UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
RESEARCH TRIANGLE PARK, NC 27711

OFFICE OF
AIR QUALITY PLANNING
AND STANDARDS

MAR 0 8 2013

MEMORANDUM

SUBJECT: Use of ASOS meteorological data in AERMOD dispersion modeling

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TO: Regional Modeling Contacts

1. Introduction

When performing dispersion modeling for a project, the selection of meteorological data can play a major role in the outcome of the modeling results. The *Guideline on Air Quality Models* ("*Guideline*"), published as Appendix W to 40 CFR Part 51, (U.S. EPA, 2005), states in Section 8.3.1.1 that the user should acquire sufficient meteorological data "*to ensure that worst-case conditions are adequately represented in the model results*." For regulatory modeling applications such as New Source Review (NSR), Prevention of Significant Deterioration (PSD), and State Implementation Plans (SIPs) , the *Guideline* recommends that when using National Weather Service (NWS)[1] meteorological data, five consecutive years of the most recent, readily available data should be used (Section 8.3.1.2). Alternatively, the *Guideline* provides that at least 1 year, up to five years, of site specific meteorological data may be used. Regardless of whether NWS or site-specific meteorological data are used, the *Guideline* emphasizes that the data should be adequately representative of the study area (Section 8.3.1.2.a).

Prior to the early 1990's, standard[2] hourly NWS meteorological observations were human observer-based. Beginning in 1991, NWS stations began to transition to an Automated Surface Observing System (ASOS) to record hourly observations. Although the ASOS system improved some aspects of meteorological data collection, the transition to ASOS introduced some issues and challenges with the use of airport data for purposes of dispersion modeling. The purpose of

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[1] Although Section 8.3 of the *Guideline* includes many references to National Weather Service (NWS) data, the discussion and recommendations in Section 8.3 also apply to data from the Federal Aviation Administration (FAA) airports, military stations, and other agencies, provided that "*such data are equivalent in accuracy and detail to the NWS data, and they are judged to be adequately representative for the particular application*" (Section 8.3.2.2.d). The term "NWS" is used generically in this memorandum to apply to NWS, FAA, or other airport data.

[2] Standard hourly observation refers to those single 2-minute observations that are generally taken about 10 minutes before the hour to represent conditions for the hour, i.e., an observation at 12:50 PM represents 1:00 PM.

this memorandum is to provide some background information related to the transition to ASOS and to address more recent developments and potential issues associated with the use of NWS meteorological data for dispersion modeling. The memo also addresses EPA's development of the AERMINUTE meteorological processor (U.S. EPA, 2011) to take advantage of additional meteorological data resources that have become available in recent years to support AERMOD dispersion modeling (U.S. EPA, 2004a; U.S. EPA, 2012a). We also acknowledge that with the promulgation of new National Ambient Air Quality Standards (NAAQS) for NO_2 and SO_2 in 2010, concerns from the stakeholder community (regulatory agencies and industry) have arisen about the use of NWS data, specifically the use of low wind speeds (< 1 m/s) in AERMOD associated with application of the AERMINUTE tool (U.S. EPA, 2011). This memorandum will discuss:

- The implementation of ASOS and the sensitivity of AERMOD results to ASOS observations versus conventional human observer-based observations;
- The impact of the Meteorological Terminal Air Report (METAR) coding of calm and variable winds on NWS meteorological data;
- The development and use of the AERMINUTE tool; and
- The application of a wind speed threshold option in AERMET for 1-minute ASOS data to address concerns about low wind speeds.

2. ASOS implementation and ramifications for dispersion modeling

Although the ASOS system improved the efficiency in acquiring surface weather data, and has resulted in a significant increase in the number of airports with continuous hourly observations, a number of limitations associated with ASOS raised concerns within the dispersion modeling community regarding the adequacy of ASOS data for such purposes (Pierce and Turner, 1987). One of the main limitations identified when ASOS was introduced was the limit of 12,000 feet on the vertical range for the ASOS ceilometers. Furthermore, ASOS lacks the ability of the human observer to spatially integrate some of the weather elements over a large area, such as ceiling height and opaque cloud cover. Additional details regarding the differences between ASOS and observer-based methods for the meteorological variables that can affect modeled concentrations are provided below:

Cloud cover and ceiling height

To determine cloud cover and ceiling height, ASOS utilizes a vertical-pointing ceilometer. A cloud "hit" or "no hit" is stored along with one or two cloud base heights. Since the ceilometer has a vertical range of only 12,000 feet, any clouds above this height are not detected. Additionally, the ceilometer currently cannot distinguish between transparent and opaque clouds, thus the cloud fraction derived is recorded as total cloud cover. The reported cloud base heights are the most frequent and meteorologically significant during the period, with up to three layers reported for each hour. Initially, ASOS reported cloud cover based on four possible sky conditions, as follows:

Clear	less than 10% sky cover
Scattered	10% to 50% sky cover
Broken	51% to 90% sky cover
Overcast	more than 90% sky cover

When the METAR coding system standard was adopted in July 1996, an additional sky condition of "Few" was included, as follows:

Clear	0% sky cover
Few	less than 25% sky cover (but not 0%)
Scattered	25% to 50% sky cover
Broken	51% to 90% sky cover
Overcast	more than 90% sky cover

Since meteorological processors for dispersion models, including AERMET, MPRM and PCRAMMET, include algorithms based on fractional sky cover, the sky conditions reported by ASOS must be converted to a representative decimal sky cover value. Additional complications ensue in assigning a single cloud cover value when multiple cloud layers are reported.

To obtain the ceiling height under the conventional method, the human observer evaluates the trace on a chart that records the amount of light reflected by the cloud layer. The observer then views the sky to obtain cloud layer and cloud amount which is an instantaneous, areally integrated average over the celestial dome at the time of the observation. This view also allows the observer to modify the ceiling height if there are high clouds, and to make a determination on the transparency of the clouds. Both total and opaque cloud cover were reported under the observer-based system.

Temperature

In ASOS, the one minute average temperature is calculated from two 30-second samples. The ambient and dew point temperatures are 5-minute averages calculated from the 1-minute averages. The conventional method was based on an instantaneous reading at the observation time (5-10 minutes before the hour).

Wind

In ASOS, wind speed and direction are collected once per second and an average is computed every five seconds. A running 2-minute average is calculated from the 5-second data and recorded every minute, resulting in overlapping 2-minute averages. The 2-minute averages are computed from 24 5-second values which are truncated to whole knots[3]. The truncation of ASOS wind speeds is discussed further in Section 3.2. The 2-minute average that occurs at the standard observation time is reported for the hourly observation (i.e., one 2-minute average represents the whole hour). The conventional observer-based method for reporting the winds is to take a 1-minute average at the standard observation time.

2.1 Summary of EPA's 1997 analysis of ASOS implementation

Prompted by concerns regarding the advent of ASOS, EPA performed a study (U.S. EPA, 1997) to assess the affect of ASOS meteorological data on refined dispersion modeling, specifically the ISCST3 model (U.S. EPA, 1995), the EPA preferred near-field dispersion model at the time.

[3] http://www.nws.noaa.gov/ops2/Surface/documents/IFWS_BelfordWS_comparison.pdf. The 1997 ASOS study for ISCST3 assumed that 5-second values were rounded to the nearest degree and knot.

The study included six meteorological sites for two 1-month periods when concurrent ASOS and conventional observations were available. The study compared observer-based and ASOS observations for the variables that can affect modeled concentrations (cloud cover and ceiling height, temperature, and wind), and compared key modeling parameters derived from the data (stability category and mixing height). The study concluded that:

- ASOS observations tend to underestimate cloud cover, as compared to standard observer-based cloud cover, likely due in part to the limited vertical range of 12,000 feet for the ASOS ceilometers;
- ASOS wind speeds tend to be slightly less than observer-based wind speeds;
- ASOS tends to report more calms; and
- ASOS temperatures tend to be lower than observer-based temperatures.

An increase in the frequency of calms for ASOS vs. observer-based data was also found based on a comparison of pre-ASOS vs. post-ASOS calm frequencies for 115 stations from 1990 to 1995 included on the National Climatic Data Center's Hourly U.S. Weather Observations (HUSWO) dataset. The analysis of HUSWO data (Atkinson, et. al, 2000) found that nearly all stations showed an increase in calm frequency after the ASOS commissioning date, with an average ratio of post-ASOS/pre-ASOS calm frequency of 2.4. Nearly all of the stations (6 out of 8) showing a post-ASOS decrease in calm frequency were commissioned in the last 3 months of 1995.

As part of the 1997 study, sensitivity analyses of ISCST3 modeled concentrations were performed for six point sources (two with downwash), one volume source, and one area source (see Table A-1 of Attachment A of this memorandum for the source parameters) under two comparisons of the meteorological data using the following sets of input:

- ASOS cloud cover and ceiling height combined with other observer-based variables vs. full observer-based data; and
- Full ASOS data vs. full observer-based data.

The study found that ISCST3 results could differ significantly based on the use of conventional meteorological data vs. ASOS meteorological data, with the largest differences due primarily to the effect of the limited vertical range of the ASOS ceilometers on stability category. In the cases with the largest concentration differences, the difference between "clear below 12,000 feet" for ASOS vs. overcast above 12,000 feet for the observer-based data could result in a difference between stability class A (very unstable) for ASOS data and stability class D (neutral) for observer-based data. Such a significant difference in stabilty class may result in significant differences in ground-level concentrations, especially for elevated sources, with the ASOS-based result generally showing higher concentrations than the observer-based result. Figure 6.2 from the 1997 ASOS study, shown below as Figure 1, illustrates this effect for a 35-meter buoyant point source for the Kansas City and Milwaukee sites.

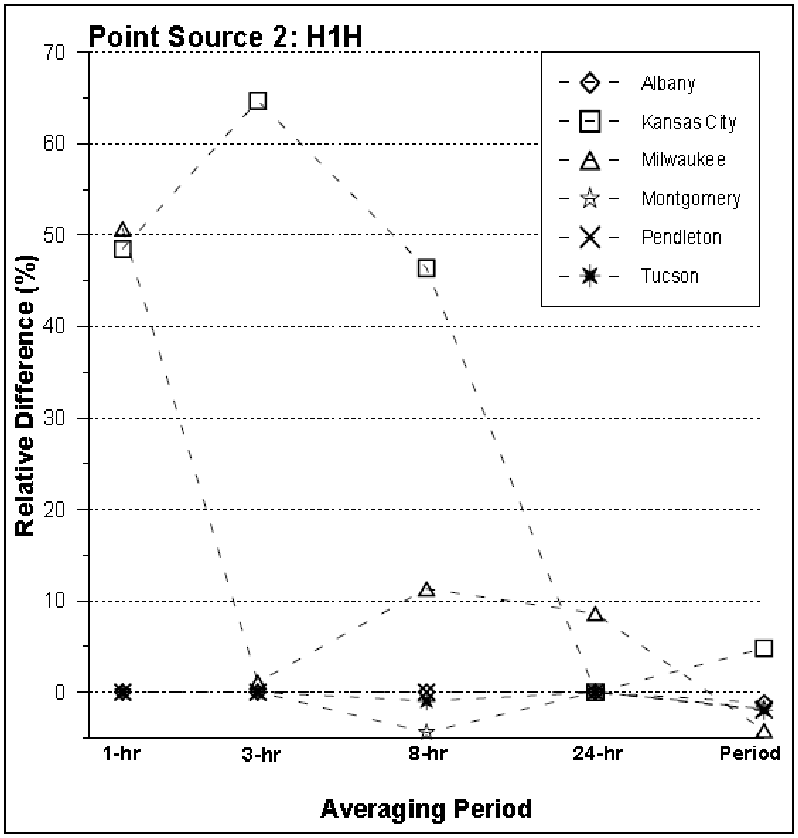

Figure 1. Relative percent difference ([ASOS-Obs]/Obs) between the high-1st-high (H1H) 1-hr ISCST3 concentrations using ASOS vs. Observer-based clouds for a 35-meter buoyant point source, based on Figure 6.2 of EPA (1997)

In response to concerns regarding the limitations of ASOS data, EPA invited public comment in April 2000 (U.S. EPA, 2000a) on the usefulness of ASOS meteorological data for air quality dispersion modeling, and specifically on whether the policy on modeling with the most recent 5 years of NWS meteorological data (Section 8.3.1.2 of Appendix W) should include ASOS data. In response to public comments on the April 2000 proposed rule, where a majority of commenters felt that the ASOS data were inferior to observer-based data for use with Gaussian models, EPA revised Section 8.3.1.2 to recommend that "*[W]here professional judgment indicates NWS-collected ASOS (automated surface observing stations [sic]) data are inadequate {for cloud cover observations}, the most recent 5 years of NWS data that are observer-based may be considered for use.*"

2.2 Summary of AERMOD sensitivity to ASOS implementation

As part of the AERMOD Implementation Workgroup (AIWG), the meteorological data sub-group of AIWG performed an analysis of ASOS sensitivity for AERMOD based on the 1997 ISCST3 study[4]. Note that the version of AERMET used did not include the 0.5 knot truncation

[4] AERMET version 06341; AERMOD version 07026

adjustment for ASOS winds. Preliminary results of the AERMOD study were presented at the 2008 Regional/State/Local Modelers Workshop[5] and final results are presented in Attachment A of this memorandum. Comparing the results for AERMOD and ISCST3 shows that AERMOD is generally less sensitive to the implementation of the ASOS system than ISCST3, especially in relation to sensitivity to the limited vertical range of 12,000 feet for ASOS cloud cover. This is illustrated in Figure 2 below, which shows differences in AERMOD model results due to use of ASOS vs. observer-based cloud cover for a 35m buoyant point source, for comparison to the ISCST3 model results shown in Figure 1 for the same source. The reduced sensitivity shown for AERMOD associated with the ASOS 12,000 foot cloud cover limit is likely due to the more refined treatment of the evolution of the convective boundary layer in AERMET, the meteorological processor for AERMOD. Unlike ISCST3, where the difference between clear below 12,000 feet and overcast may result in a significant change from stability class A to stability class D for a particular hour, the convective boundary layer height in AERMET in based on the integrated surface heat flux since sunrise which limits the influence of differences in cloud cover for a particular hour on the level of convective turbulence. Differences in the treatment of the interaction of elevated plumes with the mixing height between ISCST3 and AERMOD may also contribute to less sensitivity to ASOS cloud cover issues for AERMOD.

Given the relative insensitivity of AERMOD results to ASOS data, especially as compared to the sensitivity of the ISCST3 model to use of ASOS cloud data, the caveat regarding the adequacy of ASOS cloud cover data included in Section 8.3.1.2 of Appendix W should generally not be a concern when using ASOS data in dispersion modeling with AERMOD.

[5] http://www.cleanairinfo.com/regionalstatelocalmodelingworkshop/archive/2008/presentations/AIWG_Met.pdf

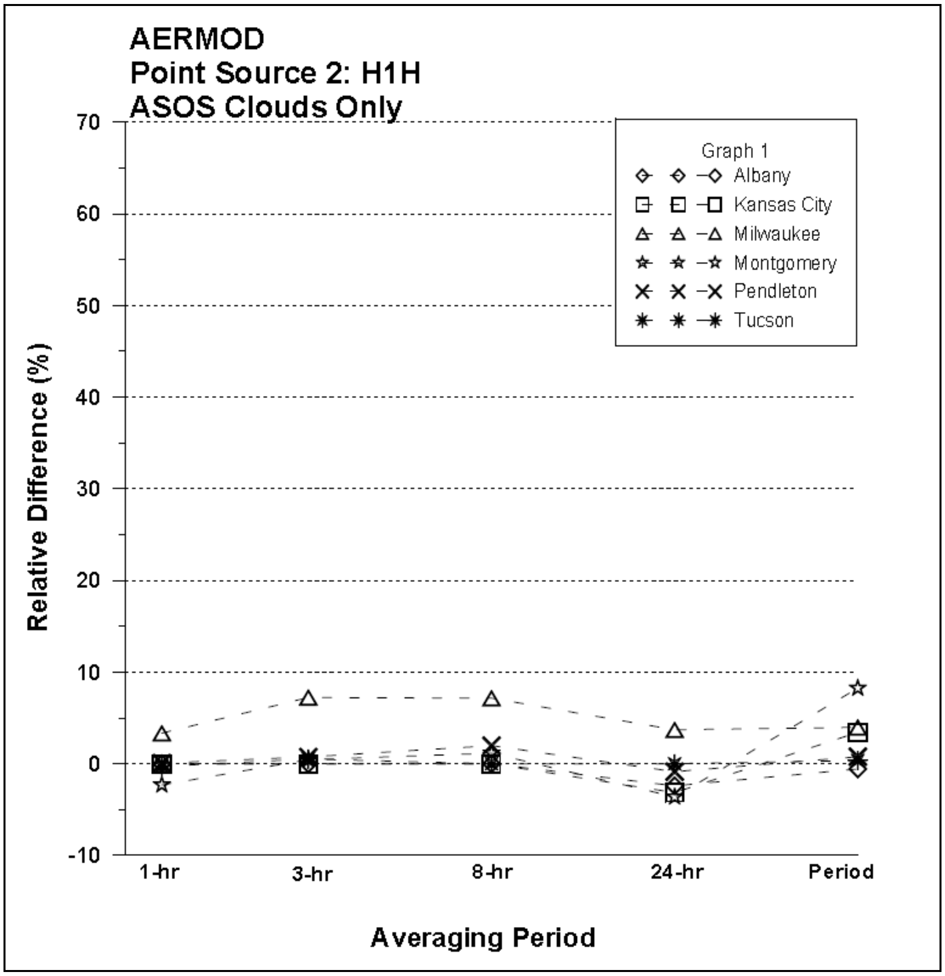

Figure 2.

Figure 2. Relative difference ([ASOS-Obs]/Obs) between the high-1st-high (H1H) 1-hr AERMOD concentrations using ASOS vs. Observer-based clouds for a 35-meter buoyant point source.

2.3 Impacts of ASOS calculation and reporting methodology on winds in AERMOD

In addition to the ASOS vs. conventional measurement differences discussed above, there are reporting and calculation methodologies associated with NWS observations that may have an impact on dispersion modeling. The first issue is related to the reporting of calms and variable winds in NWS hourly observations using the METAR coding system. Beginning in July 1996, the METAR coding system imposed a strict wind speed threshold of 3 knots, such that all cases with wind speeds below 3 knots were treated as calms (NOAA, 2005). The METAR coding system also introduced the variable wind designation into the standard hourly reports. An observation is classified as a variable wind, and the wind direction is considered to be missing, if the wind direction varies more than 60 degrees during the 2-minute averaging period for the observation and the wind speed is less than or equal to six knots. An observation may also be considered variable if the wind speed is greater than six knots, based on the wind direction varying by more than 60 degrees, but the wind direction is not treated as missing in those cases.

The METAR coding for calms and variable winds, in conjunction with the tendency of ASOS to report more calms as shown in the 1997 ASOS study and analysis of the HUSWO data, has resulted in significantly more calm and missing hours from ASOS observations when compared to conventional observer-based observations. These data gaps can be very important in dispersion model calculations since concentrations are not calculated for hours with missing data or calm observations, which can significantly affect the predicted concentrations (discussed in Section 3.1). The significant increase in the frequency of missing and calm hours associated with ASOS data under the METAR coding system, together with the fact that the data gaps are inherently biased toward low wind speeds (and may also be biased toward nighttime/stable conditions), may raise serious concerns regarding the representativeness of ASOS data in some cases.

It was also discovered in 2010 that the 5-second ASOS wind data that are used to calculate the 2-minute average winds are truncated rather than rounded to whole knots (as initially assumed in the 1997 ISCST3 study). For example, a 5-second wind of 2.9 knots is reported as 2 knots, not 3 knots. To account for this truncation of ASOS winds (either standard hourly observations or AERMINUTE output), an adjustment of 0.5 knots or 0.26 m/s is added to the ASOS winds in AERMET Stage 3 processing (beginning with version 11059), unless specified otherwise by the user. EPA believes that 0.5 knots is an appropriate value for the truncation adjustment because, on the average, the difference between an hourly wind speed using rounded 5-second values vs. using truncated 5-second values is approximately 0.5 knots. For more details about the truncation adjustment, refer to the AERMET User's Guide Addendum (U.S. EPA, 2012b). It's also worth noting that the bias toward lower wind speeds for ASOS vs. observer-based data found in the 1997 ASOS study was likely due in large part to the truncation of the ASOS wind speeds. The average difference between ASOS vs. observer-based wind speeds in the 1997 study was 0.24 m/s, or 0.47 knots.

3. Development of AERMINUTE

To address concerns regarding the impact of large data gaps on the adequacy and representativeness of ASOS wind data for regulatory dispersion modeling under the *Guideline*, EPA developed a preprocessor to AERMET (version 11059 and later) in February 2011, called AERMINUTE, that can read 2-minute average ASOS winds (reported every minute) in the National Climatic Data Center (NCDC) DSI-6405 dataset (NCDC, 2006), and calculate hourly average wind speeds and directions. The NCDC has made the DSI-6405 data reported from the ASOS network, also referred to as the "1-minute ASOS wind data", freely available beginning with year 2000 data for first-order NWS ASOS sites, and beginning with March 2005 for all other ASOS sites.

The rationale for development of AERMINUTE is based on recommendations in the *Guideline*. Specifically, Section 8.3.3.2.c of the *Guideline* addresses missing meteorological dataand recommends that "*[A]fter valid data retrieval requirements have been met, hours in the record having missing data should be treated according to an established data substitution protocol provided that data from an adequately representative alternative site are available*". Further guidance for data recovery and substitution can be found in Sections 5.3 and 6.8 of the *Meteorological Monitoring Guidance for Regulatory Modeling Applications* (U.S. EPA, 2000b). Because the 1-minute ASOS wind data are from the same ASOS stations as the standard hourly observations, these data obviously satisfy the "*adequately representative alternative site*" criterion for data substitution set in Section 8.3.3.2.c of the *Guideline*.

It should also be noted here that, unlike the ISCST3 model, AERMOD does not require 100% data completeness (including calms) under the regulatory default option. The AERMOD model treats calm and missing hours the same in calculating multi-hour averages, in accordance with Section 8.3.4.2.a of the *Guideline*.

3.1 Implementation of AERMINUTE

In AERMET, the AERMINUTE output, if available, is substituted for the standard NWS wind observations, regardless of whether the standard NWS observed winds are missing, calm, variable, or valid. While the original motivation for AERMINUTE was to minimize data gaps by substituting for hours that were calm or missing due to variable or missing winds, taking advantage of the fact that the inputs to AERMINUTE have not been subjected to the METAR coding for variable winds or calm winds, EPA decided to substitute AERMINUTE output for any standard NWS wind observation[6] (which is based on a single 2-minute average wind speed and direction for the hour) because the hourly-averaged winds from AERMINUTE are more appropriate inputs for dispersion modeling.

The use of hourly-averaged wind directions from AERMINUTE also eliminates the need to randomize the wind directions associated with standard NWS observations, which are reported to the nearest 10 degrees. To address the lack of precision in the standard NWS wind direction observations, AERMET and other meteorological preprocessors, such as PCRAMMET and MPRM, incorporate a "standard" set of random numbers, based on the month and day, that have been used to adjust the standard observed wind directions within +/- 5 degrees of the original observation. Randomizing the standard NWS wind direction observations was necessary to avoid the potential for overstating the wind persistence based on the original observations which could lead to overly conservative modeled impacts.

An illustration of an hourly-averaged wind based on AERMINUTE compared to a standard NWS observation is presented in Figure 3 for Rochester, MN (RST) for June 26, 2007 for 8:00 PM LST. The gray arrows represent the direction of flow for the 30 2-minute winds that are used in the calculation of an hourly-averaged wind in AERMINUTE. The orange arrow represents the hourly average flow direction calculated by AERMINUTE. The blue arrow represents the standard observation wind that would be input into AERMOD when using standard NWS observations only. In this example, the hourly mean wind and standard observation wind are clearly in different directions, with the AERMINUTE hourly-averaged wind from the southwest while the standard NWS observation is from the northeast. This could have a significant impact on model concentrations for a particular hour, depending on the terrain features in the area, receptor placement, influence of building downwash, and if surface roughness (z_o) varies by wind direction. While wind direction differences between the standard NWS observation and AERMINUTE values can be large for a given hour, EPA believes that the hourly-averaged wind speed and direction better reflect what a plume may be experiencing over an hour.

[6] When site-specific data is used in AERMET, AERMINUTE output is not substituted for valid non-calm site-specific observations.

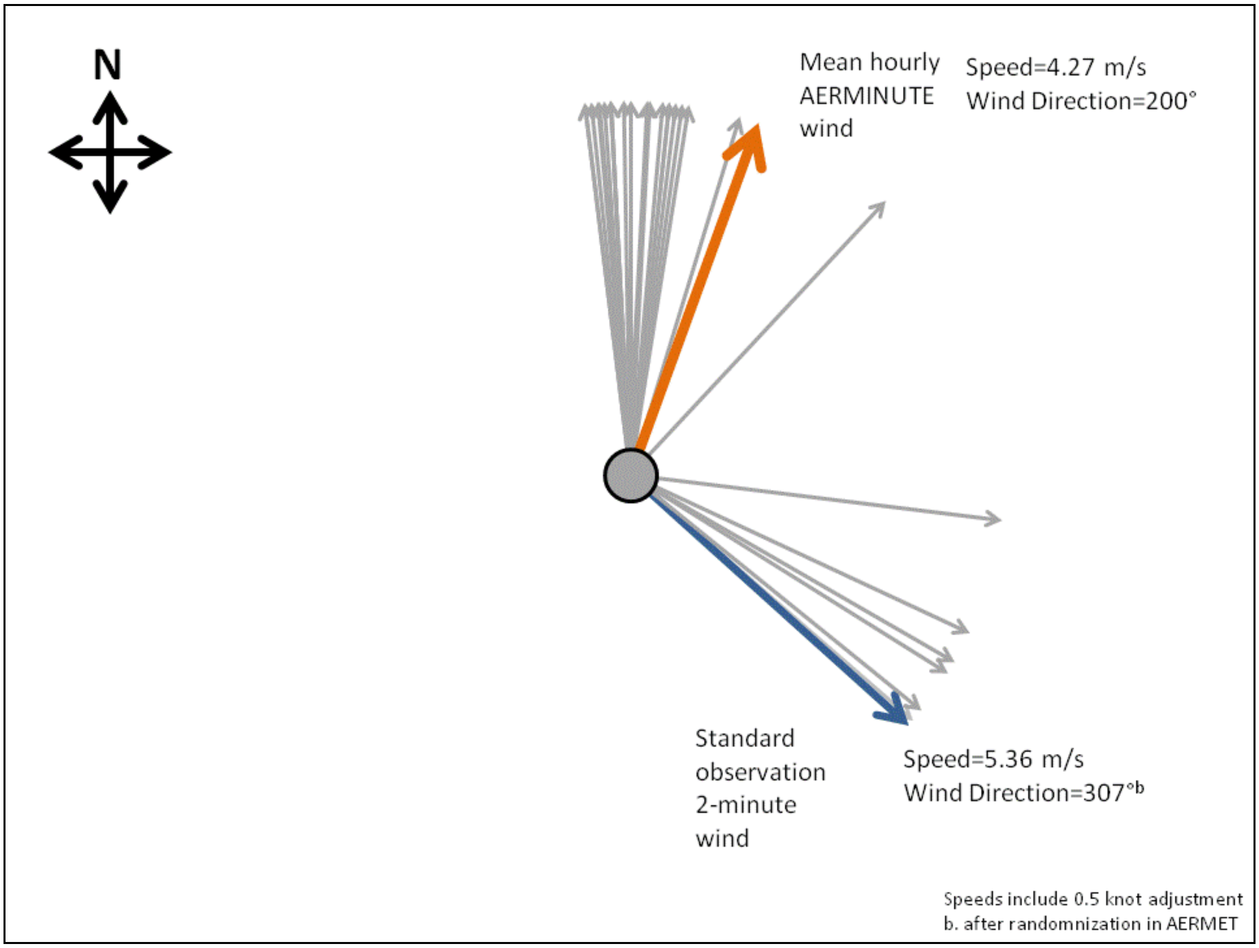

Figure 3. 2-minute flow directions (gray arrows), AERMINUTE mean hourly flow direction (orange), and standard observation flow arrow (blue) for June 26, 2007 8:00 PM LST for Rochester, MN. Arrow lengths are not proportional to wind speeds. Reported wind directions are based on the directions from which wind is blowing.

3.2 AERMINUTE wind speeds

The use of AERMINUTE generally results in a reduced number of calms and missing winds and a corresponding increase in the number of valid hours used in concentration calculations. Tables B-1 and B-2 of Attachment B provide comparisons of the percent calm and missing winds and minimum wind speeds, with and without AERMINUTE output, for 62 ASOS stations. Another important consequence of the AERMINUTE program is the introduction of lower wind speeds (< 1.5 m/s or 3 knots) into the meteorological data used in AERMOD as compared to the use of standard NWS observations only. One of the factors that has contributed to the introduction of lower wind speeds based on AERMINUTE is the replacement of traditional cup and vane anemometers at ASOS sites with more sensitive sonic anemometers as part of the implementation of the Ice Free Winds (IFW) program at NWS and Federal Aviation Administration (FAA) ASOS sites to eliminate icing in winter (Lewis and Dover, 2004; U.S. NWS, 2008). Due to the fact that the starting wind speed threshold for sonic anemometers is essentially zero, 1-minute ASOS wind speeds less than three knots are considered to be valid for IFW sites and are included in the hourly-averaged winds.

3.3 Sensitivity analyses of inclusion of AERMINUTE output in meteorological data

To examine the sensitivity of AERMOD meteorological inputs to the application of AERMINUTE, EPA has analyzed meteorological data from sixty-two stations for the years 2006-2010 to determine the changes in calms and missing hours when using AERMINUTE. This period was chosen because 2006 is the first year where all stations had at least one complete year of 1-minute data files. Attachment B provides a detailed summary of the sensitivity analysis. EPA also performed NO_2 modeling for Atlanta, GA using emissions inputs used in the 2008 NO_2 NAAQS Risk and Exposure Analysis (REA) (U.S. EPA, 2008), which is summarized in Attachment B. The NO_2 modeling allowed the comparison of AERMOD output against observed NO_2 concentrations. The general conclusions based on these analyses are:

- Use of AERMINUTE output decreased the number of missing hours in the meteorological datasets when compared to datasets with standard observations only;
- Minimum modeled wind speeds were lower (< 1 m/s) with the use of AERMINUTE output than with the use of standard observations only. This is due to most stations being part of the IFW group during a portion of the data period.
- Modeled design values for NO_2, SO_2, $PM_{2.5}$, and lead were generally higher with AERMINUTE meteorological data than with meteorological data based on standard observations only. Some source types were more sensitive to the inclusion of AERMINUTE data than other sources. The higher concentrations were generally attributable to lower wind speeds and changes in the annual distribution of daily 1-hour maximum concentrations (for NO_2 and SO_2) or daily average concentrations (for 24-hour $PM_{2.5}$), and the increase in the number of hours available for averaging (lead and annual $PM_{2.5}$).

See Attachment B for more detailed statistics.

- For the Atlanta NO_2 REA modeling, both the modeling results using standard observations only and results based on including AERMINUTE output generally exhibited slight over-prediction except at the highest concentration, where both modeling results showed slight under-prediction when compared to the observed concentrations, with AERMINUTE output being the higher of the two (see Figure B-6 in Attachment B).

4. Use of AERMINUTE

4.1 Summary of applicable guidance

The development of AERMINUTE was motivated primarily to address growing concerns regarding the adequacy and representativeness of ASOS meteorological data for purposes of dispersion modeling due to increased gaps in the data associated with the introduction of the variable wind condition under the METAR coding system and a significant increase in the frequency of calm winds after the transition to ASOS from an observer-based system. The fact that the data gaps (due to calm and variable winds) are inherently biased toward low wind speed conditions added to the concerns regarding representativeness of standard ASOS data. The identification of the 1-minuate ASOS wind data provided an opportunity to significantly mitigate concerns regarding data completeness and representativeness of ASOS data, and provided the added benefit of being able to calculate hourly-averaged wind data as a more appropriate input to AERMOD, as compared to the standard ASOS wind observation based on a single 2-minute value for each hour.

The implementation of AERMINUTE is consistent with the recommendation regarding missing data substitution in Section 8.3.3.2.c of the *Guideline*, which states that "*[A]fter valid data retrieval requirements have been met, hours in the record having missing data should be treated according to an established data substitution protocol provided that data from an adequately representative alternative site are available.*" Since the 1-minute ASOS wind data are from the same ASOS station as the standard observations, these data obviously satisfy the criterion for data substitution in Section 8.3.3.2.c. For site-specific meteorological data, the "*valid data retrieval requirements*" are provided in EPA's meteorological data guidance document (U.S. EPA, 2000b), which requires 90% data completeness by quarter based on joint capture of the variables required for model simulations. Although the *Guideline* does not establish a minimum requirement on data completeness for NWS data, the 90% joint capture by quarter serves as a useful benchmark, and If NWS data completeness is less than 90% by quarter with the use of AERMINUTE, then the representativeness of the data may be suspect and alternative sources of meteorological data should be considered. However, such cases are likely to be rare.

4.2 Recommendation on use of AERMINUTE

Given the limitations and significant concerns regarding the adequacy of standard ASOS data, and considering the relevant recommendations in the *Guideline* related to these concerns, we recommend that AERMINUTE be routinely used to supplement the standard ASOS data with hourly-averaged wind speed and direction to support AERMOD dispersion modeling. Since the 1-minute ASOS wind data used as input to AERMINUTE are freely available to the public, this recommendation should not impose any significant burden on permit applicants applying the AERMOD model.

4.3 Implementation of wind speed threshold in AERMET

While AERMINUTE can significantly increase the data retrieval rate for ASOS wind data, and improve the adequacy and representativeness of the data, one concern noted above is that AERMINUTE output may lead to an increase in the frequency of lower wind speeds when compared to standard observations only, especially for ASOS sites that have installed sonic anemometers under the IFW program. Neither the *Guideline* or EPA's meteorological monitoring guidance (U.S. EPA, 2000b) addresses the question of a minimum wind speed threshold for ASOS or other airport data. However, since the alternative to the use of NWS data is to collect site-specific meteorological data and the minimum wind speed threshold for site-specific data is 0.5 m/s (U.S. EPA, 2000b), we believe that it is reasonable and appropriate to apply the same 0.5 m/s threshold to the hourly-averaged wind speeds provided by AERMINUTE. To facilitate implementation of this recommendation, EPA has added a wind speed threshold option in AERMET (version 12345) to treat winds below the threshold as calms. The recommended value for the threshold is 0.5 m/s, which is based on the upper bound of the recommended starting speed for anemometers as listed in Table 5-2 of Section 5.2 of the meteorological monitoring guidance (U.S. EPA, 2000b). Use of the ASOS wind speed threshold option in AERMET Stage 3 should be documented in the modeling protocol.

Although the ASOS threshold option should be justified in most cases, we recommend that joint data capture after application of threshold be checked, and if the joint data capture falls much below 90% then the adequacy of the data should be further assessed. It should be noted that valid calm hours do not count against the 90% data capture requirement for site-specific data, and we recommend that ASOS data be treated similarly. We also reiterate that AERMOD does not require 100% data completeness (including calms) under the regulatory default option, and we do not recommend substitutions for missing periods beyond the use of adequately representative data from an alternative site (including the use of 1-minute ASOS data processed by AERMINUTE).

4.3 Sensitivity analysis of ASOS wind speed threshold option in AERMET

Comparisons of the sixty-two stations (Table B-2 in Attachment B) between the use of 1-minute ASOS data with and without a threshold a threshold of 0.5 m/s showed that the threshold option resulted in little difference in percentages of calms/missing (maximum difference of 4%). Minimum wind speeds increased from 0.28 m/s for most cases to between 0.51 and 0.53 m/s.

The effect of standard meteorology and AERMET meteorology with and without a 0.5 m/s threshold on modeled concentrations was also examined for the sixty-two stations. The datasets used in the comparison were based on meteorological data including AERMINUTE output. Results of the sensitivity test can be found in Attachment B. Generally design values were less using a threshold.

5. Summary

This memorandum has presented an assessment of the use of ASOS meteorological data in AERMOD and the development of the AERMINUTE processor. In summary:

- EPA has previously analyzed the effects of ASOS implementation on dispersion modeling and found that generally AERMOD was not as sensitive as the ISCST3 model to the implementation of ASOS and the implementation of the ASOS system over the conventional observation system should not preclude the use of ASOS stations in AERMOD dispersion modeling.
- EPA has implemented an adjustment factor (0.5 knots) in AERMET to adjust for wind speed truncation in ASOS processing of 2-minute winds.
- EPA has developed the AERMINUTE processor to calculate hourly average winds from 1-minute ASOS winds, whose purpose is to replace the single 2-minute winds that represent an hour with an hourly-averaged wind that is reflective of actual conditions and more appropriate for input for dispersion modeling.
- EPA recommends that AERMINUTE be routinely used in general practice in AERMOD modeling as the hourly average winds better reflect actual conditions over the hour as opposed to a single 2-minute observation.
- EPA has also implemented a threshold option in AERMET to treat winds below the threshold as calms, with a recommended minimum wind speed of 0.5 m/s, consistent with the threshold required for site-specific data.

6. References

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Attachment A. Analyses of AERMOD sensitivity to the implementation of ASOS

As stated in the memorandum, the 1997 EPA ISCST3 ASOS sensitivity study compared observation methods between observer and ASOS methods for cloud cover and ceiling height, temperature, and wind speed. This attachment summarizes the results of AERMOD sensitivity to the use of ASOS data. Figures A-1 and A-2 below summaries the mean relative differences (among six meteorological sites) for each of eight sources (six point, one area, and one volume) shown in Table A-1 and across all eight sources.

Table A-1. Sources used in AERMOD simulations.

Point sources							
Source ID	Stack ht. (m)	Stack diameter	Exit velocity (m/s)	Exit Temp. (K)	Bldg. ht (m)	Bldg. width & length (m)	Emissions (g/s)
P1	10.0	2.4	11.7	432	Not modeled		100.0
P2	35.0	2,4	11.7	432	Not modeled		100.0
P3	35.0	2.4	11.7	432	34	60	100.0
P4	55.0	2.4	11.7	432	34	60	100.0
P5	100.0	4.6	18.8	416	Not modeled		100.0
P6	200.0	5.6	26.5	425	Not modeled		100.0
Volume source							
Source ID	Release ht. (m)	Initial lateral dispersion (m)			Initial vertical dispersion (m)		Emissions (g/s)
VOL1	35.0	14.0			16.0		100.0
Area source							
Source ID	Release ht. (m)	Length (m)	Width (m)	Area (m^2)	Initial vertical dispersion (m)	Orientation angle to North (deg)	Emissions ($g/s/m^2$)
AREA1	0.01	500	500	250,000	0	0	0.0004

Figure A-1 presents the relative differences for both ISCST3 and AERMOD when using ASOS cloud observations with other conventionally measured variables versus full conventional data. Generally, AERMOD tends to be less sensitive to the use of ASOS cloud cover than ISCST3, especially for 1-hour concentrations. Figure A-2 presents the relative differences for AERMOD when using full ASOS data versus full conventionally measured data. The differences are larger and more divergent than those presented in Figure A-1 because all of the meteorological variables of interest are differing between the ASOS and conventional data. It should be noted that the truncation adjustment for ASOS wind speeds was not applied for these sensitivity analyses.

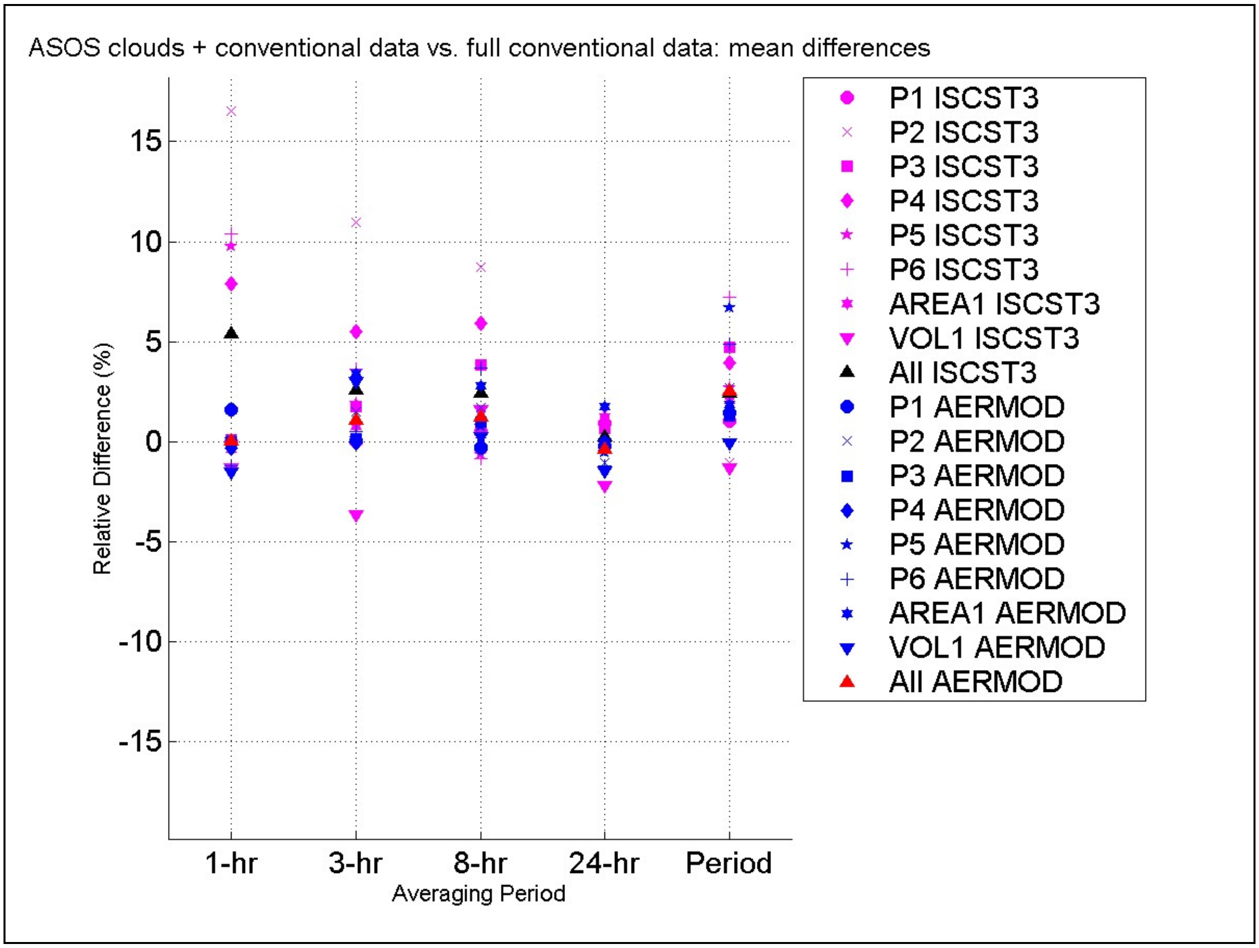

Figure A-1. AERMOD and ISCST3 relative differences ([ASOS-Obs]/Obs) for ASOS cloud plus conventional data vs. full conventional data.

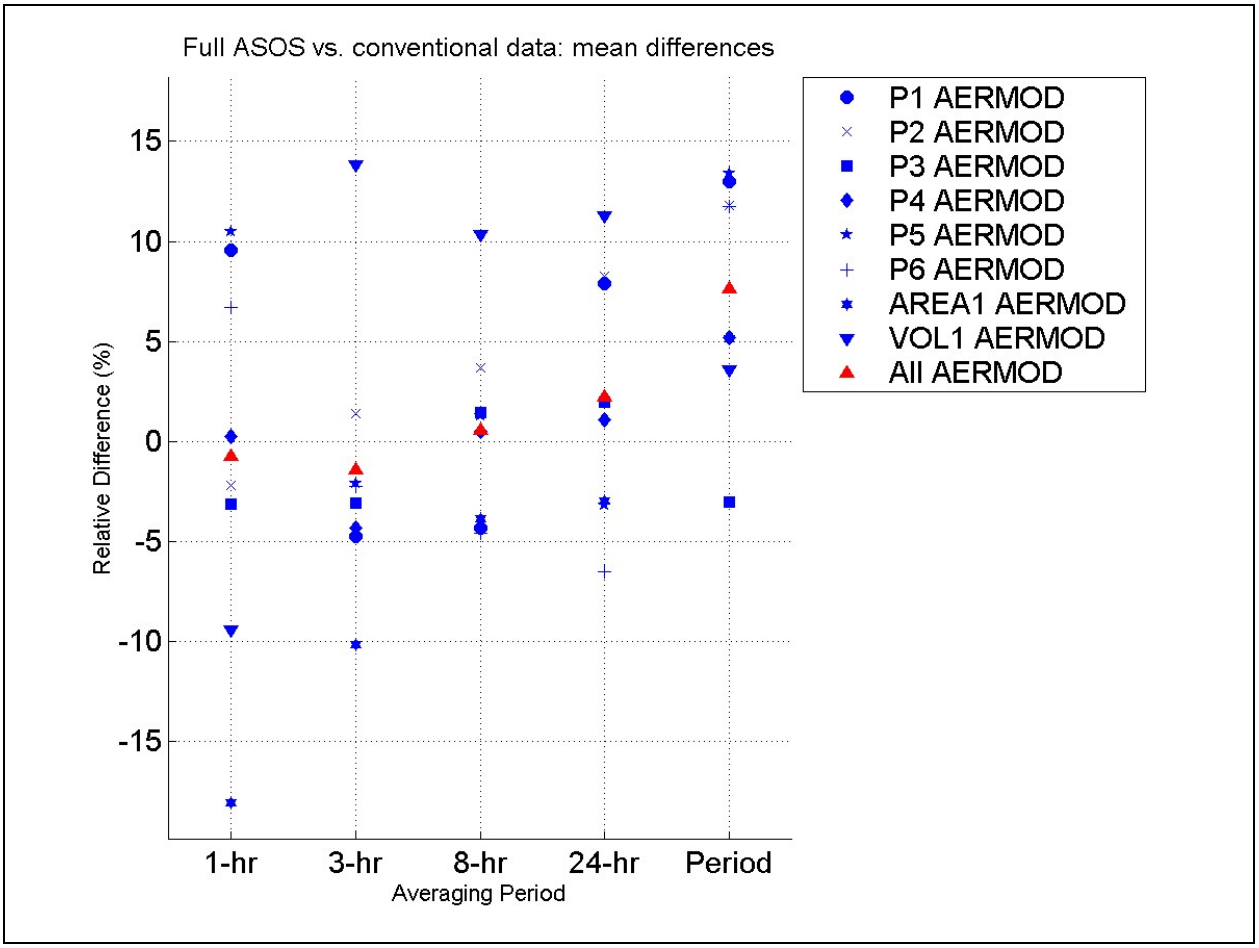

Figure A-2. AERMOD relative differences ([ASOS-Obs]/Obs) for full ASOS data vs. full conventional data.

Attachment B. Analyses of AERMOD using standard observations, standard observations supplemented with AERMINUTE and application of a threshold

1. Wind analyses

To aid in the development of guidance regarding the use of AERMINUTE, EPA has analyzed sixty-two stations for the years 2006-2010 to determine the changes in calms and missing hours when using AERMINUTE. This period was chosen because 2006 is the first year where a majority of ASOS stations had at least one complete year of observations. Table B-1 lists the total percent calms and missing winds (either missing wind speed or direction due to variable wind code) and valid hours for each station with standard ASOS observations only and standard observations plus AERMINUTE output included. Minimum modeled wind speeds are also listed as well as the percentage of hours where the standard observations were substituted with AERMINUTE output. Note that the number of missing hours does not include missing hours due to other missing meteorological variables such as temperature, etc. Table B-2 lists the mean number of hours per day that would be modeled by AERMOD as well as the mean number of days per year that have less than 18 modeled hours per day. Values are listed for standard observations only and when using AERMINUTE output. In Table B-2, the number of valid hours excludes calm hours and missing hours (missing winds and/or other missing variables). Some highlights of the comparisons are:

- For standard observations only:
  - Fifty-seven of the 62 stations exceeded 10% calms/missing winds. Twenty-six exceeded 25% calms/missing. The average calms/missing percentage was 24%. (Table B-1).
  - VSF, VT and SMQ, NJ had the highest percentage of calms/missing at 40%
  - The lowest percentage of calms/missing was RST, MN at 7%.
  - Most stations' minimum modeled wind speed was 1.76 m/s, with the average being 1.73 m/s.
  - Of the 62 stations, 22 stations had an average number of valid hours/day less than 18 hours. Two stations, VSF, VT and SMQ, NJ only had an average of 9 valid hours/day. The average number of valid hours/day was 18 hours/day.
  - Those same 22 stations also averaged over 180 days/year of days with less than 18 hours of valid hours. VSF had 333 days and SMQ had 324 days. The average number of days with less than 18 hours of valid hours was 143 days.
- Inclusion of AERMINUTE output:
  - Calms/missing percentages decreased to less than 10% for most stations. Three stations still exceeded 10% for calms/missing with SMQ, NJ at 21%. VSF, VT dropped to 4%. RST, MN dropped from 7% to 3% calms/missing. The average calms/missing percentage was 4%.
  - The percentage of AERMINUTE output hours substituted in AERMET was on the average of 91%, ranging from 74% for SMQ to 96% for several stations (RAC, RST, SGF, STL, and TAD).
  - The minimum wind speed modeled by AERMOD decreased to less than 1 m/s. The range was from 0.28 m/s to 0.52 m/s with the average at 0.29 m/s. All of the stations were part of the Ice Free Winds Group (IFW) during all of or part of the data period.

- The number of stations with less than 18 hours/day of valid hours decreased to zero stations. SMQ averaged 18 hours per day and VSF averaged 22 hours/day. The average number of valid hours/day increased from 18 to 22 hours/day.
- The number of stations with more than 180 days/year with less than 18 valid hours decreased to zero stations. SMQ dropped to 141 days and VSF to 33 days. The average number of days decreased from 143 to 34 days.

As noted above, many stations had high percentages of calms/missing when using standard observations only. Many of these stations would not be considered representative of their areas because of the high number of calms/missing but inclusion of AERMINUTE output dropped the percentage of calms/missing dramatically, making these stations more likely to be considered representative. Only one station, SMQ still had calms/missing over 20%, which is still problematic. Results can vary as recovery of data depends on the quality and temporal coverage of data in the 1-minute data files. See the AERMINUTE User's Guide (U.S. EPA, 2011) for more details about data quality in the 1-minute data files.

Table B-1. Percent calms/missing winds and valid wind hours without and with AERMINUTE output.

ID	Airport	State	IFW date	Standard ASOS observations only			Standard + AERMINUTE			
				% calm & missing	% Valid	Minimum wind speed (m/s)	% AERMINUTE	% calm & missing	% Valid	Minimum wind speed (m/s)
OAK	Metropolitan Oakland International	CA	02/15/2007	17%	83%	1.76	90%	2%	98%	0.28
RNM	Ramona	CA	02/13/2006	45%	55%	1.76	85%	7%	93%	0.28
SIY	Siskiyou County	CA	10/27/2005	40%	60%	1.76	91%	4%	96%	0.28
CAG	Craig-Moffat	CO	03/26/2007	44%	56%	1.76	91%	6%	94%	0.28
CEZ	Cortez Municipal	CO	04/04/2007	27%	73%	1.76	93%	2%	98%	0.28
TAD	Perry Stokes	CO	10/28/2008	14%	86%	1.76	95%	1%	99%	0.45
FLL	Fort Lauderdale - Hollywood International	FL	08/01/2009	12%	88%	1.76	90%	3%	97%	0.28
PNS	Pensacola Regional	FL	03/27/2007	15%	85%	1.76	92%	2%	98%	0.28
SPG	Albert Whitted	FL	01/08/2009	12%	88%	1.76	91%	3%	97%	0.28
HNL	Honolulu International Airport	HI	05/12/2009	9%	91%	1.76	93%	1%	99%	0.36
BOI	Boise Air Terminal	ID	01/09/2007	20%	80%	1.76	93%	2%	98%	0.28
JER	Jerome County	ID	05/04/2006	13%	87%	1.76	92%	2%	98%	0.33
BMG	Monroe County	IN	05/25/2007	30%	70%	1.76	91%	5%	95%	0.28
HUF	Terre Haute Hulman Regional	IN	01/16/2003	23%	77%	1.76	94%	2%	98%	0.28
MHK	Manhattan Regional	KS	02/21/2007	30%	70%	1.76	93%	4%	96%	0.28
BWI	Baltimore - Thurgood Marshall	MD	09/20/2006	28%	72%	1.76	93%	2%	98%	0.28
BGR	Bangor International	ME	09/27/2006	27%	73%	1.26	86%	9%	91%	0.28
TVC	Cherry Capital	MI	05/17/2007	35%	65%	1.76	93%	4%	96%	0.28
DLH	Duluth International	MN	07/25/2007	9%	91%	1.76	94%	1%	99%	0.28
HIB	Chisholm-Hibbing	MN	10/20/2005	29%	71%	1.26	95%	2%	98%	0.28
RST	Rochester International	MN	05/30/2007	6%	94%	1.76	96%	0%	100%	0.34
CGI	Cape Girardeau Regional	MO	12/16/2005	30%	70%	1.76	88%	9%	91%	0.28
SGF	Springfield Regional	MO	09/20/2006	11%	89%	1.76	96%	1%	99%	0.28
STL	St. Louis Lambert International	MO	09/26/2006	13%	87%	1.76	96%	1%	99%	0.28

Table B-1. Continued.

ID	Airport	State	IFW date	Standard ASOS observations only			Standard + AERMINUTE			
				% calm & missing	% Valid	Minimum wind speed (m/s)	% AERMINUTE	% calm & missing	% Valid	Minimum wind speed (m/s)
GLH	Mid Delta Regional	MS	01/30/2007	25%	75%	1.76	86%	9%	91%	0.28
RDU	Raleigh-Durham International	NC	07/08/2009	31%	69%	1.76	86%	10%	90%	0.28
GRI	Central Nebraska Regional	NE	09/19/2006	8%	92%	1.76	95%	1%	99%	0.28
CON	Concord Municipal	NH	10/20/2005	37%	63%	1.76	92%	3%	97%	0.28
MIV	Millville Municipal	NJ	09/26/2006	39%	61%	1.76	87%	6%	94%	0.28
SMQ	Somerset	NJ	10/07/2008	60%	40%	1.76	74%	21%	79%	0.28
CAO	Clayton Municipal Airpark	NM	05/03/2007	7%	93%	1.76	92%	1%	99%	0.52
ART	Watertown International	NY	11/07/2005	24%	76%	1.26	91%	4%	96%	0.28
BGM	Binghamton Regional Airport	NY	02/13/2007	11%	89%	1.76	93%	1%	99%	0.28
FRG	Republic	NY	05/18/2009	14%	86%	1.76	91%	3%	97%	0.28
LPR	Lorain County Regional	OH	12/06/2006	16%	84%	1.76	92%	3%	97%	0.28
VTA	Newark-Heath	OH	12/06/2006	44%	56%	1.76	81%	15%	85%	0.28
ZZV	Zanesville Municipal	OH	03/09/2007	32%	68%	1.76	91%	5%	95%	0.28
MKO	Muskogee/Davis Field	OK	02/09/2007	14%	86%	1.76	92%	3%	97%	0.28
SPB	Scappoose Industrial Airpark	OR	02/27/2006	46%	54%	1.76	92%	4%	96%	0.28
UAO	Aurora State	OR	01/15/2003	40%	60%	1.76	92%	3%	97%	0.28
AOO	Altoona-Blair County Airport	PA	08/21/2008	28%	72%	1.76	90%	6%	94%	0.28
JST	Johnstown Cambria County	PA	08/25/2006	11%	89%	1.26	93%	1%	99%	0.28
PHL	Philadelphia International	PA	07/30/2009	10%	90%	1.76	93%	2%	98%	0.29
RDG	Reading Regional Field	PA	11/19/2008	33%	67%	1.76	85%	9%	91%	0.28
CHS	Charleston International	SC	06/10/2009	17%	83%	1.76	90%	4%	96%	0.28
PIR	Pierre Regional	SD	11/17/2005	18%	82%	1.76	88%	8%	92%	0.28

Table B-1. Continued.

ID	Airport	State	IFW date	Standard ASOS observations only: % calm & missing	% Valid	Minimum wind speed (m/s)	Standard + AERMINUTE: % AERMINUTE	% calm & missing	% Valid	Minimum wind speed (m/s)
BNA	Nashville International	TN	04/05/2007	22%	78%	1.76	93%	2%	98%	0.28
CKV	Outlaw Field	TN	04/19/2007	35%	65%	1.76	85%	11%	89%	0.28
DHT	Dalhart Municipal	TX	09/05/2006	15%	85%	1.76	85%	9%	91%	0.28
ELP	El Paso International	TX	11/13/2008	19%	81%	1.76	93%	2%	98%	0.38
HRL	Valley International	TX	05/09/2007	10%	90%	1.76	88%	2%	98%	0.28
SGR	Sugar Land Municipal and Hull Field	TX	06/22/2007	20%	80%	1.76	91%	3%	97%	0.28
LGU	Zanesville Municipal	UT	11/07/2005	47%	53%	1.76	92%	4%	96%	0.28
ORF	Norfolk International	VA	03/27/2007	15%	85%	1.76	92%	2%	98%	0.28
PHF	Newport News	VA	03/20/2007	21%	79%	1.76	86%	4%	96%	0.28
RIC	Richmond International	VA	03/28/2007	19%	81%	1.76	91%	3%	97%	0.28
VSF	Springfield/Hartness State	VT	11/07/2005	60%	40%	1.76	94%	4%	96%	0.28
ASX	Ashland Kennedy	WI	11/17/2005	20%	80%	1.76	94%	1%	99%	0.28
GRB	Austin Straubel International	WI	08/26/2005	15%	85%	1.76	95%	1%	99%	0.28
RAC	John H Batten	WI	10/27/2005	11%	89%	1.76	96%	1%	99%	0.28
CKB	Benedum	WV	05/22/2007	38%	62%	1.76	88%	8%	92%	0.28
MRB	Eastern WV Regional Airport	WV	03/14/2007	36%	64%	1.76	91%	5%	95%	0.28
Average				**24%**	**76%**	**1.73**	**91%**	**4%**	**96%**	**0.29**

Table B-2. Mean number of modeled hours/day and mean number of days/year with less than 18 hours modeled hours without and with AERMINUTE output.

ID	Airport	State	Standard ASOS observations only		Standard + AERMINUTE	
			Modeled Hours/day	Days/year < 18 modeled hours	Modeled Hours/day	Days/year < 18 modeled hours
OAK	Metropolitan Oakland International	CA	20	97	23	19
RNM	Ramona	CA	13	321	21	61
SIY	Siskiyou County	CA	14	266	21	77
CAG	Craig-Moffat	CO	13	295	22	44
CEZ	Cortez Municipal	CO	17	186	23	26
TAD	Perry Stokes	CO	20	55	23	28
FLL	Fort Lauderdale - Hollywood International	FL	21	65	23	25
PNS	Pensacola Regional	FL	20	75	23	18
SPG	Albert Whitted	FL	21	59	23	24
HNL	Honolulu International Airport	HI	21	38	23	13
BOI	Boise Air Terminal	ID	19	116	23	16
JER	Jerome County	ID	21	57	23	28
BMG	Monroe County	IN	17	184	22	37
HUF	Terre Haute Hulman Regional	IN	18	141	23	22
MHK	Manhattan Regional	KS	16	198	22	38
BWI	Baltimore - Thurgood Marshall	MD	17	178	23	16
BGR	Bangor International	ME	17	146	21	43
TVC	Cherry Capital	MI	15	225	22	34
DLH	Duluth International	MN	22	40	23	13
HIB	Chisholm-Hibbing	MN	17	190	23	27
RST	Rochester International	MN	22	27	23	14
CGI	Cape Girardeau Regional	MO	17	174	21	45
SGF	Springfield Regional	MO	21	56	23	15
STL	St. Louis Lambert International	MO	21	63	23	12
GLH	Mid Delta Regional	MS	18	131	21	57
RDU	Raleigh-Durham International	NC	16	191	21	59
GRI	Central Nebraska Regional	NE	22	39	23	18
CON	Concord Municipal	NH	15	237	23	26
MIV	Millville Municipal	NJ	14	237	22	52
SMQ	Somerset	NJ	9	324	18	141
CAO	Clayton Municipal Airpark	NM	22	28	23	23
ART	Watertown International	NY	18	148	22	34
BGM	Binghamton Regional Airport	NY	21	53	23	18
FRG	Republic	NY	20	74	22	27
LPR	Lorain County Regional	OH	20	94	22	29
VTA	Newark-Heath	OH	13	243	20	83
ZZV	Zanesville Municipal	OH	16	191	22	39

Table B-2. Continued.

ID	Airport	State	Standard ASOS observations only		Standard + AERMINUTE	
			Modeled Hours/day	**Days/year < 18 modeled hours**	**Modeled Hours/day**	**Days/year < 18 modeled hours**
MKO	Muskogee/Davis Field	OK	20	78	22	36
SPB	Scappoose Industrial Airpark	OR	13	283	22	40
UAO	Aurora State	OR	14	248	22	34
AOO	Altoona-Blair County Airport	PA	17	171	22	40
JST	Johnstown Cambria County	PA	21	61	23	21
PHL	Philadelphia International	PA	21	46	23	11
RDG	Reading Regional Field	PA	16	214	21	62
CHS	Charleston International	SC	20	94	22	26
PIR	Pierre Regional	SD	19	80	21	48
BNA	Nashville International	TN	19	130	23	14
CKV	Outlaw Field	TN	15	195	20	58
DHT	Dalhart Municipal	TX	20	64	21	55
ELP	El Paso International	TX	19	100	23	12
HRL	Valley International	TX	21	52	23	25
SGR	Sugar Land Municipal and Hull Field	TX	19	130	22	29
LGU	Zanesville Municipal	UT	12	302	22	44
ORF	Norfolk International	VA	20	78	23	16
PHF	Newport News	VA	19	136	22	34
RIC	Richmond International	VA	19	113	23	19
VSF	Hartness State	VT	9	333	22	33
ASX	Ashland Kennedy	WI	19	119	23	24
GRB	Austin Straubel International	WI	20	86	23	15
RAC	John H Batten	WI	21	56	23	15
CKB	Benedum	WV	15	227	21	57
MRB	Eastern WV Regional Airport	WV	15	222	22	47
Average			**18**	**143**	**22**	**34**

2. Use of AERMINUTE and impact on design values

To assess the potential impact of AERMINUTE output and the effects of the threshold (0.5 m/s threshold) option, AERMOD simulations were performed for the eight source types used in the ASOS sensitivity studies for AERMOD (See Table A-1 of Attachment A of this memorandum). Simulations were made using the latest versions of AERMET and AERMOD, version 12345. U* was not adjusted in AERMET and the BETA LOWWIND options were not invoked in AERMOD. Wind speeds were assumed to be scalar averages. Five year design values were calculated for each of the eight source types for NO_2, SO_2, $PM_{2.5}$ (24-hour and annual), and lead. Simulations were performed for these pollutants as modeling applications for these pollutants are the most common applications of AERMOD (NSR, PSD, SIP implementation, etc.) and represent different averaging times (1-hour, 24-hour, monthly, and annual). For the sake of simplicity, the NO_2 AERMOD simulations assumed full conversion of NOx to NO_2 (Tier 1).

As stated previously, for NO_2, SO_2, $PM_{2.5}$, and lead, the number of calms or missing data can have an impact on the overall design values. For NO_2 and SO_2, the initial basis of the design value calculation is the maximum 1-hour concentration for a day. The selection of the daily maximum 1-hour concentration can be impacted by exclusion of light wind hours. For $PM_{2.5}$, the initial basis of the design value is the 24-hour average concentration and is impacted by the number of valid hours per day. For lead the monthly average is impacted by the number of valid hours per month. For annual PM2.5, the number of number of calms or missing data impacts the design values because those hours are not included in the annual average concentrations. For all of the pollutants, often the excluded hours would be the hours of light winds and of greatest interest, the very hours that the standard observations tend to report as calm given the METAR coding of calm winds.

For modeling, two stations were analyzed, Springfield/Hartness, VT (VSF) and Rochester, MN (RST). VSF was chosen since it was a station that had a dramatic decrease in calm and missing winds with AERMINUTE and RST was chosen since it was a station that was fairly complete without AERMINUTE output. VSF is located in a valley in southern Vermont and RST is located in southern Minnesota (Figure B-1).

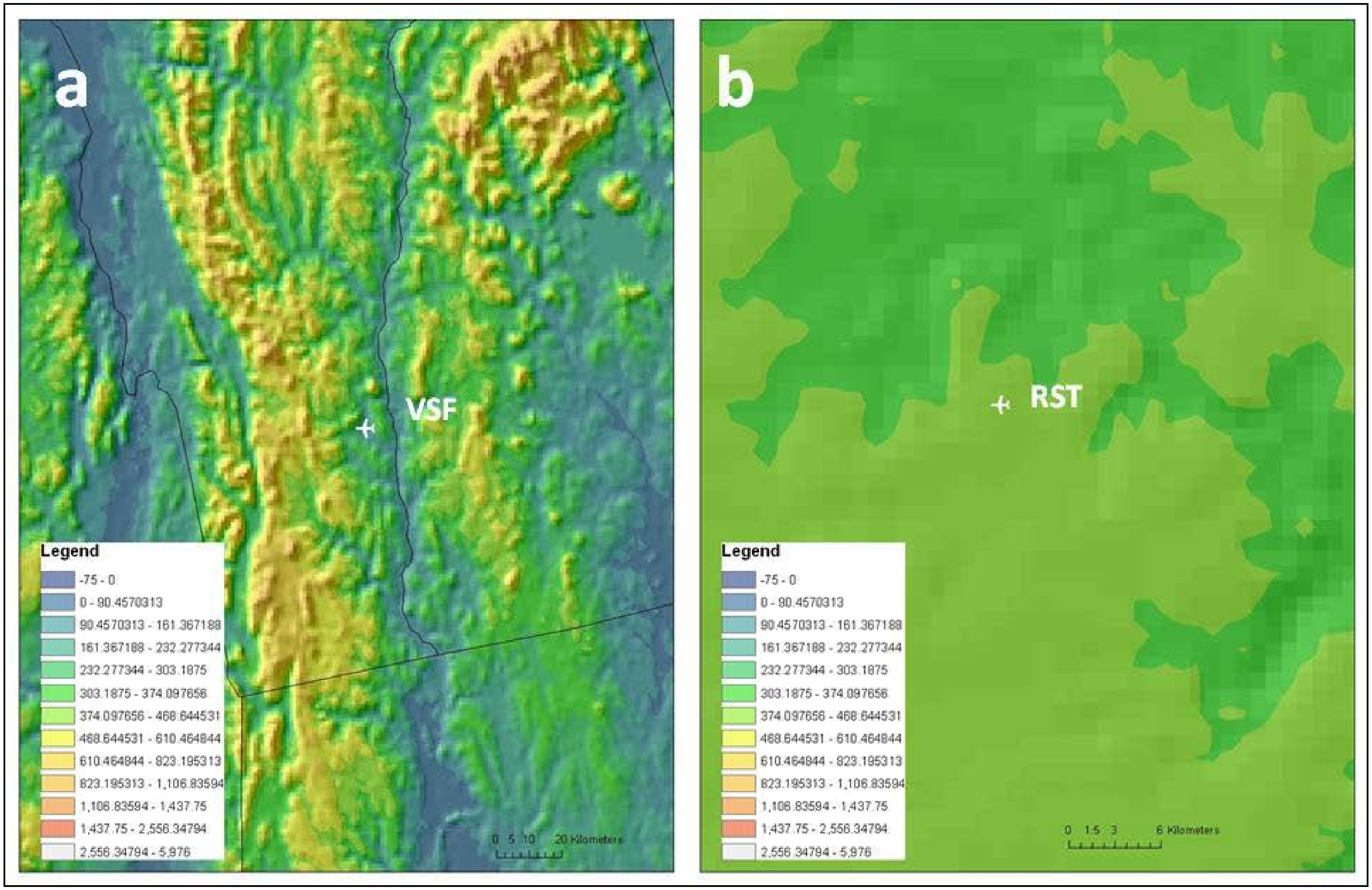

Figure B-1. Locations of a) VSF and b) RST with terrain elevations (m).

An analysis of the number of days and hours with calms/missing reveals how AERMINUTE can dramatically increase data recovery. For VSF:

- As shown in Table B-1, the percent calms/missing decreased from 60% (with standard observations only) to 4 % (with AERMINUTE included). The large number of calms/missing data with standard observations were mostly due to calm reports.
- The average number of valid hours per day (averaged over five years) increased from 9 hours per day (standard observations only) to 22 hours per day (with AERMINUTE).
- The average number of days per year with less than 18 valid hours per day decreased from 333 days per year (standard observations only) to 33 days per year (with AERMINUTE)
- The average number of calm/missing hours per month decreased from 444 hours (with standard observations only) to 49 hours (with AERMINUTE included).

For RST, the difference was less dramatic as the data was already fairly complete with standard observations only. For RST:

- As shown in Table b-1, the percent calms/missing decreased from 6% (with standard observations only) to 0% (with AERMINUTE included).
- The average number of valid hours per day (averaged over five years) changed very little, increasing from 22 hours to 23 hours per day. The average number of days with less than 18 valid hours per day decreased from 27 to 14 days.
- The average number of calm/missing hours per month decreased from 51 hours (with standard observations only) to 20 hours (with AERMINUTE included).

To assess the impact of AERMINUTE output on design values, relative differences for maximum design values for the eight sources and pollutants for VSF and RST are shown in Figures B-2 and B-3. Note the design values used in the comparisons may not be necessarily paired in time or space. Figures B-2a and B-3a compare the relative differences between design values using AERMINUTE and design values using standard observations only. Figures B-2b and B-3b compare the relative differences between the mean wind speeds associated with the design values in Figures B-2a and B-3a. Of the point sources, with the exception of P5 and P6, the relative differences were less than 500%. P5 and P6 were the two sources with the higher stack heights (100 and 200 m). The area source also experienced higher relative differences, because of the low dispersion of the source. Mean AERMINUTE wind speeds associated with the design values, tended to be less than the standard observation wind speeds. For RST, the relative differences for all sources and pollutants were 140 % or less and wind speeds tended to have smaller differences. In fact, there were a number of cases where the AERMINUTE output wind speed was higher than the standard observation wind speed. Differences at VSF were much higher than RST because the standard observation data had few valid hours (40%), so maximum daily 1-hour concentrations, and average daily, monthly, and annual concentrations were most likely underestimated at VSF because of the lack of valid hours when using standard observations only. Including the AERMINUTE output made the VSF meteorological data more representative of the actual conditions that could be experienced by emissions sources in the vicinity of VSF.

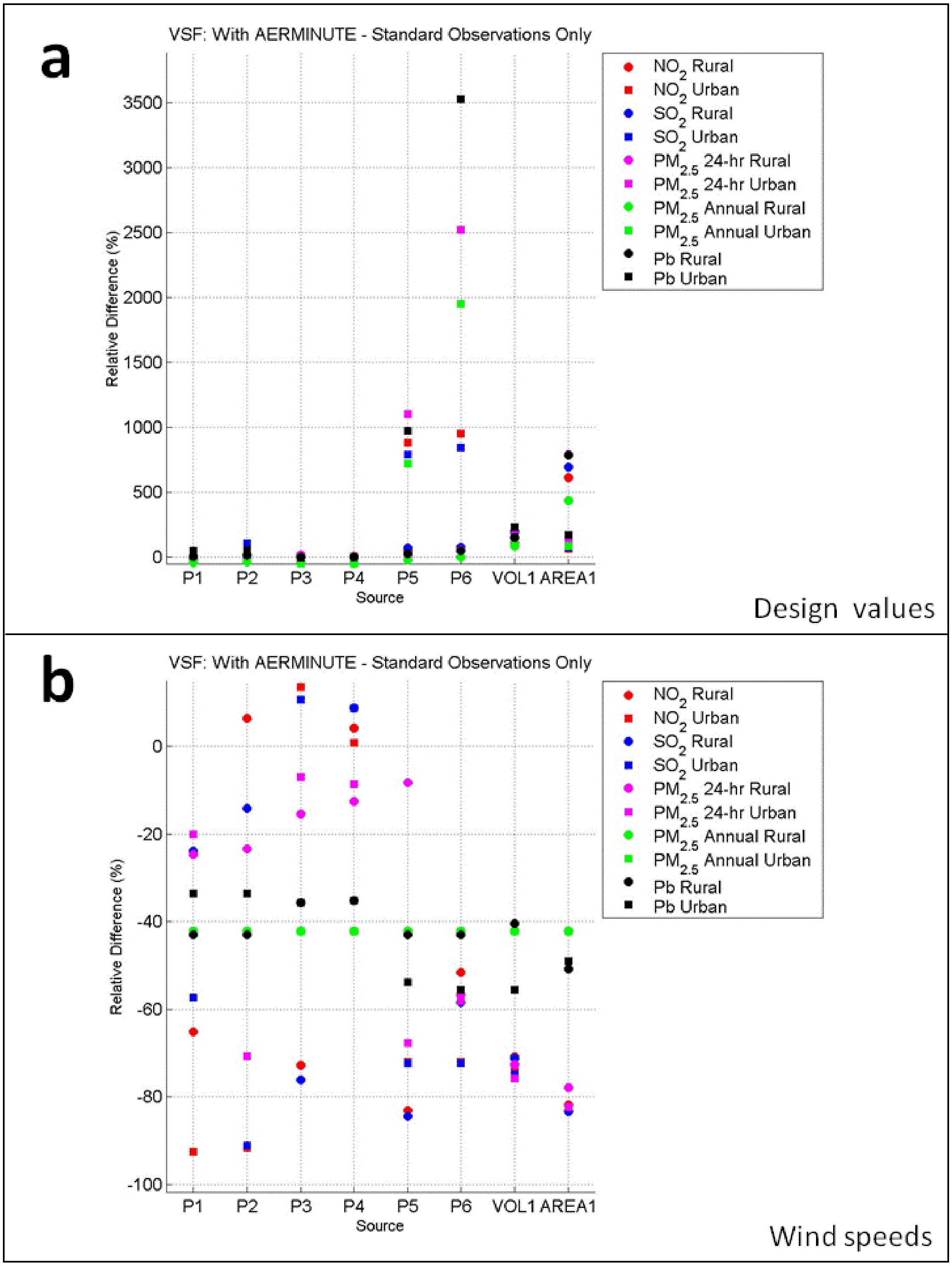

Figure B-2. VSF relative differences (AERMINUTE-standard observations only) for NO_2, SO_2, 24-hour and annual $PM_{2.5}$ and lead: a) design values and b) mean wind speeds associated with design values.

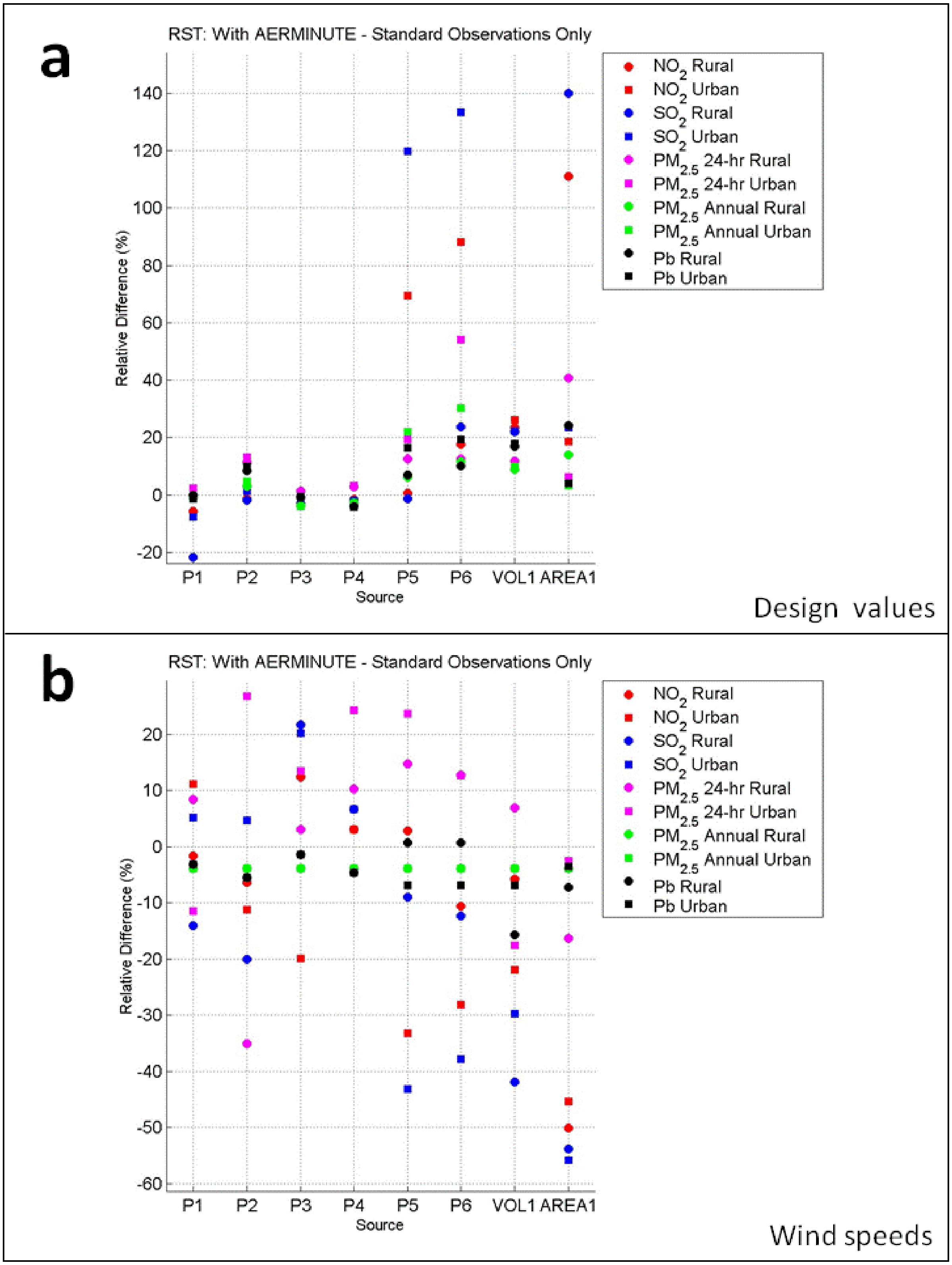

Figure B-3. RST relative differences (AERMINUTE-standard observations only) for NO_2, SO_2, 24-hour and annual $PM_{2.5}$ and lead: a) design values and b) mean wind speeds associated with design values.

To assess the impact of the threshold option on design values, Figures B-4 and B-5 present the relative differences between design values with a threshold invoked to design value without a threshold. The figures are analogous to Figures B-2 and B-3, except the differences are with a threshold minus without a threshold. All data included AERMINUTE output. Design values differences for VSF (Figure B-4) were mostly between 5 and -15% with a couple of cases less than -35%. Wind speed differences with usually below 100%, with an outlier of over 400% for the P1 NO2 urban design value.

In the case of the P1 NO2 rural results, the maximum design values with and without the threshold were just over 5% in difference. The mean wind speed associated with the maximum 5-year design value without the threshold was 0.46 m/s and the maximum design value occurred at 500 m from the source. All five hours of the daily maximum 1-hour concentrations used to calculate the 5-year design value were hours where the wind speed was below 0.5 m/s. With the 0.5 m/s threshold invoked, this hour and other hours below the threshold that were daily 1-hour maximum concentrations would be considered calm, so those hours were dropped from the annual distribution of daily 1-hour maximum concentrations, thus re-ordering the annual distributions of daily 1-hour maximum concentrations, changing the 5-year design values and location of the maximum 5-year design value.

When the threshold was applied and the annual distributions of daily maximum 1-hour concentrations were calculated, the receptor that was the maximum location with no threshold became the 4th highest receptor for design values with the threshold. The receptor that represented the maximum location for the design value with the threshold rose from the 13th highest (without the threshold) to the maximum location as the result of the threshold application with a mean wind speed of 2.68 m/s and distance of 100 m from the source.

For RST (Figure B-5), design value differences were fairly small (less than 4% in magnitude) while wind speed differences were usually within 25%.

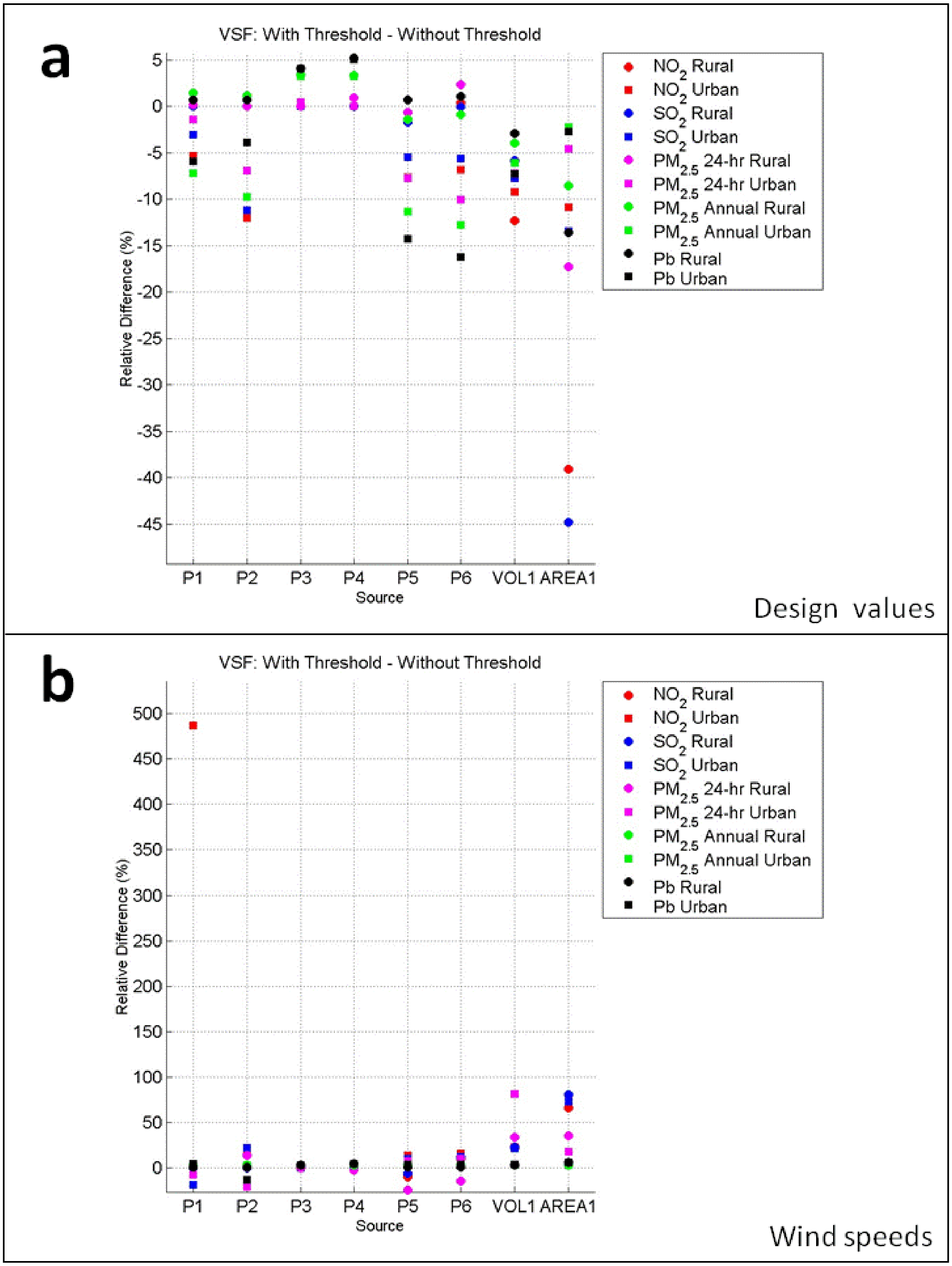

Figure B-4. VSF relative differences (With threshold-without threshold) for NO_2, SO_2, 24-hour and annual $PM_{2.5}$ and lead: a) design values and b) mean wind speeds associated with design values.

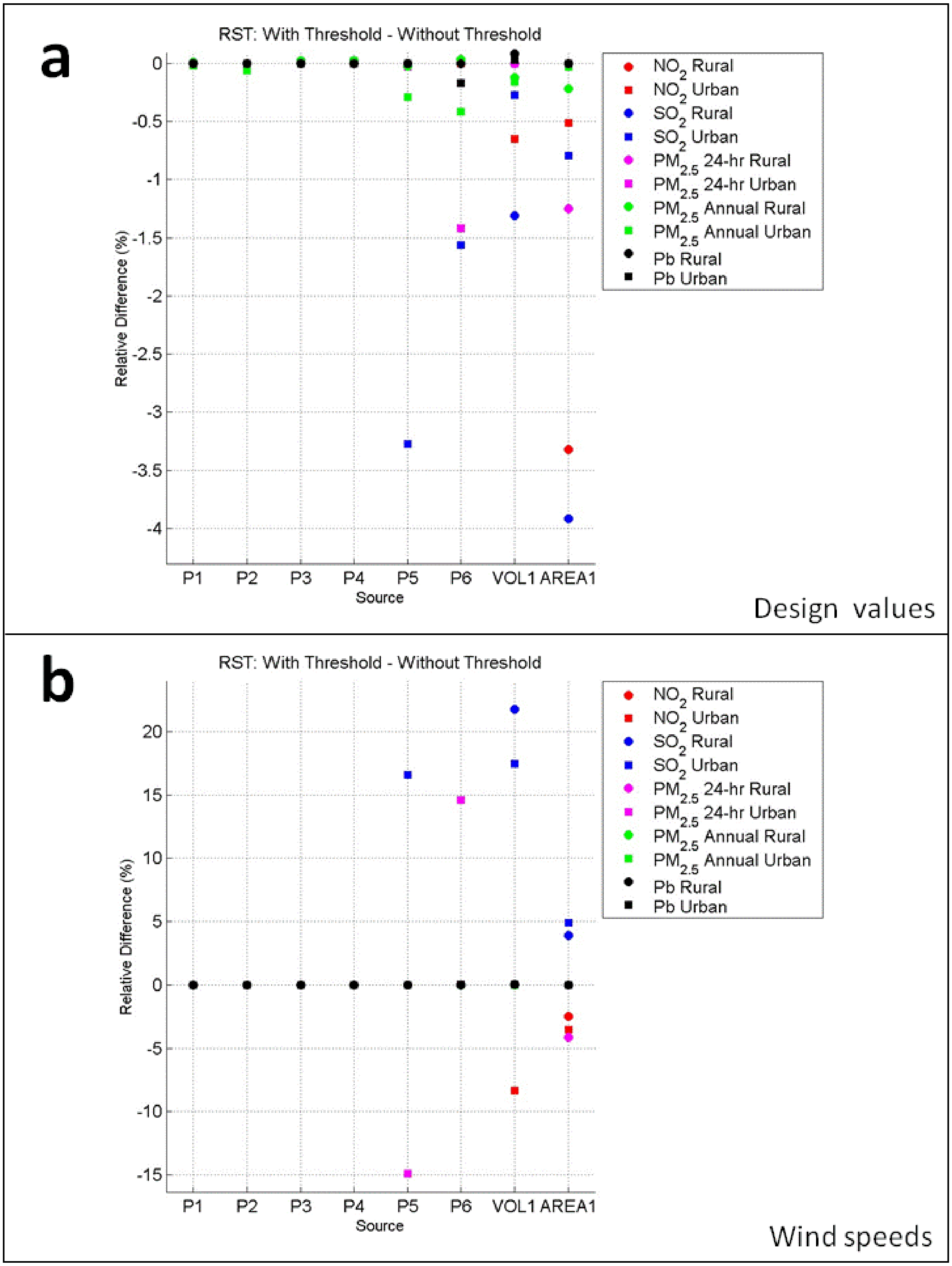

Figure B-5. RST relative differences (With threshold-without threshold) for NO_2, SO_2, 24-hour and annual $PM_{2.5}$ and lead: a) design values and b) mean wind speeds associated with design values.

3. NO_2 model to monitor comparisons with AERMINUTE

As part of the 2010 NO_2 NAAQS, a Risk and Exposure Assessment (REA) was conducted for Atlanta, GA for 2001-2003 (U.S. EPA, 2008). As part of the REA, AERMOD modeling was used to simulate 1-hour concentrations for mobile source emissions, point source emissions, and airport emissions in the Atlanta metropolitan area. Mobile source emissions were parameterized as rectangular area sources for major roads and census tract polygons for minor roads. For details about the dispersion modeling of Atlanta in the REA see Section 8 of the NO_2 REA (U.S. EPA, 2008). The modeling of the REA was recreated here to with the exception that the meteorological data was solely from Hartsfield International (ATL) instead of a mix of a meteorological monitor in Atlanta and ATL as done for the REA. Modeling was performed using standard hourly observations only (no AERMINUTE output) and including AERMINUTE. Because the simulated period, 2001-2003, is before Hartsfield's IFW commission date (March 27, 2007), low wind speeds (< 1 m/s) were not present. Model simulations were performed using the sources included in the REA modeling at three monitoring sites using the latest versions of AERMET and AERMOD with settings as described in Section 2 of this attachment. Table B-3 lists statistics of the winds. Figure B-6 presents QQ plots of observed vs. modeled 1-hour concentrations among the three monitors (unpaired in space and time). The QQ plots showed that AERMOD slightly over-predicted when compared to observations from 0 to around 120 ppb. Above 120 ppb, AERMOD tended to slightly under-predict. AERMOD results with AERMINUTE tended to be slightly higher than results with standard observations only.

Table B-3. Percentage calms and missing and valid hours with minimum modeled wind speeds for Atlanta 2001-2003.

Data	Percent calm & missing	Percent valid	Minimum modeled wind speed (m/s)
Standard observations only	15%	85%	1.76
AERMINUTE	3%	97%	1.03

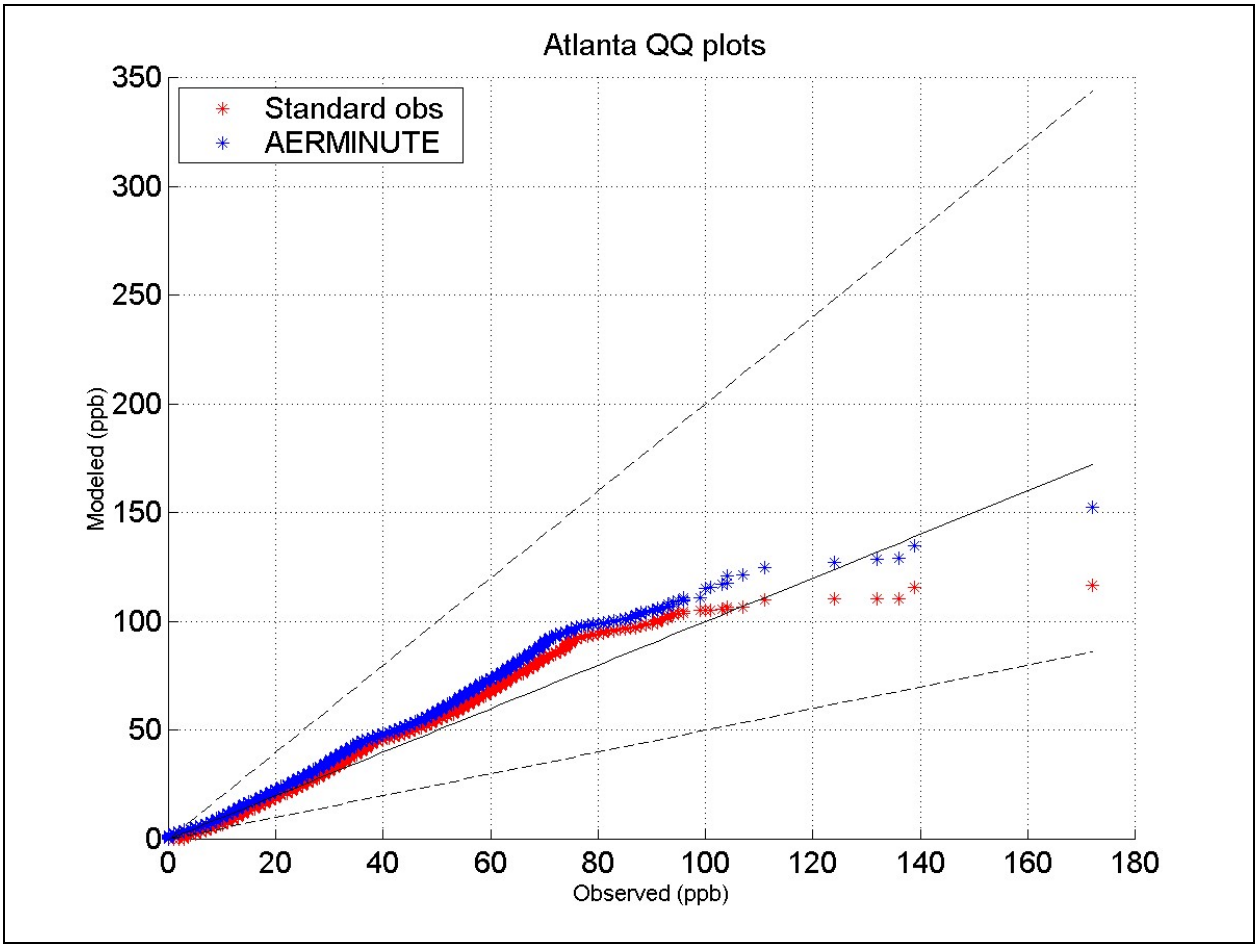

Figure B-6. QQ plots of hourly observed vs. modeled NO_2 concentrations for Atlanta.

4. References

U.S. EPA, 2008: Risk and Exposure Assessment to Support the Review of the NO_2 Primary National Ambient Air Quality Standard. EPA-452/r-08-008a. U.S. Environmental Protection Agency, Research Triangle Park, North Carolina, 27711. http://www.epa.gov/ttnnaaqs/standards/nox/data/20081121_NO2_REA_final.pdf