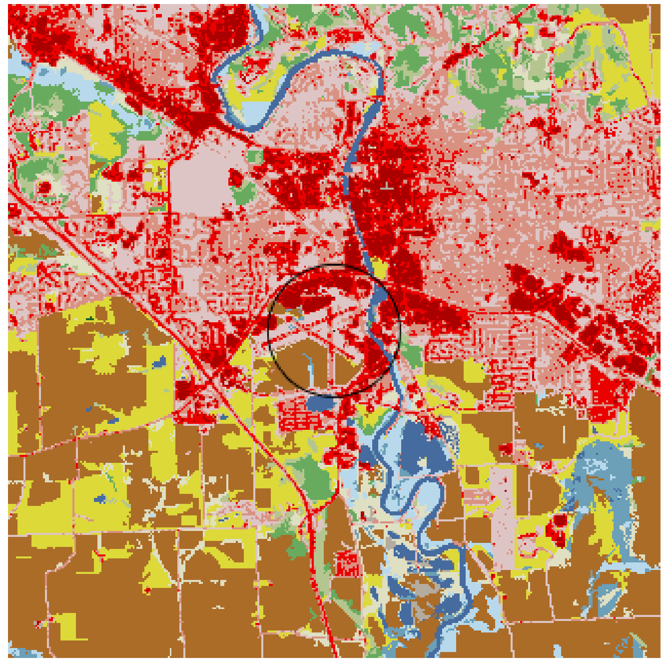

Figure 127. Land Use Data – KIOW

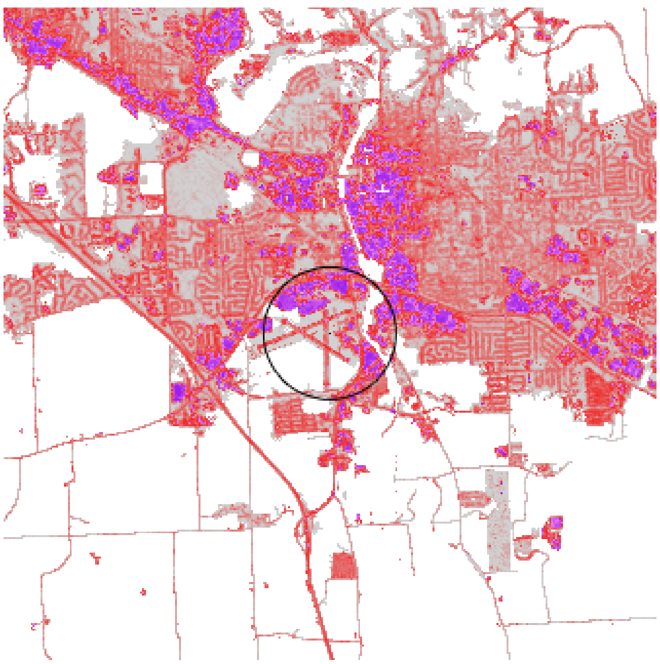

Figure 128. Impervious Data – KIOW

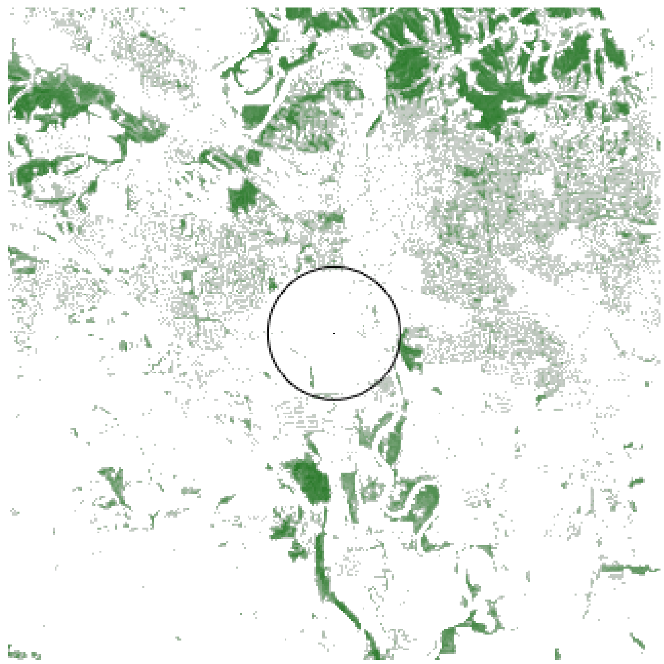

Figure 129. Canopy Data – KIOW

Surface Characteristics Data for KLWD (Lamoni, IA)

Figure 130. Aerial Photograph with Sectors – KLWD

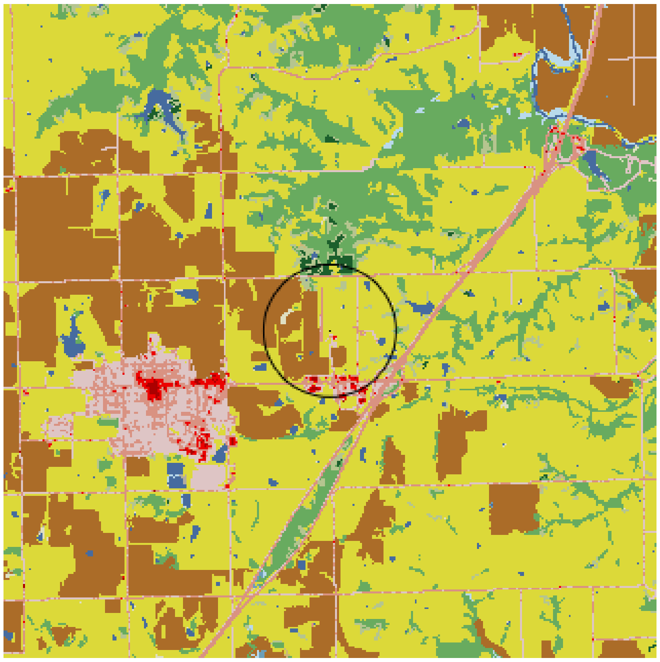

Figure 131. Land Use Data – KLWD

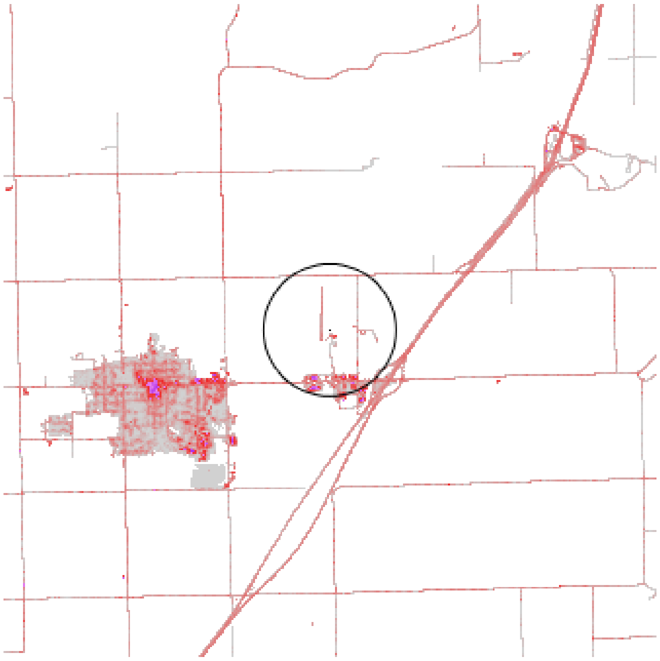

Figure 132. Impervious Data – KLWD

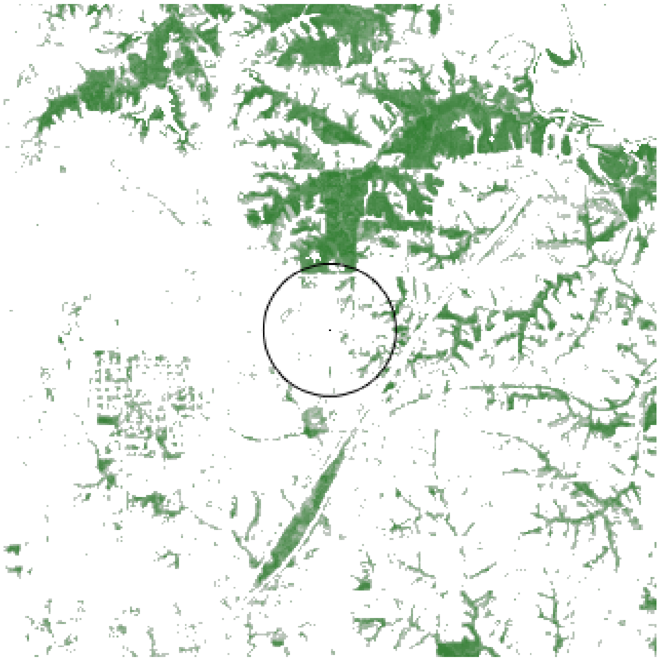

Figure 133. Canopy Data – KLWD

Surface Characteristics Data for KMCW (Mason City, IA)

Figure 134. Aerial Photograph with Sectors – KMCW

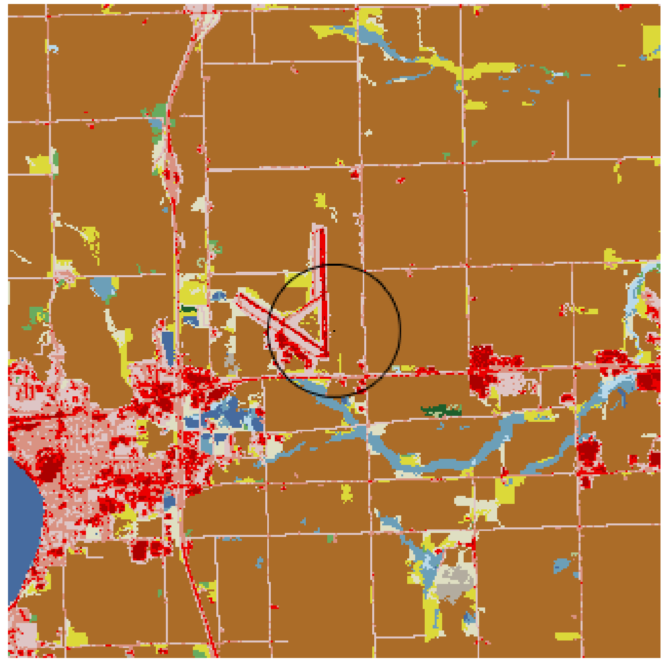

Figure 135. Land Use Data – KMCW

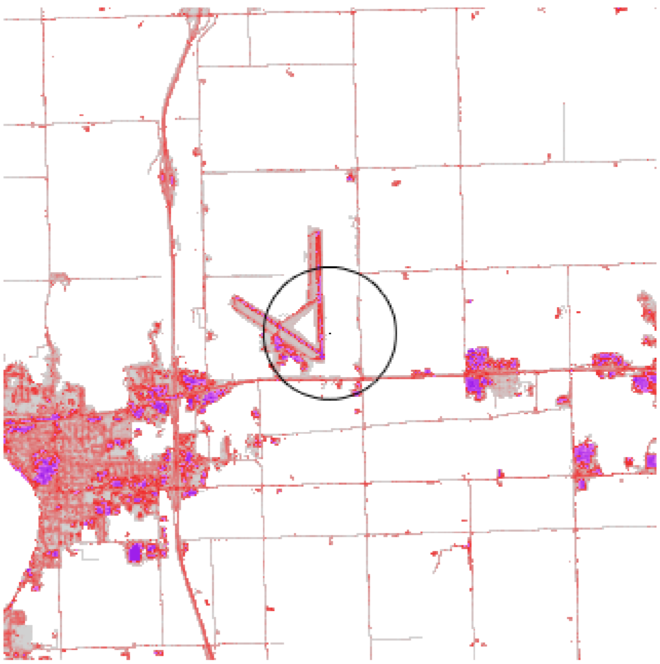

Figure 136. Impervious Data – KMCW

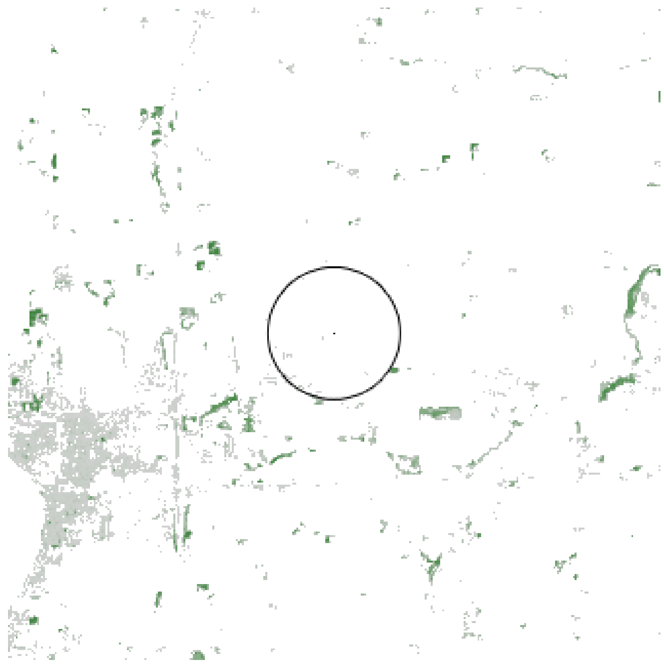

Figure 137. Canopy Data – KMCW

Surface Characteristics Data for KMIW (Marshalltown, IA)

Figure 138. Aerial Photograph with Sectors – KMIW

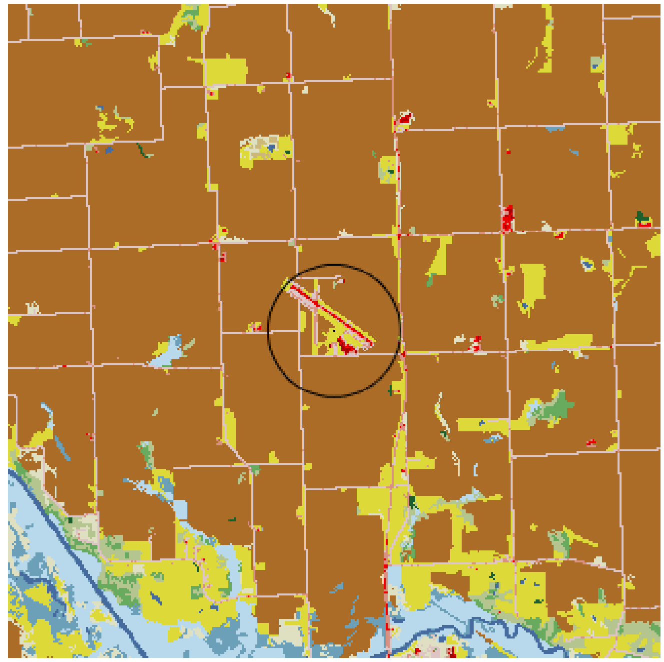

Figure 139. Land Use Data – KMIW

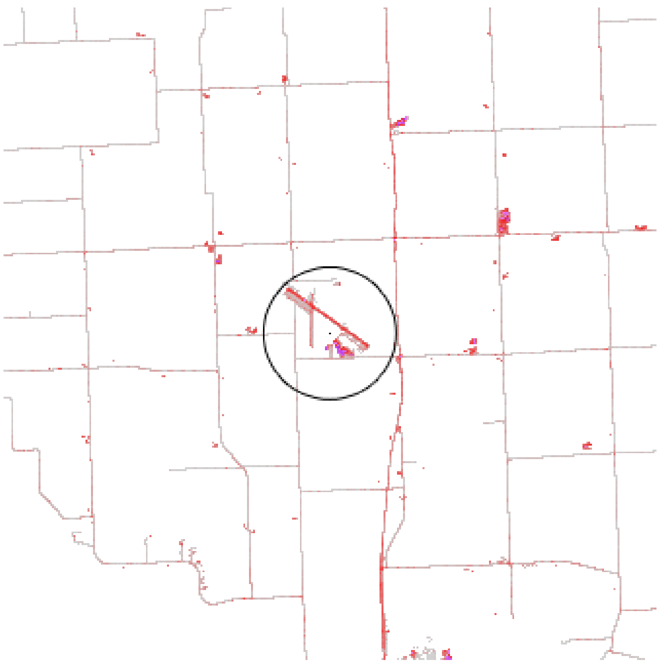

Figure 140. Impervious Data – KMIW

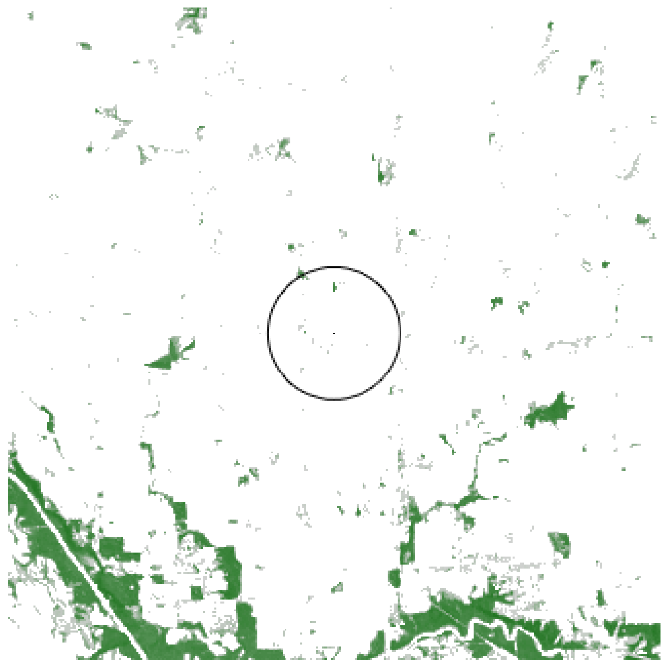

Figure 141. Canopy Data – KMIW

Surface Characteristics Data for KMLI (Moline, IL)

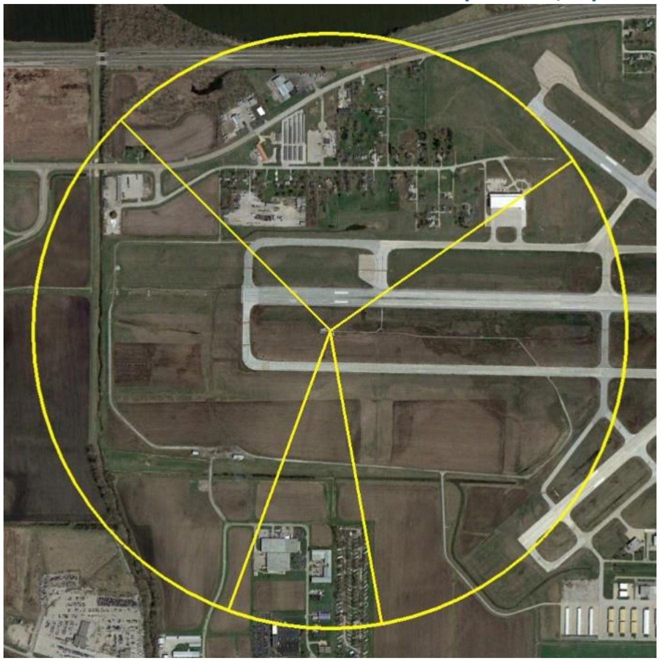

Figure 142. Aerial Photograph with Sectors – KMLI

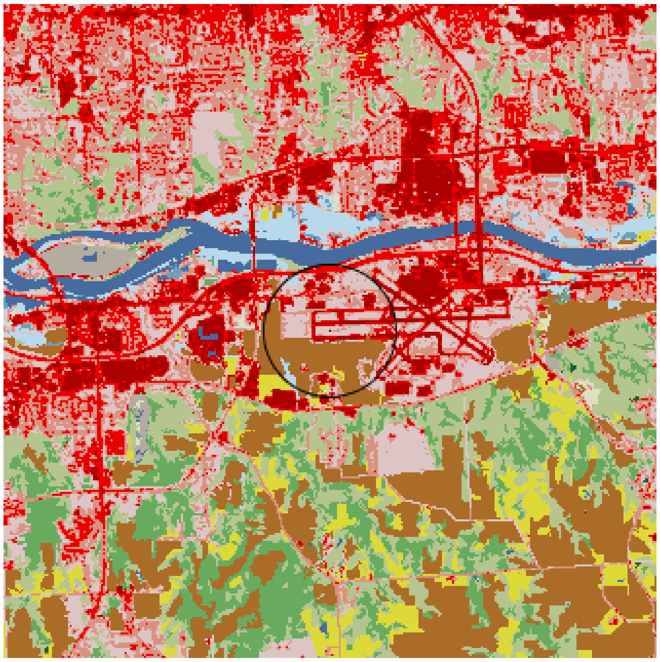

Figure 143. Land Use Data – KMLI

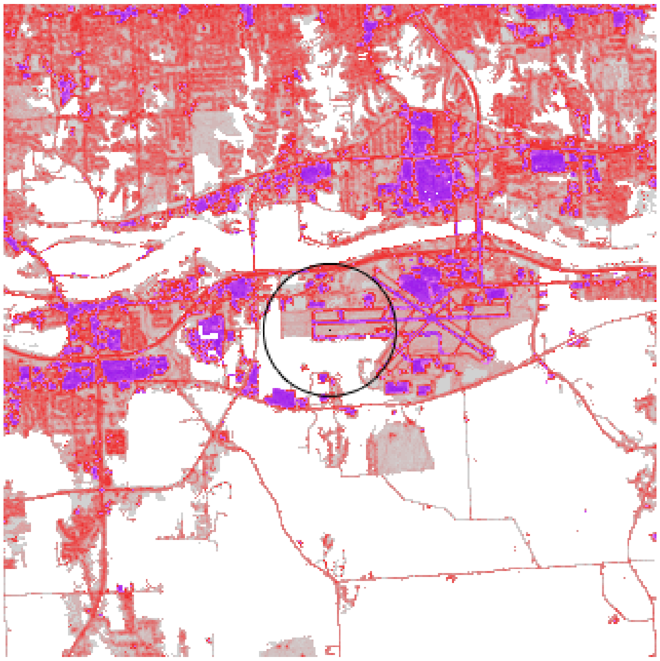

Figure 144. Impervious Data – KMLI

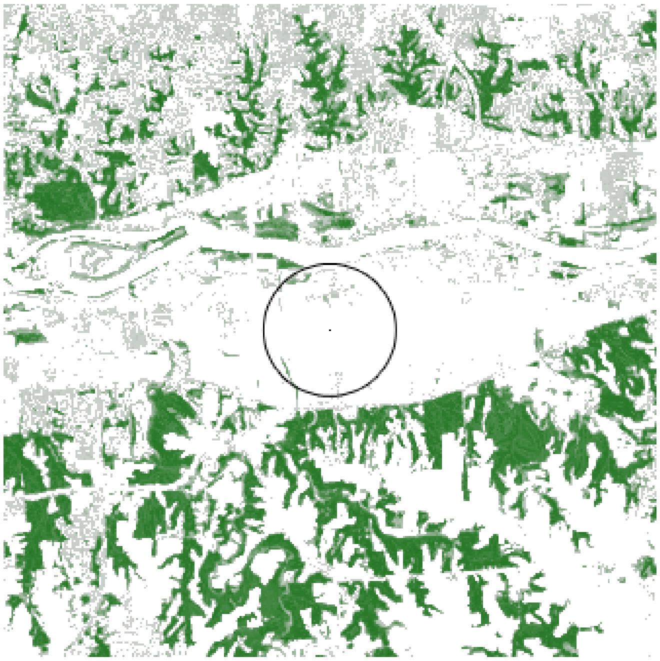

Figure 145. Canopy Data – KMLI

Surface Characteristics Data for KOMA (Omaha, NE)

Figure 146. Aerial Photograph with Sectors – KOMA

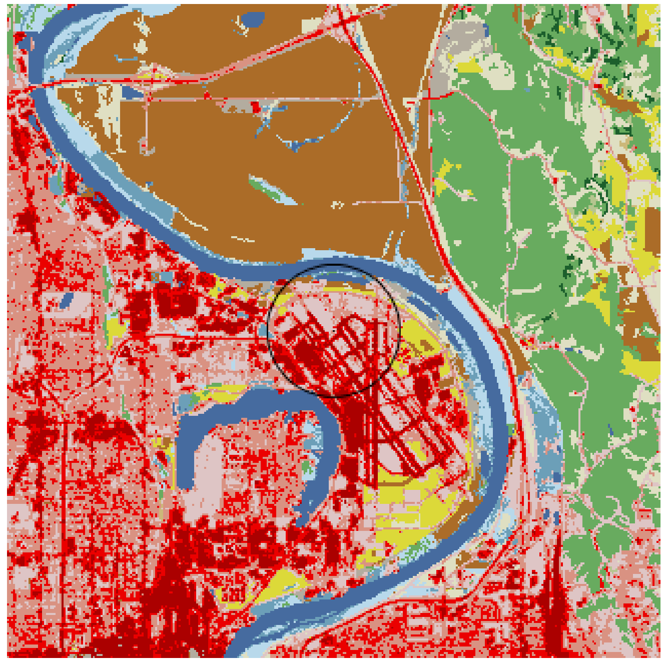

Figure 147. Land Use Data – KOMA

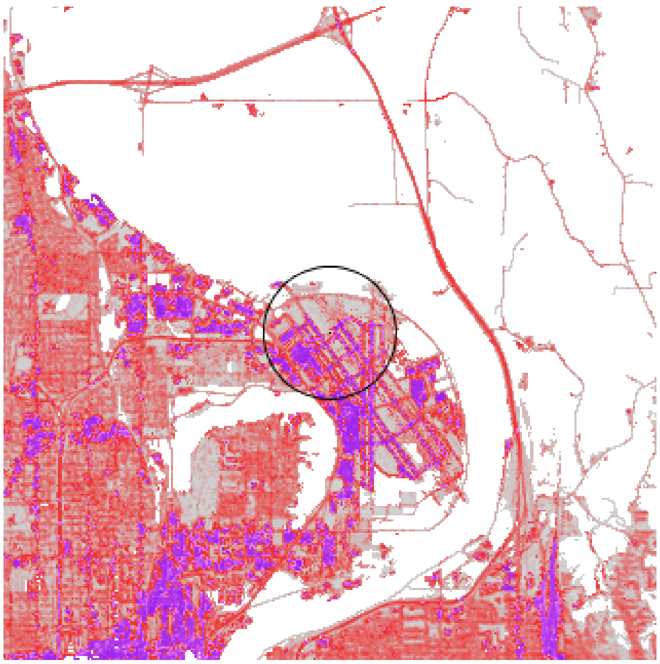

Figure 148. Impervious Data – KOMA

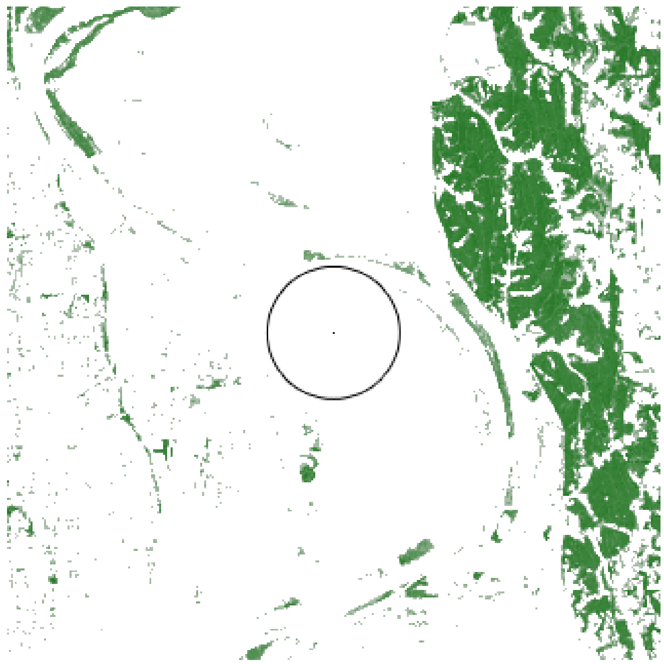

Figure 149. Canopy Data – KOMA

Surface Characteristics Data for KOTM (Ottumwa, IA)

Figure 150. Aerial Photograph with Sectors – KOTM

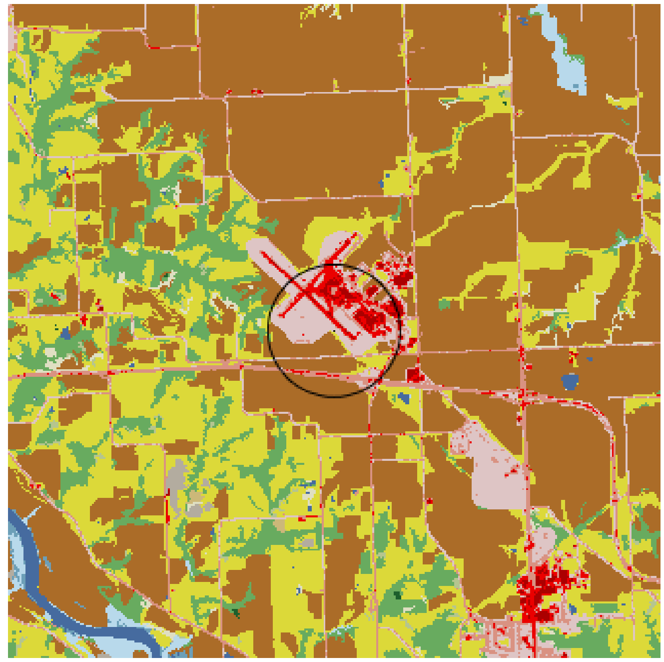

Figure 151. Land Use Data – KOTM

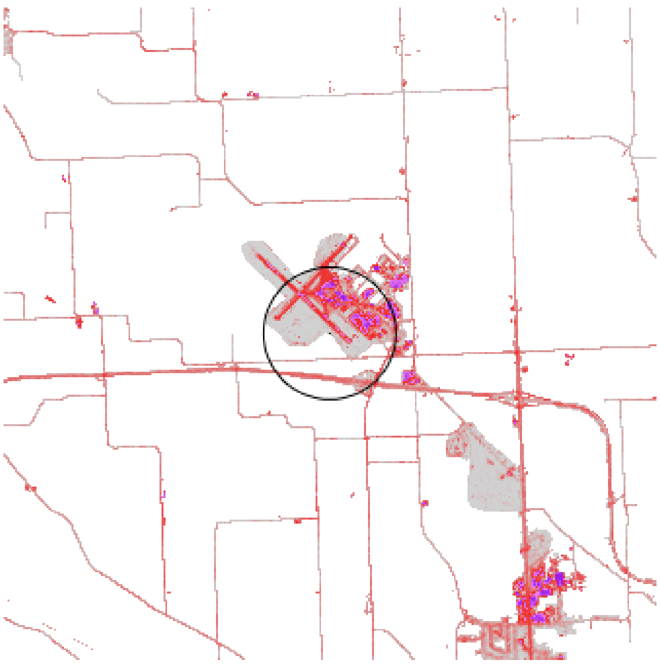

Figure 152. Impervious Data – KOTM

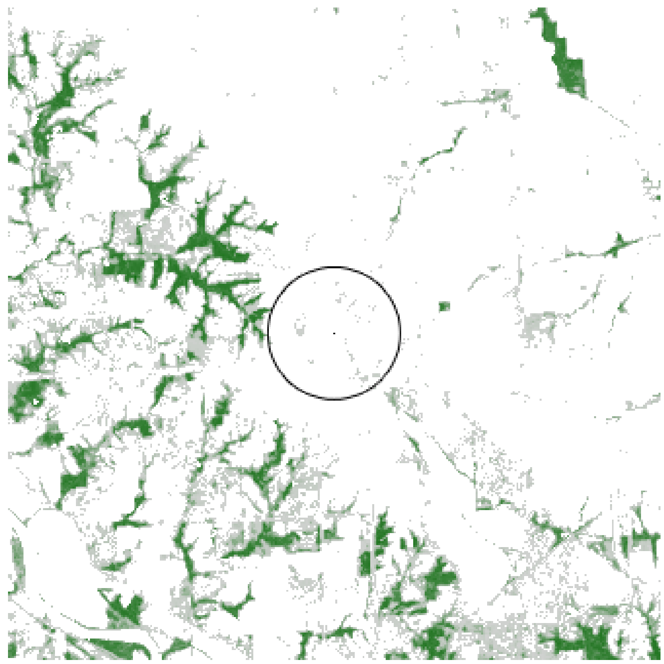

Figure 153. Canopy Data – KOTM

Surface Characteristics Data for KSPW (Spencer, IA)

Figure 154. Aerial Photograph with Sectors – KSPW

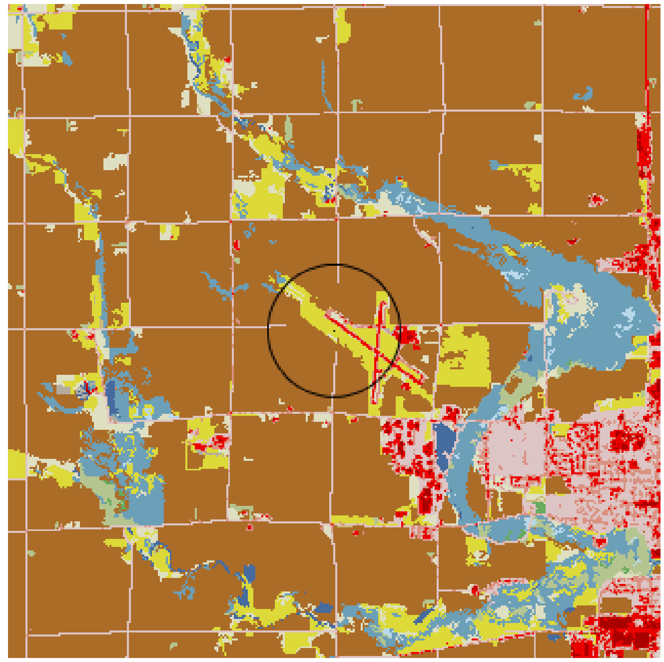

Figure 155. Land Use Data – KSPW

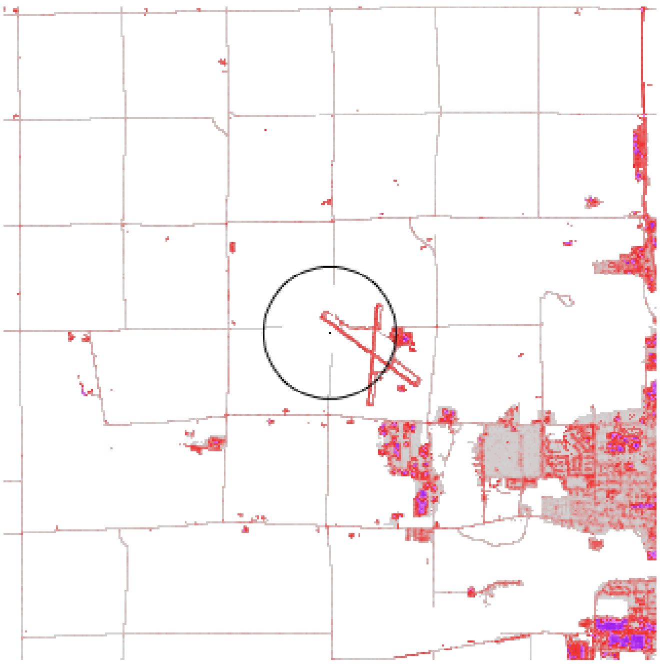

Figure 156. Impervious Data – KSPW

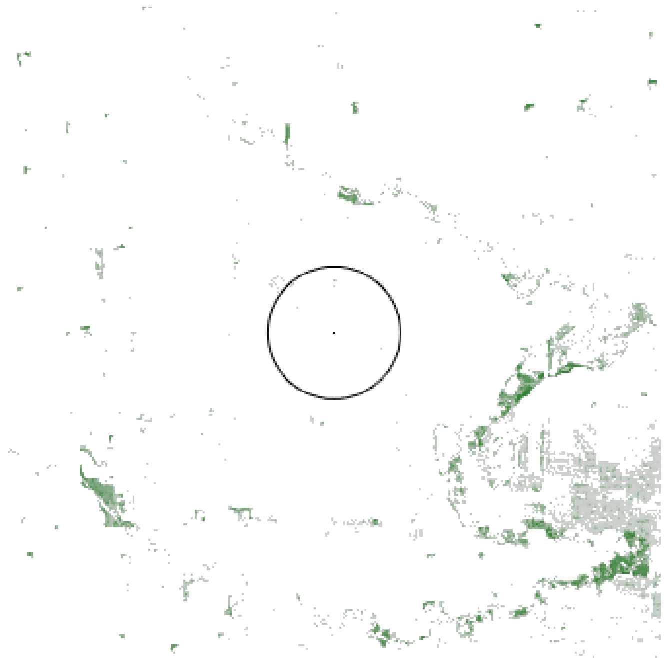

Figure 157. Canopy Data – KSPW

Surface Characteristics Data for KSUX (Sioux City, IA)

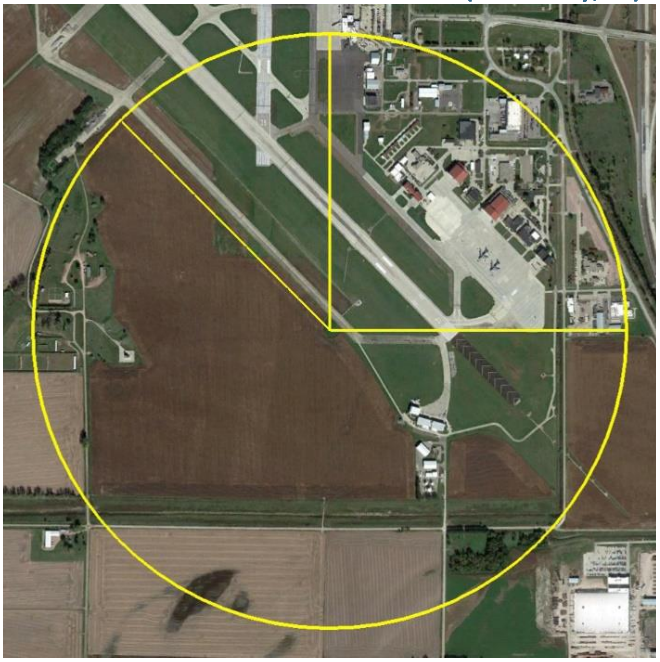

Figure 158. Aerial Photograph with Sectors – KSUX

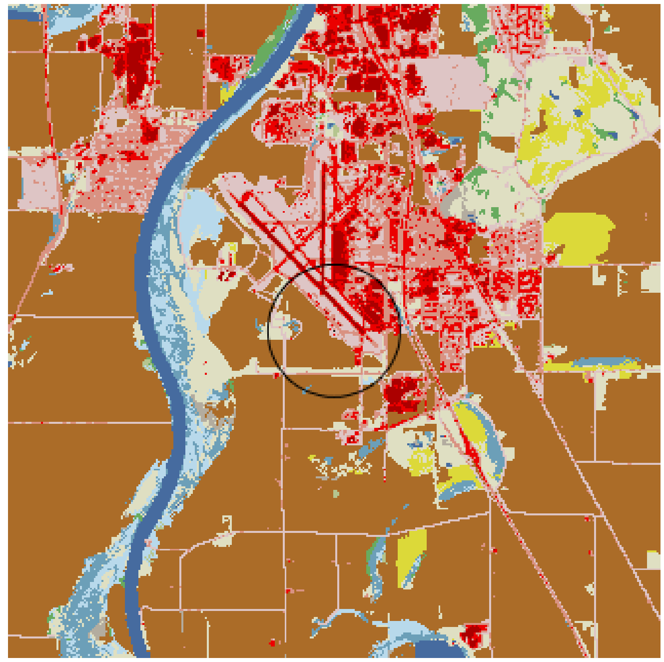

Figure 159. Land Use Data – KSUX

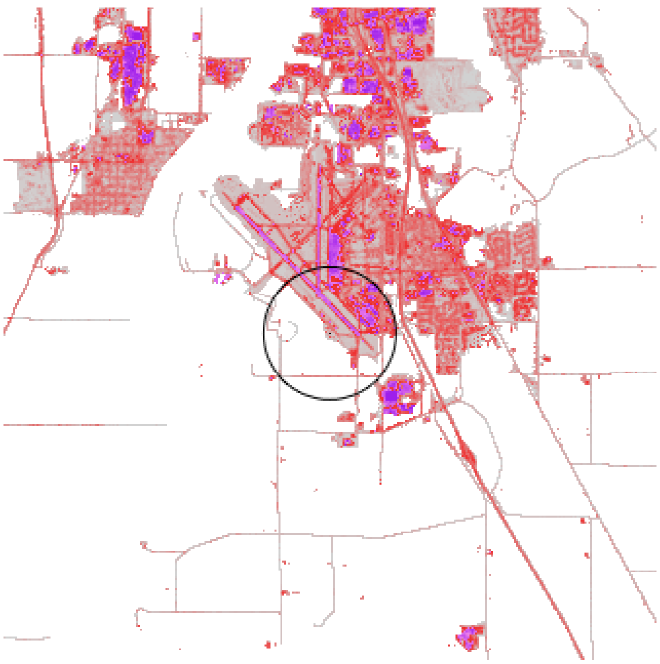

Figure 160. Impervious Data – KSUX

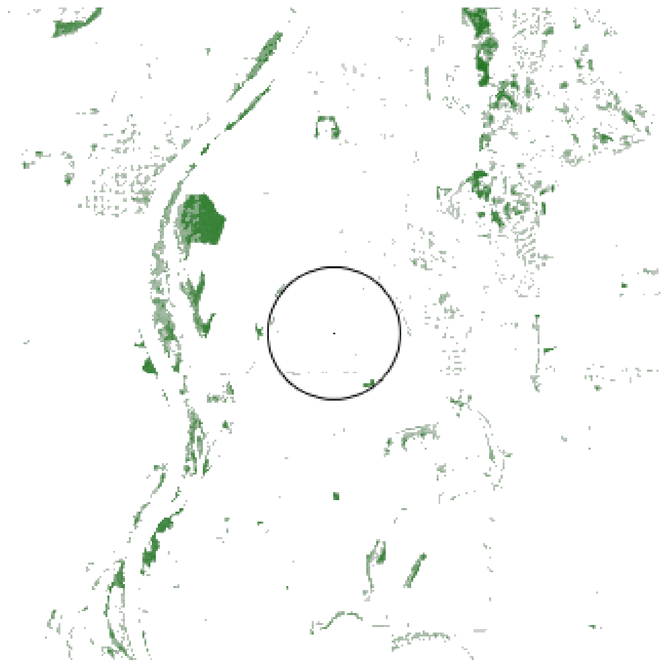

Figure 161. Canopy Data – KSUX

Appendix C – Comparison of Model Results by Location

This appendix contains an analysis comparing model results using the previous 2010-2014 AERMOD meteorological data to the new 2015-2019 AERMOD meteorological data. The results are represented in terms of the average ratio of new model results to old (values greater than one indicating an average increase in model concentration due to the change in meteorological data, and values less than one indicated an average decrease). In each chart, lines represent the average change for three different types of sources (blue for point sources, red for volume sources, and green for area sources).

Unlike the comparison of model results presented in the main body of this document, all combinations of source type, release height and averaging period are shown. Therefore, some of the data presented herein may not be realistic for real-world application.

New Ames Data vs. Old Ames Data

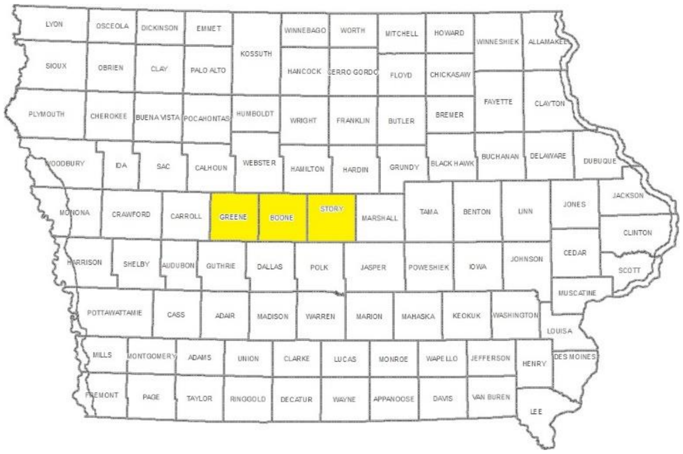

Figure 162. Map of Applicable Area

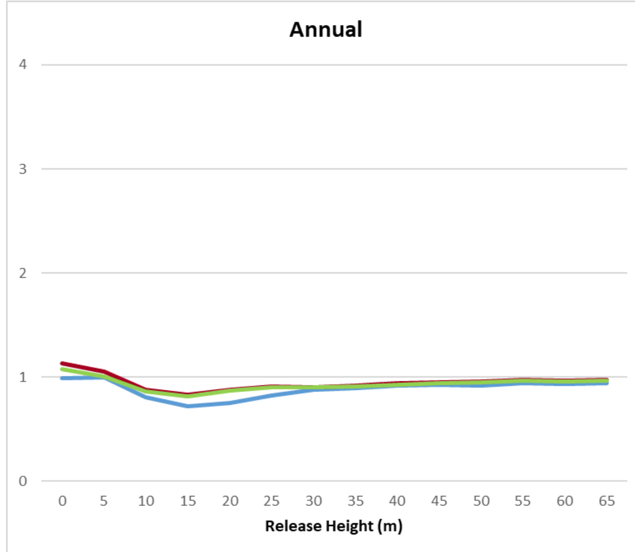

Figure 163. Relative Change in Annual Average

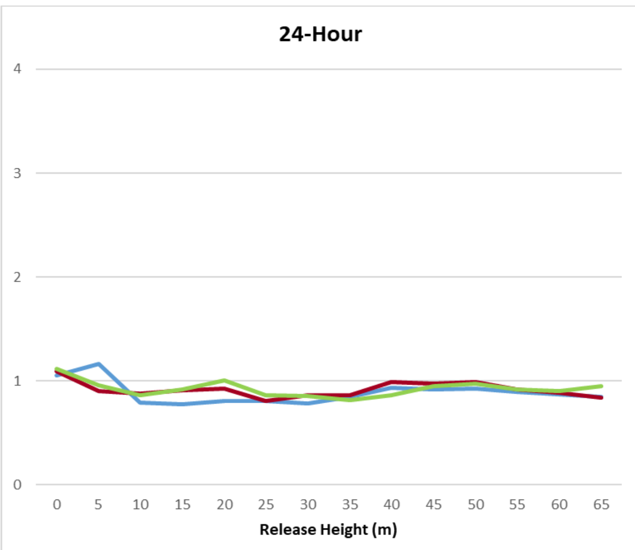

Figure 164. Relative Change in 24-hour Average

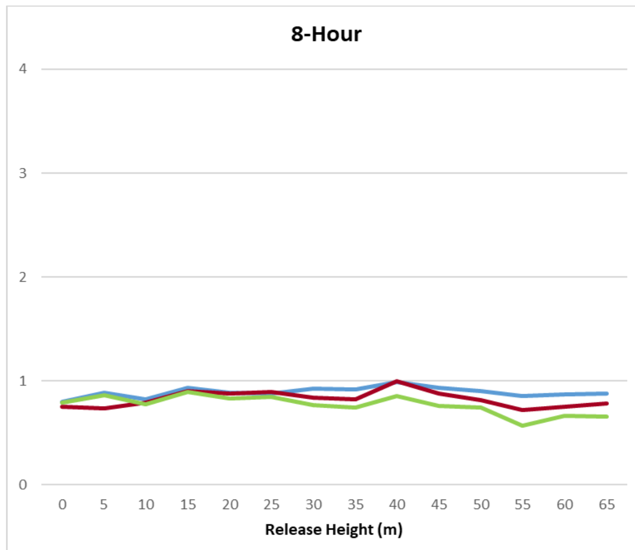

Figure 165. Relative Change in 8-hour Average

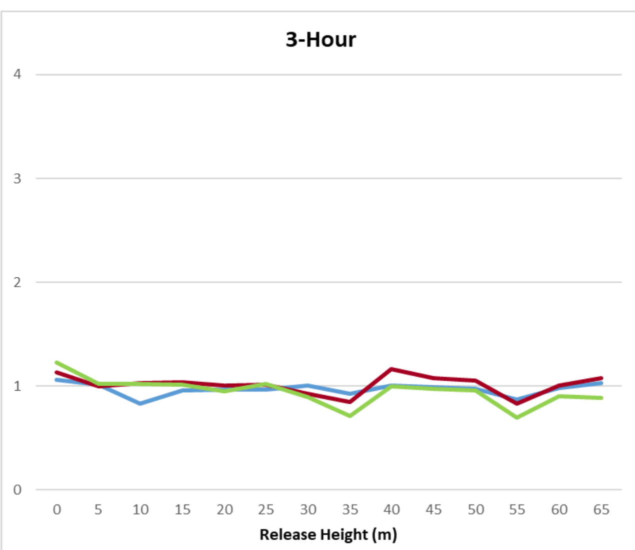

Figure 166. Relative Change in 3-hour Average

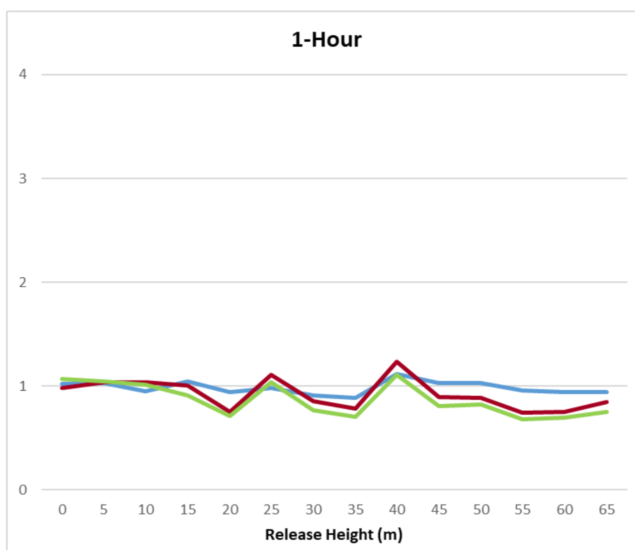

Figure 167. Relative Change in 1-hour Average

New Fort Dodge Data vs. Old Ames Data

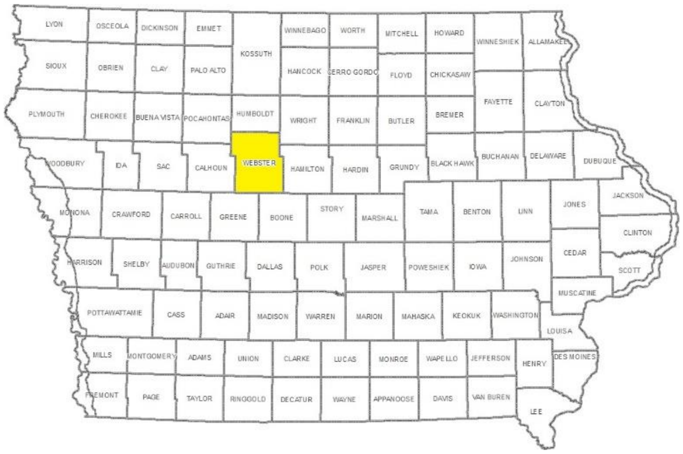

Figure 168. Map of Applicable Area

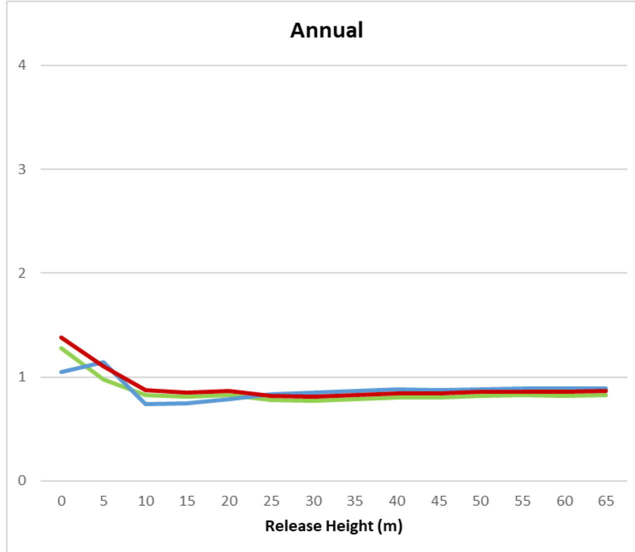

Figure 169. Relative Change in Annual Average

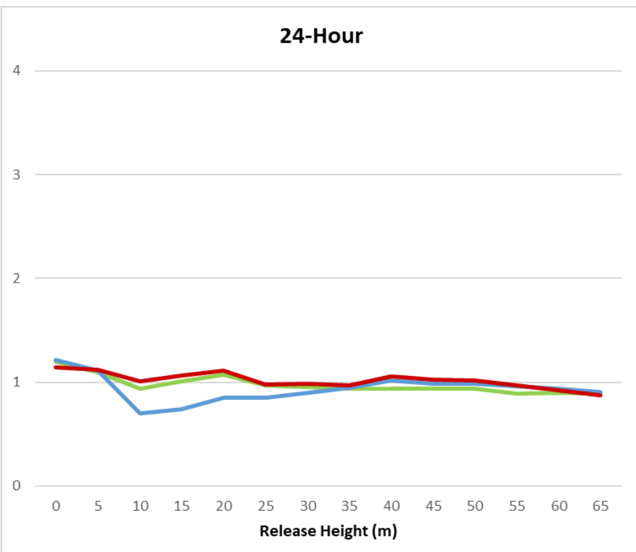

Figure 170. Relative Change in 24-hour Average

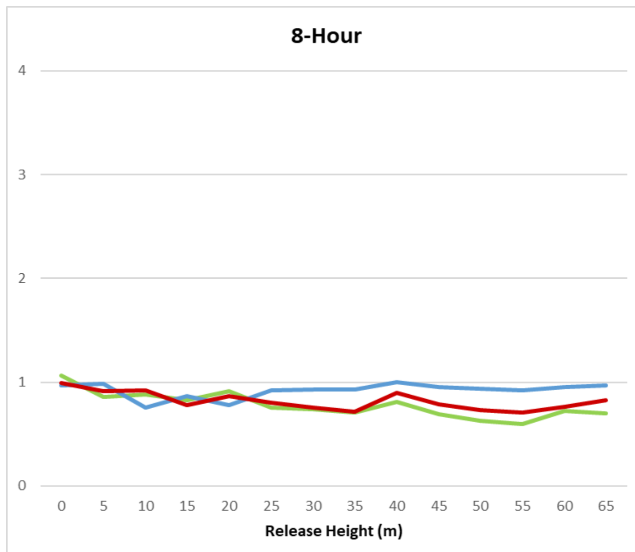

Figure 171. Relative Change in 8-hour Average

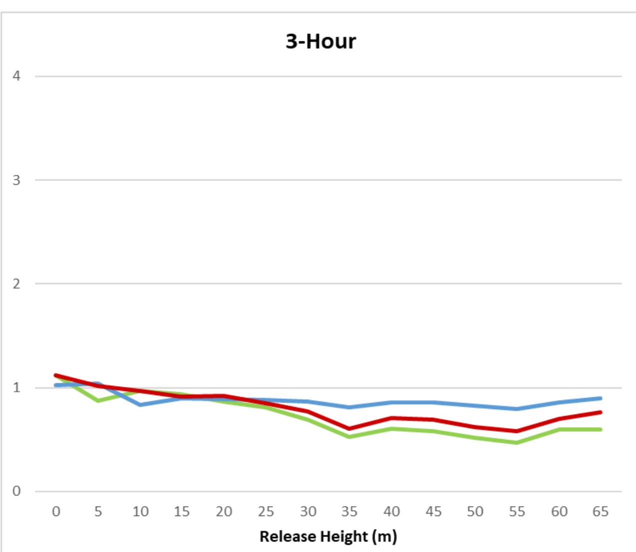

Figure 172. Relative Change in 3-hour Average

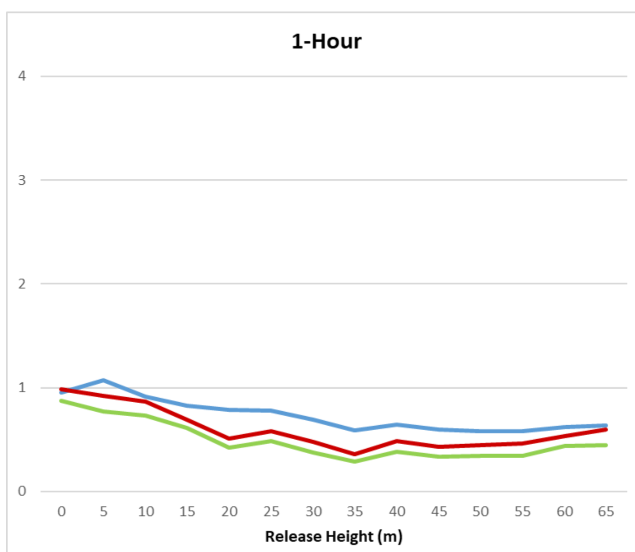

Figure 173. Relative Change in 1-hour Average

New Marshalltown Data vs. Old Ames Data

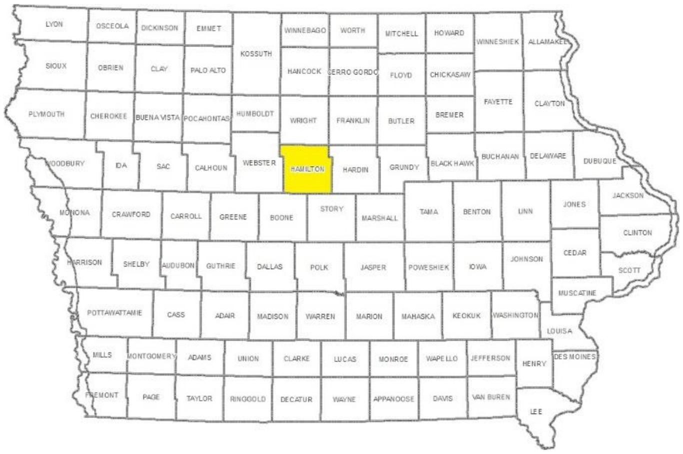

Figure 174. Map of Applicable Area

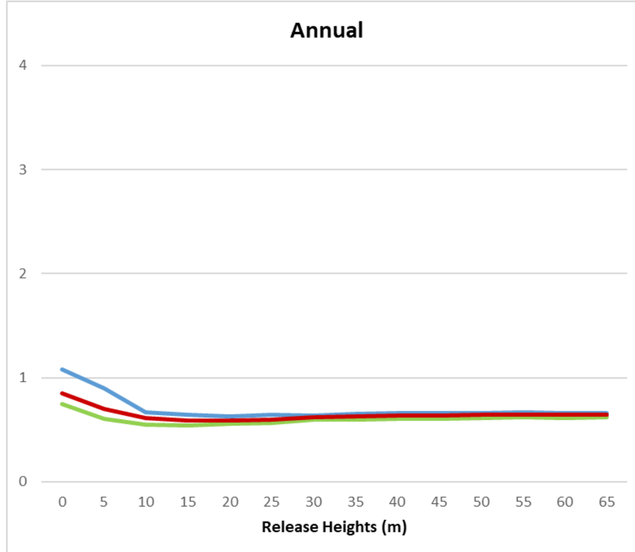

Figure 175. Relative Change in Annual Average

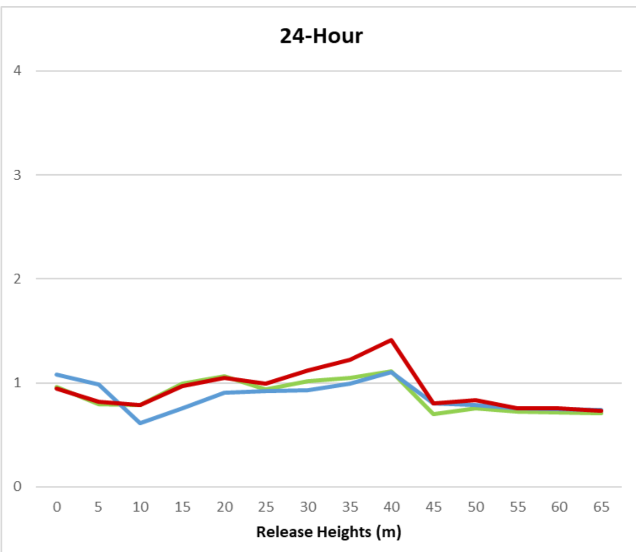

Figure 176. Relative Change in 24-hour Average

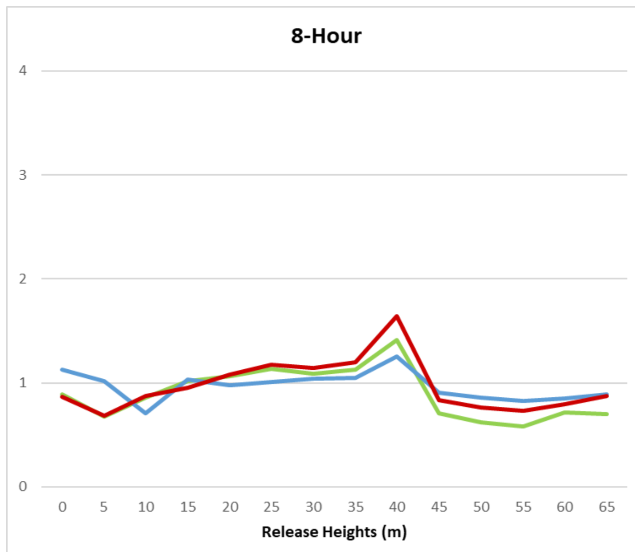

Figure 177. Relative Change in 8-hour Average

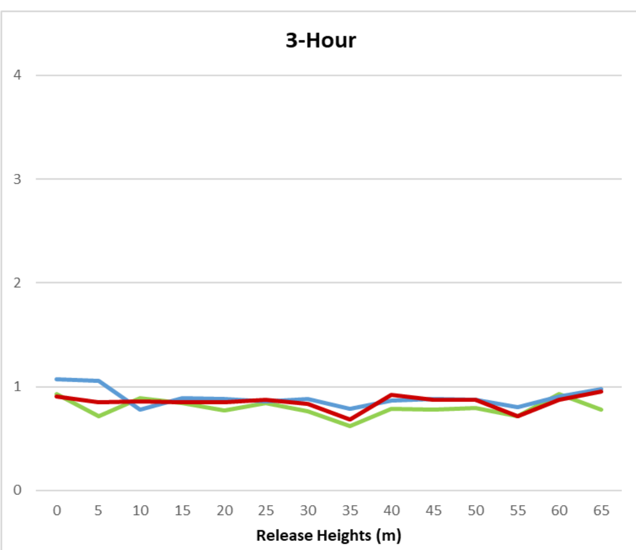

Figure 178. Relative Change in 3-hour Average

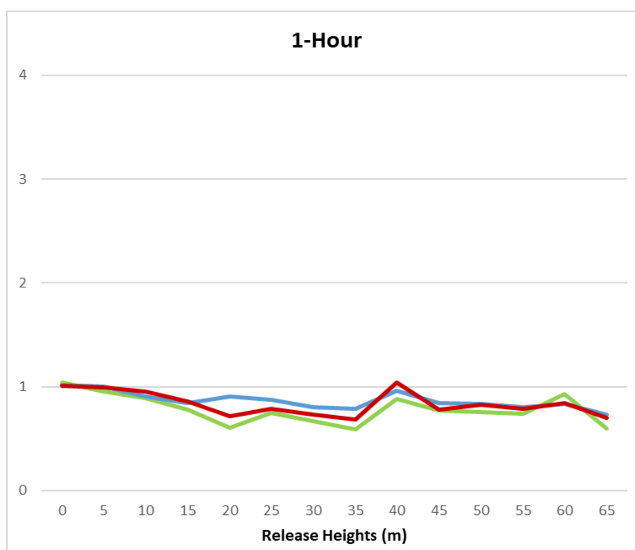

Figure 179. Relative Change in 1-hour Average

New Burlington Data vs. Old Burlington Data

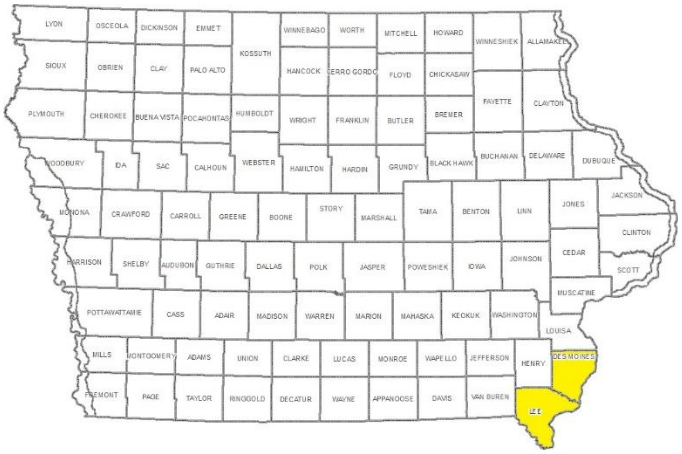

Figure 180. Map of Applicable Area

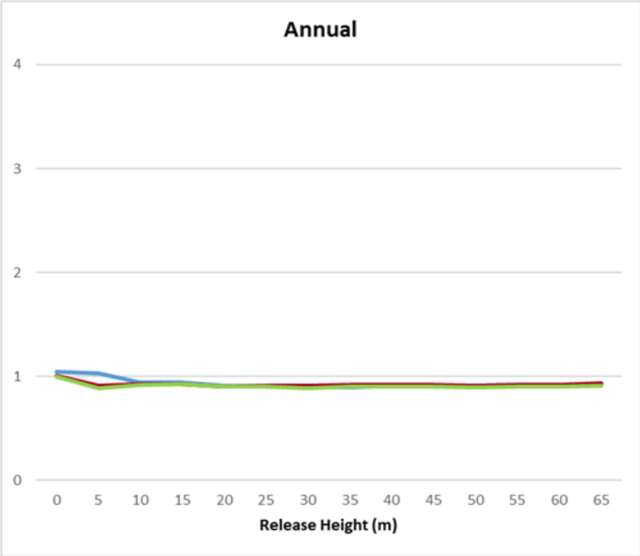

Figure 181. Relative Change in Annual Average

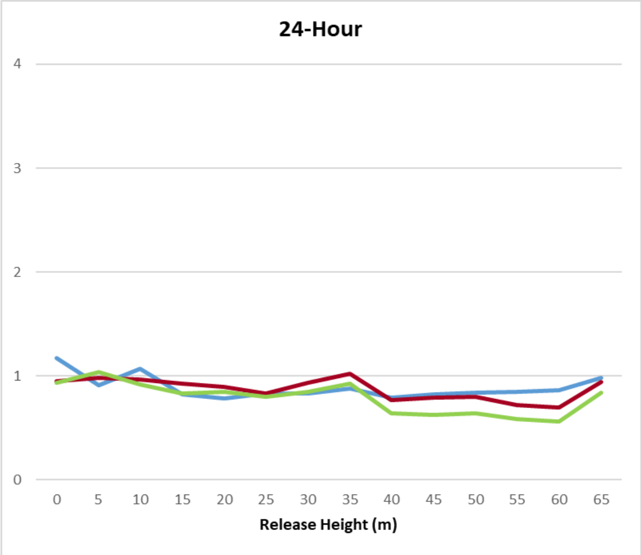

Figure 182. Relative Change in 24-hour Average

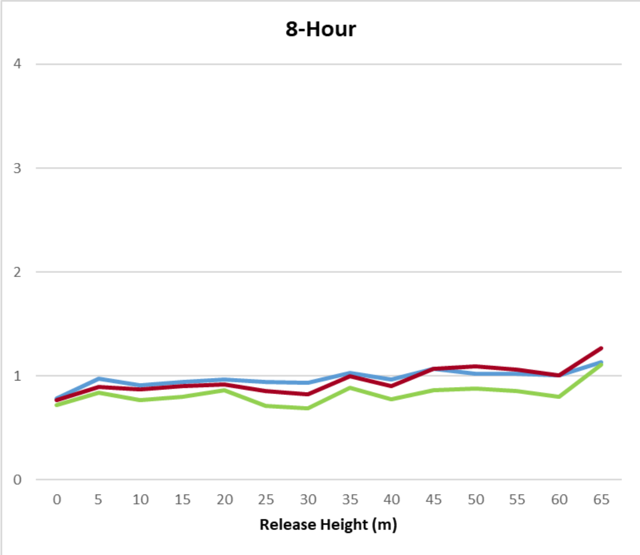

Figure 183. Relative Change in 8-hour Average

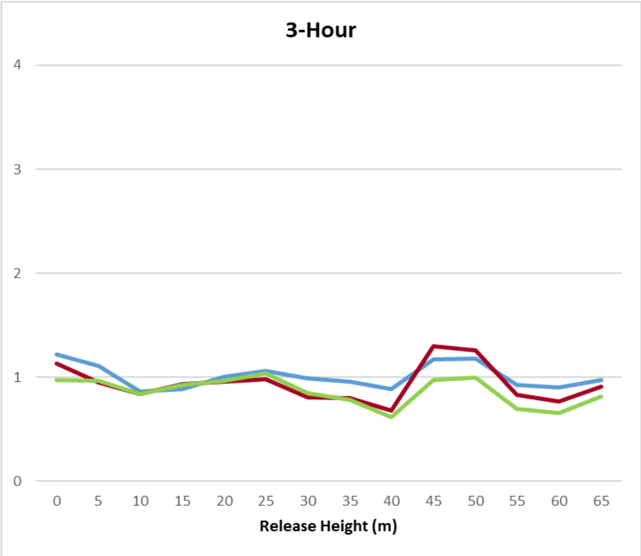

Figure 184. Relative Change in 3-hour Average

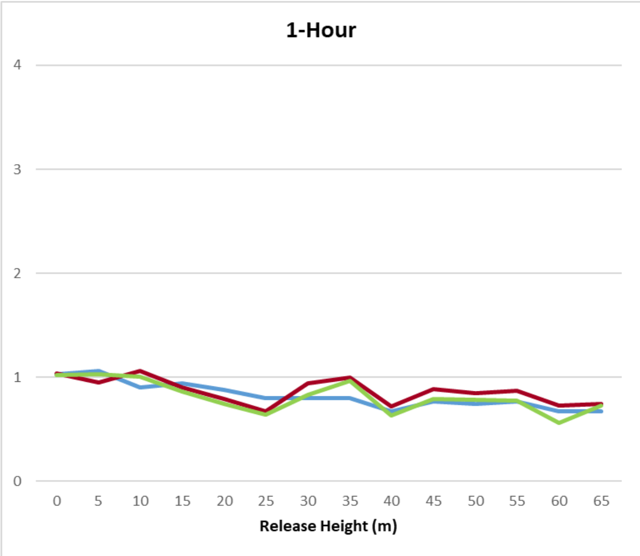

Figure 185. Relative Change in 1-hour Average

New Burlington Data vs. Old Ottumwa Data

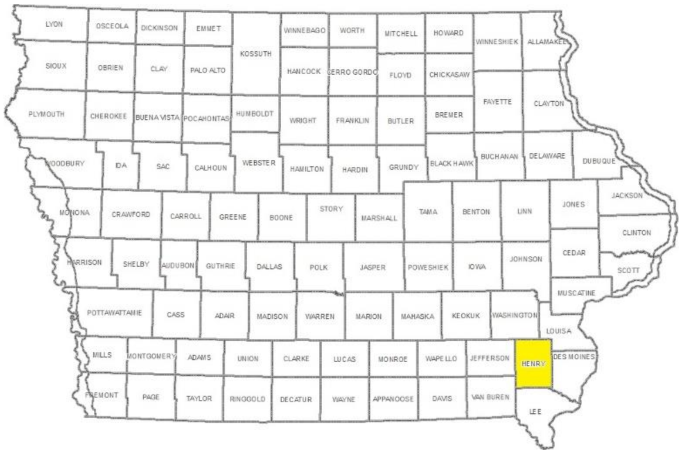

Figure 186. Map of Applicable Area

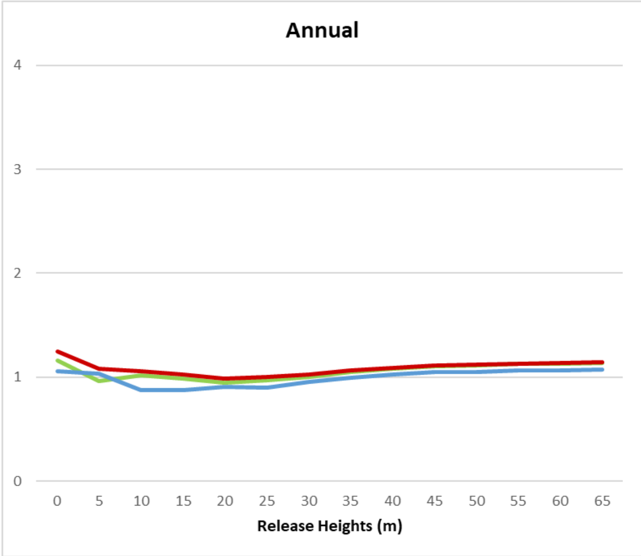

Figure 187. Relative Change in Annual Average

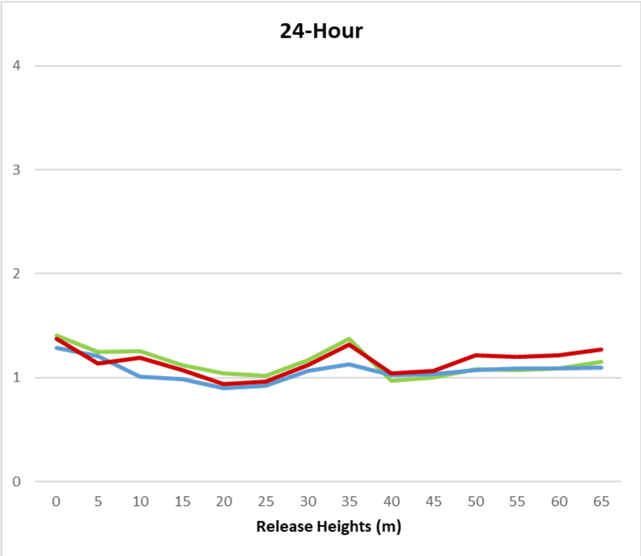

Figure 188. Relative Change in 24-hour Average

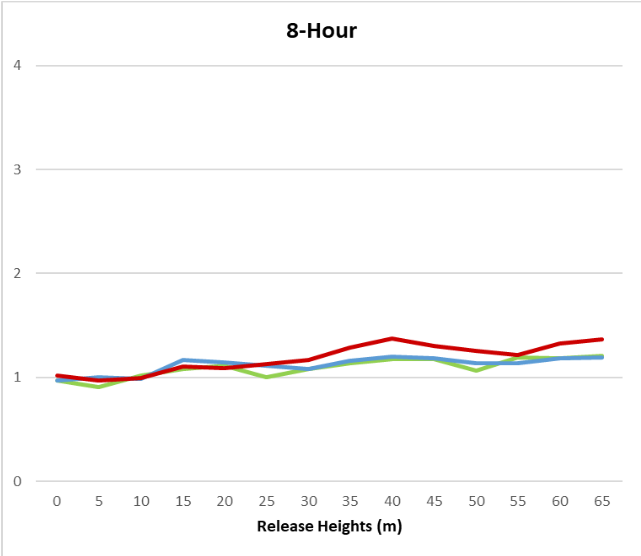

Figure 189. Relative Change in 8-hour Average

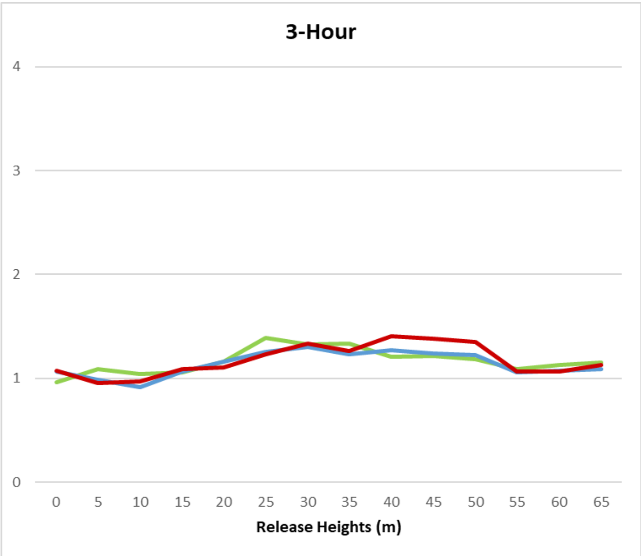

Figure 190. Relative Change in 3-hour Average

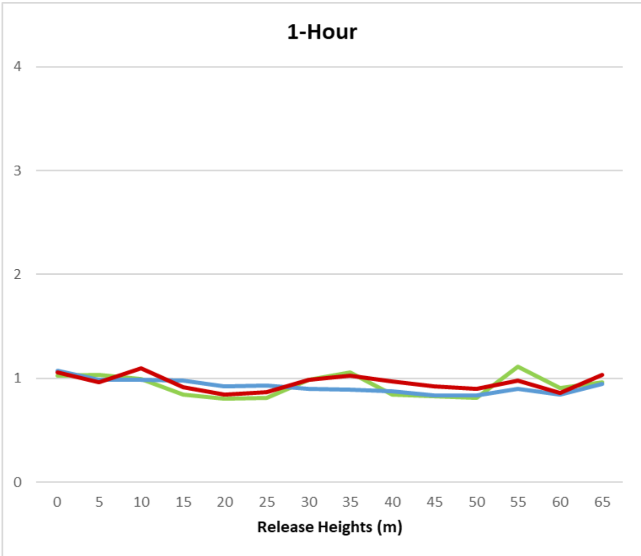

Figure 191. Relative Change in 1-hour Average

New Blair Data vs. Old Sioux Falls Data

Figure 192. Map of Applicable Area

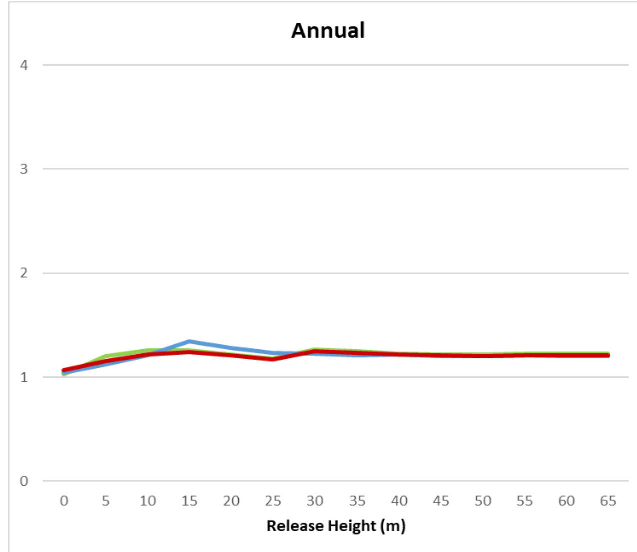

Figure 193. Relative Change in Annual Average

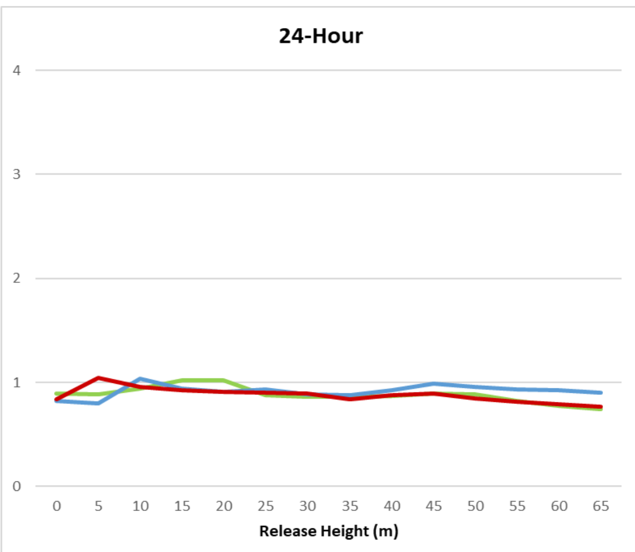

Figure 194. Relative Change in 24-hour Average

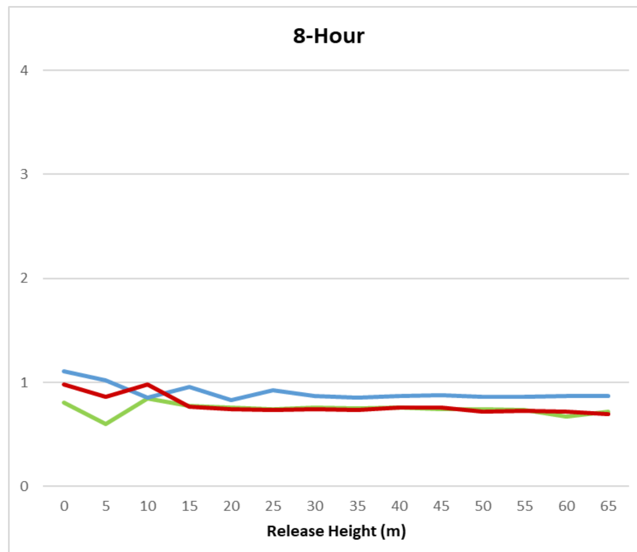

Figure 195. Relative Change in 8-hour Average

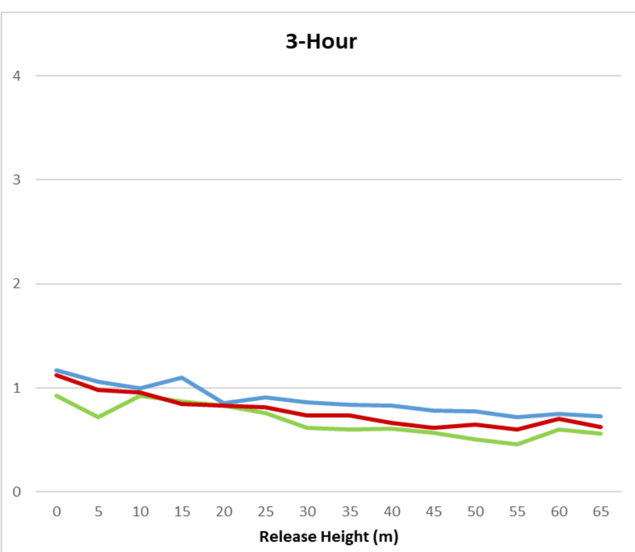

Figure 196. Relative Change in 3-hour Average

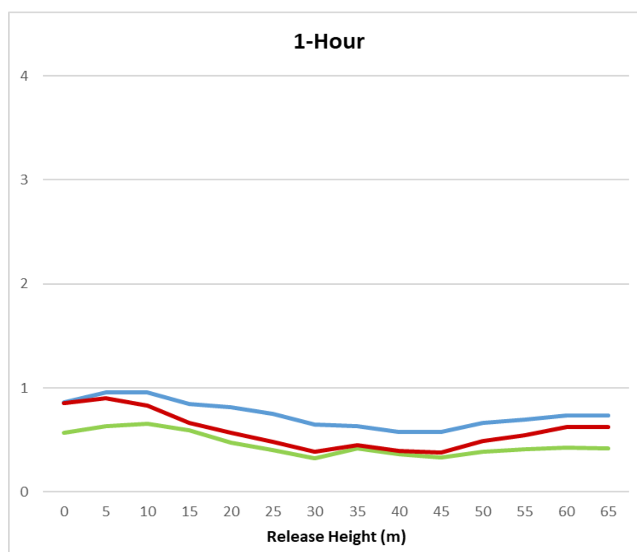

Figure 197. Relative Change in 1-hour Average

New Blair Data vs. Old Spencer Data

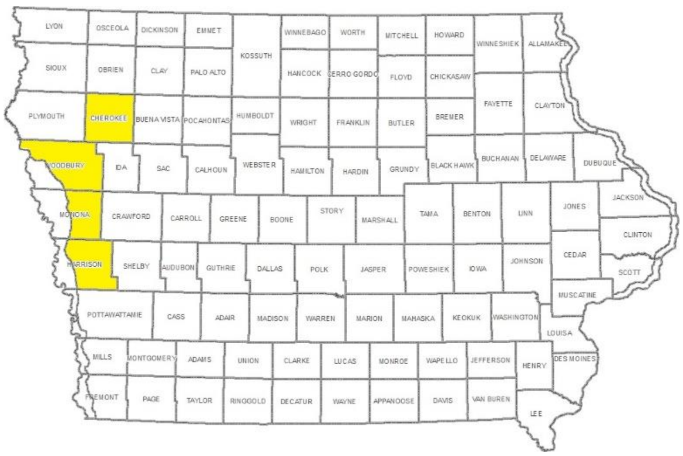

Figure 198. Map of Applicable Area

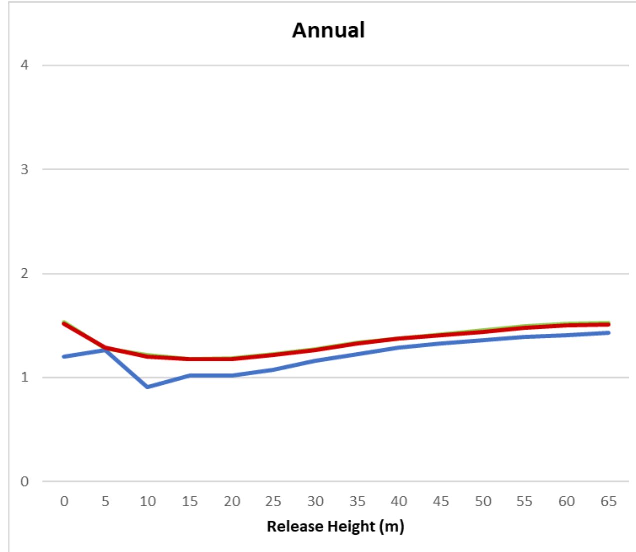

Figure 199. Relative Change in Annual Average

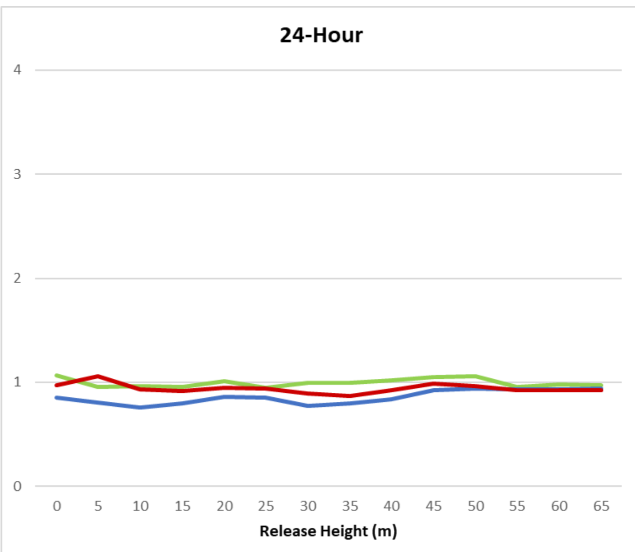

Figure 200. Relative Change in 24-hour Average

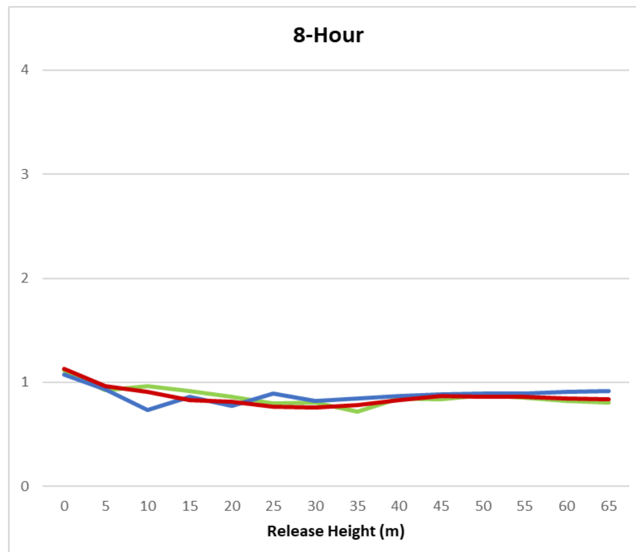

Figure 201. Relative Change in 8-hour Average

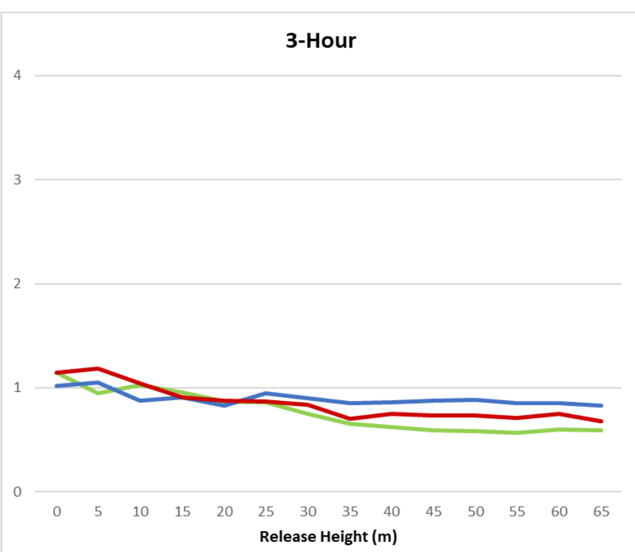

Figure 202. Relative Change in 3-hour Average

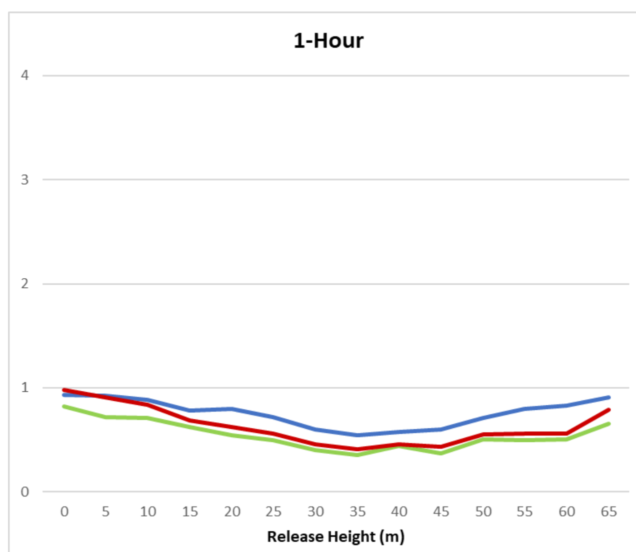

Figure 203. Relative Change in 1-hour Average

New Blair Data vs. Old Des Moines Data

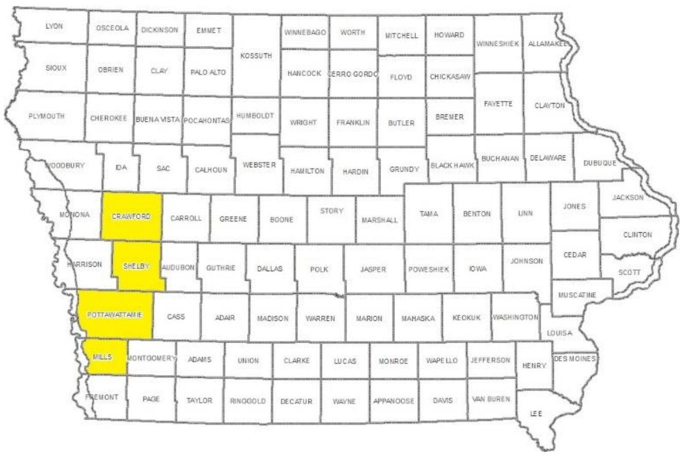

Figure 204. Map of Applicable Area

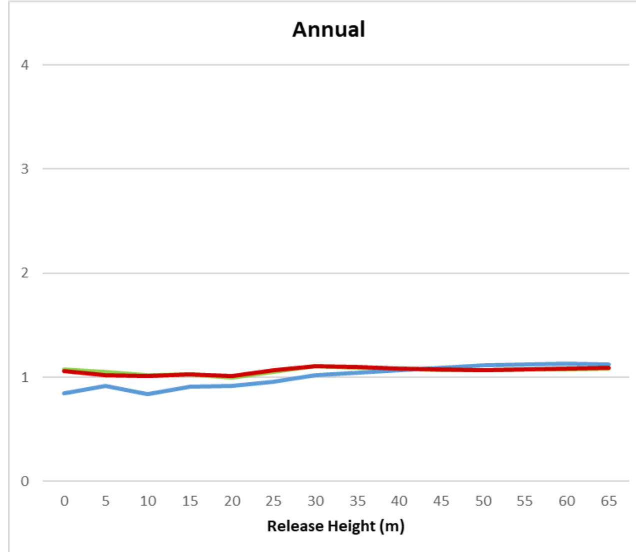

Figure 205. Relative Change in Annual Average

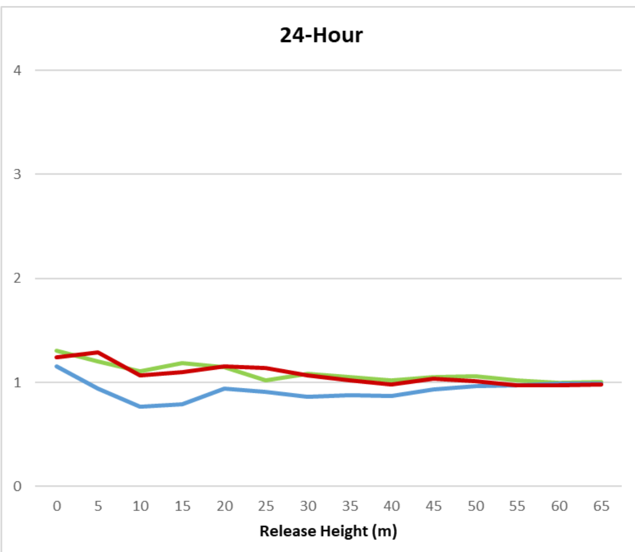

Figure 206. Relative Change in 24-hour Average

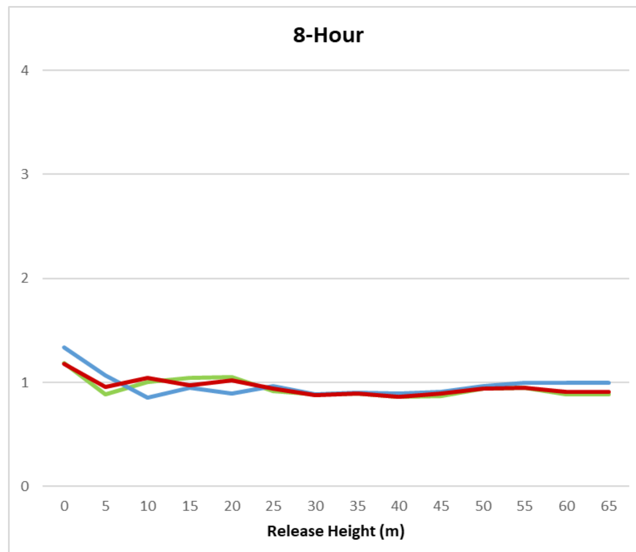

Figure 207. Relative Change in 8-hour Average

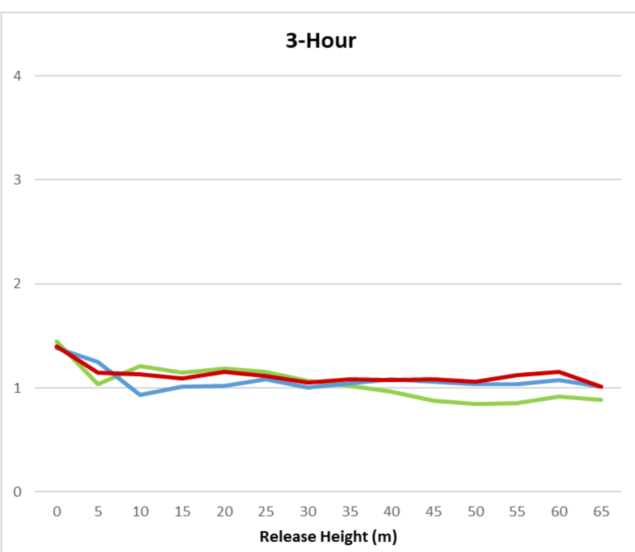

Figure 208. Relative Change in 3-hour Average

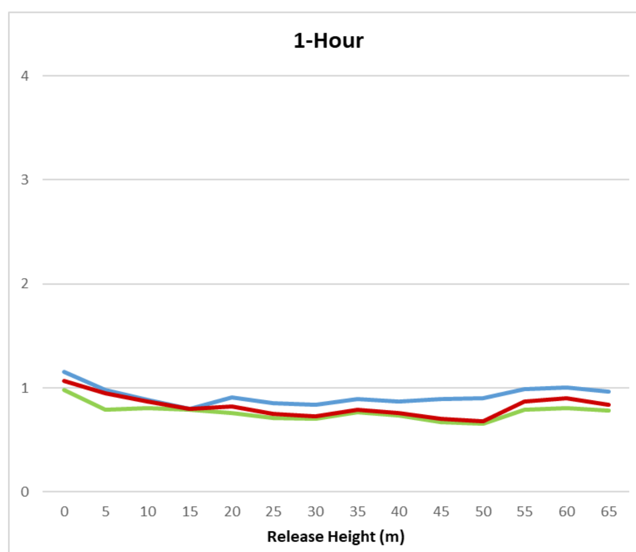

Figure 209. Relative Change in 1-hour Average

New Blair Data vs. Old Lamoni Data

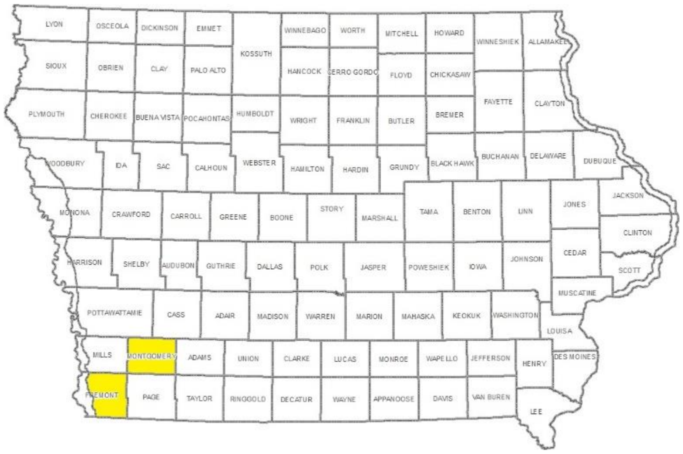

Figure 210. Map of Applicable Area

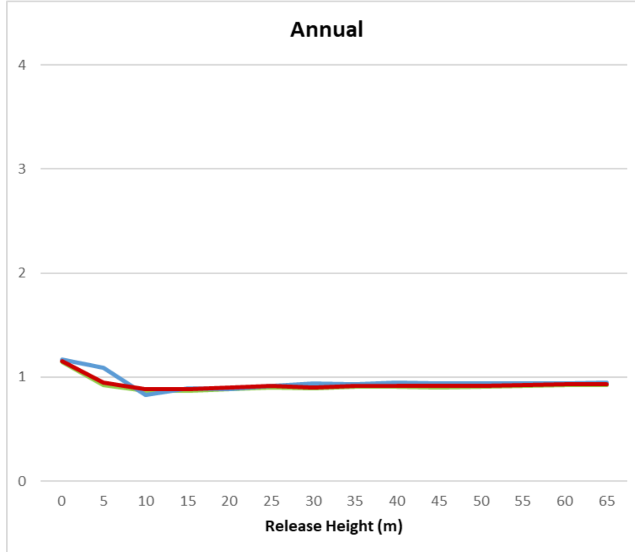

Figure 211. Relative Change in Annual Average

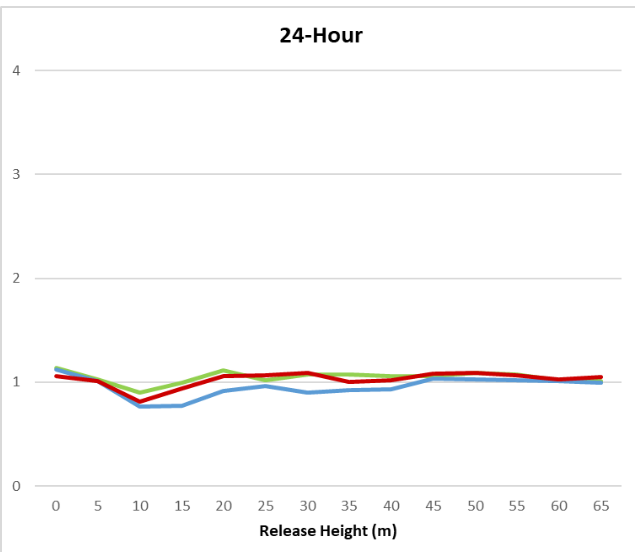

Figure 212. Relative Change in 24-hour Average

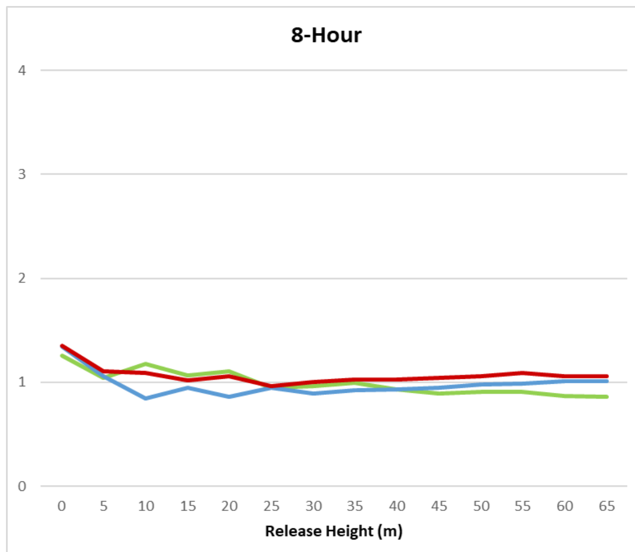

Figure 213. Relative Change in 8-hour Average

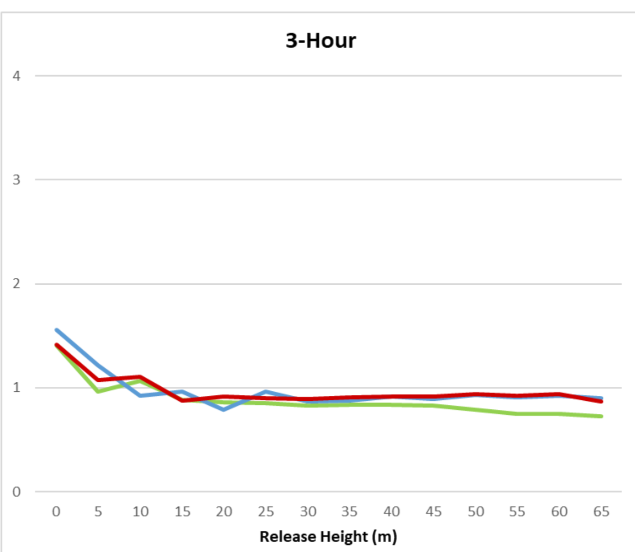

Figure 214. Relative Change in 3-hour Average

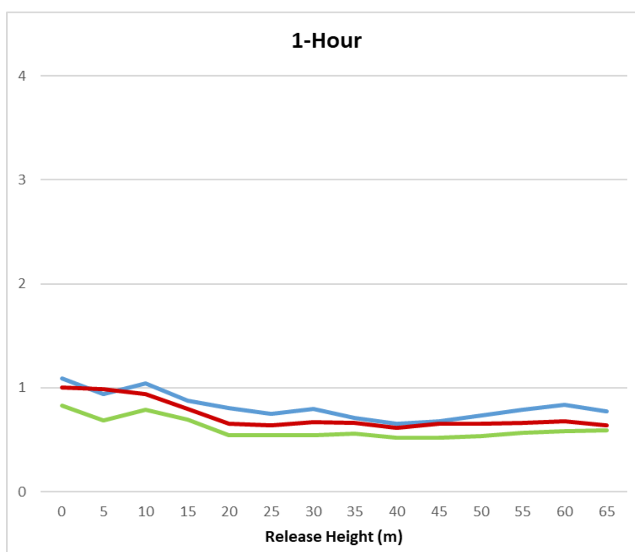

Figure 215. Relative Change in 1-hour Average

New Cedar Rapids Data vs. Old Cedar Rapids Data

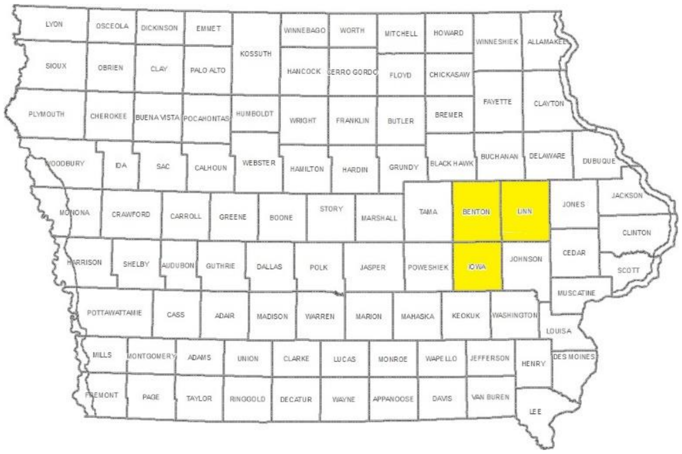

Figure 216. Map of Applicable Area

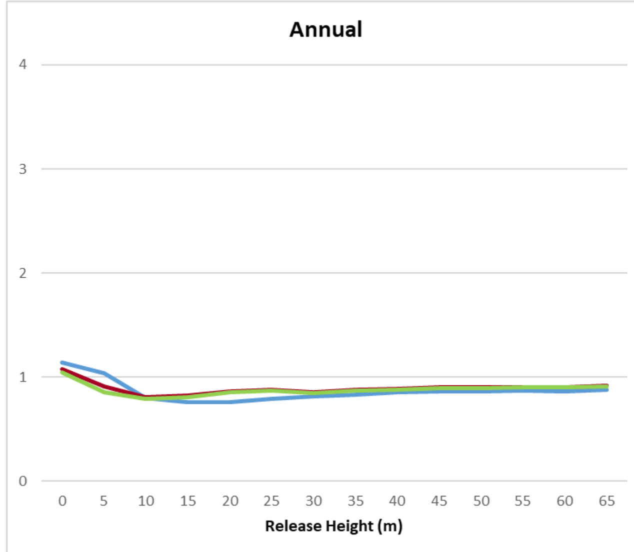

Figure 217. Relative Change in Annual Average

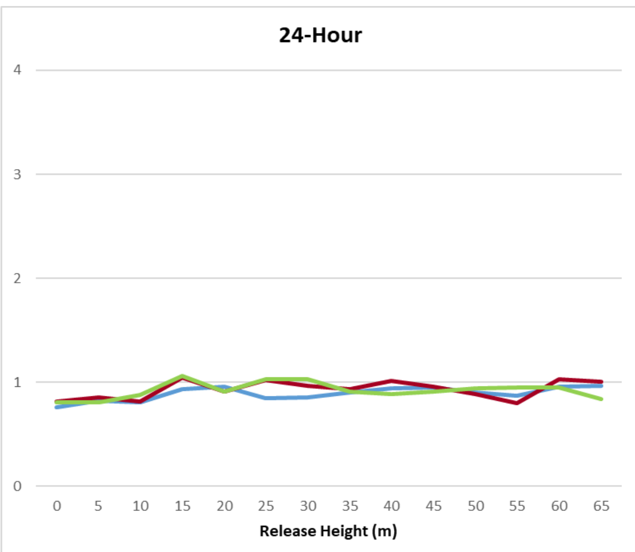

Figure 218. Relative Change in 24-hour Average

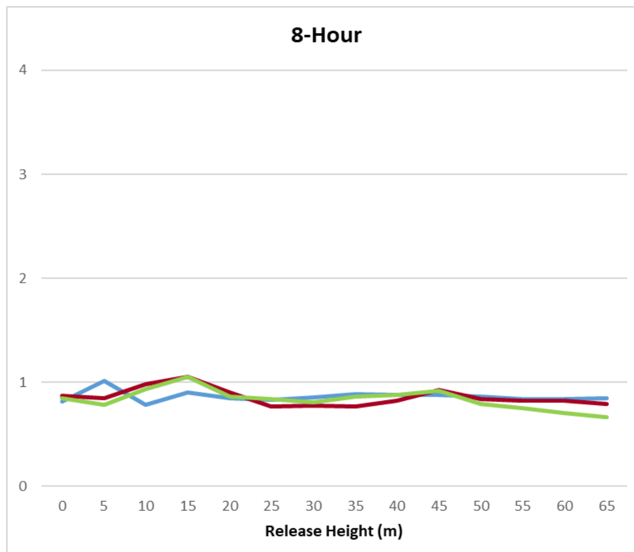

Figure 219. Relative Change in 8-hour Average

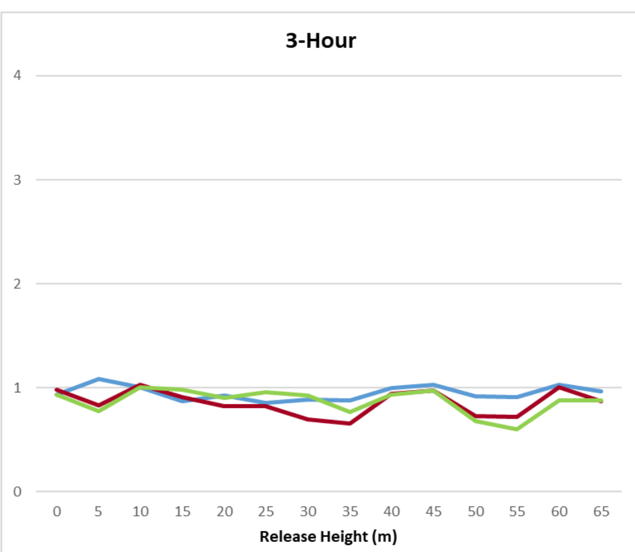

Figure 220. Relative Change in 3-hour Average

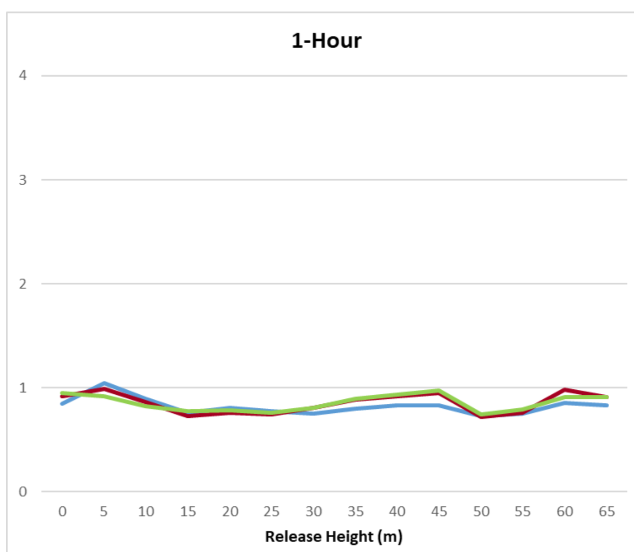

Figure 221. Relative Change in 1-hour Average

New Cedar Rapids Data vs. Old Iowa City Data

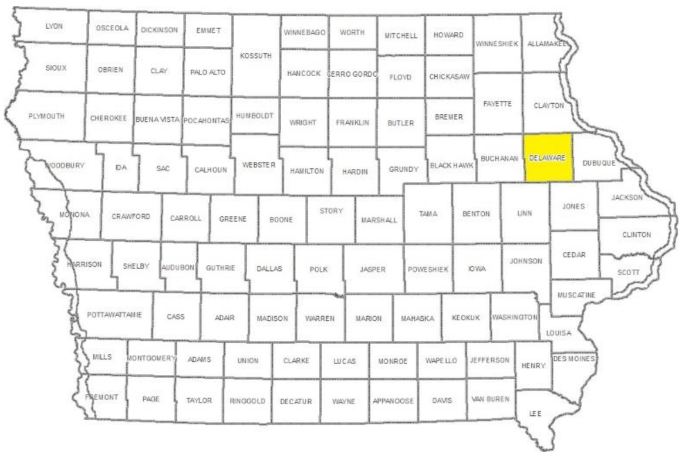

Figure 222. Map of Applicable Area

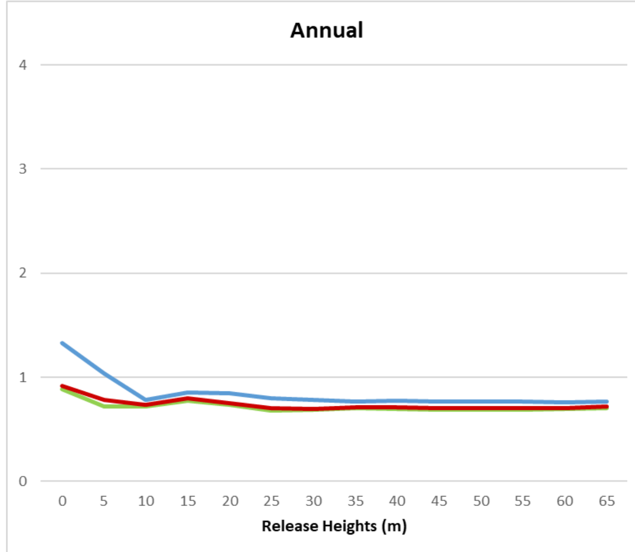

Figure 223. Relative Change in Annual Average

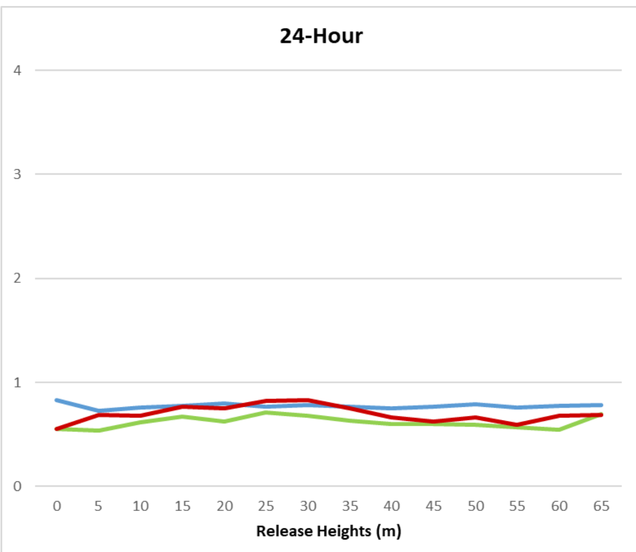

Figure 224. Relative Change in 24-hour Average

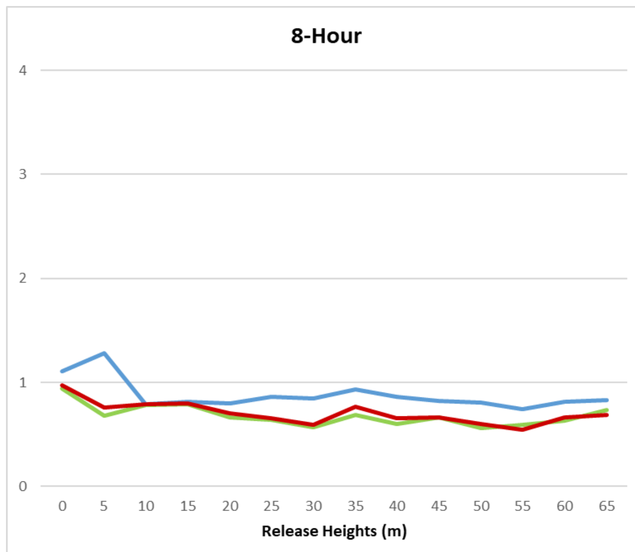

Figure 225. Relative Change in 8-hour Average

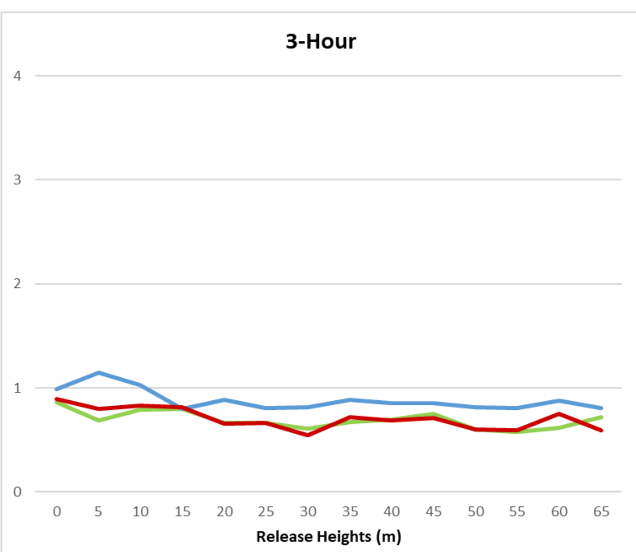

Figure 226. Relative Change in 3-hour Average

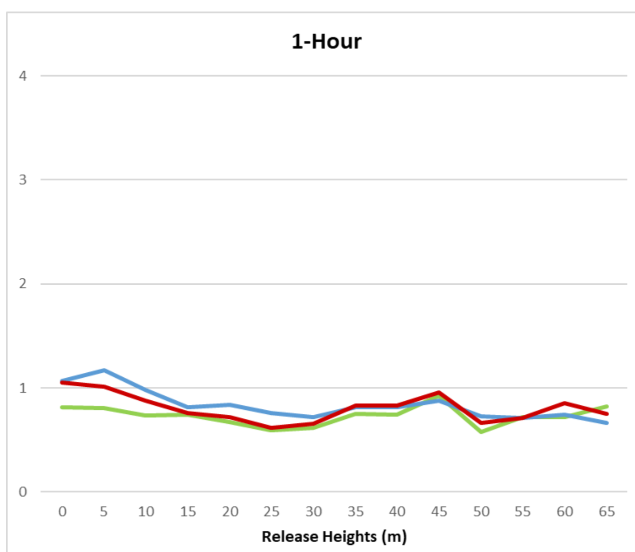

Figure 227. Relative Change in 1-hour Average

New Davenport Data vs. Old Davenport Data

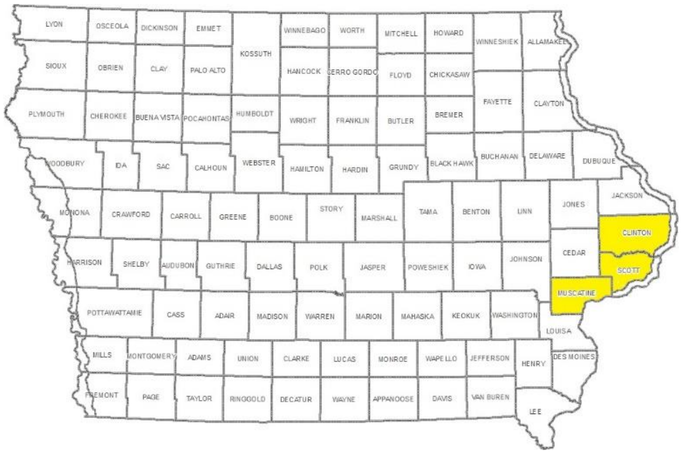

Figure 228. Map of Applicable Area

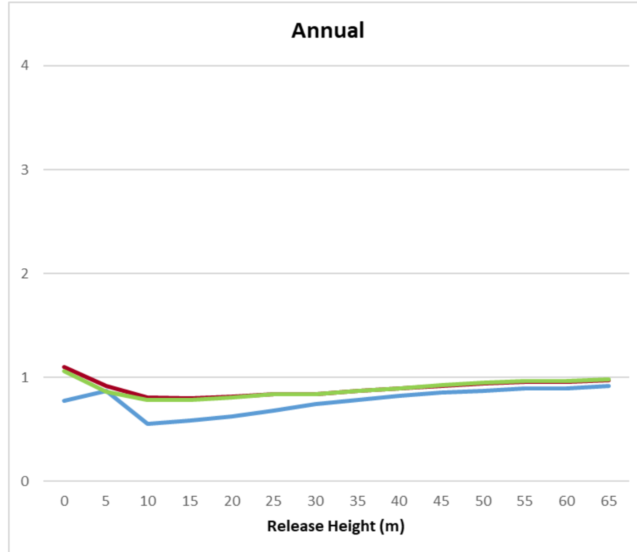

Figure 229. Relative Change in Annual Average

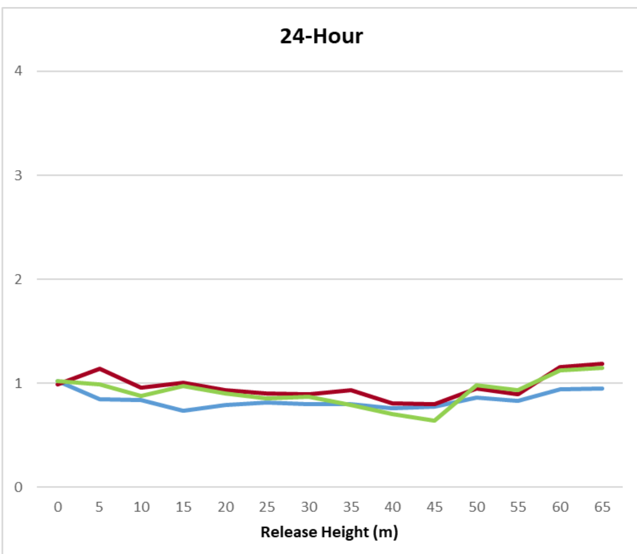

Figure 230. Relative Change in 24-hour Average

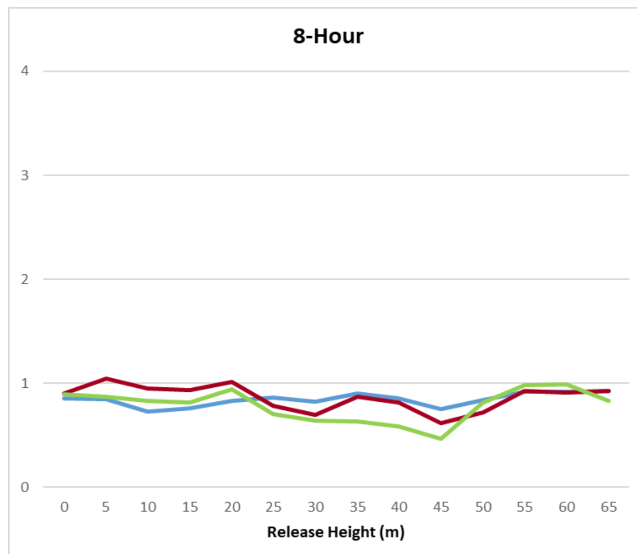

Figure 231. Relative Change in 8-hour Average

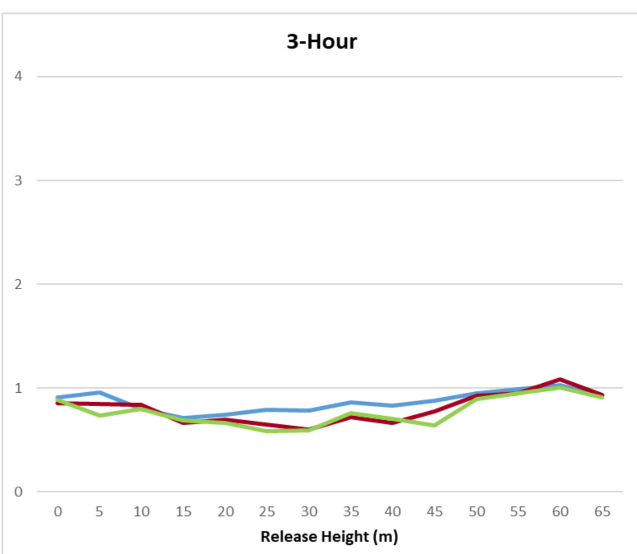

Figure 232. Relative Change in 3-hour Average

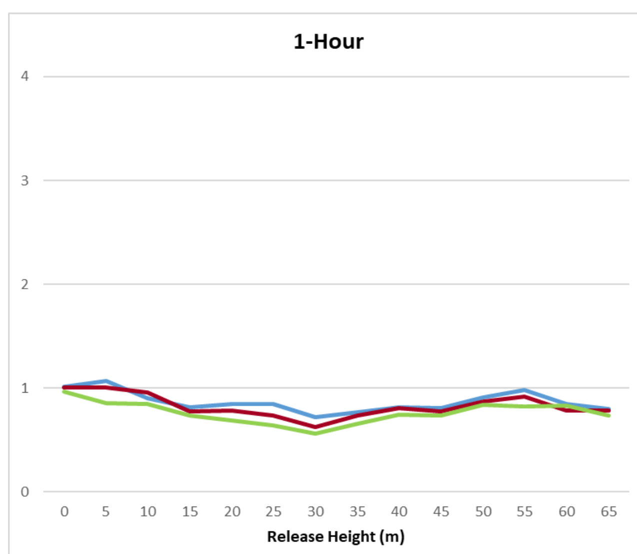

Figure 233. Relative Change in 1-hour Average

New Decorah Data vs. Old Iowa City Data

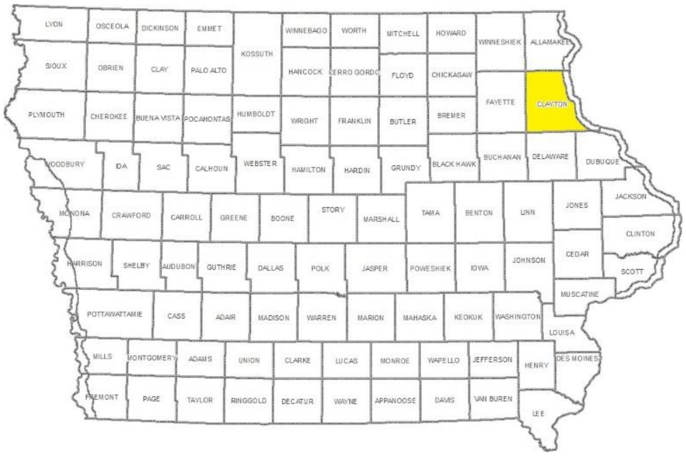

Figure 234. Map of Applicable Area

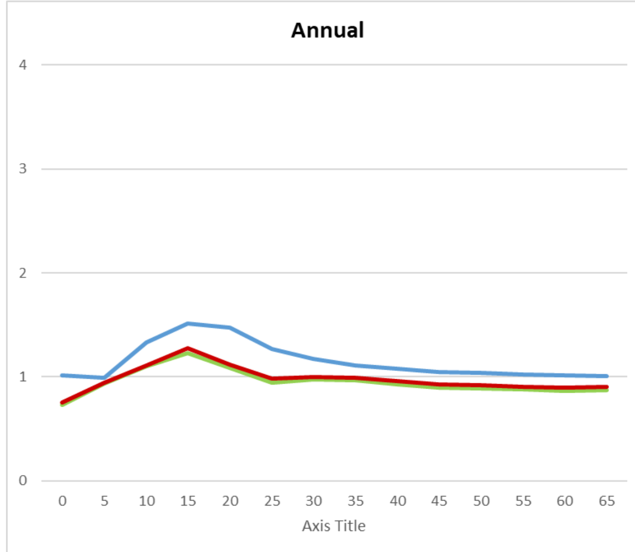

Figure 235. Relative Change in Annual Average

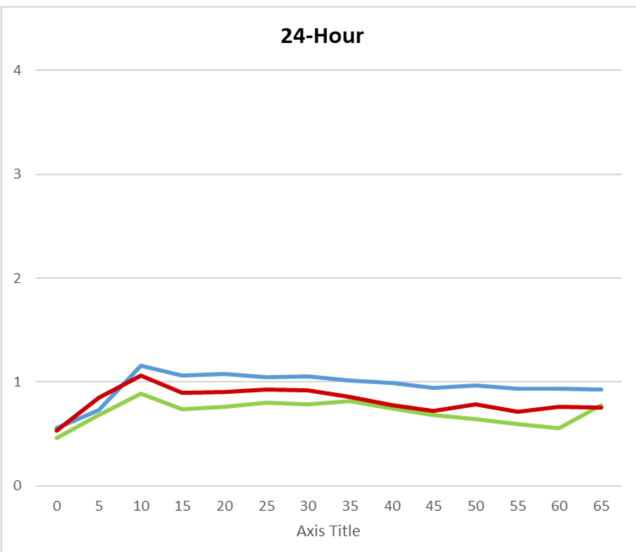

Figure 236. Relative Change in 24-hour Average

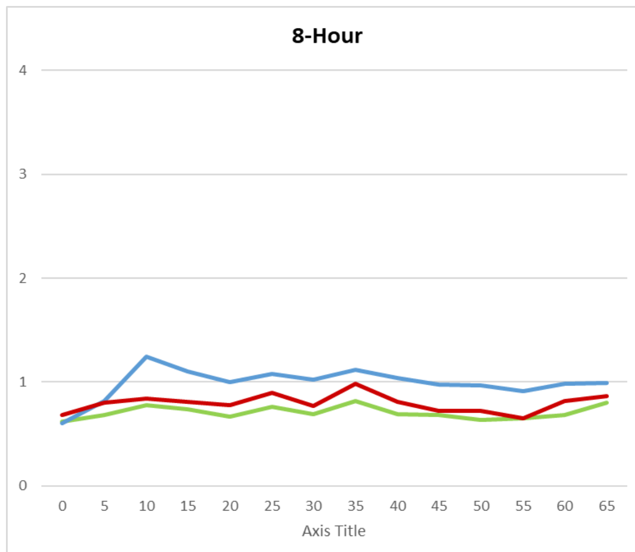

Figure 237. Relative Change in 8-hour Average

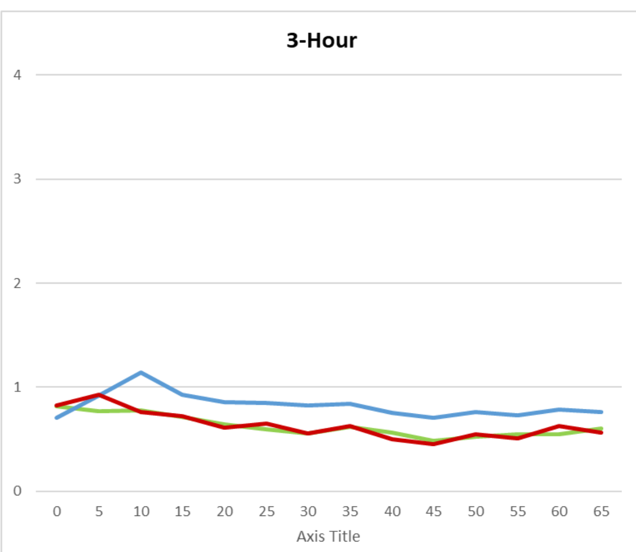

Figure 238. Relative Change in 3-hour Average

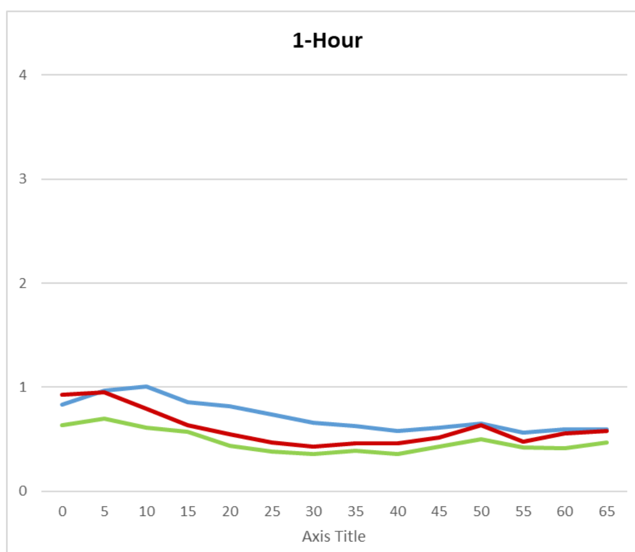

Figure 239. Relative Change in 1-hour Average

New Decorah Data vs. Old Iowa City Data

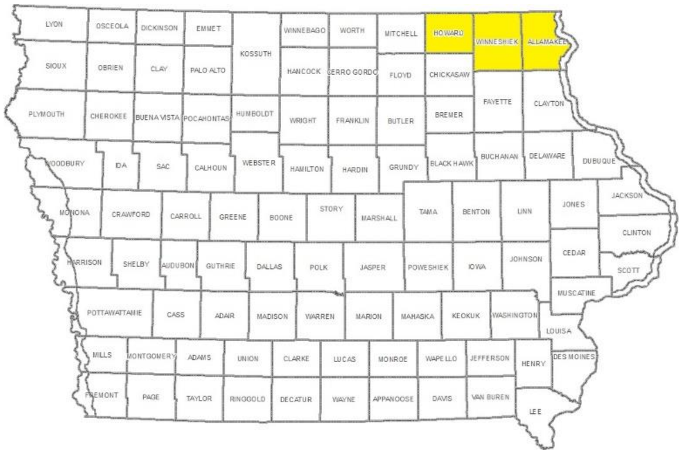

Figure 240. Map of Applicable Area

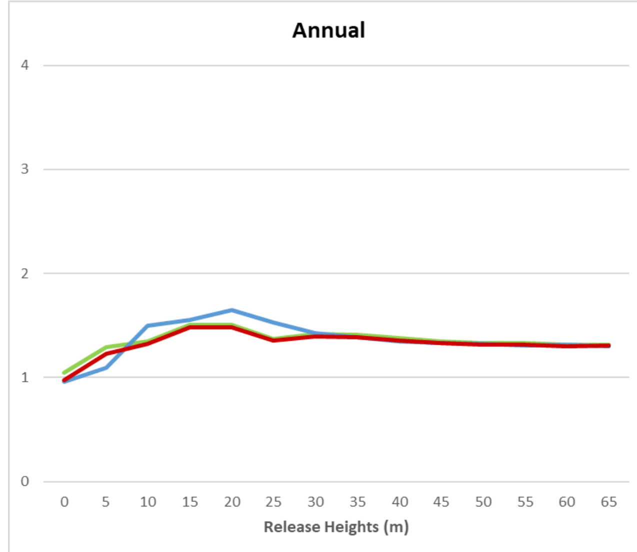

Figure 241. Relative Change in Annual Average

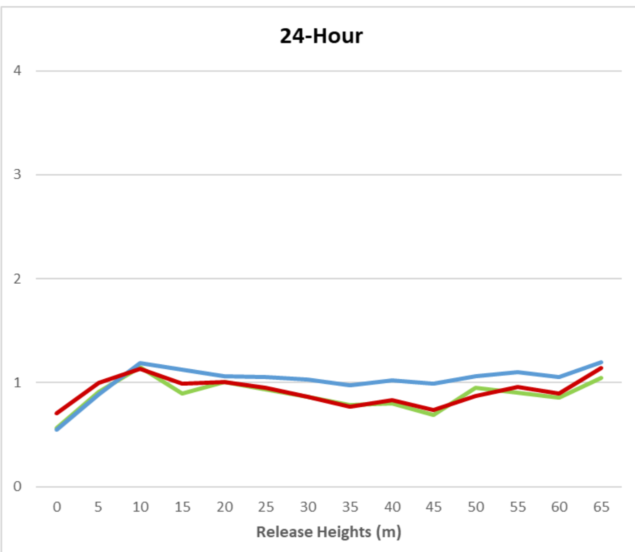

Figure 242. Relative Change in 24-hour Average

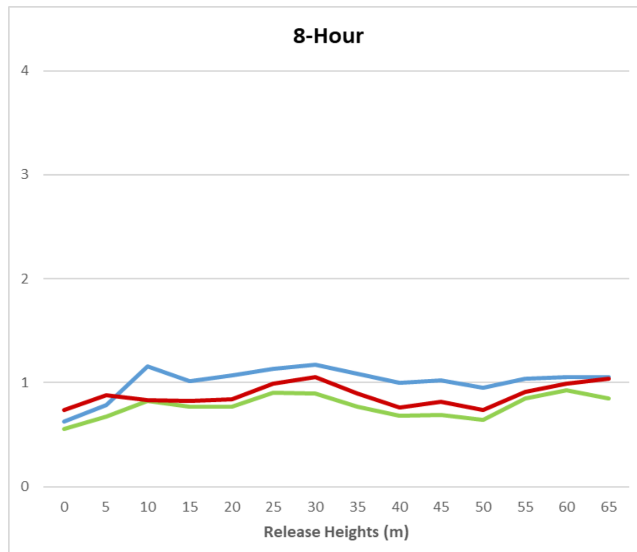

Figure 243. Relative Change in 8-hour Average

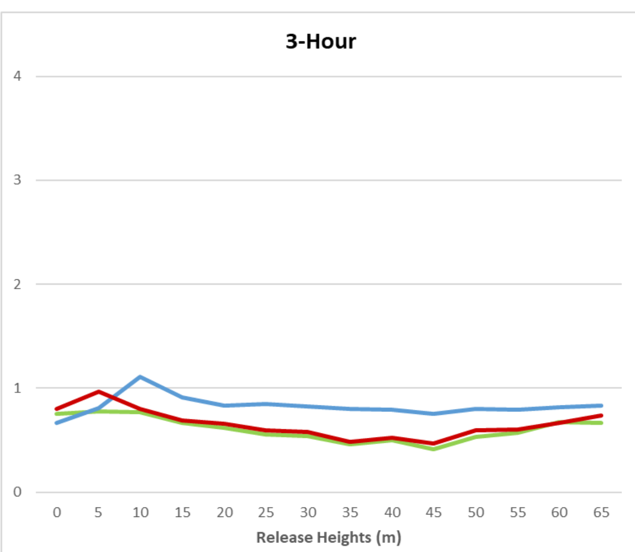

Figure 244. Relative Change in 3-hour Average

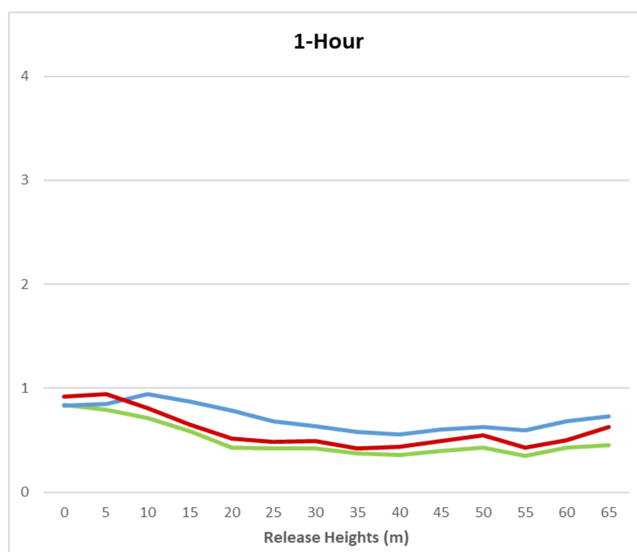

Figure 245. Relative Change in 1-hour Average

New Des Moines Data vs. Old Des Moines Data

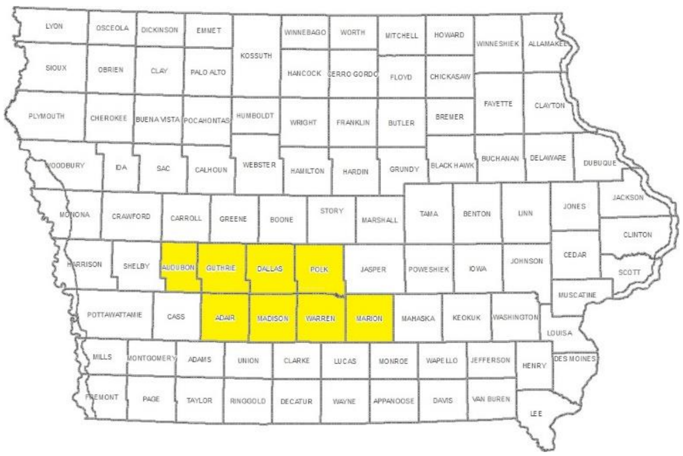

Figure 246. Map of Applicable Area

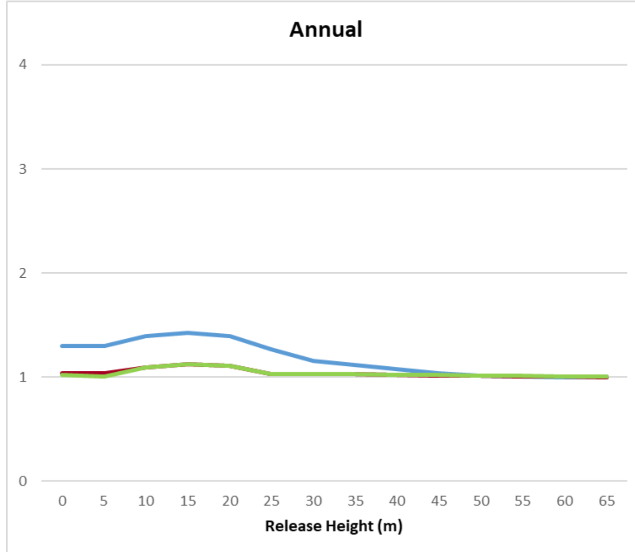

Figure 247. Relative Change in Annual Average

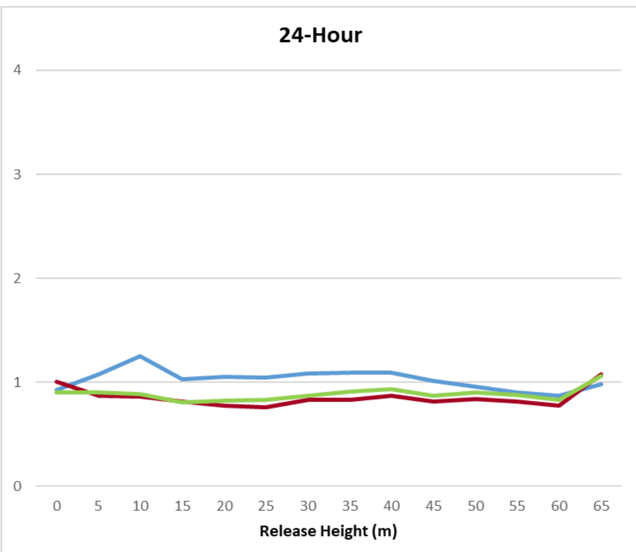

Figure 248. Relative Change in 24-hour Average

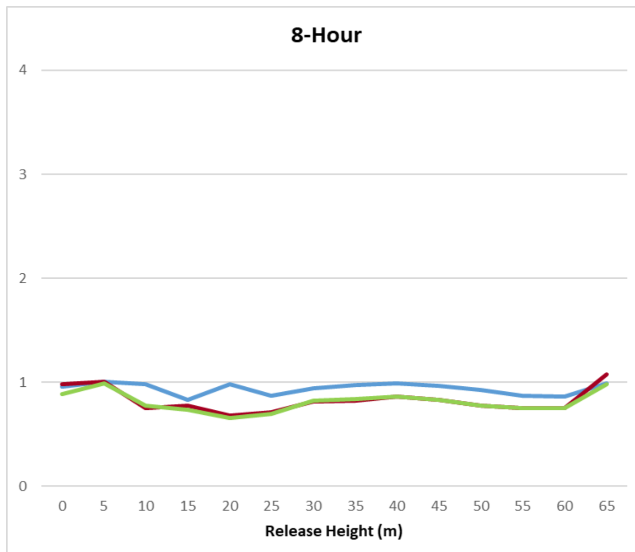

Figure 249. Relative Change in 8-hour Average

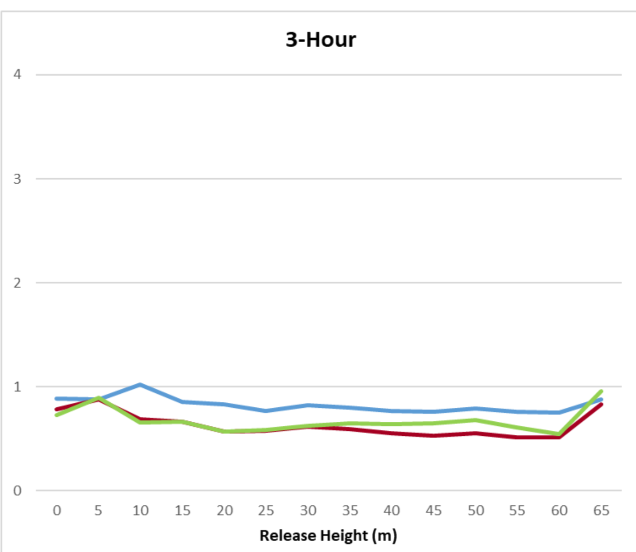

Figure 250. Relative Change in 3-hour Average

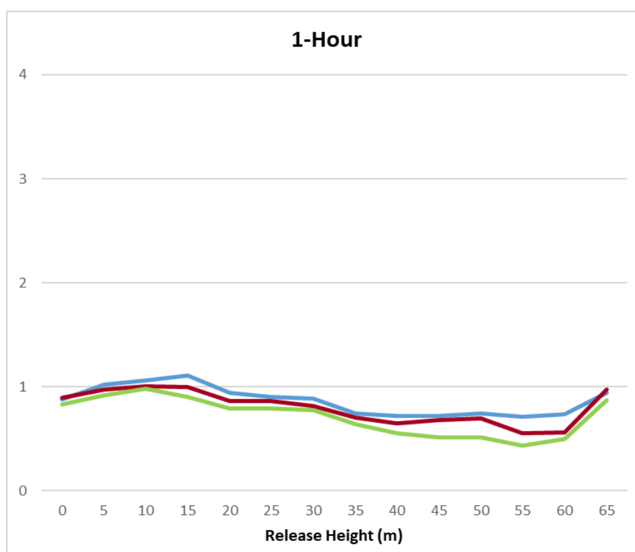

Figure 251. Relative Change in 1-hour Average

New Des Moines Data vs. Old Marshalltown Data

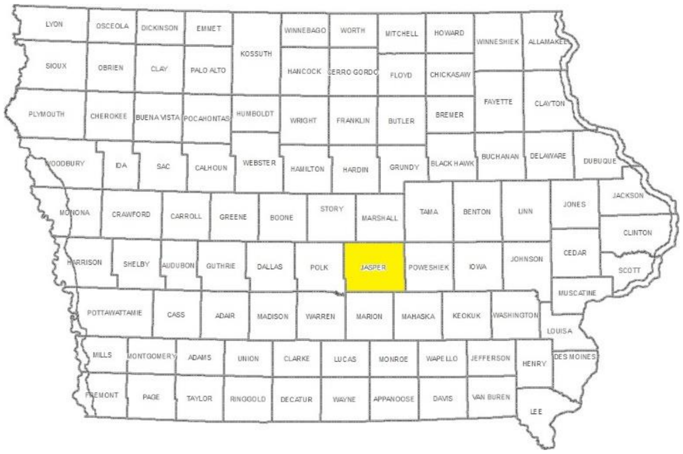

Figure 252. Map of Applicable Area

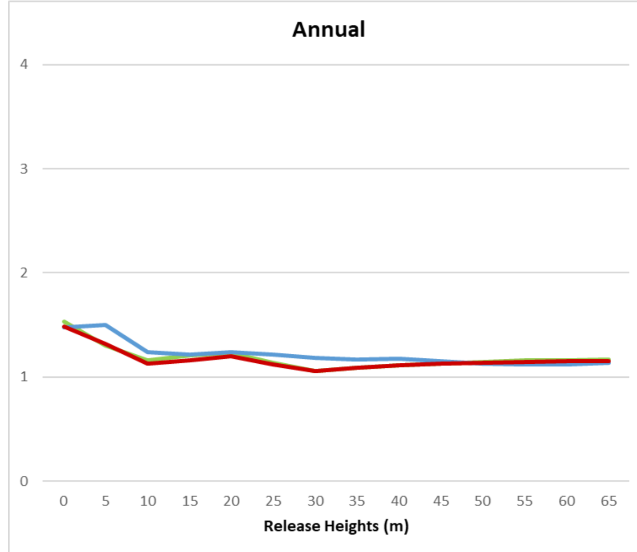

Figure 253. Relative Change in Annual Average

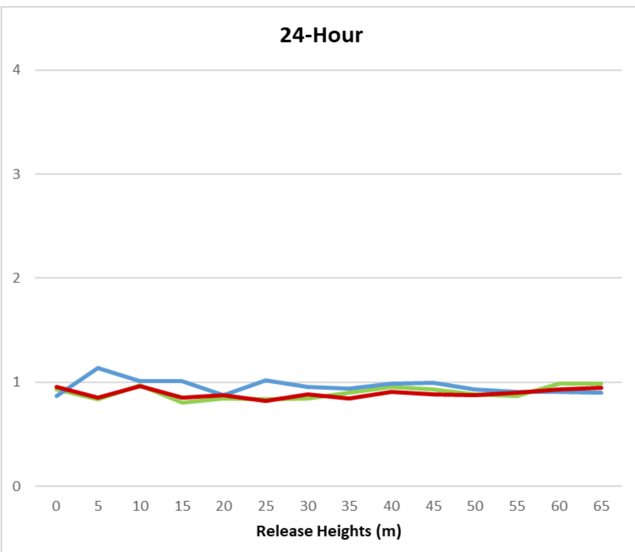

Figure 254. Relative Change in 24-hour Average

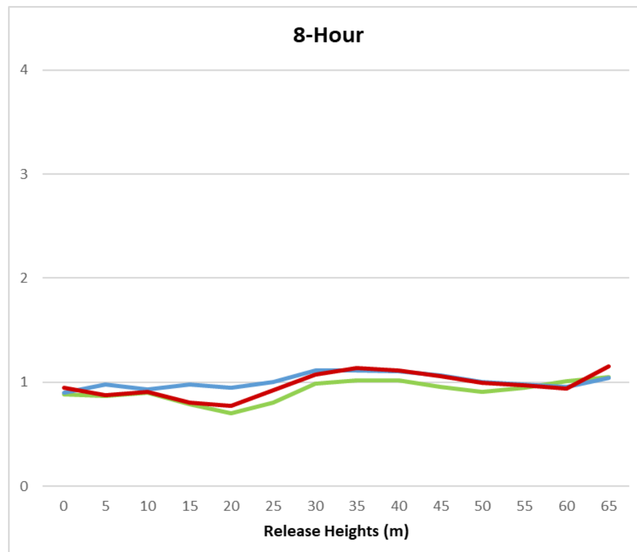

Figure 255. Relative Change in 8-hour Average

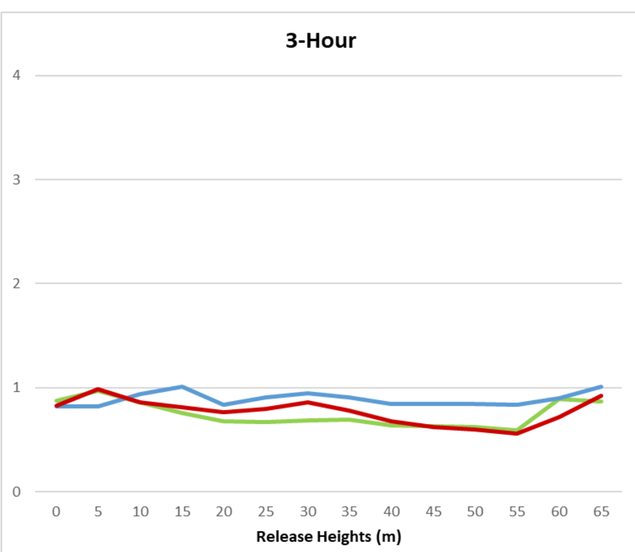

Figure 256. Relative Change in 3-hour Average

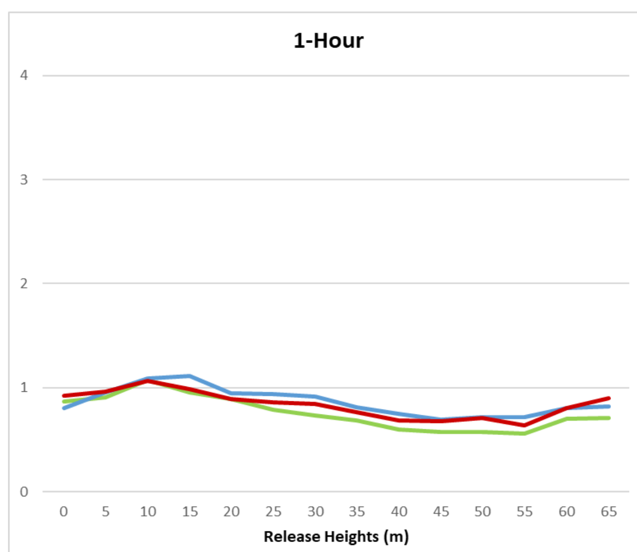

Figure 257. Relative Change in 1-hour Average

New Estherville Data vs. Old Estherville Data

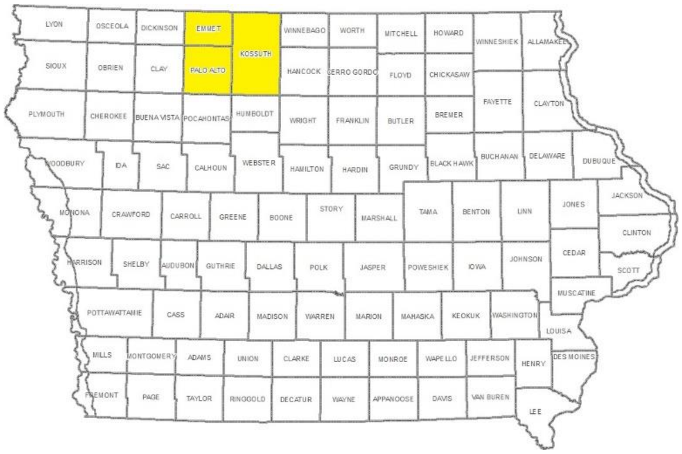

Figure 258. Map of Applicable Area

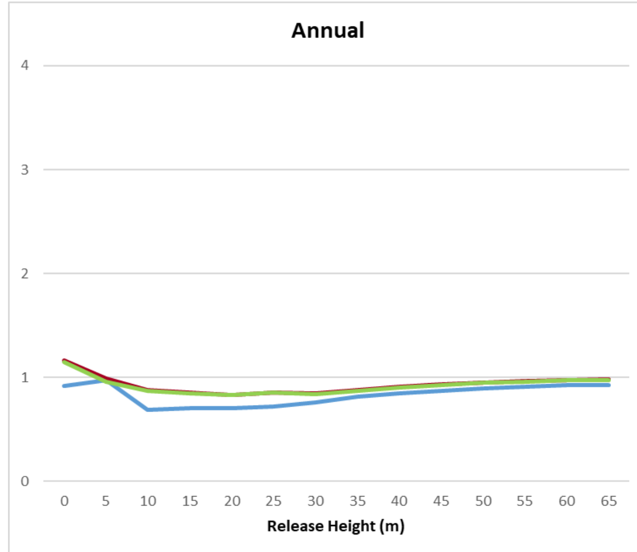

Figure 259. Relative Change in Annual Average

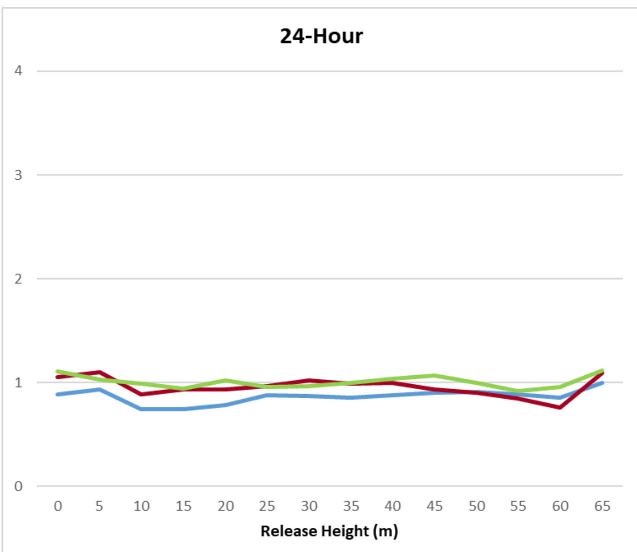

Figure 260. Relative Change in 24-hour Average

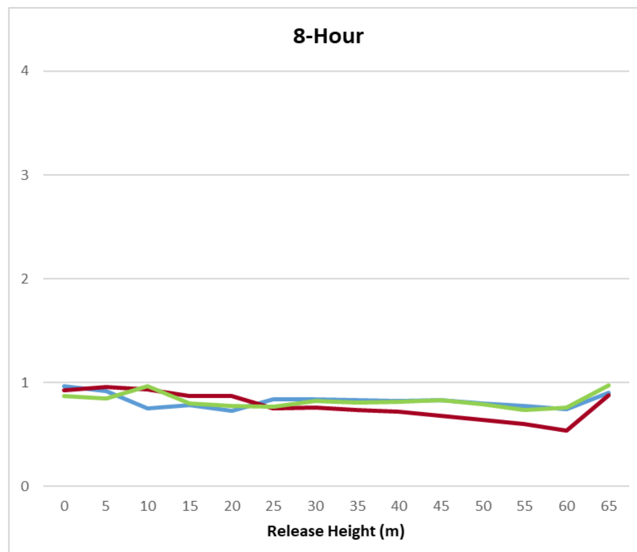

Figure 261. Relative Change in 8-hour Average

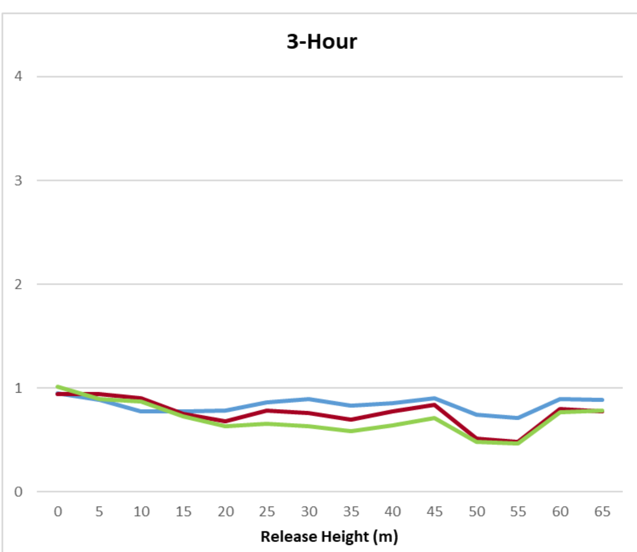

Figure 262. Relative Change in 3-hour Average

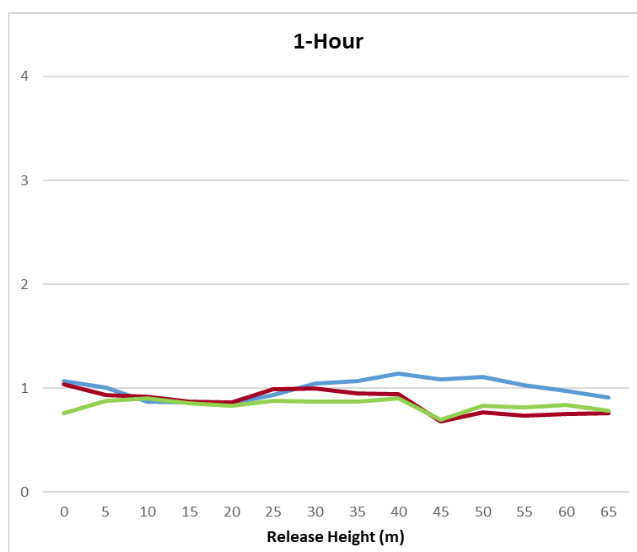

Figure 263. Relative Change in 1-hour Average

New Fort Dodge Data vs. Old Estherville Data

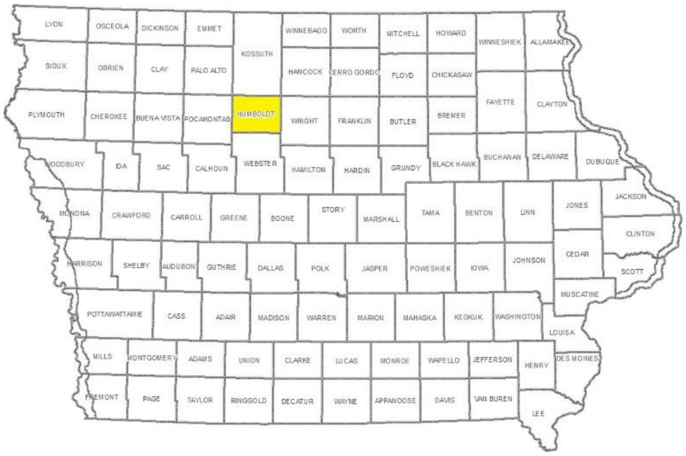

Figure 264. Map of Applicable Area

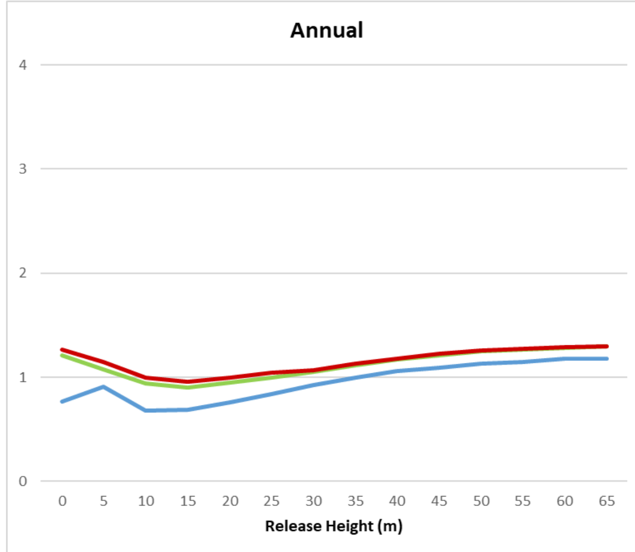

Figure 265. Relative Change in Annual Average

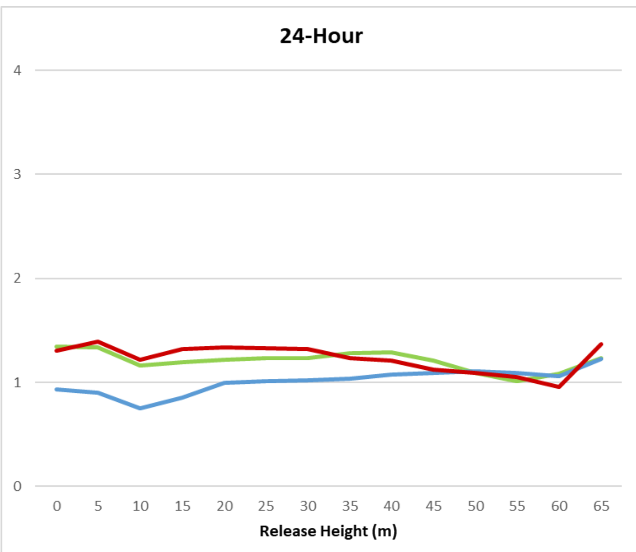

Figure 266. Relative Change in 24-hour Average

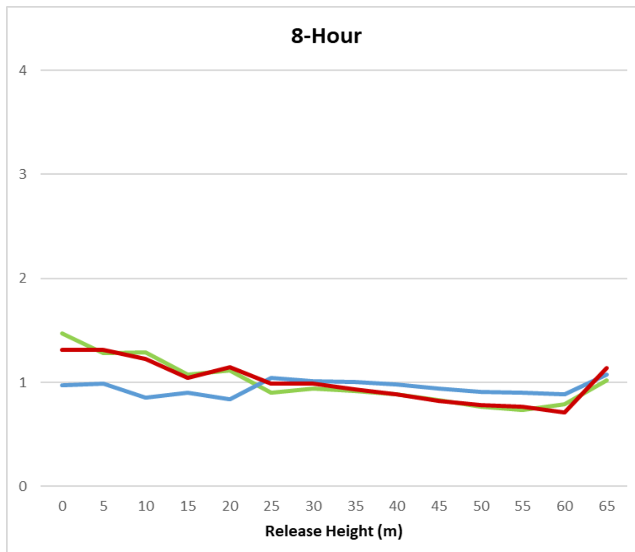

Figure 267. Relative Change in 8-hour Average

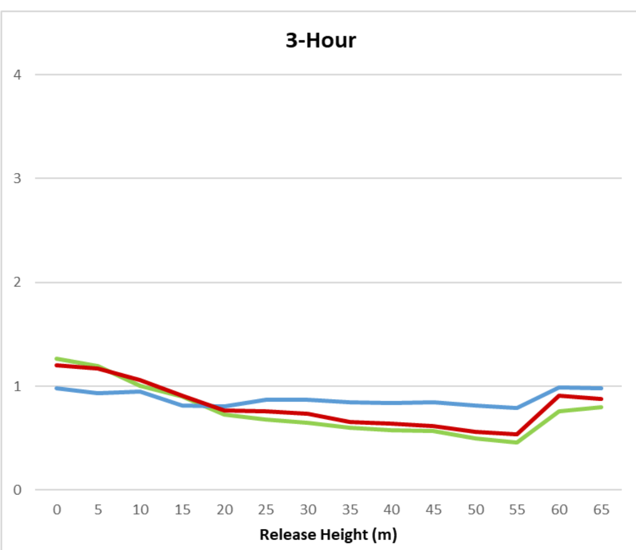

Figure 268. Relative Change in 3-hour Average

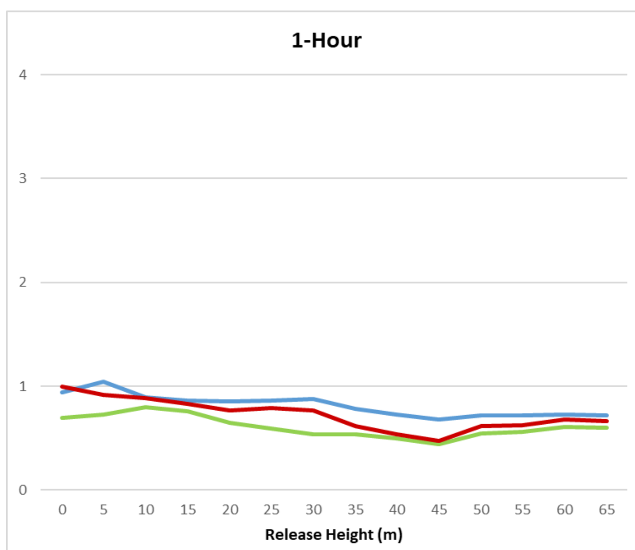

Figure 269. Relative Change in 1-hour Average

New Iowa City Data vs. Old Iowa City Data

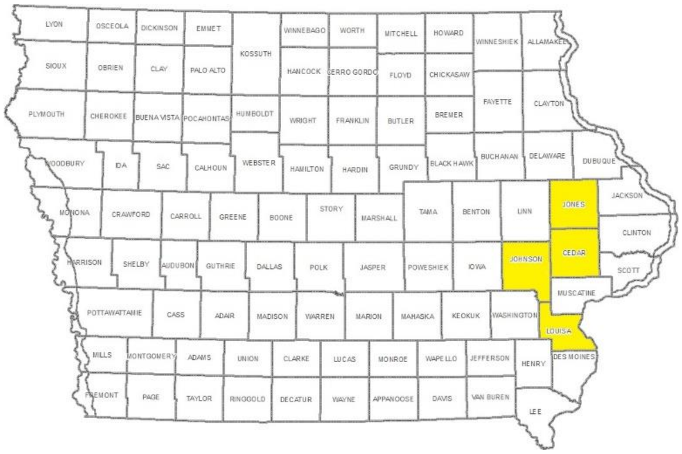

Figure 270. Map of Applicable Area

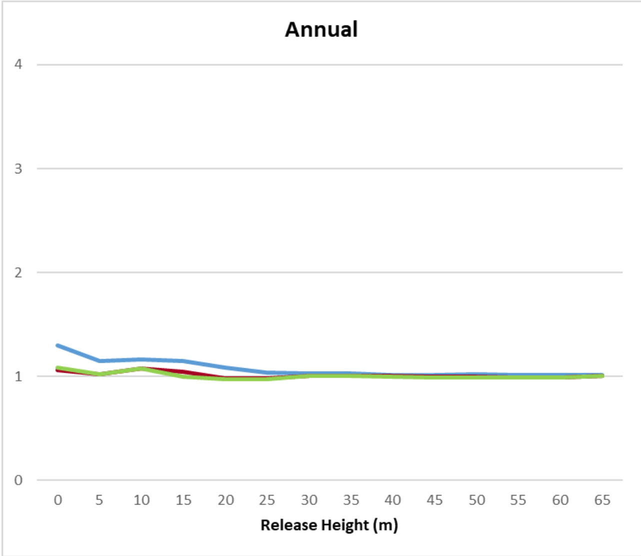

Figure 271. Relative Change in Annual Average

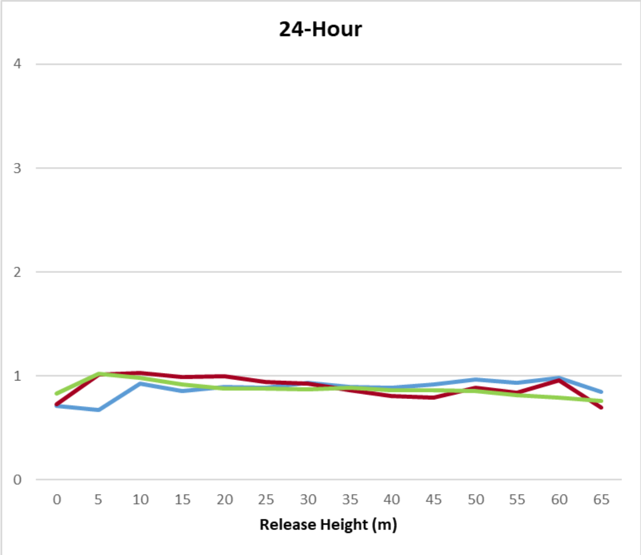

Figure 272. Relative Change in 24-hour Average

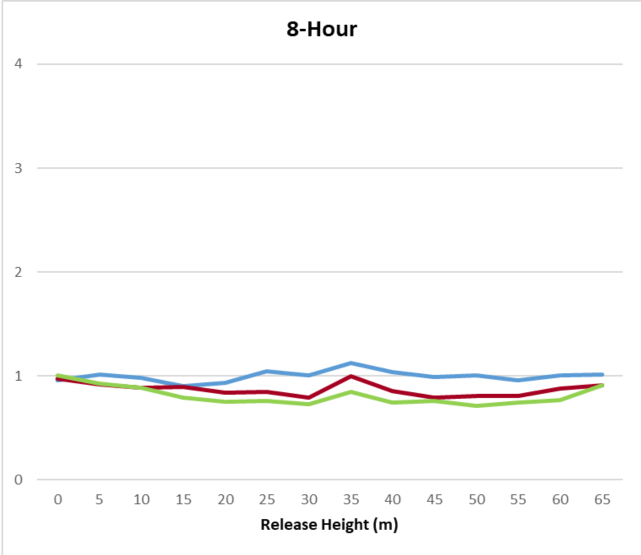

Figure 273. Relative Change in 8-hour Average

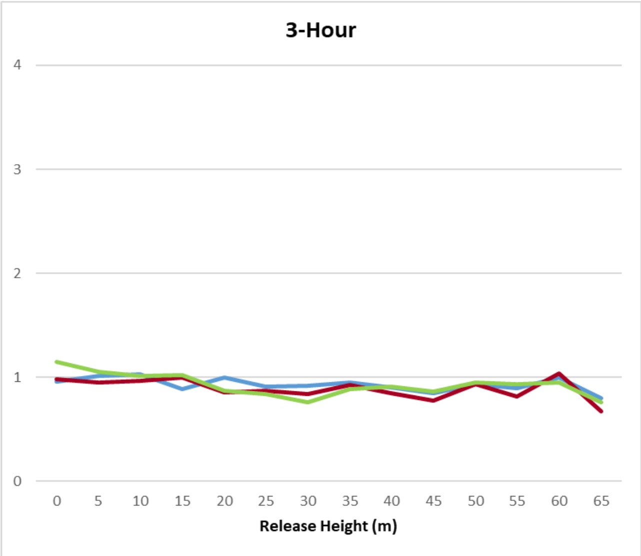

Figure 274. Relative Change in 3-hour Average

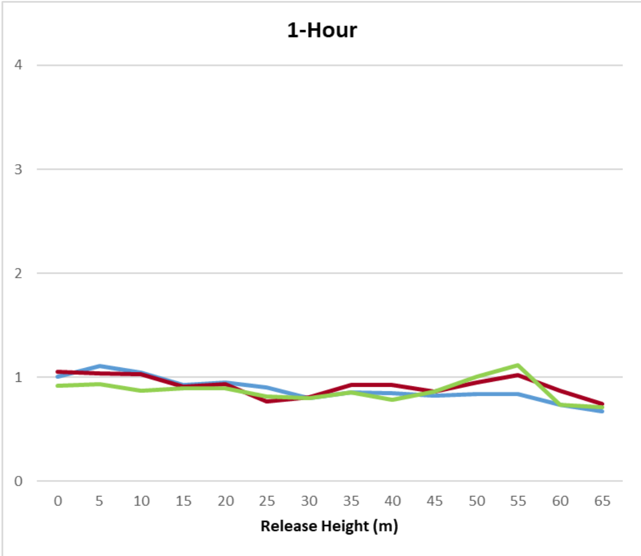

Figure 275. Relative Change in 1-hour Average

New Lamoni Data vs. Old Lamoni Data

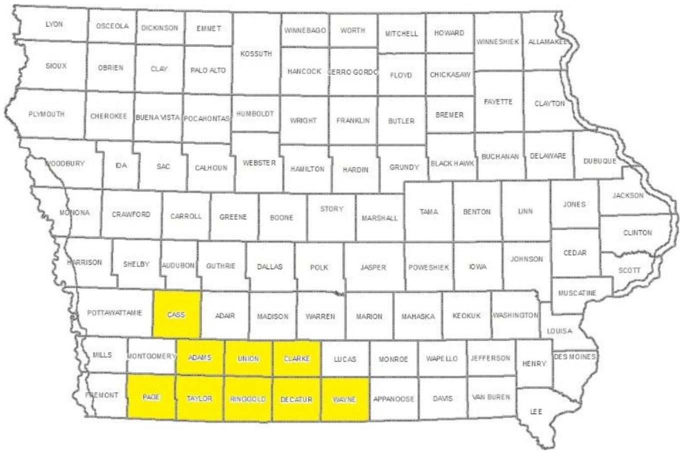

Figure 276. Map of Applicable Area

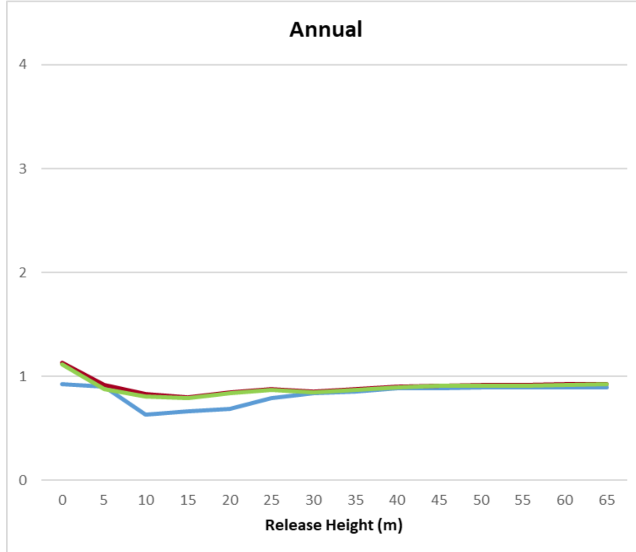

Figure 277. Relative Change in Annual Average

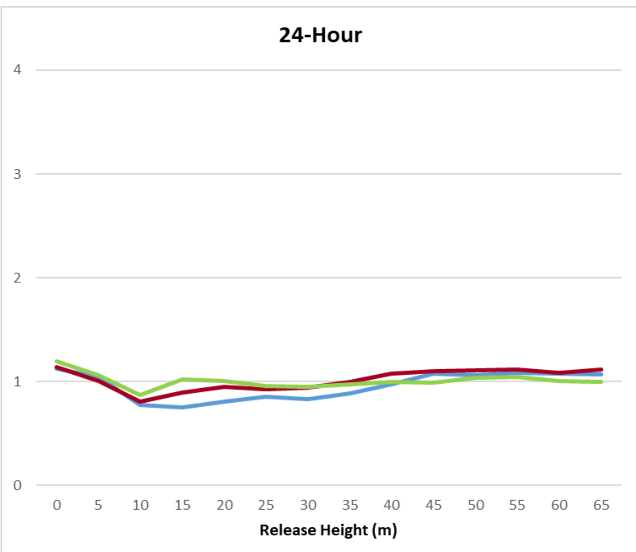

Figure 278. Relative Change in 24-hour Average

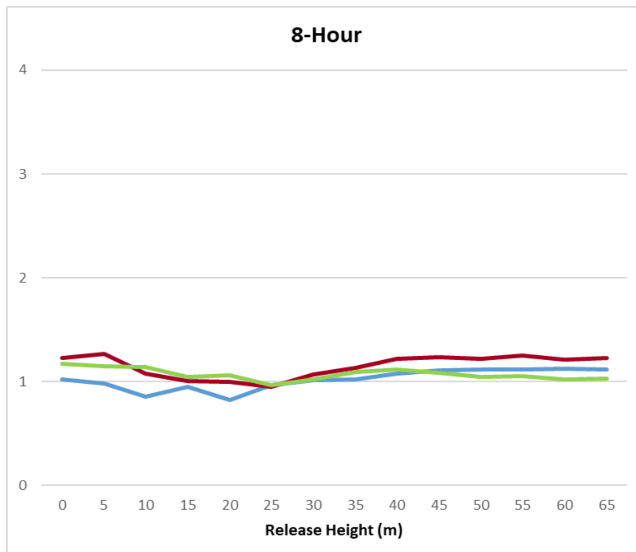

Figure 279. Relative Change in 8-hour Average

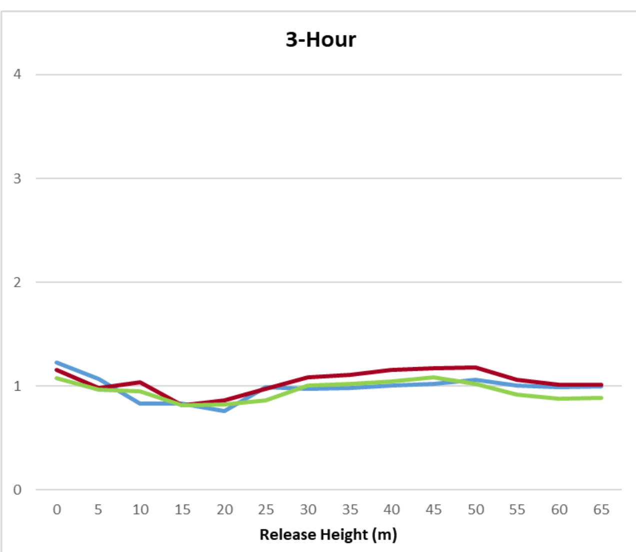

Figure 280. Relative Change in 3-hour Average

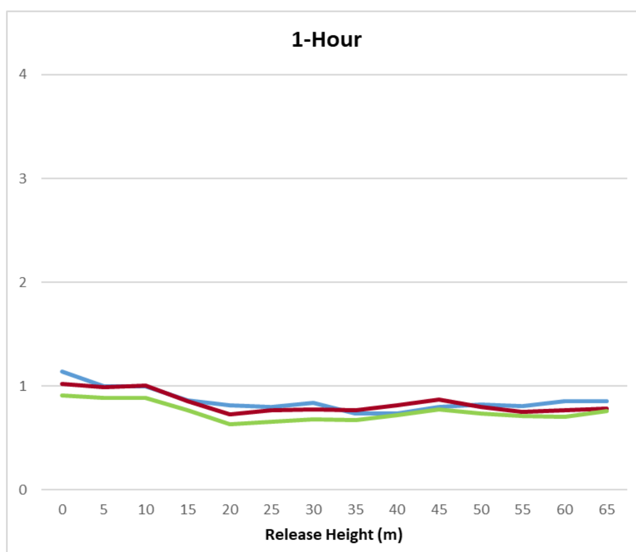

Figure 281. Relative Change in 1-hour Average

New Marshalltown Data vs. Old Marshalltown Data

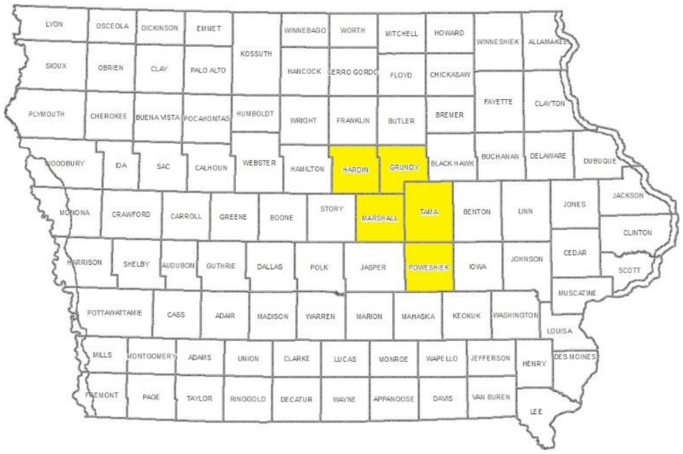

Figure 282. Map of Applicable Area

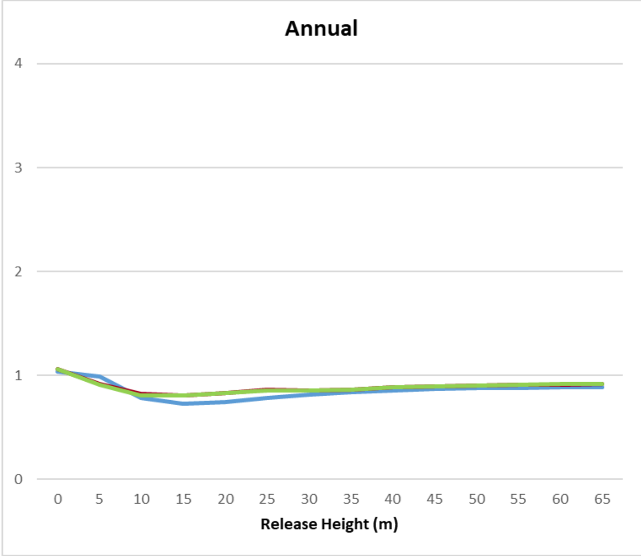

Figure 283. Relative Change in Annual Average

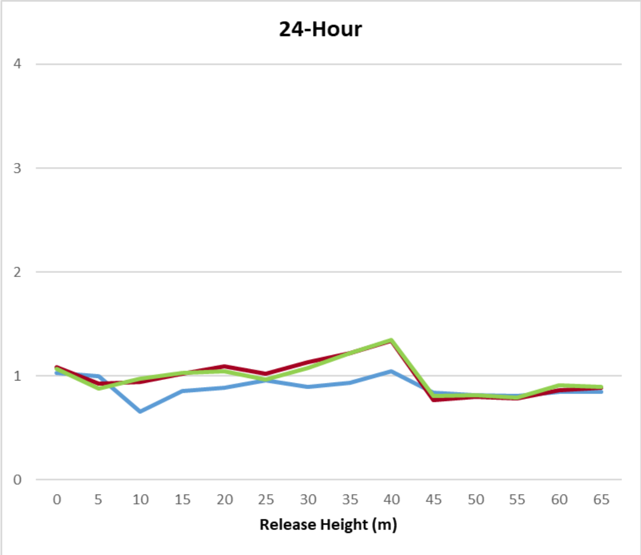

Figure 284. Relative Change in 24-hour Average

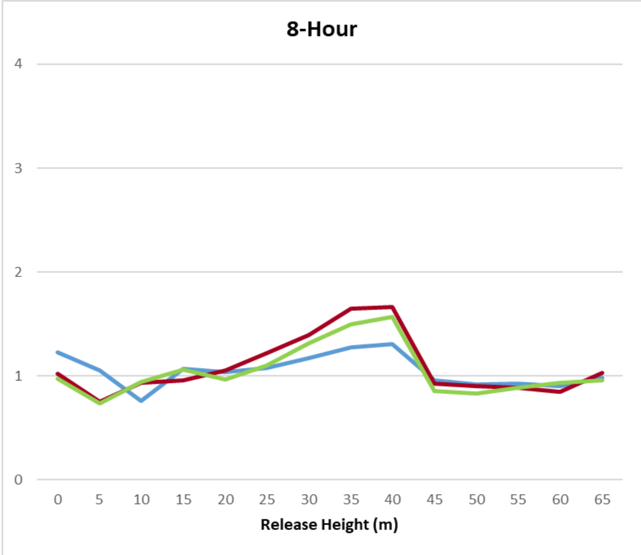

Figure 285. Relative Change in 8-hour Average

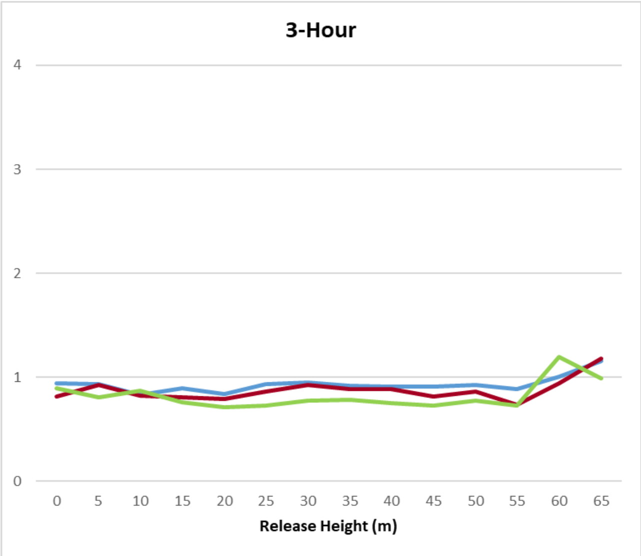

Figure 286. Relative Change in 3-hour Average

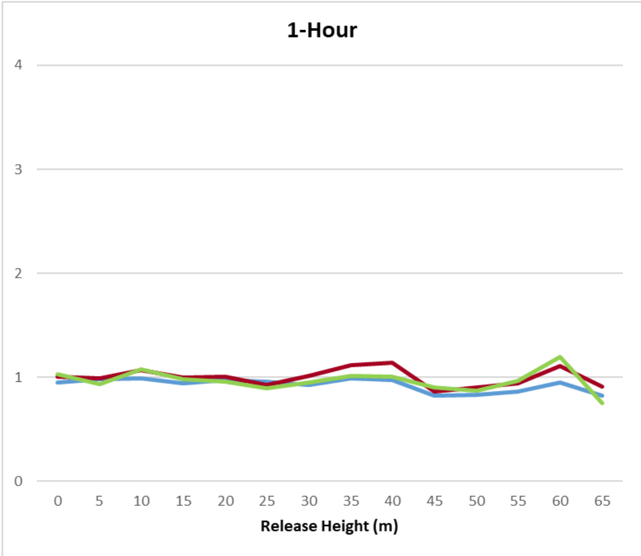

Figure 287. Relative Change in 1-hour Average

New Mason City Data vs. Old Mason City Data

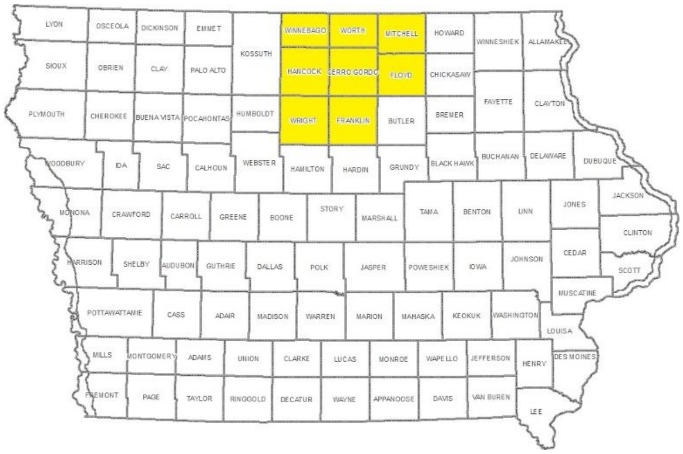

Figure 288. Map of Applicable Area

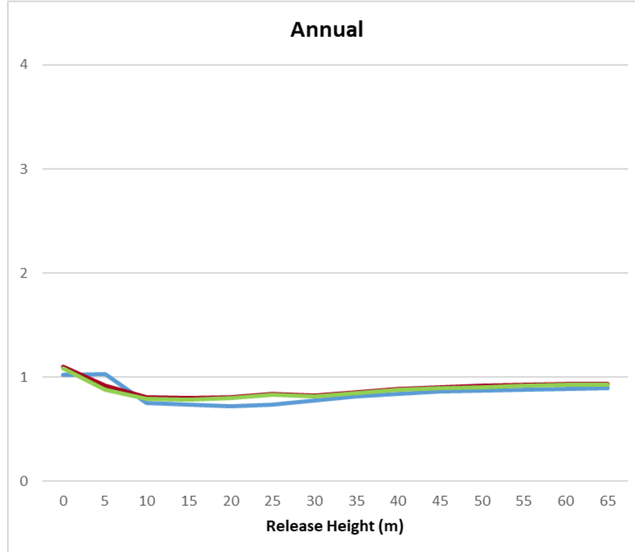

Figure 289. Relative Change in Annual Average

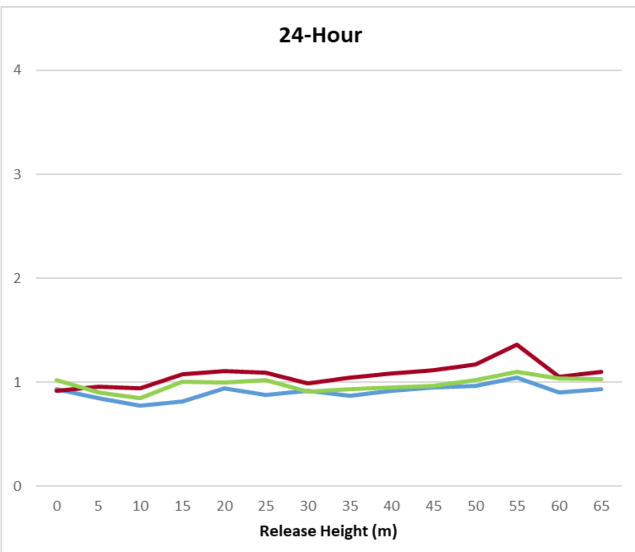

Figure 290. Relative Change in 24-hour Average

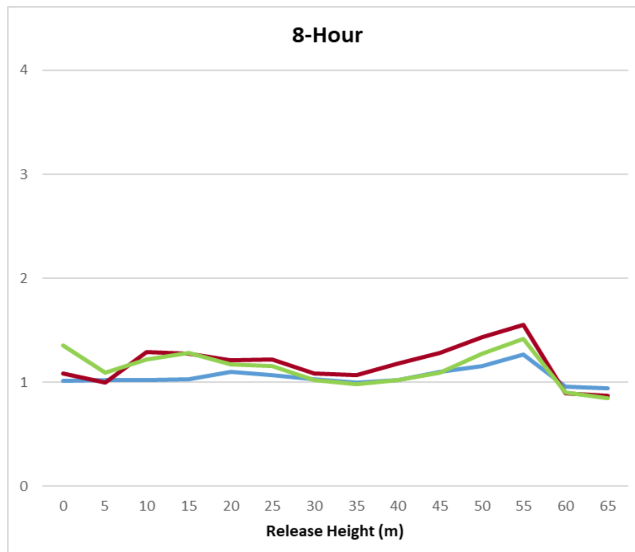

Figure 291. Relative Change in 8-hour Average

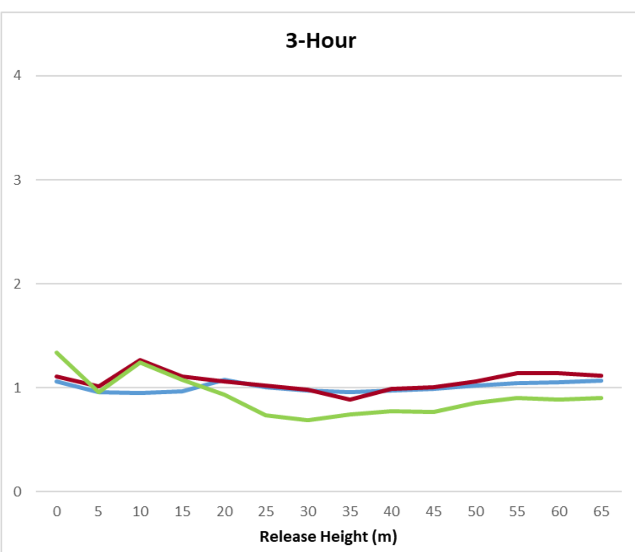

Figure 292. Relative Change in 3-hour Average

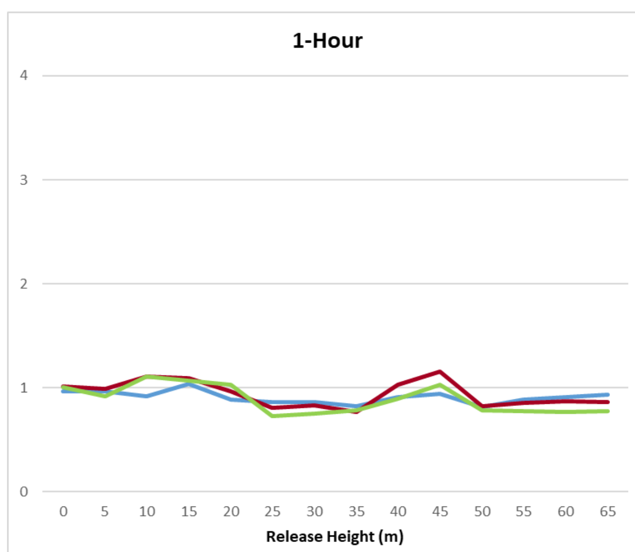

Figure 293. Relative Change in 1-hour Average

New Moline Data vs. Old Moline Data

Figure 294. Map of Applicable Area

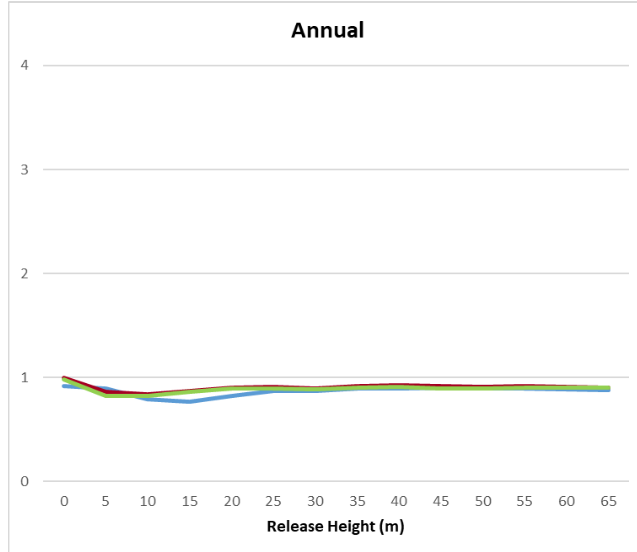

Figure 295. Relative Change in Annual Average

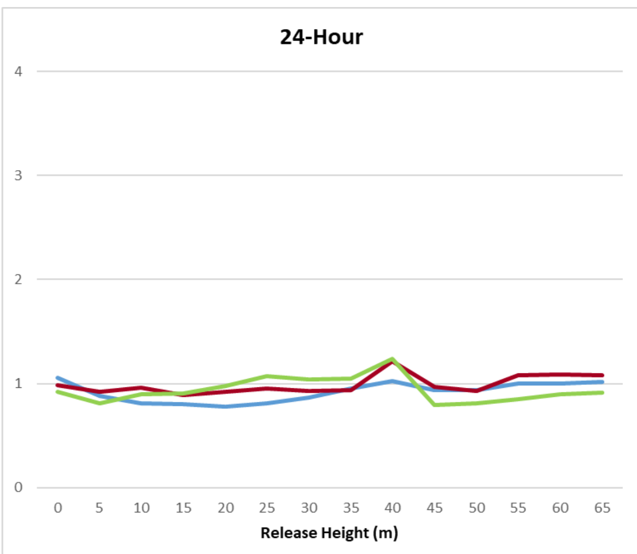

Figure 296. Relative Change in 24-hour Average

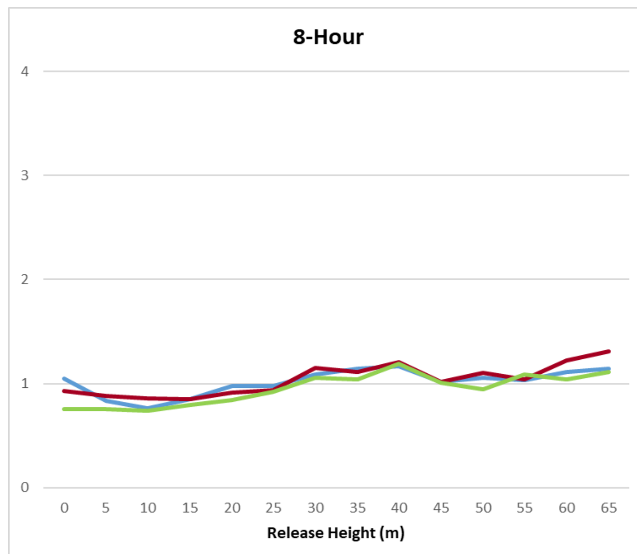

Figure 297. Relative Change in 8-hour Average

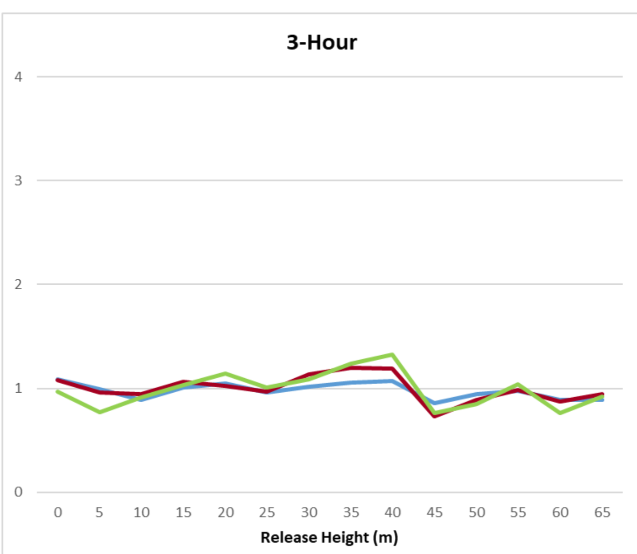

Figure 298. Relative Change in 3-hour Average

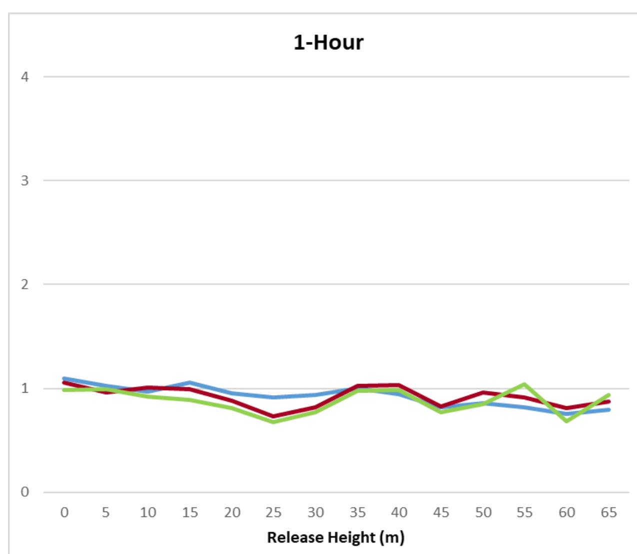

Figure 299. Relative Change in 1-hour Average

New Omaha Data vs. Old Omaha Data

Figure 300. Map of Applicable Area

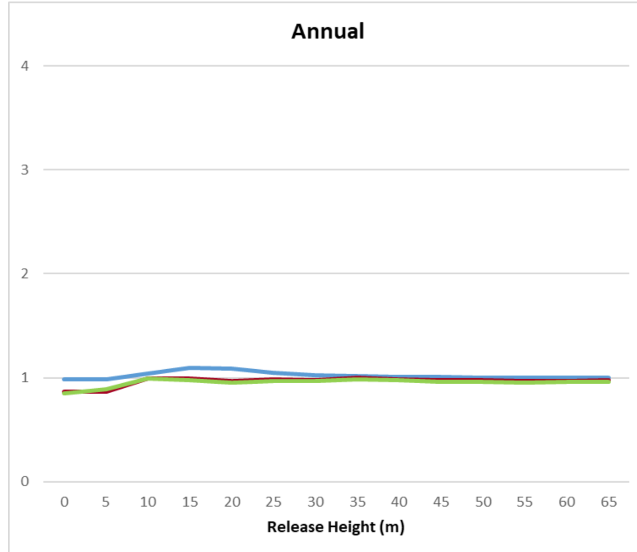

Figure 301. Relative Change in Annual Average

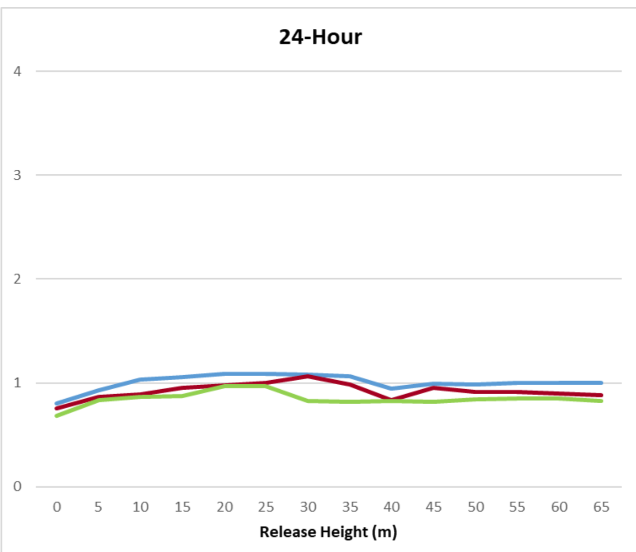

Figure 302. Relative Change in 24-hour Average

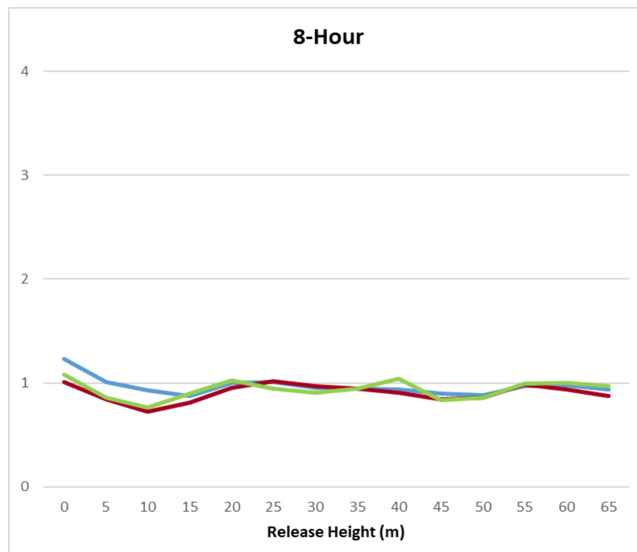

Figure 303. Relative Change in 8-hour Average

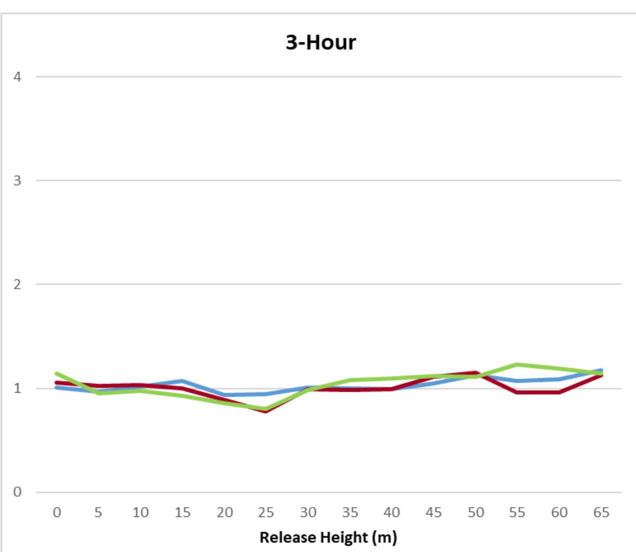

Figure 304. Relative Change in 3-hour Average

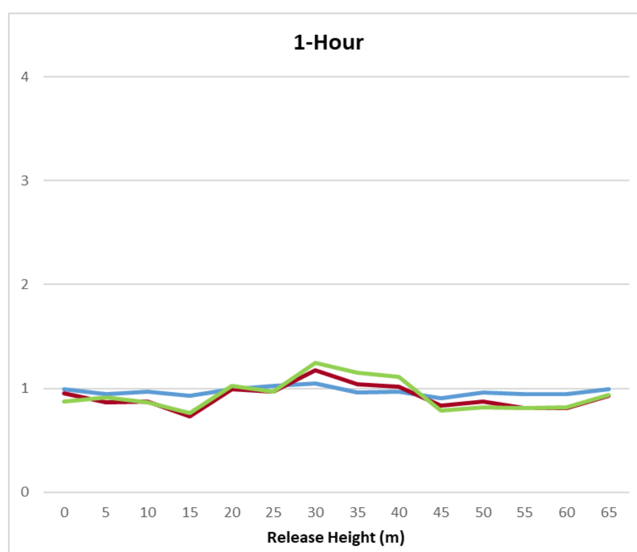

Figure 305. Relative Change in 1-hour Average

New Ottumwa Data vs. Old Ottumwa Data

Figure 306. Map of Applicable Area

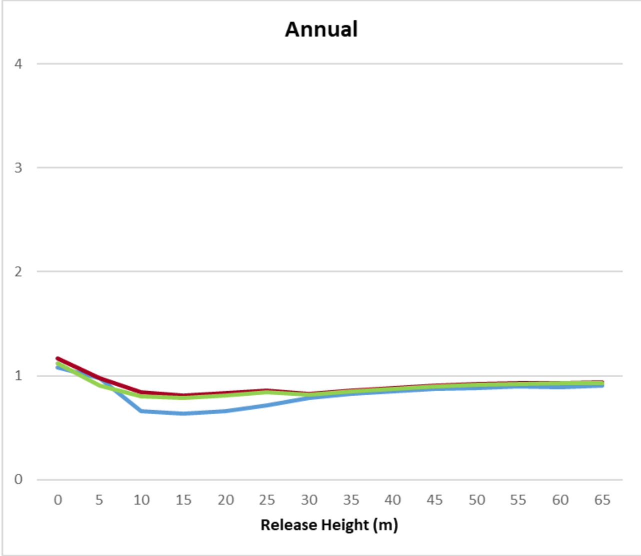

Figure 307. Relative Change in Annual Average

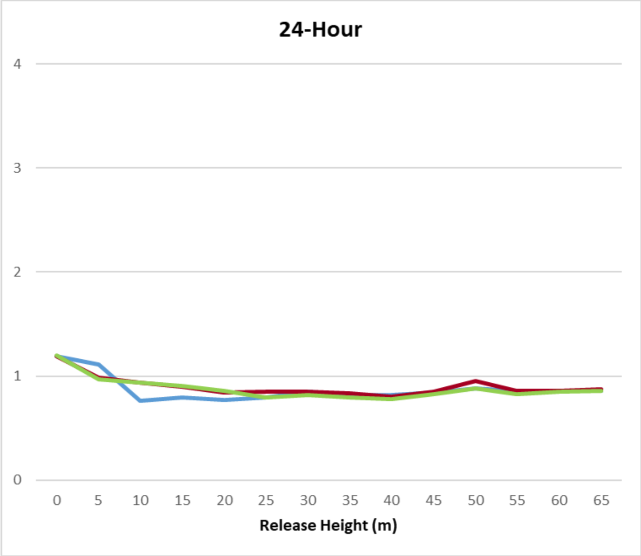

Figure 308. Relative Change in 24-hour Average

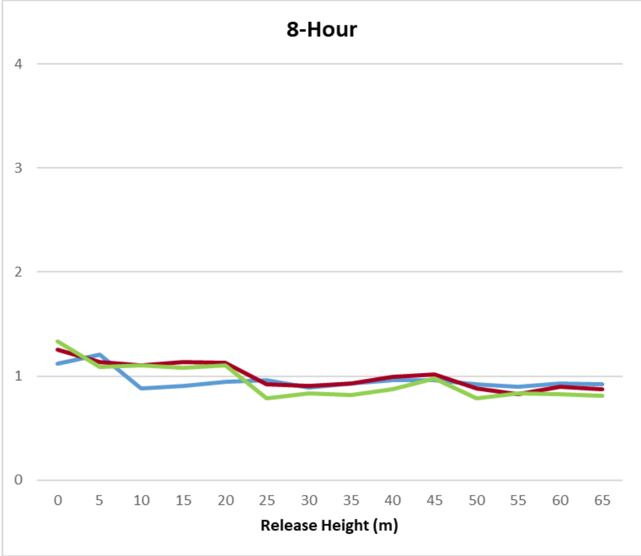

Figure 309. Relative Change in 8-hour Average

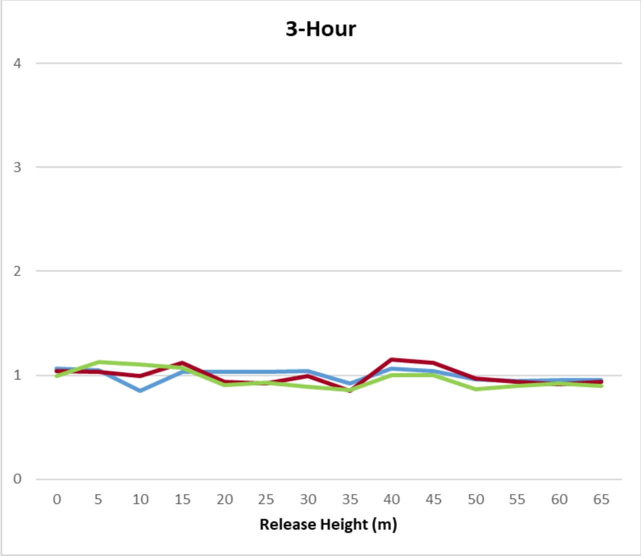

Figure 310. Relative Change in 3-hour Average

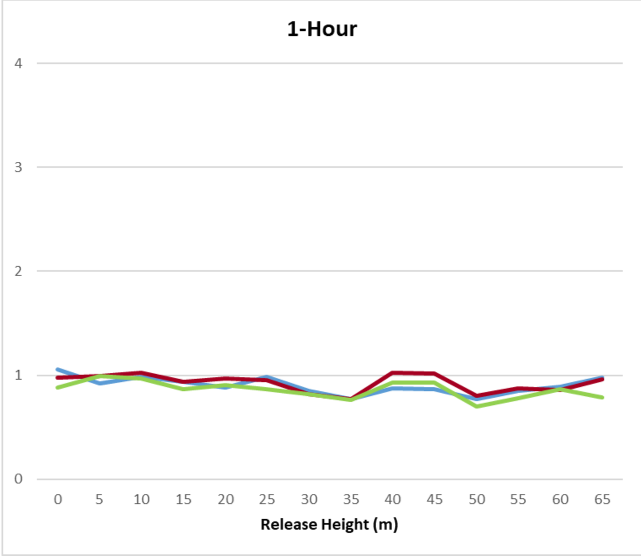

Figure 311. Relative Change in 1-hour Average

New Sioux City Data vs. Old Sioux City Data

Figure 312. Map of Applicable Area

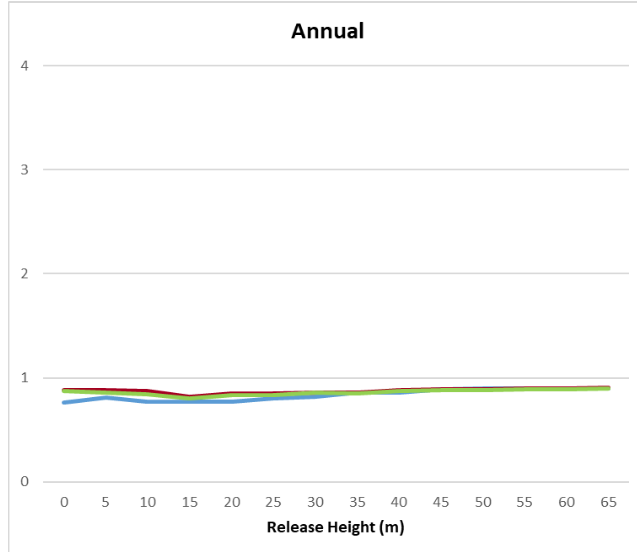

Figure 313. Relative Change in Annual Average

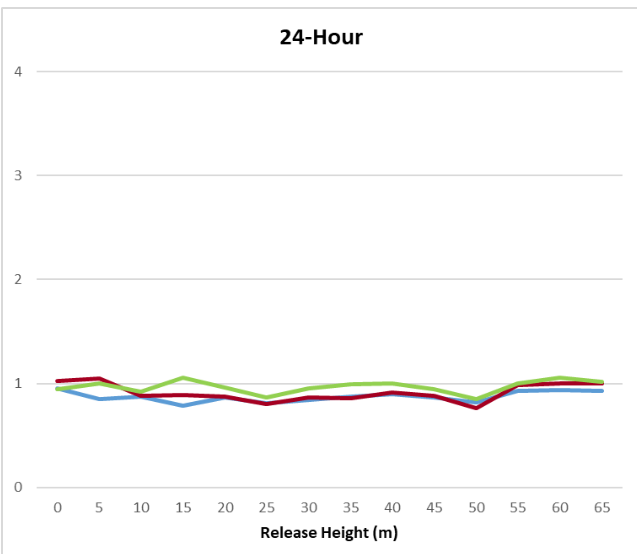

Figure 314. Relative Change in 24-hour Average

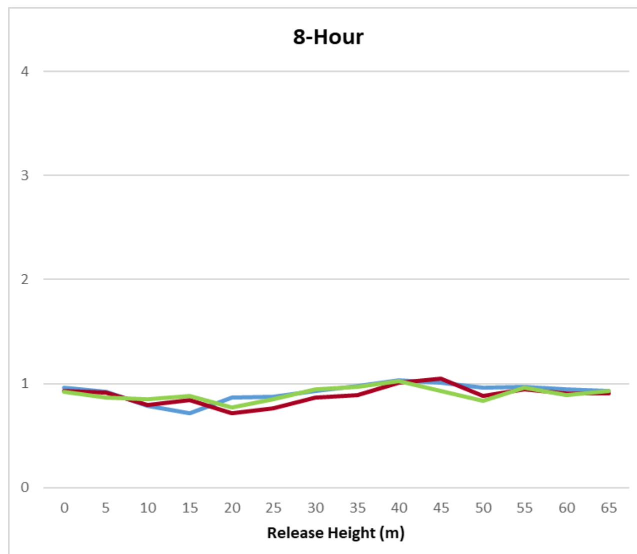

Figure 315. Relative Change in 8-hour Average

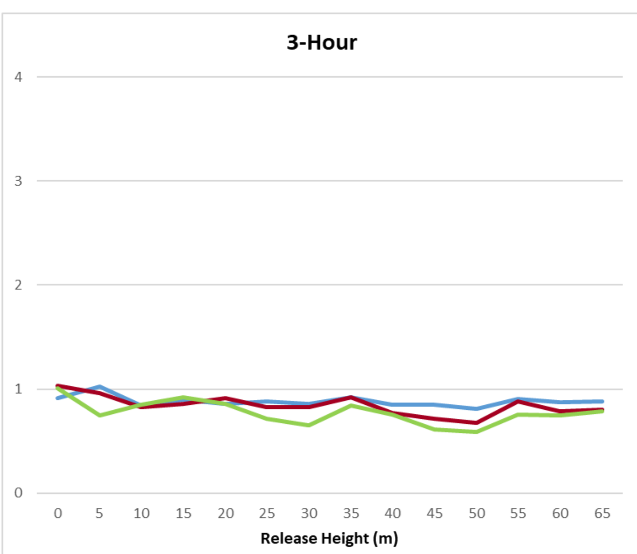

Figure 316. Relative Change in 3-hour Average

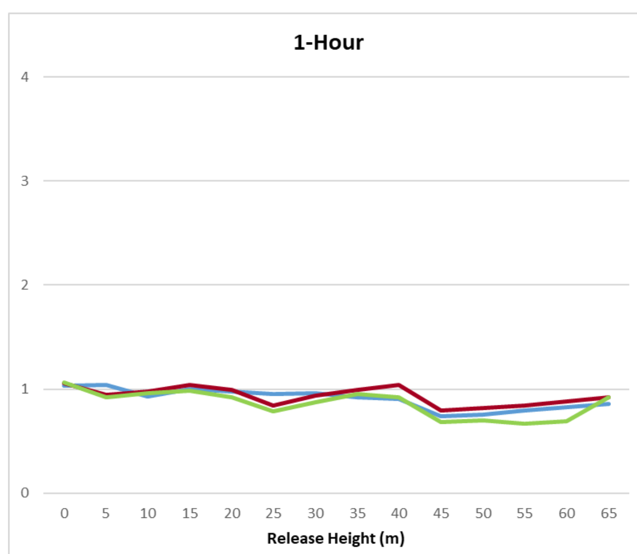

Figure 317. Relative Change in 1-hour Average

New Sioux Falls Data vs. Old Sioux Falls Data

Figure 318. Map of Applicable Area

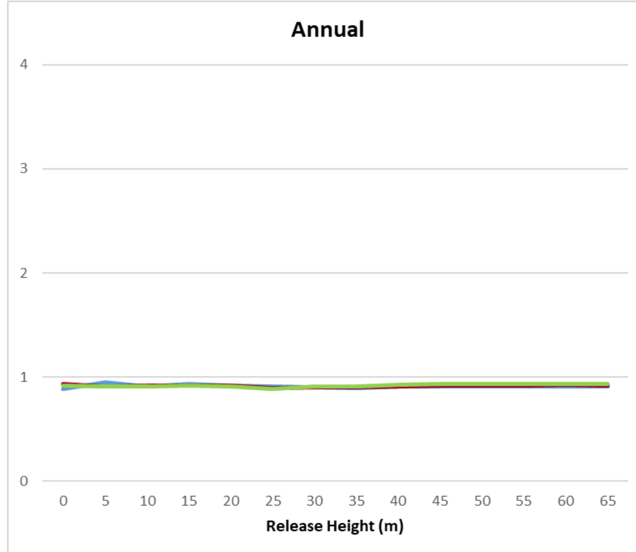

Figure 319. Relative Change in Annual Average

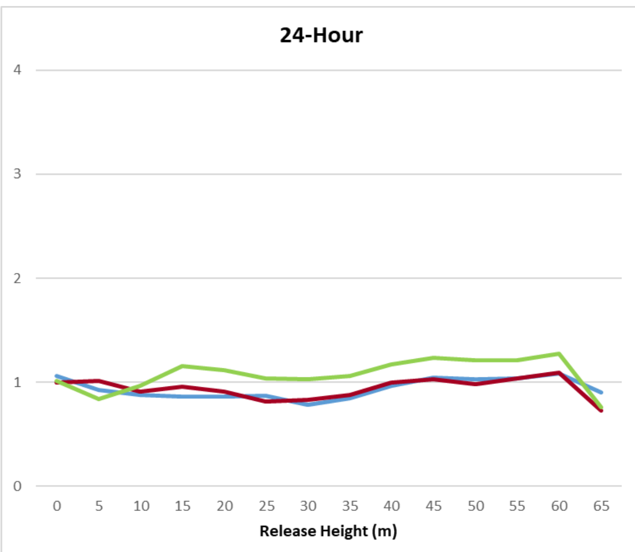

Figure 320. Relative Change in 24-hour Average

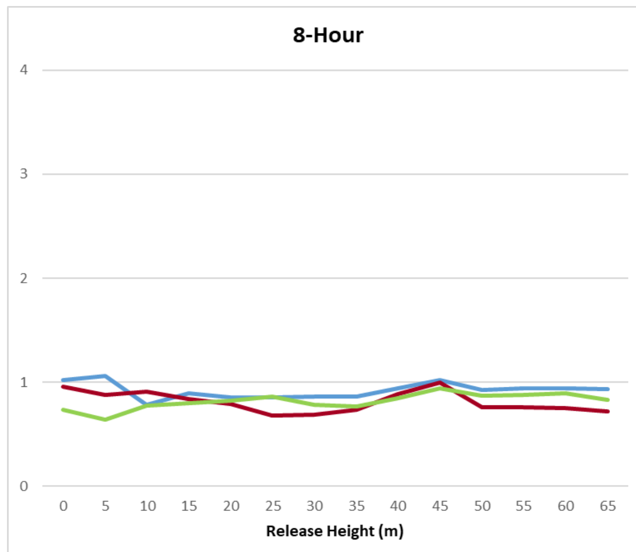

Figure 321. Relative Change in 8-hour Average

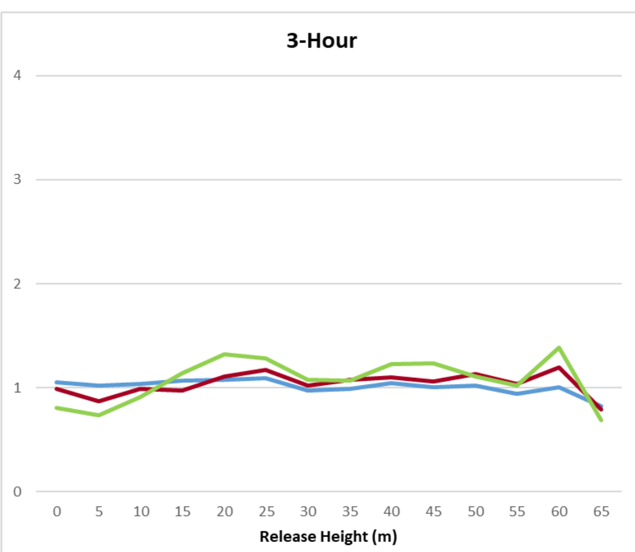

Figure 322. Relative Change in 3-hour Average

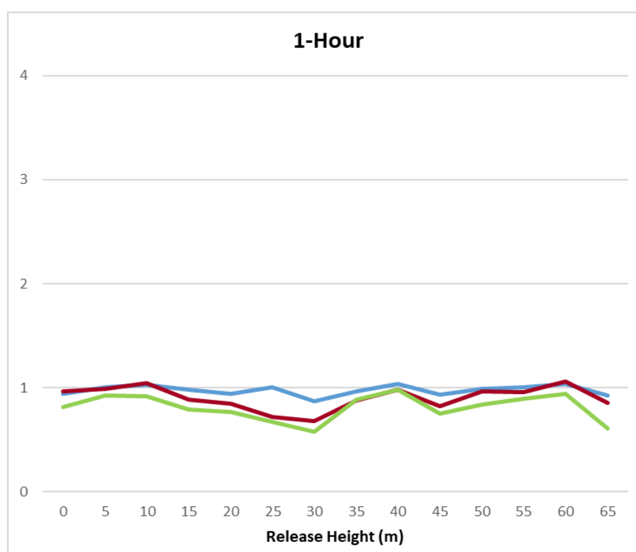

Figure 323. Relative Change in 1-hour Average

New Spencer Data vs. Old Spencer Data

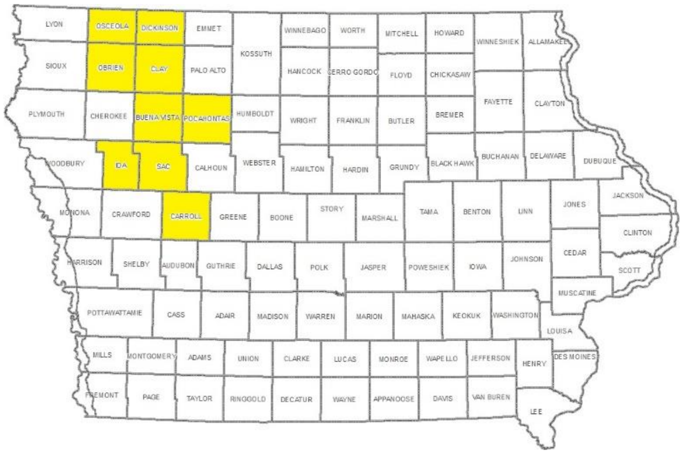

Figure 324. Map of Applicable Area

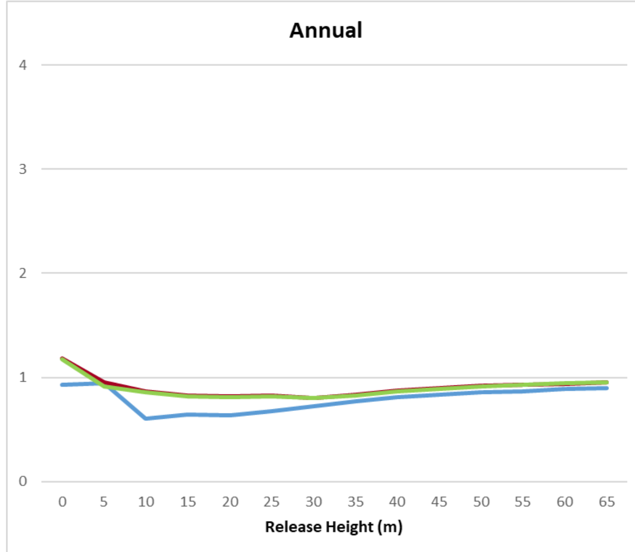

Figure 325. Relative Change in Annual Average

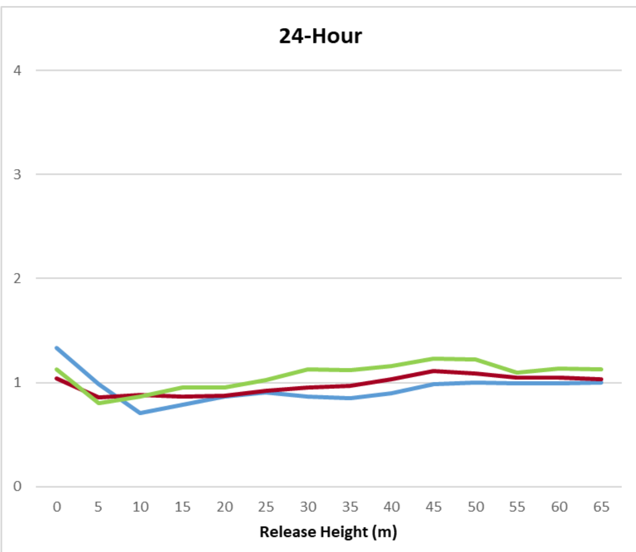

Figure 326. Relative Change in 24-hour Average

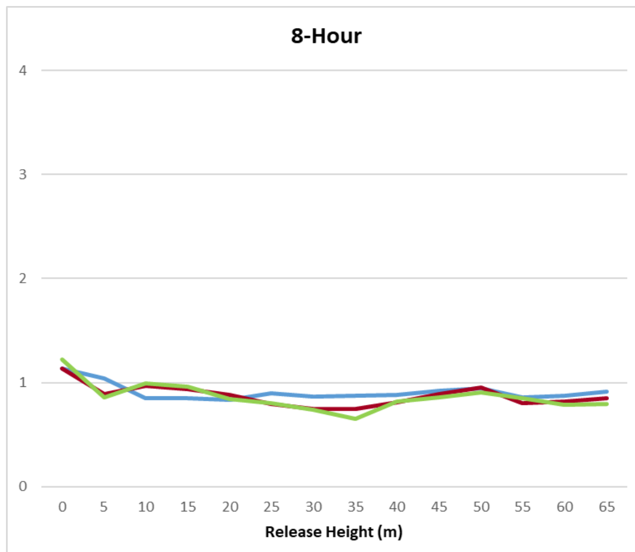

Figure 327. Relative Change in 8-hour Average

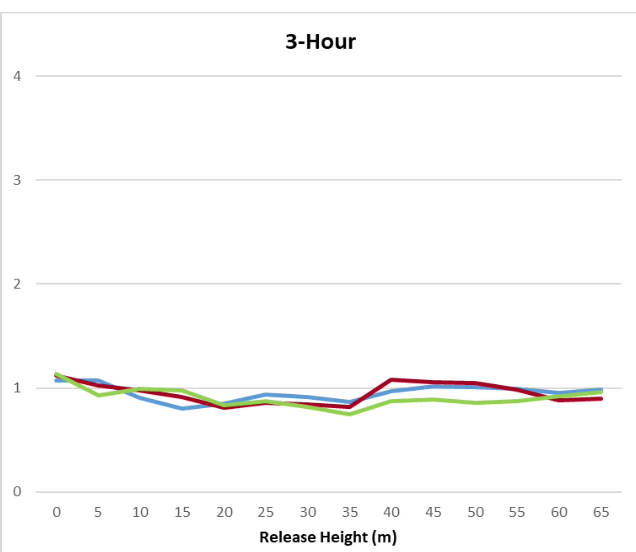

Figure 328. Relative Change in 3-hour Average

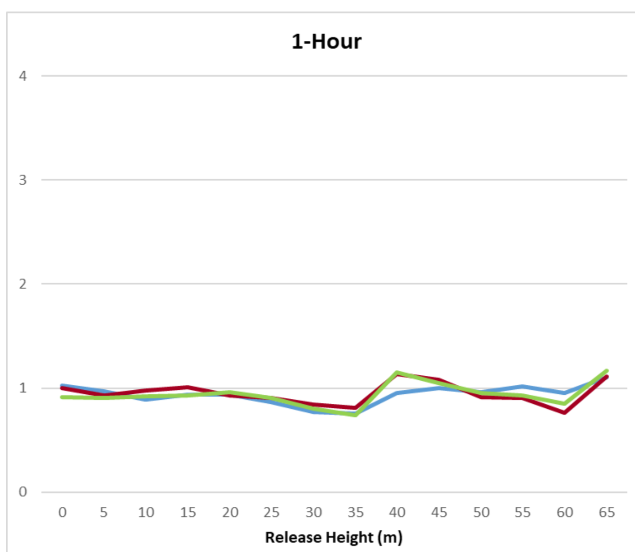

Figure 329. Relative Change in 1-hour Average

New Waterloo Data vs. Old Waterloo Data

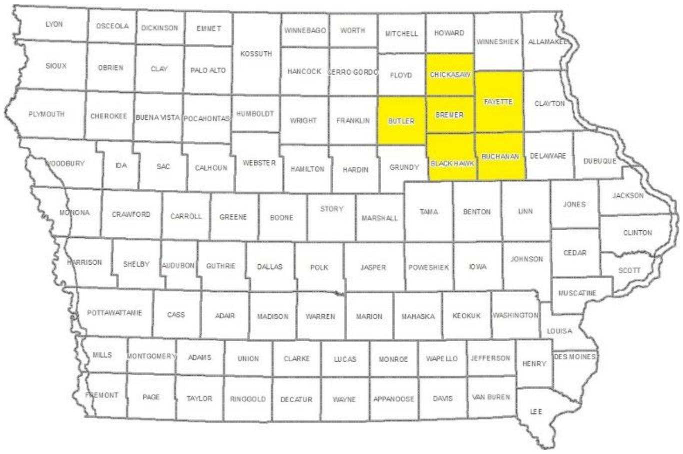

Figure 330. Map of Applicable Area

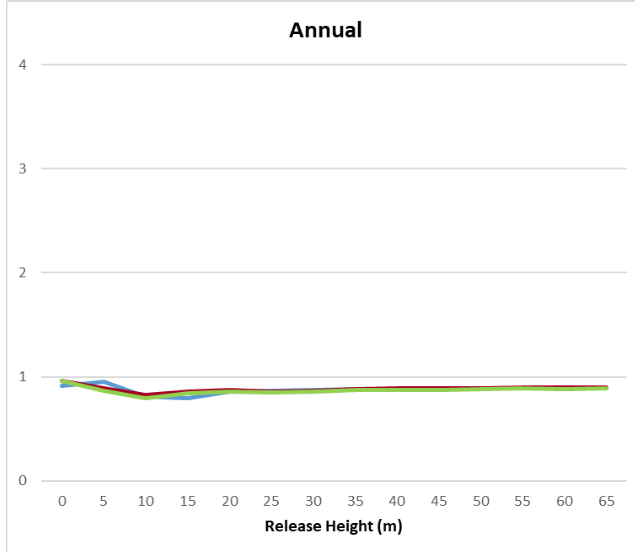

Figure 331. Relative Change in Annual Average

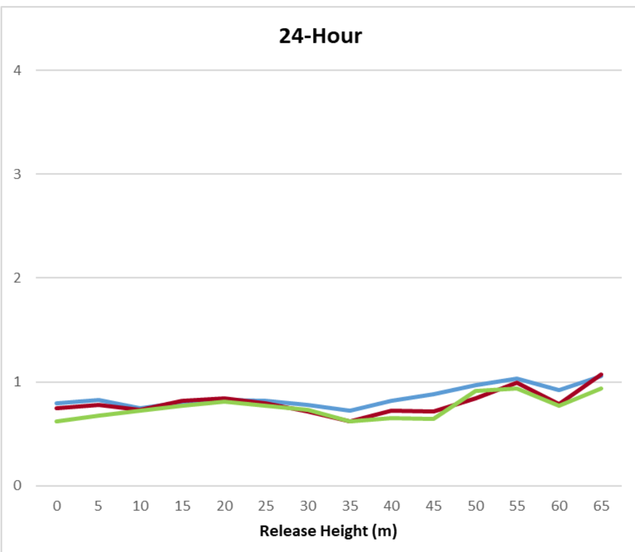

Figure 332. Relative Change in 24-hour Average

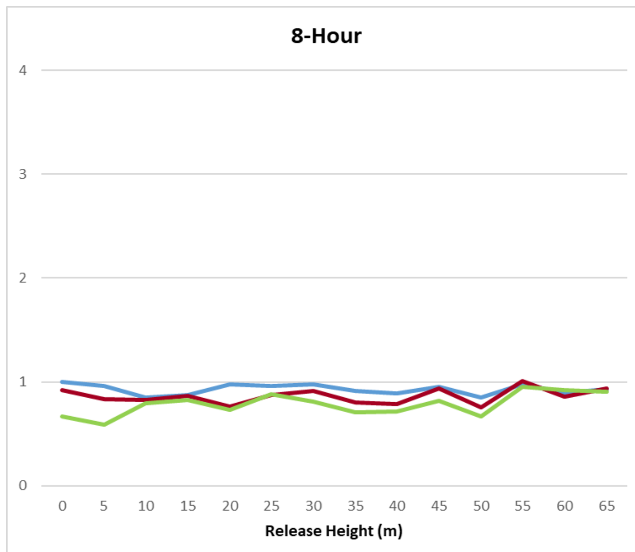

Figure 333. Relative Change in 8-hour Average

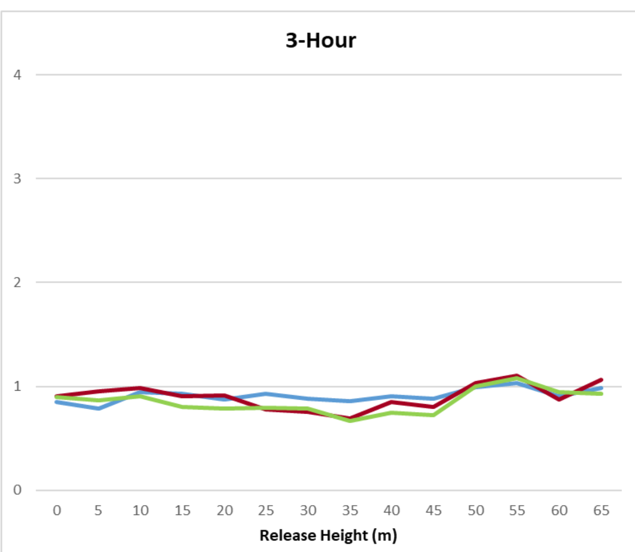

Figure 334. Relative Change in 3-hour Average

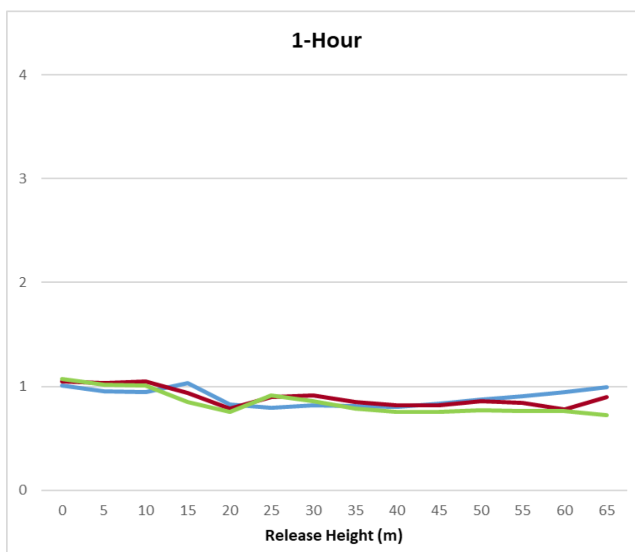

Figure 335. Relative Change in 1-hour Average