HOW WINDY IS MY BACKYARD?

ON THE USE OF PORTABLE WEATHER MONITORING STATIONS TO ACCOMPANY NOISE MONITORINGS

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1. INTRODUCTION

Equipment used for conducting environmental noise monitorings is more elaborate than ever before with the ability to collect large amounts of data on the noise levels. Coupled with the ability to conduct simultaneous digital audio recordings, the Acoustical Engineer has the tools to very accurately discern the noise climate in the area monitored. Generally, the missing component is useful weather data which is specific to the monitoring area. Equipment used for this must be portable, battery powered, and capable of relatively accurate results. The purpose of the paper is to discuss portable weather monitoring stations for use in the field in conjunction with the noise monitoring stations, the applicability to noise data analysis, and the relative level of accuracy compared to full scale weather monitoring stations.

2. BACKGROUND

Portable weather monitoring stations are useful for obtaining weather conditions local to the noise monitoring location. This data can be used to assist in determining contributions from various noise sources during the noise monitoring and can provide a record of weather conditions during complaint driven noise monitorings to ensure the conditions matched those required by the complainant. Typically, weather data near the study area is not available since Environment Canada and the Weather Network do not have many weather logging stations. In some areas there are industry owned weather stations (i.e. at various industrial facilities), however, this data is often difficult to obtain. In addition, at locations which do have logged data available, the data is typically presented in 1-hour increments. It is often desired to have the weather data in a finer resolution than this (5 – 10 minutes for example).

Using portable weather monitoring stations does not come without concerns, however. In particular, the accuracy of the measurements relative to large scale permanent weather stations is of prime importance. Most permanent installations collect the wind speed and direction at a height of 10m above grade. This is generally difficult (although not impossible) in a portable situation. As such, a lower measurement height is the tradeoff for portability and ease of setup/takedown. How the reduced height affects the results is an issue. In addition, the equipment must be selected such that there is true portability (i.e. not too large or heavy, capable of being battery powered for at least 24-hours, and relatively fast and easy to setup and takedown).

To answer this, there are several weather monitoring systems available. Some are designed specifically to be portable while others are small enough to be easily modified for portability. Various systems use various methods to obtain the appropriate data. As an example, many use the typical wind-vane and cup anemometer system to obtain wind speed and direction while others employ a non-moving-part method of particle motion sensing within a tri-pronged probe for wind speed and direction. Still others use the wind-vane for direction and a hot-wire anemometer for wind speed. Most use similar methods for temperature and relative humidity sensing. In addition, there are sensors for rain quantities, dew collection, and UV Radiation intensity.

3. MEASUREMENT METHODS

The weather monitoring system discussed in this paper consists of various components from Nova-Lynx. The equipment is originally designed for permanent installation, but has been easily modified for portability. There is a combination wind-vane and cup anemometer, a combination temperature sensor (with solar radiation shield) and hygrometer, and a black-box containing logging electronics. The electronics box runs off 12 VDC and contains a clock battery. The power consumption is relatively low, allowing the unit to run for approximately 5-days off a single 7 Ah gel cell battery.

The long term test was conducted adjacent to the Edmonton International Airport. This was an ideal location since both Environment Canada and the Weather Network provided logged weather data and the ground surrounding the Airport is flat and relatively un-obstructed by buildings or vegetation. The monitoring systems, as shown in Figure 1, were set-up along the western edge of the Airport boundary in an open area adjacent to a gravel road. This situated the monitors approximately 1.0 km from the Airport Weather Monitor Tower.

The wind-vane and anemometers were installed on poles at heights of approximately 3.0m and 4.7m above grade. The temperature sensor and hygrometer were located on the same poles approximately 2.5m and 3.5m above grade. The systems were set-up to collect data in 5-minute sampling periods with average and peak wind speeds, wind direction, temperature, and relative humidity. With a 5-minute sampling period, the particular monitors used have enough memory for approximately 1-month worth of continuous data collection. For this test, the monitors ran for a continuous 52-hour period under various weather conditions. There was also some snow during the monitoring period.

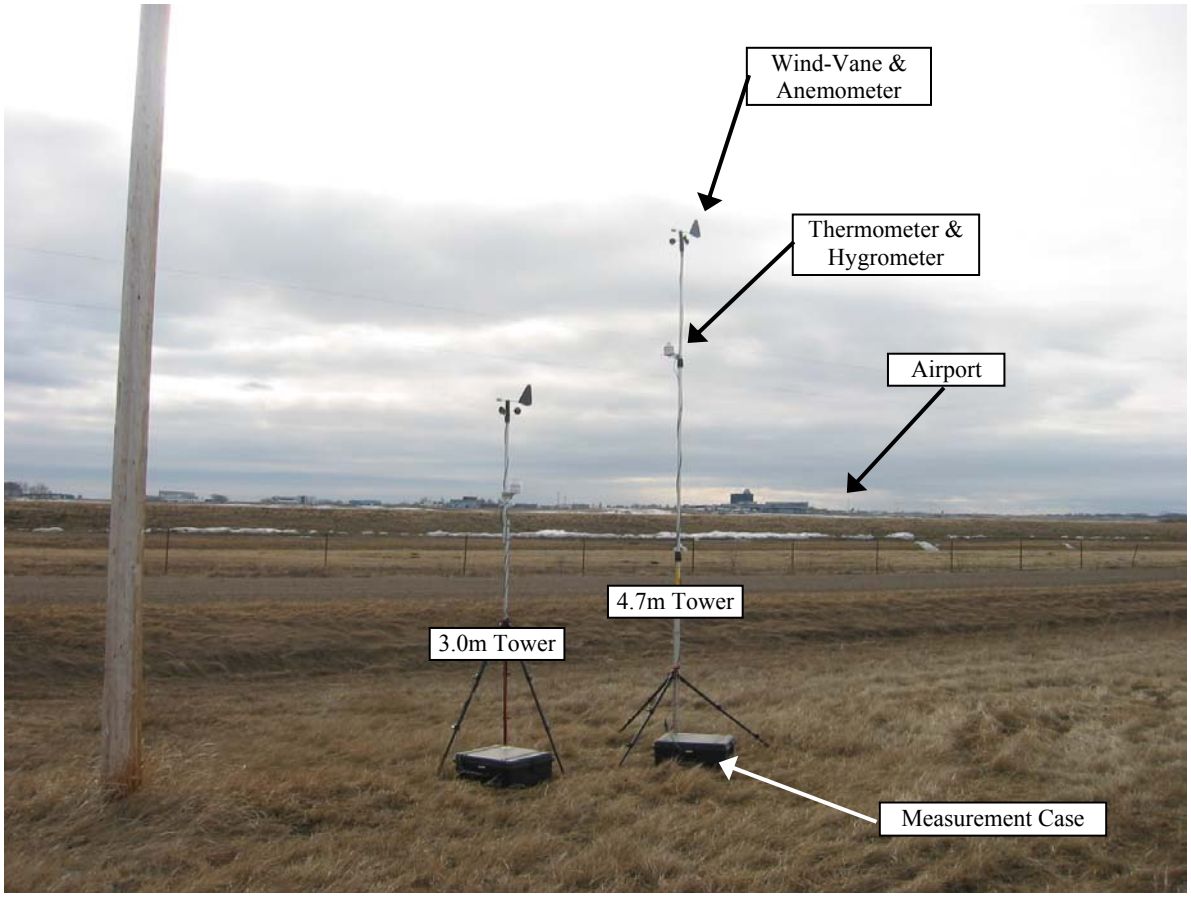

Figure 1. Weather Monitoring Equipment

4. RESULTS

During the monitoring period, weather data was obtained from the Environment Canada and Weather Network websites for the Edmonton International Airport. This data was then graphed and compared to the data obtained from the portable weather monitor. The analysis is divided into 4 different categories: wind speed, wind direction, temperature, and relative humidity.

4.1 Wind Speed

The wind speed comparison between the weather monitors and Environment Canada is provided in Figures 2 & 3. It can be seen that the average wind speed values obtained from the monitor are generally lower than those provided by Environment Canada (by approximately 20%). In addition, the taller tower resulted in slightly higher wind speeds. This is very much as expected due to the difference in elevation relative to ground level of the various monitoring systems. Boundary layer fluid mechanics dictates that the theoretical velocity directly at ground level is zero with an inversely exponentially increasing value as the elevation increases until the steady state is reached. This means that there is an expected difference in wind speed at 3.0m, 4.7m and 10.0m.

The maximum wind speed values obtained by the monitor are generally higher than the Environment Canada data by approximately 20%. This is a more difficult value to directly compare since the maximum instantaneous wind speed measured is subject to greater variability due to the equipment sampling time, crest factor, etc. However, both the maximum and average value seem to provide a good band in which the Environment Canada data is generally contained.

It is also important to discuss how the Environment Canada wind speeds are obtained. Information provided by Environment Canada personnel indicate that the reported wind speed is the average value during the 2-minute period ending at the time of the observation. When a wind gust is reported, it is the strongest wind during the 10-minute period ending at the time of the observation. As such, for the average values, there is a 58-minute span in which the wind is not being recorded. Given that the portable weather monitor results are consistently lower than the Environment Canada results, it is still safe to conclude that this will generally be the case. However, this gives additional incentive to obtain data in shorter time intervals.

With this data in hand, the portable monitoring systems can be calibrated relative to the Environment Canada Data.

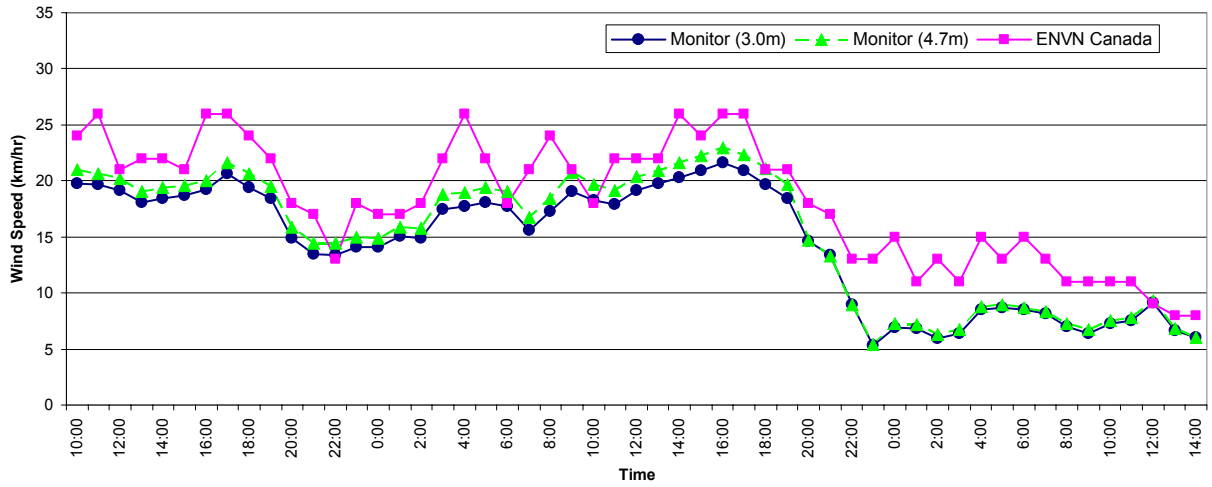

Figure 2. Long Term Wind Speed Monitoring Results (Monitored Average Wind Speeds)

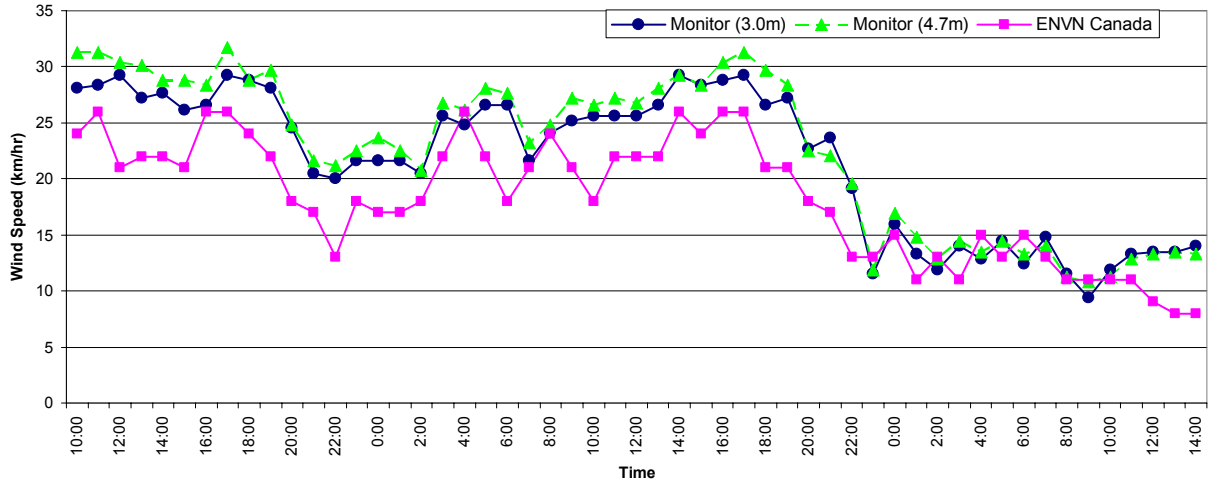

Figure 3. Long Term Wind Speed Monitoring Results (Monitored Peak Wind Speeds)

4.2 Wind Direction

The wind direction comparison between the weather monitor and Environment Canada is provided in Figure 4. There is indeed good comparison between the three data sets. In addition, in order to understand the comparison, it is important to understand the resolution of each data set. The information provided by Environment Canada, using the "last 24-hours" option on the website, is presented in the typical 16-direction wind-rose values (i.e. N, NNE, NE, ENE, etc.) which provides 22.5 degree resolution. This was the resolution used for the analysis. When using the "long term" data provided on the website, the wind directions are provided in 10 degree resolution. The portable weather monitoring system has a resolution of approximately 3 degrees with a quoted accuracy of ±3%.

In addition, it is important to discuss the relative desired level of accuracy in wind direction. For most noise monitoring purposes, a difference of one wind-rose direction (i.e. about 22.5 degrees) would generally be considered acceptable. The portable measured results are generally within this range. The biggest discrepancies from this typically occur at time of low wind speed when there is not enough force to point the wind vane in the correct direction. Under these conditions, however, the direction is not as much of a concern because the wind is essentially calm.

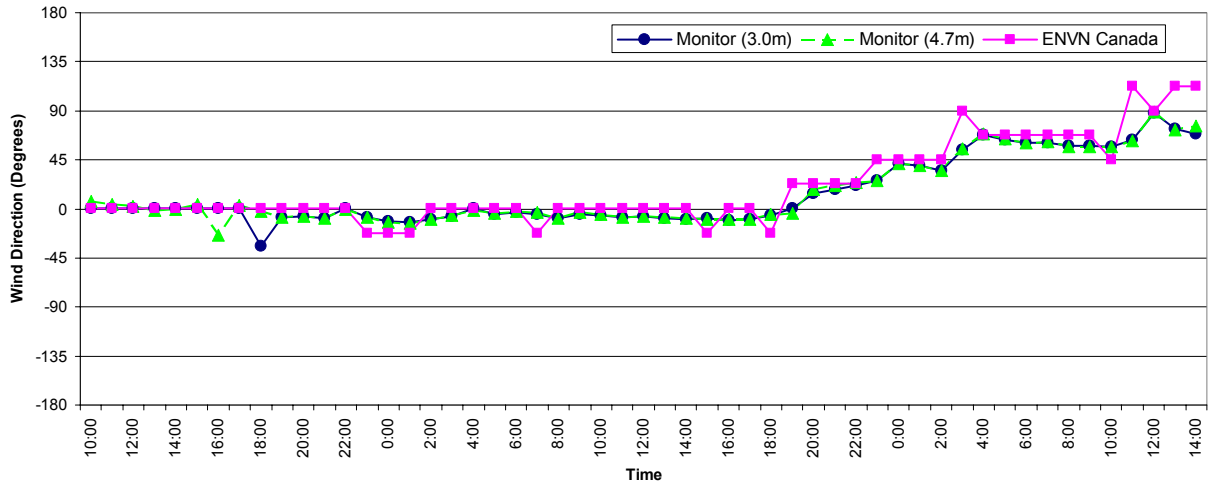

Figure 4. Long Term Wind Direction Monitoring Results

4.3 Temperature

The temperature comparison between the weather monitors and Environment Canada is provided in Figure 5. The three data sets match very well with each other, typically resulting in differences of less than 2^0C. Even still, differences of 3 – 4^0C are still quite good and will not make a significant difference in the noise monitoring results analysis. Typically one of the major items that can be revealed by reviewing the temperature is the possibility of a temperature inversion. This can sometimes manifest itself by large sudden changes in temperature. This would easily show up in the portable monitor.

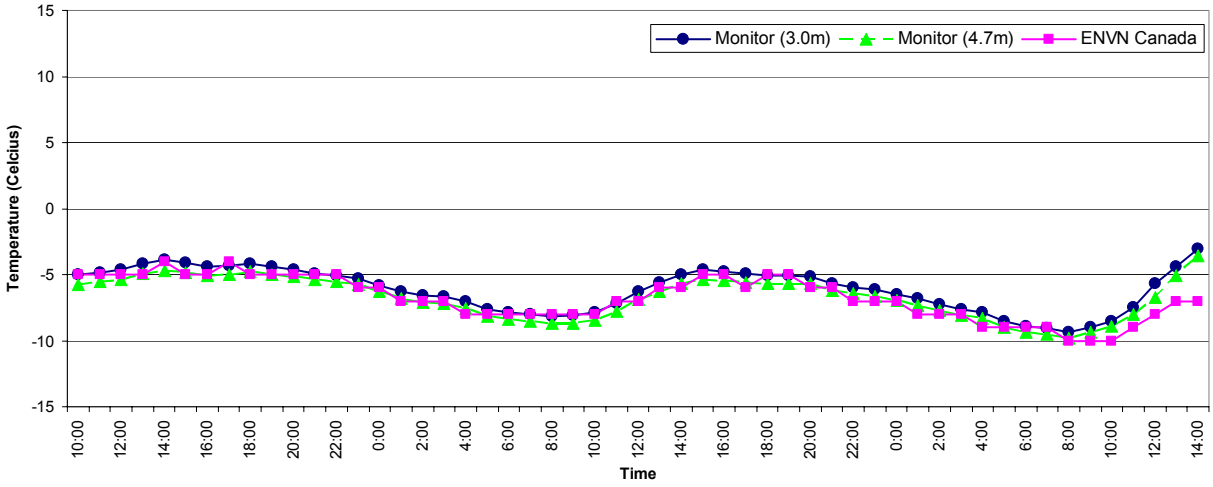

Figure 5. Long Term Temperature Monitoring Results

4.4 Relative Humidity

The relative humidity comparison between the weather monitors and Environment Canada is provided in Figure 6. Again, as with the temperature results, the three data sets match quite well. Also, more so than with the temperature comparison, small differences in relative humidity are not a major concern. A difference of 10 – 20 % will not have a significant impact on the noise monitoring results analysis. Finally, as with the temperature monitoring, the relative humidity monitoring can also provide an indication of the presence of a temperature inversion. Sharp changes in relative humidity will show up in monitored results.

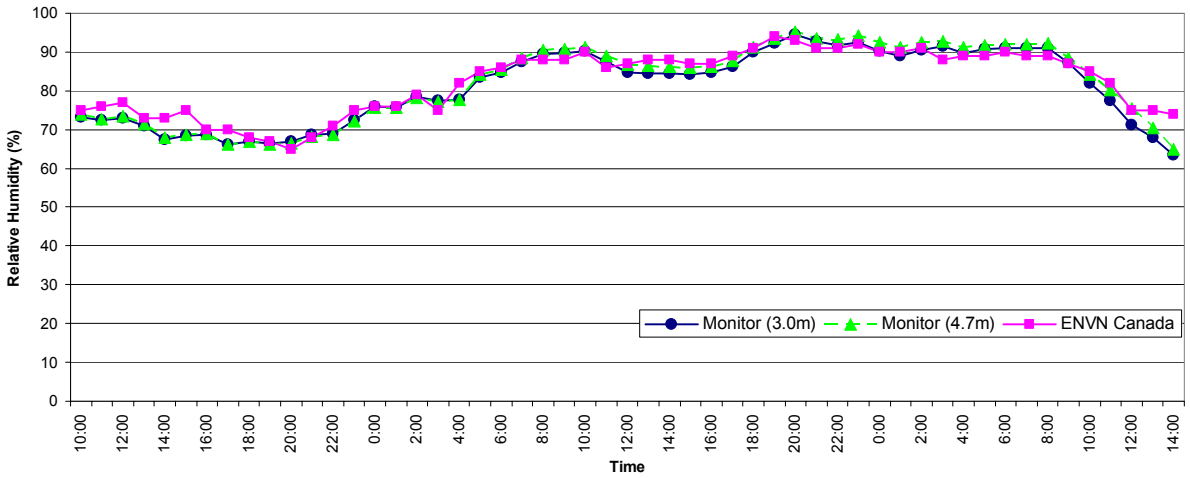

Figure 6. Long Term Relative Humidity Monitoring Results

4.5 Environment Canada Compared to Weather Network

Since the data was collected anyway, as an exercise, the "last 24-hours" data provided by Environment Canada was compared to that provided by the Weather Network. The results provided in Figures 7 – 10 show that the two data sets match almost exactly for all of the four major parameters. The author is unaware of any data sharing between the two sources, but is it possible; especially considering that most of the monitoring stations are the same for both sources. In any event, this provides good evidence that either website could be used as a source for weather data with similar results.

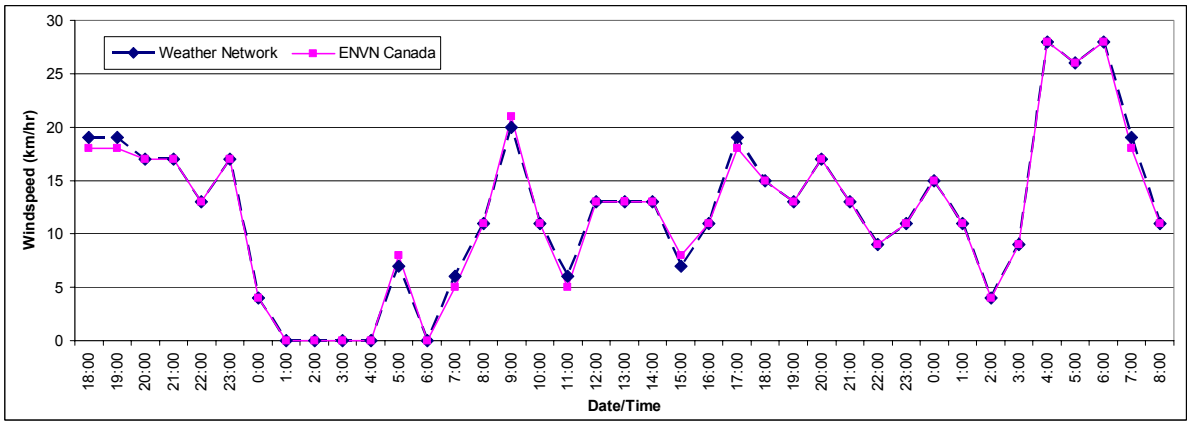

Figure 7. Long Term Wind Speed Comparison Between Environment Canada and the Weather Network

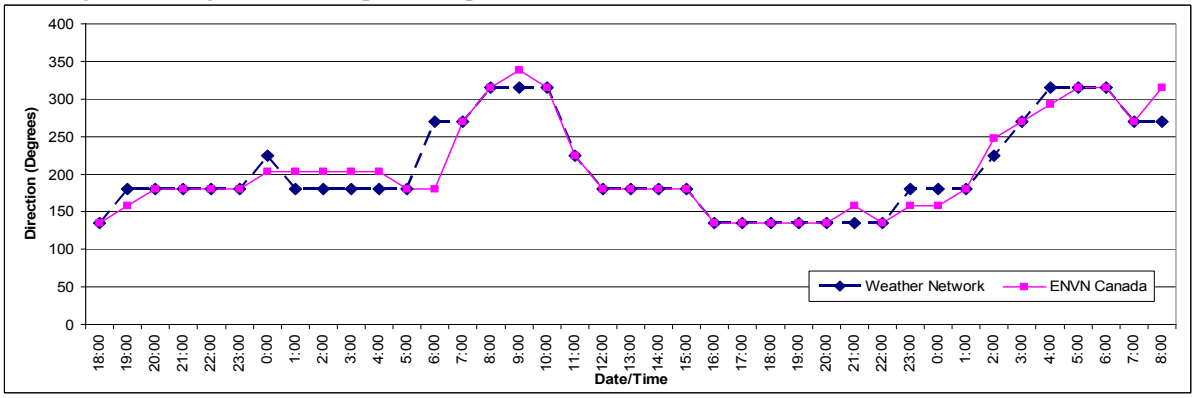

Figure 8. Long Term Wind Direction Comparison Between Environment Canada and the Weather Network

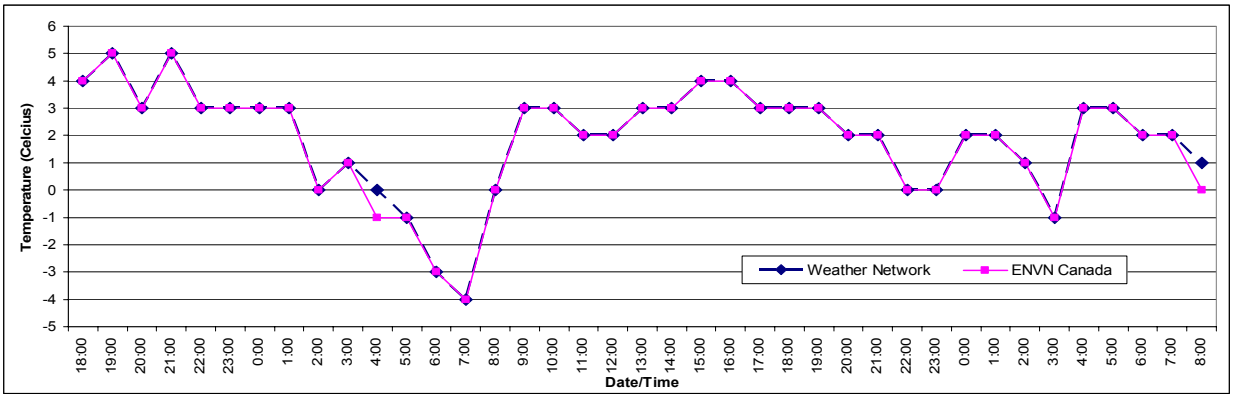

Figure 9. Long Term Temperature Comparison Between Environment Canada and the Weather Network

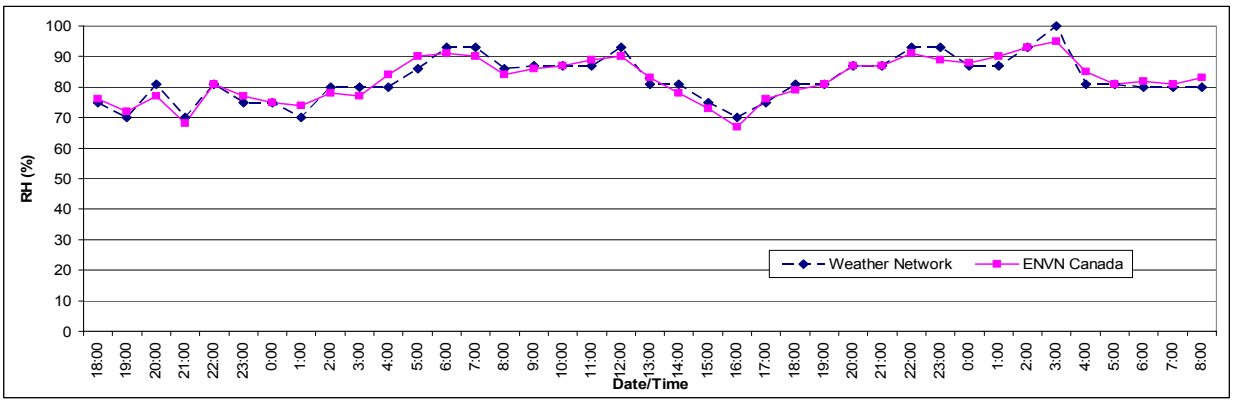

Figure 10. Long Term Relative Humidity Comparison Between Environment Canada and the Weather Network

5. CONCLUSION

The measured data obtained by the portable weather monitor indicates good trend comparison to the Environment Canada data. Although the amplitudes do not match exactly (in particular for the wind speed information), the portable monitor is very useful in providing general wind information such as (for example) if the wind was essentially calm, generally mild, or well in excess of acceptable noise monitoring conditions. With the calibration data obtained, the monitored results can be adjusted to match those at a height of 10.0m. The wind direction, temperature, and relative humidity data matched very well with that obtained from Environment Canada. Finally, the comparison between Environment Canada and the Weather Network resulted in essentially identical results indicating that either source could be used.