Roxana Air Quality Study – Meteorology[1]

Version 1 / July 3, 2012

Wind Speed and Wind Direction

Horizontal wind speed and wind direction are measured at 10m using a three-cup anemometer and a wind vane, respectively (Wind Mark III Wind Sensor, Model CS800, Climatronics). The starting threshold for both sensors is < 0.45 m/s with wind speed accuracy of ± 0.11 m/s or ± 1.5% (whichever is greater) and wind direction accuracy of 0.3°. Data are recorded at 1 Hz with 5- and 60-minute averages logged for: scalar mean horizontal wind speed; unit vector mean wind direction; and resultant mean wind direction. Standard deviation of wind speed is calculated using the scalar wind speed. Standard deviation of wind direction is calculated using the Yamartino algorithm and a Campbell Scientific algorithm.

One concern with the RAQS winds measurements is the proximity of the 10m meteorology tower to a tree ~15 m to the southwest (**Figure 1**). This tree is sufficiently close that siting criteria are not met; however, this was the only option for locating the tower. Care must be exercised when using these data to understand the possible influence of this obstruction on the representativeness of the winds measurements. This issue is addressed later in this memorandum.

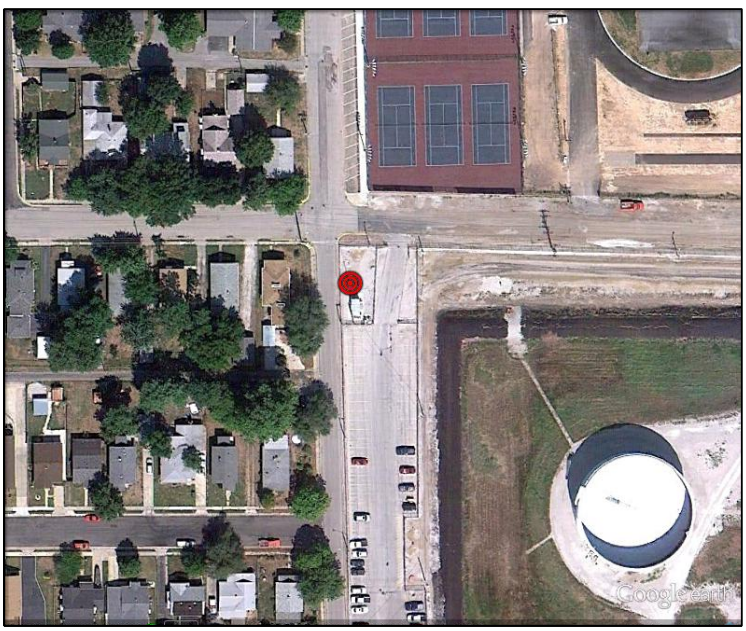

Figure 1. RAQS 10 meter meteorology tower location (red circle) with the closest tree ~15m to the southwest and a storage tank ~85m to the southeast. Image from GoogleEarth.

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To place the RAQS surface winds in context, RAQS hourly-average wind direction data were compared to data from STL Lambert International Airport (KSTL). These sites are separated by ~25 km (**Figure 2**). ASOS 2-minute average data from KSTL were used as input to AERMINUTE to generate time series of hourly average scalar mean wind speed (m/s) and unit vector wind direction (°N). Data from calendar year 2011 were censored to include only those hours with scalar mean wind speeds greater than 1 m/s at both sites. **Figure 3** compares the wind directions. In general there is good agreement with most of the data falling within ± 45° (dashed lines around the 1:1 solid line and dashed lines in the upper-left and lower-right corners). The most notable feature is for KSTL winds from the southeast clockwise through the southwest which tend to fall in a much narrower wind direction band at ~180°N for RAQS. This pattern is consistent with drainage flow along the Mississippi River which runs in a north-south direction about 3 km west of the RAQS site. To further investigate this pattern, RAQS and KSTL winds were compared to surface winds data collected by Illinois EPA at the 23rd & Madison SLAMS station in Granite City (**Figure 4**). Granite City data were available for January-April 2012 only. Figure 4a shows that for winds from the south, Granite City has the same behavior as RAQS (Figure 3) when compared to KSTL. Figure 4b shows very good agreement between Granite City and RAQS for winds from the south. These patterns are consistent with both Granite City and Roxana being in the Cahokia Bottom which is influences by drainage flow in the valley along the Mississippi River.

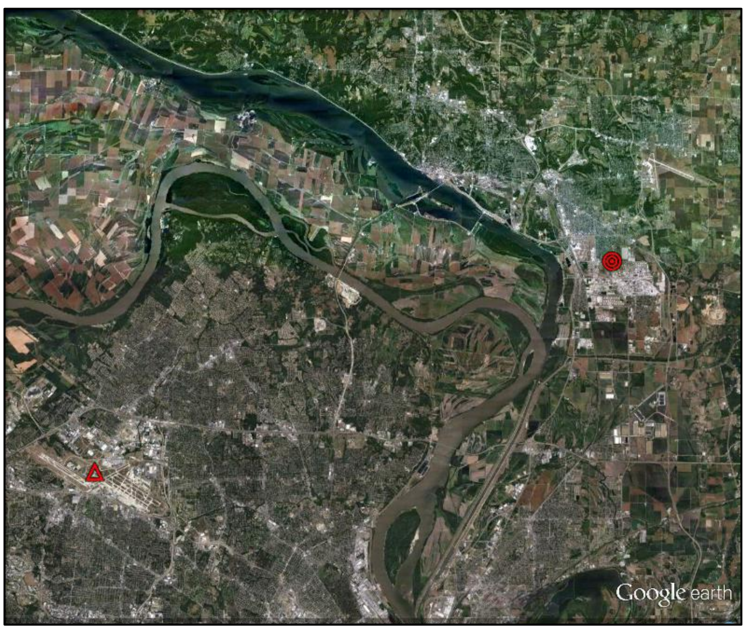

Figure 2. Meteorology stations at RAQS (red circle) and STL Lambert International Airport (red triangle). Image from GoogleEarth.

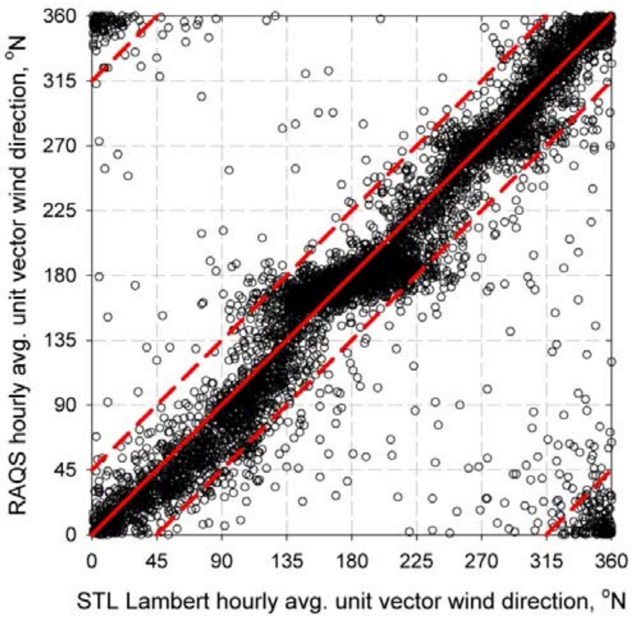

Figure 3. Hourly-average wind direction at RAQS versus KSTL. Data censored to include only those hours with scalar wind speed at both sites greater than 1 m/s. Data for calendar year 2011. KSTL data processed using AERMINUTE. Dashed lines are 45° deviations from 1:1 correspondence.

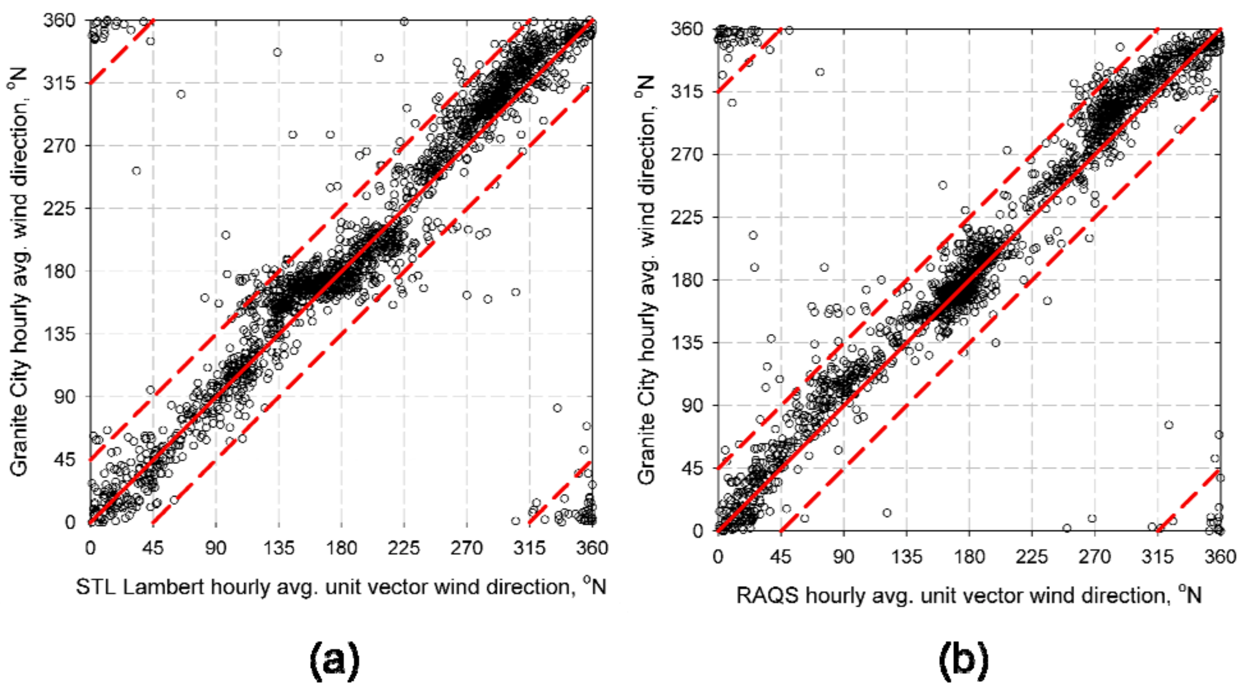

Figure 4. Hourly-average wind direction at: (a) Granite City versus KSTL; and (b) Granite City versus RAQS. Data censored to include only those hours with scalar wind speed at both sites greater than 1 m/s. Data are for the period 1/11/2012-4/23/2012. KSTL data processed using AERMINUTE. Dashed lines are 45° deviations from 1:1 correspondence.

A preliminary analysis was conducted to determine whether the tree to the southwest of the RAQS meteorology tower significantly influences the winds measurements. Figure 4b shows there is no discernible bias between Granite City and RAQS wind directions for winds from the southwest. This observation must be qualified because there are relatively few hours with winds from this sector during the period available for comparison (January-April 2012). **Figure 5** shows box plots for the RAQS to Granite City wind speed ratio for the same period. The data were censored to include only those hours with wind speeds greater than 1 m/s at both sites. The "SW Winds" box plot corresponds to data pairs with both wind directions in the sector 225 ± 22°N while the "All Data" box plot includes all data pairs. RAQS wind speeds are persistently lower than Granite City wind speeds for winds from the SW sector compared to the entire data set. This pattern is consistent with an obstruction but there might be other explanations that have not yet been elucidated. At this point, for the winter/spring period the obstruction appears to have little influence on wind direction and possibly decreases the wind speed. The effect during the summer period – when the tree foliage might cause a larger effect – remains unknown. A more detailed analysis will be conducted in early 2013 when Granite City data are available for calendar year 2012.

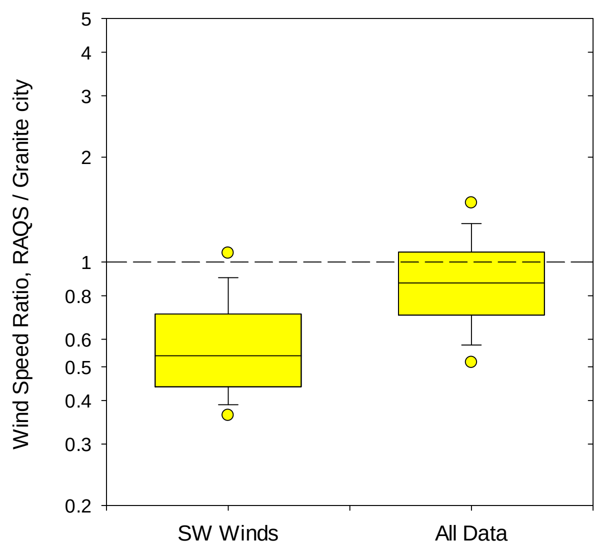

Figure 5. Distribution of hourly-average wind speed ratios (RAQS / Granite City) for southwest winds (i.e., wind direction at both sites in the sector 225 ± 22°N) and all data. Data censored to include only those hours with scalar wind speed at both sites greater than 1 m/s. Data are for the period 1/11/2012-4/23/2012.