6.3 The Feasability of Field Transformation Functions for Air Humidity Measurements

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1. INTRODUCTION

Water vapor is one of the most important variables in the atmosphere. Only accurate air humidity climate records will reveal the role of water vapor in long-term climate monitoring trends. However, current climate monitoring networks such as Automated Surface Observing System (ASOS); Automated Weather Station System (AWS); and the new U.S. Climate Reference Network (USCRN) are taking measurements from different air humidity sensors and corresponding shields : HO-1088 hygrothermometer in the ASOS and HMP45C in the AWS. We are investigating the candidate relative humidity (RH) sensors to aid in the selection of a RH sensor for the USCRN. Our field comparison observations are taken at two sites: Lincoln, Nebraska and Baton Rouge, Louisiana starting from March of 2002.

A number of studies have shown that capacitive RH sensors exhibited ambient air temperature dependency bias and ambient RH bias For example, Andreas et al, 2001 in the SHEBA study and Dery and Stieglitz, 2000 in the Canadian Arctic locations. They attempted to illustrate that RH sensors are most likely to encounter 100% relative humidity with respect to ice (RH_i) which suggests that RH measurements should be corrected or adjusted for more accurate climate records under such conditions. Previous studies (Anderson, 1994 and 1996; Fleming 1998) developed RH correction models for specific RH sensors. It should be noted that both Anderson and Fleming focused on specific RH sensors but current RH sensors used in the climate networks above are relatively new and were not included in previous studies. In addition, it is known that there are derived biases either from dew point temperature toward the RH (Appleman, 1963, Hubbard et al, 2002) or from RH toward the dew point temperature (Gates, 1994 and Hubbard et al, 2002). Considering the above RH related issues, we set up a parallel intercomparison experiment at Lincoln, Nebraska and Baton Rouge, Louisiana to investigate the feasability of field transformation functions for air humidity measurements. The objective of this study is to develop transfer functions for RH measurements among the ASOS, AWS, and USCRN networks. To accomplish this objective, we investigate the air temperature, air humidity, and air pressure dependencies of each RH/dew point temperature bias based on our field observations.

2. DATA AND METHODS

An array of capacitive RH sensors were included in this study. They are two HMP45C inside the non aspirated shields, two HMP45C, two HMP233, and two MP101A sensors inside the USCRN aspirated shields. Two ASOS hygrothermometers (Technical Services Laboratory Inc) were installed at the site with their own shields. A DewTrack 200M Meteorological Humidity System (EdgeTech Inc) was selected as a reference for both RH and dew point temperatures. The accuracy of the DewTrack 200M is ± 0.25°C dew point temperature and ±1.0 to 1.5% relative humidity. All RH sensors, ASOS, DewTrack 200M, and three USCRN temperature sensors as well as air pressure, solar radiation, wind speed, and ground surface temperature were measured by a CR7 datalogger (Campbell Scientific. Inc.) for analog output sensors and a PC for digital output sensors at the height of 1.5 meters. The 1.5 meter height refers to air intake height for aspirated sensors and the sensor height for non aspirated shields.

All measurement sampling rates were 5 seconds with one minute average outputs. Testing and startup data were excluded and the available data were taken from June 1st, 2002 to present.

The data collected from field observations could provide a wide range of ambient air temperature, RH, and air pressure as well as the solar radiation and wind speed. Therefore, a possible general RH transformation/correction function is suggested as,

$$Y = f(T_a, RH, P, SR, WS \ldots.)$$

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Where Y is the bias of each RH/dew point sensor; f represents a function relationship; and T_a ambient air temperature, RH relative humidity, P air pressure, SR solar radiation, and WS wind speed.

3. PRELIMINARY RESULTS AND DISCUSSION

Research so far has focused on the evaluation of microclimate factors effecting RH biases and dew point biases during summer time. Forthcoming data during winter time will further enhance the range of microclimate factors and make observation data more sufficient to explore the transformation functions for the RH and dew point measurements. Preliminary results, based on observations of two sites, show that the RH bias did vary slightly with the changes of ambient air temperature and ambient air pressure (Fig. 1) at Lincoln site. Figure 2 illustrates that the dew point temperature bias linearly decreased with increases of solar radiation but not for air pressure. Similarly, observations in July at Lincoln site showed that increasing ambient air pressure increased the RH biases of all RH sensors (Fig.3). It is interesting that that the RH bias was much more dependent of the surface ground temperature and RH conditions at Baton Rouge site (Fig. 4). The RH bias for both HMP45 used in AWS and MP101A linearly increased with increases of ground surface temperatures. However, the RH bias for both type sensors decreased with increasing of RH.

The field comparison study presented in this paper is very preliminary, and deserves more extensive work including possible laboratory study on possible lower temperature conditions which may not be achieved at our experimental sites. Further results will be forthcoming with the increasing observations at both sites.

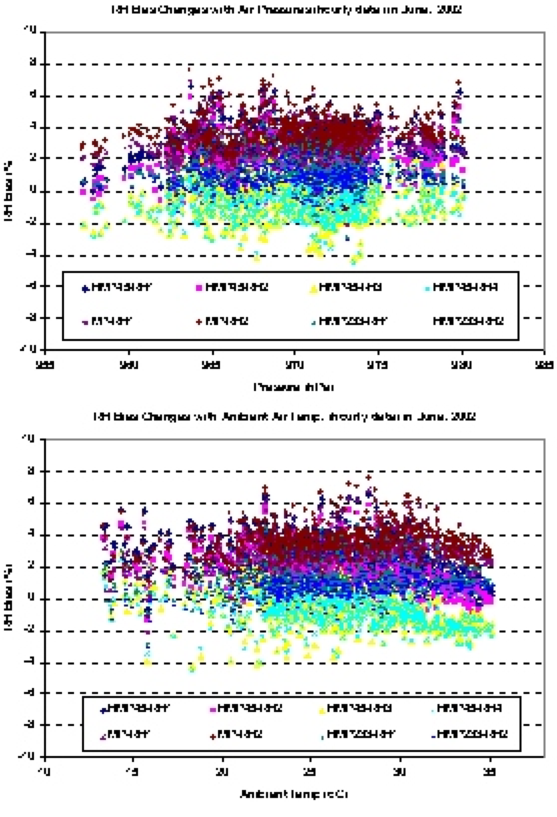

Fig.1. RH bias changes with ambient air pressure and air temperature in June, 2002 at Lincoln site.

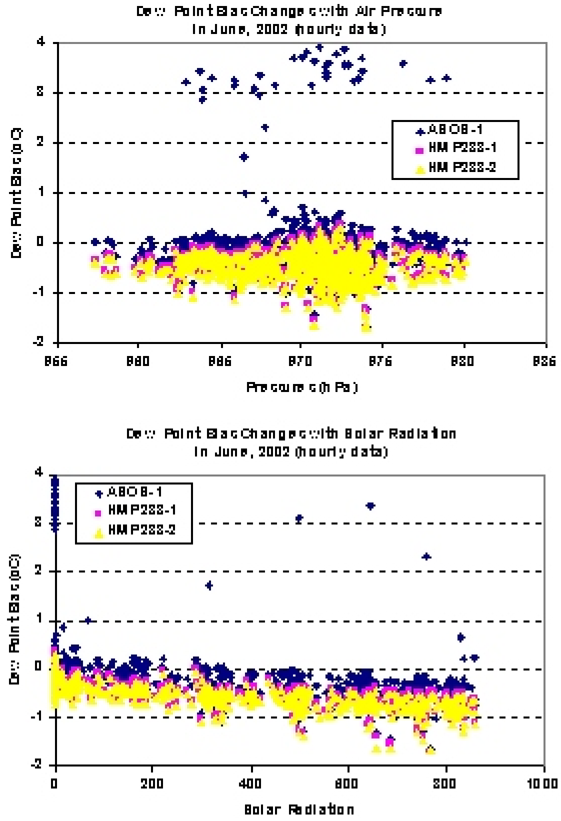

Fig. 2. Dew point bias changes with ambient air pressure and solar radiation in June, 2002 at Lincoln site.

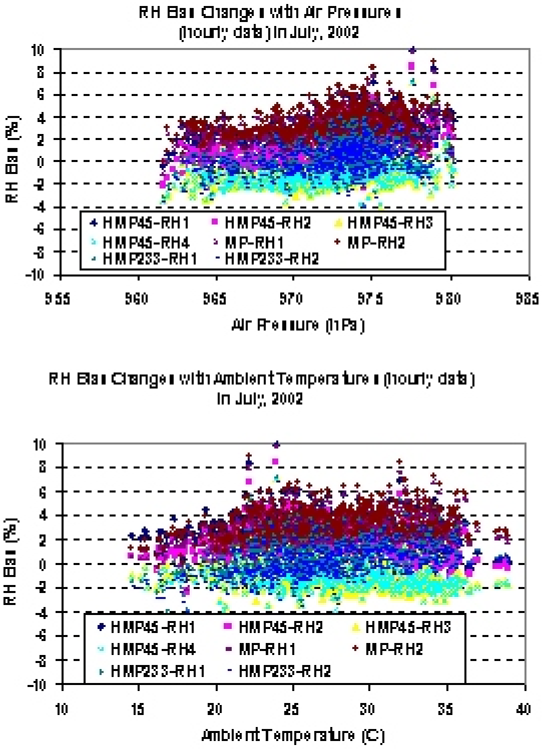

Fig.3. RH bias changes with ambient air temperature and air pressure in July, 2002 at Lincoln site.

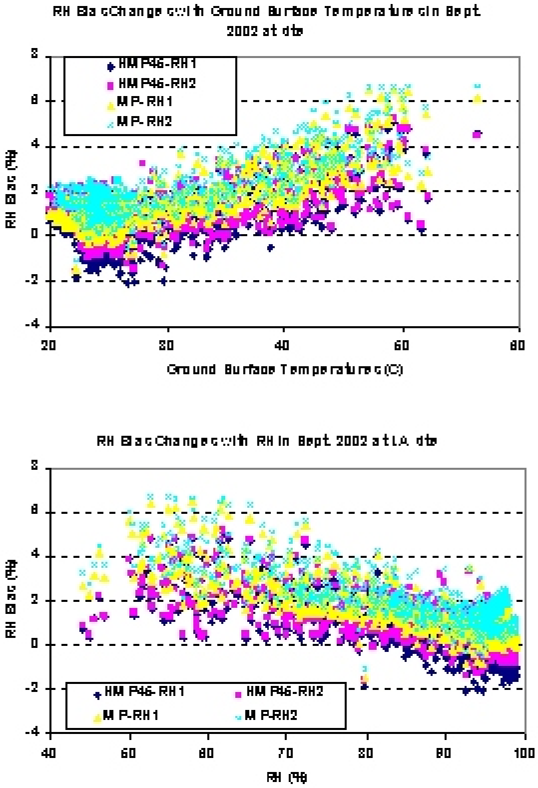

Fig. 4. RH bias changes with the ground surface temperature and RH in September, 2002 at Baton Rouge site.

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