6.2 COMPARISON OF CO-LOCATED DCNet AND AWS WEATHERBUG URBAN TEMPERATURE OBSERVATIONS

William R. Pendergrass, Christoph A. Vogel
NOAA/Air Resources Laboratory/Atmospheric Turbulence and Diffusion Division,
Oak Ridge, TN

Bruce B. Hicks
MetCorps, Norris, TN

Bill Callahan
Weatherbug, AWS Convergence Technologies, Germantown, MD

ABSTRACT

The Air Resources Laboratory (ARL) of the National Oceanic and Atmospheric Administration initiated a research program involving the private sector, to explore the utility of using local meteorological data from private as well as government sources in forecasting for urban areas. The program is generally referred as UrbaNet. The first studies focused on the National Capital Region using ARL's DCNet system of urban observations as the core network. The work has been in collaboration with AWS Convergence Technologies, Inc. (AWS Weatherbug), which operates a private/commercial meteorological network with a large array of meteorological measurement sites within the United States. The AWS Weatherbug network provides data on wind velocity and temperature, averaged over fifteen minute periods, and accompanying evaluations of the variability of each meteorological component.

The goal of this cooperative agreement has been to determine an optimal methodology for determining how meteorological data collected by entities other than the National Weather Service can be integrated with observations presently employed, so as to improve the accuracy of urban and other local forecasts. While the focus continues to be on the forecasting of personal exposures to hazardous materials, the suite of observations can be used to address a wide range of issues to include climate. In this study, aspirated temperature systems as currently deployed within NOAA's Climate Reference Network were installed at three DCNet stations co-located with AWS Weatherbug. While there is considerable scatter between individual 15-minute average temperatures, long term means are quite correlated with correlation coefficients above 0.98.

1. INTRODUCTION

The Air Resources Laboratory (ARL) operates an intensive urban meteorological network within the National Capital Region providing critical data and insights designed to improve the predictions of the transport and dispersion of hazardous material within complex urban environments. This urban testbed provides a research network to support development of urban monitoring methodologies and observation standards to evaluate the utility of using alternative meteorological observing networks within urban environments. The strong focus on data quality facilitates development of observation standards ranging from air-quality to climatological scales. In development of the ARL DCNet monitoring system, within the suite of urban issues identified in requirements for the DCNet research network, ARL identified the question whether the myriad of public and private sources of meteorological data could be used to address real-time meteorological requirements, synoptic, and climate issues. To explore issues related to the measurement of temperature and precipitation in an urban environment, instrumentation used in NOAA's Climate Reference Network (CRN) to measure temperature and precipitation were installed at three DCNet monitoring sites which were co-located with AWS Weatherbug stations. This report details results of the inter-comparison of temperature measurement from three different measurement techniques to address questions whether alternative meteorological measurements from private sources can support climate studies and evaluations.

2.0 Field Trials

Three DCNet monitoring stations were modified to

Figure 1 NOAA/ARL DCNet research network.

accept precision temperature instrumentation as currently deployed at NOAA's CRN stations. The three DCNet stations (AGU, Howard University, and NEA) are co-located with AWS Weatherbug weather stations.

Figure 1 identifies the selected evaluation stations within the DCNet research network.

The temperature inter-comparison represents three measurement techniques. DCNet monitoring stations use naturally aspirated Campbell Scientific model HMP45C-L PRT temperature probes manufactured by Vaisala, Inc. AWS Weatherbug stations measure temperature by a naturally aspirated Dallas Semiconductor DS 1624 silicon chip digital thermometer. Temperature is determined by clock cycles from low/high temperature oscillators with circuitry provided to account for the nonlinear behavior of the oscillators over temperature. NOAA's CRN and HCN temperature measurements consist of three independent Platinum Resistance Thermometers mounted in a MET One aspirated solar shield. Table 1 provides a comparison of sensor performance standards.

Table 1 Temperature measurement standards

Station	Accuracy	Range	Resolution
DCNet[1]	+/- 0.3 °C	-40 to + 60 °C	0.17°C
AWS[2]	+/- 0.5°C	-55 to +125 °C	0.03 °C
CRN[3]	+/- 0.3 °C	-50 to +50 °C	0.01 °C
HCN[4]	+/- 0.54 °C	-50 to +50 °C	0.02°C/ for a single sensor/0.2°C for multiple sensor averages

[1] Campbell Scientific Instruction Manual, Model HMP45C Temperature and Relative Humidity Probe, revision 3/09.
[2] Weatherbug weather station Surface Observing System User's Guide, Rev. 4, July 2008.
[3] United States Climate Reference Network (USCRN) Functional Requirements Document, July 2007.
[4] Historical Climatology Network Modernization (HCN-M), Level-1 Requirements Document, Final, Version 1.12, January 22, 2009.

Relying on the manufacturer calibration, new Campbell Scientific HMP45C temperature sensors were installed at the three selected DCNet stations. AWS Weatherbug temperature probes are tested and calibrated at Weatherbug against a NIST-traceable PRT standard before installation. A review of AWS metadata indicated recent QA/QC temperature instrumentation checks ahead of the trial period. The DCNet CRN PRT's were calibrated against the designated NOAA CRN standard before installation for this trial.

3.0 Results

The present evaluation covers a roughly 8- month period between October, 2008 through May, 2009. For simplicity, only one station (AGU) will be detailed in this report; similar behavior was observed for the other two sites and summarized in the discussion. Figure 2 provides an example of the AGU measured temperature record for all three temperature sensors. A short segment of the above temperature record, as presented in Figure 3, illustrates the tracking between temperature probes. This time period was selected due to the large range in ambient temperatures. A quick look at the graph would suggest the largest differences between AWS and DCNet CRN observation occur at lower ambient temperatures.

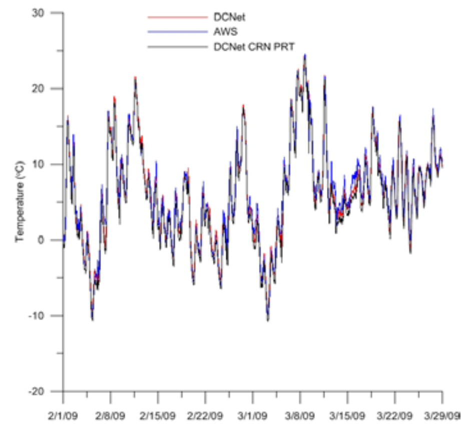

Figure 2 Example of temperature record.

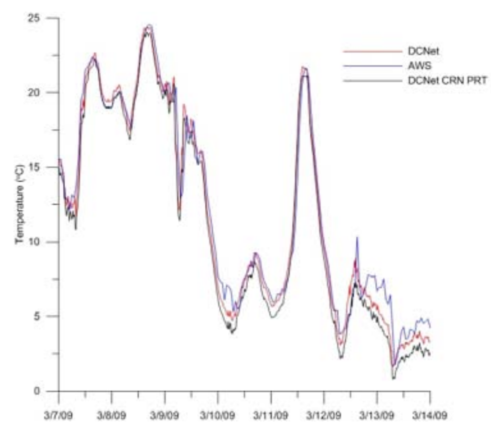

Figure 3 Expanded time period.

Figure 4 is a plot of three DCNet-CRN PRTs installed at the AGU site. PRT's 1 and 3 have been modified as indicated in the plot simply to provide an illustration of

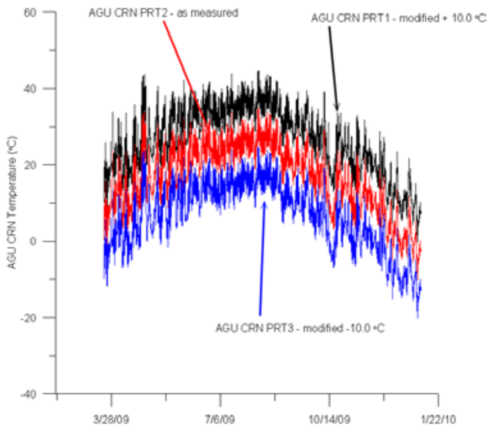

Figure 4 AGU DCNet CRN temperature observations

the accuracy in CRN temperature measurements (The mean difference between PRT1 and PRT2 is 0.06°C; the mean difference between PRT3 and PRT2 is -0.08°C).

There is, at times, considerable variability between the

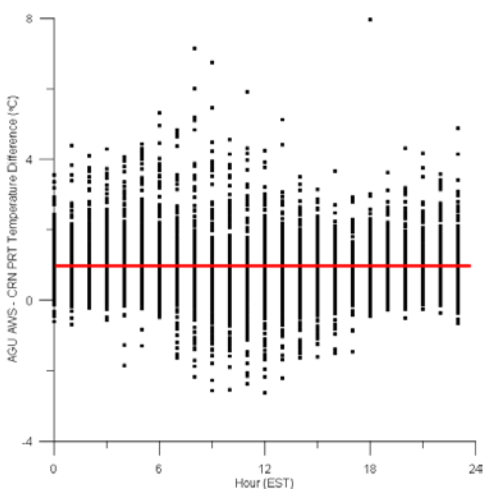

Figure 5 AGU AWS/CRN temperature difference

AWS and CRN temperature observations. This is illustrated in Figure 4. A plot of the AGU temperature difference (Figure 5) between the CRN PRT temperature and AWS measured temperature as a function of time would at first suggest over-prediction by the AWS probe by up to 4 degrees. However, the mean

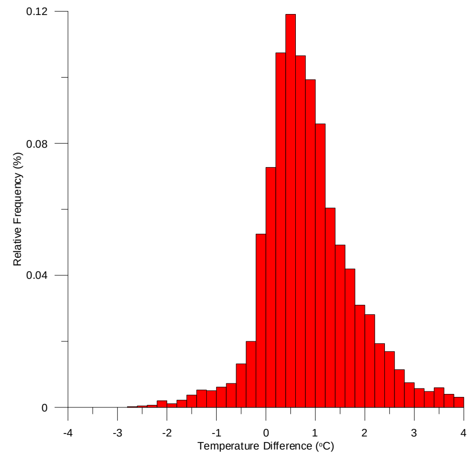

Figure 6 Histogram of AGU temperature bias

difference is approximately +0.9°C.

A histogram of temperature difference, Figure 6, suggests a possible calibration shift. Simply correcting for the mean suggests a fairly uniform distribution in the variance.

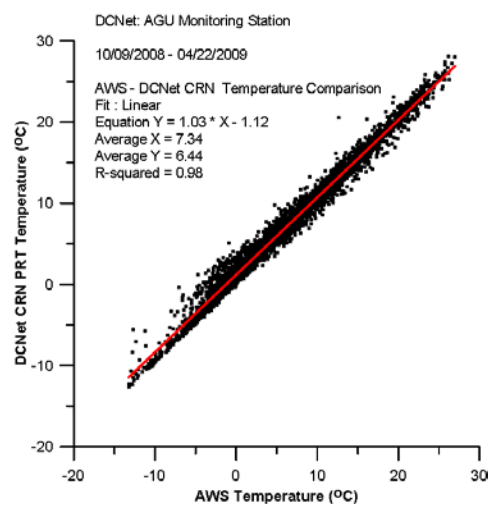

Figure 7 DCNet AGU monitoring station

4.0 Analysis

Figures 7,8, and 9 provide plots and analysis of AWS and DCNet CRN temperature measurements over the indicated trial period for stations

AGU, Howard, and NEA. Included in each plot is a linear fit for the data. Table 2 provides a summary of this analysis. It is interesting to note that the correlation between AWS and CRN temperature measurements is quite remarkable. In the three cases, R-squared is equal to 0.98 or above. As suggested in Figure 6,

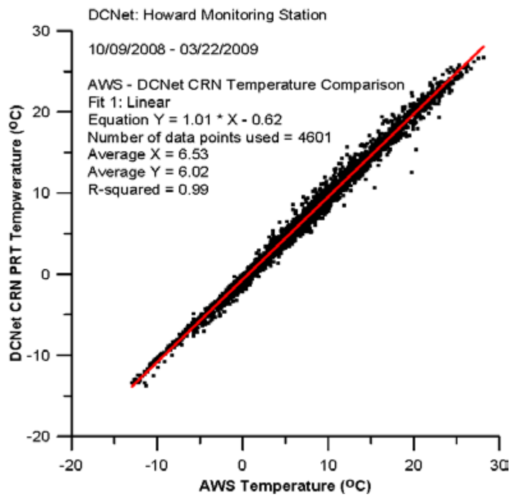

Figure 8 DCNet Howard monitoring station.

potentially part of the variability between measurements can be explained simply by calibration

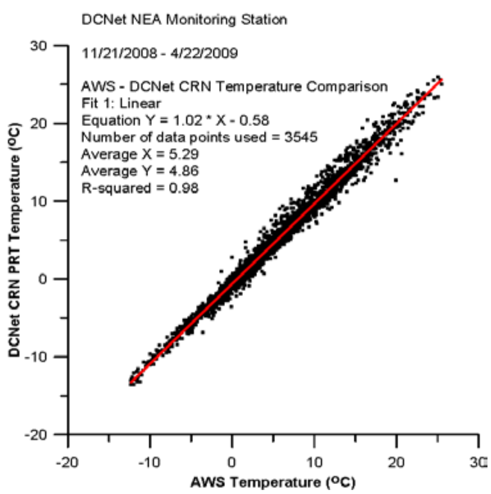

Figure 9 DCNet NEA monitoring station

issues - either differences in calibration standards of potential drift of AWS observation due to the time-in-field for the sensors. Variability can obviously be associated with aspirated versus non-aspirated temperature observations and response times. As shown in Table 2, the agreement between long-term averages is quite good. Difference between the long-term means is less than 1.0^{o}C and less than 0.5 ^{o}C for the NEA site. The closely spaced DCNet/ AWS observations provide an opportunity to define a spatial average for the central NCR urban region; the three DCNet stations fall within a 5.0 km^{2} grid. Using the three AWS observations provides a mean spatial difference of less than +0.25^{o}C.

Table 2 Analysis means/bias

Site	Mean s	(^{o}C)	Bias (^{o}C)
	AWS	DCNet -CRN	
AGU	7.34	6.44	+0.9
Howard	6.02	6.54	-0.51
NEA	5.29	4.86	+0.33

Table 3 provides a comparison of paired measured maximum and minimum temperatures for the three

Table 3 Maximum/Minimum observations

Site	Max (^{o}C)	Min (^{o}C)
	AWS/CRN	AWS/CRN
AGU	28.1/26.9	-12.6/-13.3
Howard	28.1/26.7	-12.9/-13.7
NEA	25.5/25.9	-12.3/-13.5

monitoring locations. The variation in the range of temperatures as measured by both temperature instruments at AGU would again suggest the need to account for a plausible calibration shift.

5.0 Conclusions

This study has focused on the performance of three co-located temperature measurement systems at three monitoring locations within the urban core Federal Triangle of the National Capital Region. For the study period, while there was considerable variability between paired temperature observations, the mean bias for the three monitoring stations ranged from +0.9^{o}C to -0.5 ^{o}C with correlation between AWS and DCNet CRN observations near 0.98. Distribution of the bias suggested potential calibration drift for the AWS systems as well as measurement sensitivities between aspirated and non-aspirated measurements.

6.0 References

Campbell Scientific Instruction Manual, Model HMP45C Temperature and Relative Humidity Probe, revision 3/09.

Weatherbug Weather Station Surface Observing System User's Guide, Rev. 4, July 2008.

United States Climate Reference Network (USCRN) Functional Requirements Document, July 2007.

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