4.2 Comparison of ASOS Dew Point Temperatures: HO-1088 and DTS1

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1. INTRODUCTION

The National Weather Service (NWS) ASOS HO-1088 chilled mirror dew point sensor has taken observations for ten years, but mainly due to its high maintenance costs a new version of ASOS solid-state dew point sensor was recently deployed. The replacement of ASOS HO-1088 dew point temperature sensor (Technical Services Laboratory, Inc) with ASOS DTS1 (Vaisala, Finland) in the NWS ASOS network and concern for homogenous temporal climate records prompted this comparison study. Recently the U.S. Reference Climate Network (USCRN) program required to seek a candidate of air humidity sensor for monitoring the relative humidity (RH) or dew point temperature (DP). With recent development of the solid-state dew point temperature device, the Vaisala provided a few solid-state dew point temperature sensors which are microprocessor based sensors by firstly measuring the relative humidity (RH) then calculating dew point temperature as the sensor's output. Therefore, in ASOS networks, changing instruments or sensors for air humidity with time could produce data inhomegeneity. Also, correctly selecting or determining RH instruments or sensors is critical for acquiring a long term high quality climate records in the USCRN.

In our study, the objective is to investigate the dew point temperature differences over long term field observations among different dew point temperature sensors. To accomplish this objective it is important to make intercomparison among sensors including two ASOS 1088 chilled mirror hygrometers; two new ASOS DTS1 dew point temperature sensors; two HMP243 dew point sensors, and two HMP233 sensors.

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2. EXPERIMENTAL MEASUREMENTS

The experimental measurements in the field were conducted from May to October 2003 at the University of Nebraska's Horticulture Experiment Site (40^{o}83' N, 96^{o}67' W). Two HMP233 (Vaisala, Finland) sensors were installed inside the USCRN radiation shields. Both ASOS 1088 and ASOS DTS1 have their own radiation shields. One HMP243 (243 1) (Vaisala, Finland) sensor was installed similar to the ASOS DTS1 sensor with the same non aspirated shield, and the other HMP243 (243 2) sensor was installed in the USCRN shield. During observations, two USCRN air temperature sensors combined with two USCRN air temperature radiation shields were used in this study as an air temperature reference at site. The experimental measurements also include measurements of solar radiation and ambient wind speed. Two ASOS DTS1 and one HMP243 sensors were installed at a height of 1.5 m, which means that the installation height refers to the sensor height. However, the installation height for the aspirated dew point sensors refers to the air uptake height (or sampling air height) including two HMP233, one HMP243, and two ASOS 1088. In addition, we simultaneously took measurements for the solar radiation and ambient wind speed at site. All Vaisala's dew point sensors in this study were re-calibrated and implemented a polynomial calibration equation for each of dew point sensor. The calibration was conducted using a two-pressure humidity generator (Model 2500 Humidity Generator, NIST traceable, Thunder Scientific. Co.) under different testing temperatures. The ASOS 1088 calibration was regularly conducted within every three months.

All sampling rates were 5 seconds with one minute average outputs. Data were available for 3494 hours during observations. Any hourly data was eliminated when one or more of the sensors was malfunctioning or maintenance was being performed. In this study, all dew point temperature measurements were compared to the chilled mirror ASOS 1088 sensor using hourly average data.

3. PRELIMINARY RESULTS AND DISCUSSION

a. Normalized frequency distributions of

dew point temperature differences: The distribution of dew point temperature differences are shown in Fig. 1. We found the HMP233 sensors had a highest peak value which suggests that the HMP233 sensor has highest precision relative to the ASOS 1088 sensor. Both ASOS DTS1 and HMP243 sensors had similar normalized frequency distributions (Fig. 1). The non aspirated HMP243 (243 1) performed slightly worse than the aspirated HMP243. It should be noted that the HMP243 sensor was the original module of developing the ASOS DTS1 dew point sensor. On average, the dew point temperature difference/bias compared to the ASOS 1088 were within ± 0.5 ^{o}C. Monthly average and monthly standard deviation were summarized in Table 1. From monthly average of dew point temperature differences (Table 1), all solid-stated dew point sensors performed within around ± 0.2 ^{o}C.

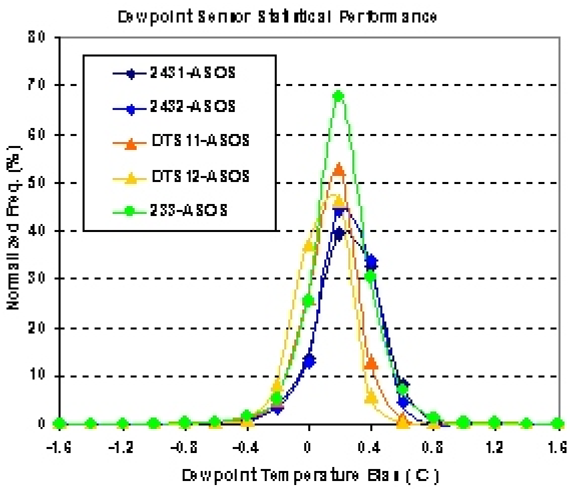

Fig. 1. Distributions of dew point (DP) temperature difference relative to the ASOS 1088 over all observations.

b. Variations of dew point temperature difference: Since HMP233, HMP243, and DTS1 sensors indirectly measured the dew point temperatures, the ambient temperature might affect the measurement of relative humidity. Thus, the ambient temperature likely affects the dew point temperature observations. Figure 2. shows the ambient temperature effects on the dew point temperature differences. Although the ambient temperature ranges were restricted due to available data collected in summer and fall time observations, it seems that higher or lower ambient temperature decreased the dew point temperature differences

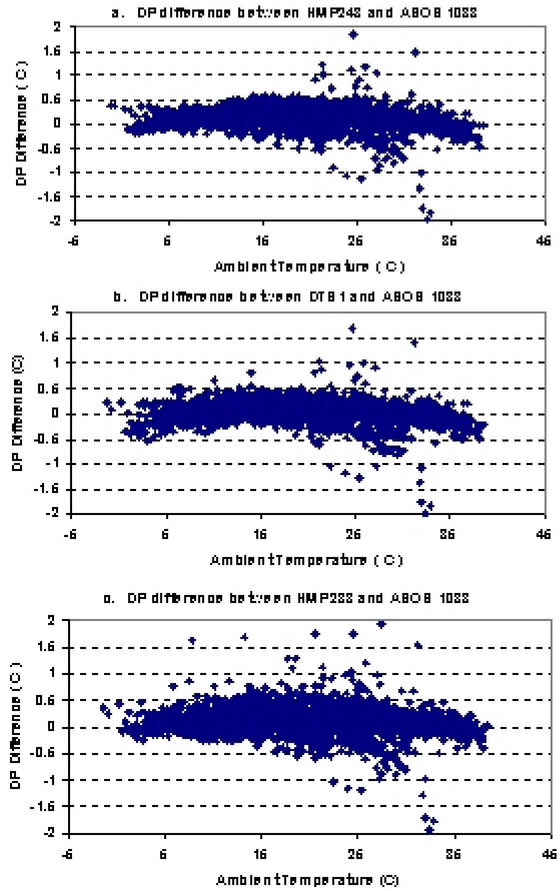

Fig. 2. Variations of the dew point temperature difference with changes of ambient temperatures.

(Figs 2a, 2b, and 2c). Currently we can not state any specific magnitudes of variations in current stage. Only with increases of observations and ambient temperature ranges the ambient temperature effects will be able to be unveiled.

Figure 3 illustrates the dew point depression effects on the dew point temperature differences or biases. The dew point depression is the difference between the ambient air temperature and dew point temperature. It is interesting that three solid-state dew point temperature performed in the same way: the increases of dew point depression decreased the dew point temperature differences or biases (Fig. 3). This result suggests that it is possible for us to correct such variations. The maximum magnitude of variations reached 0.5 ^{o}C differences when the dew point depression was larger than 20 ^{o}C. The difference under higher DPD conditions reflects the uncertainties of derived dew point temperature outputs (Lin and Hubbard 2003). Since the variations of dew point temperature difference in Fig. 3 was clearly trended, a possible correction model for this variation could be developed with further investigation.

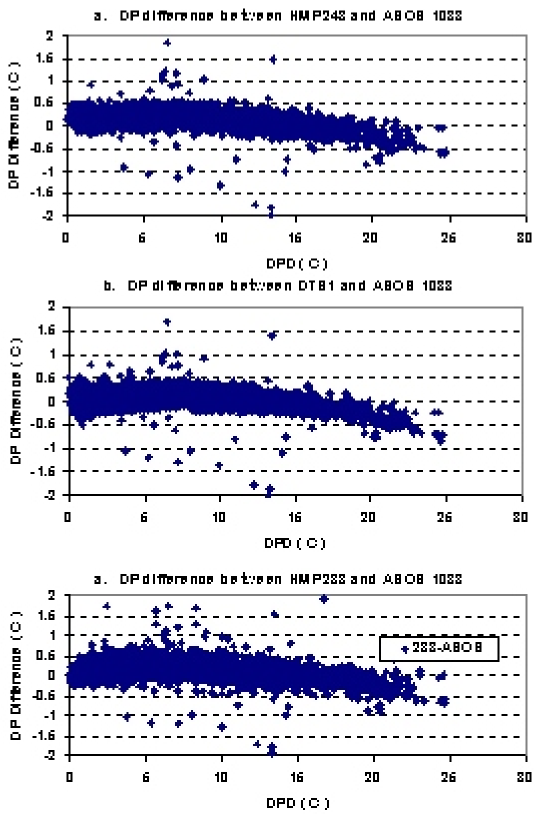

Fig. 3. Dew point depression (DPD) effects on the dew point temperature differences/biases for aspirated HMP243 (243 2), ASOS DTS1, and HMP233 sensors.

Table 1, Monthly dew point temperature differences from May to October 2003. The unit is ^{o}C for all numbers except hours column.

		2431-ASOS		2432-ASOS		DTS11-ASOS		DTS12-ASOS		233-ASOS	
	Hours	AVE	STD	AVE	STD	AVE	STD	AVE	STD	AVE	STD
May-03	568	0.3	0.2	0.2	0.2	0.1	0.2	0.0	0.2	0.1	0.2
Jun-03	465	0.3	0.2	0.3	0.1	0.2	0.1	0.1	0.1	0.3	0.2
Jul-03	589	0.1	0.2	0.1	0.2	0.0	0.2	0.0	0.2	0.1	0.2
Aug-03	586	0.1	0.2	0.2	0.2	0.0	0.2	0.0	0.2	0.1	0.2
Sep-03	678	0.2	0.2	0.2	0.2	0.1	0.1	0.0	0.1	0.1	0.2
Oct-03	608	0.1	0.2	0.0	0.2	-0.1	0.2	-0.1	0.2	0.0	0.2

4. REFERENCES

Lin, X. and K. G. Hubbard, 2003: Uncertainties of derived dew point temperatures and relative humidity. J. Applied Meteorology.(submitted)