3.4 COMPARISON OF 10-YEAR (1996-2005) OPERATIONALRADIOSONDE DATA WITH ARM RADIOSONDE AND REMOTE SENSING DATA

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I. Abstract

Assessing the accuracy and precision of radiosonde data has historically been a challenge due to changes in instrumentation, temporal and spatial differences in datasets, and a general lack in transfer standards. This paper will examine the quality of 10-year (1996-2005) operational radiosonde data from two U.S. National Weather Service (NWS) stations (Norman, Oklahoma and Barrow, Alaska) by comparing them with research-quality radiosonde data collected by the Atmospheric Radiation Measurement (ARM) programs located in Purcell, Oklahoma and Barrow, Alaska. For the radiosonde comparisons in Oklahoma, four different types of radiosonde, VIZ-B, VIZ-B2, RS80-H and RS90 were launched by the two sites between 1996 and 2002. These soundings were matched into 490 pairs, launched within a half-hour of each other. The comparisons show both known and unknown errors in the radiosonde data.]

Similar comparisons were made between samples of matched soundings in Barrow, to see if similar results could be obtained. Future research will include matching and analyzing all available sounding pairs in Alaska and comparing them with microwave radiometer data in order to gauge the performance of the radiosonde sensors. The Barrow sites were chosen because of their proximity, the availability of long term datasets spanning eight years (1998-2005), and the climate in Barrow allows for the comparison of different radiosonde types in a cold environment, where sensors typically do not perform as well.

II. Introduction

Evaluating radiosonde performance and data quality can be challenging for a number of reasons. Changes in instrumentation and temporal and spatial differences in datasets are among some obstacles encountered when attempting to assess radiosonde data quality. Additionally, a scarcity of neighboring radiosonde stations where long term datasets have been collected make these type of comparison studies difficult. This paper will examine the quality of 10-year (1996-2005) operational radiosonde data from two U.S. NWS stations (Norman, Oklahoma and Barrow, Alaska) by comparing them with research-quality radiosonde data collected by the ARM program located in Purcell, Oklahoma and Barrow, Alaska. Previous research (Wang and Young, 2005) examined comparisons made between four different types of radiosondes launched from NWS and ARM sites in Oklahoma between 1996 and 2002. This paper will first highlight the findings from that earlier research, and will then look at a sample of soundings launch from Barrow to see if similar results are obtained.

Future research will include examining all temporally matched radiosondes launched from neighboring sites in Barrow between 1998 and 2005. Additionally, comparisons between different radiosonde types and microwave radiometer data will be performed in order to gauge the performance of the radiosonde sensors in a cold environment, where sensors typically do not perform as well.

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III. Comparisons from Oklahoma

Soundings launched over a 7-year period (1994-2002) from neighboring stations, 25 km apart, in Oklahoma and were temporally matched into 593 pairs launched within a half-hour of each other. The sites are located in Norman (97.4^{o}W, 35.2^{o}N, 357m) and Purcell (97.42^{o}W, 34.97^{o}N, 344m) and are operated by the NWS and the ARM program, respectively. The paired soundings formed four types of inter-comparisons, VIZ-B vs. RS80-H, VIZ-B2 vs RS80-H, Rs80-H vs RS80-H, and RS80-H vs RS90. The soundings were first visually examined to ensure that the radiosondes sampled approximately the same air masses and based on that examination, the number of sample pairs was reduced to 490.

Figure 1 shows frequency distributions of temperature differences between varying radiosonde types launched from Norman and Purcell. Differences between the VIZ-B and RS-80H, showed that for temperature, there was good agreement near the surface, with standard deviations near ~0.6^{o}C, but the VIZ radiosondes become warmer aloft, with standard deviations increasing to approximately ~1.4^{o}C above 12 km. Temperature comparisons between the VIZ-B2 and RS80-H yielded similar results, however a cold night time bias in the upper troposphere (UT) occurred and has been attributed to no radiation correction having been applied to the VIZ soundings. Also, a warm bias caused by solar heating seen during the day was observed. Relative humidity comparisons (Figure 2) between VIZ and Vaisala radiosondes showed large differences attributed to both a lack of response of the VIZ carbon hygristors (Wang et al., 2003), and a dry bias previously identified in the RS80-H sondes (Wang et al., 2002).

When comparisons were made between RS80-H soundings, the NWS soundings at Norman showed systematically colder temperatures (~.2-.5°C) in the middle and upper troposphere. The difference was found to be caused by a coding error in the Vaisala radiation correction scheme that introduced a cold bias into the data. This same cold bias was evident in comparisons made between the RS80-H and RS90 radiosondes. Relative humidity comparisons between the RS80-H radiosondes showed excellent agreement, but for unknown reasons the RS90 radiosondes were considerably drier (5%) in the UT than were the RS80-H.

IV. Comparisons from Alaska

The Barrow sites were chosen because of their proximity and the availability of long term datasets spanning eight years. Additionally, the tendency of radiosondes to behave less reliably in cold environments makes Barrow an ideal location for a comparison study.

The ARM facility (71.32° N, 156.62°W) is located approximately 6 km away from the NWS station (71.3° N, 156.78°W). The NWS launches VIZ-B2 radiosondes while at the ARM facility, RS80-H were launched between 1998 and April 2002 and RS90 were used between May 2002 and July 2006. During an eight year period, spanning 1998-2005, the NWS launched 5751 radiosondes and ARM launched 2380 (Figure 3). Of those, 45 pairs of soundings, matched to within 3 hours of each other, were identified. However, further examination is needed to determine if these pairs sampled the same air masses. Two sets of sounding pairs were chosen for initial comparison of the VIZ-B2 and RS80-H temperature and RH sensors (Figure 4). The first pair, launched May 31, 1998 show very good agreement of temperature, but relative humidity comparisons seem to indicate a possible dry bias associated with the RS80-H sonde. This example also shows that the VIZ carbon hygristor stopped responding to humidity changes at temperatures colder than ~-40°C, which is consistent with the Norman comparisons (Wang and Young, 2005). A second pair, collected on March 06, 2001 was also examined (Figure 4). The temperature profiles agree well however, for RH, the VIZ sonde is slightly drier below 5 km, but becomes more moist above that height.

In comparing the VIZ-B2 and RS90 radiosondes, again a sample of two matched pairs was chosen for examination (Figure 5). The temperature profiles all show very good agreement. The RH comparison on October 15, 2004 shows the RS90 radiosonde is significantly drier than the VIZ sonde, with differences as high as ~30%. The larger RH of the VIZ sensor, at 2-3 km, is possibly due to the slower response of VIZ humidity sensor. However, in contrast, the soundings from July 13, 2005 show no such differences, with excellent agreement below 7km. Both of these profile comparisons do show an increasing difference in RH in the UT, likely a result of lack of response of the VIZ sensors in a cold environment.

V. Conclusions

Results from Oklahoma identified both known and unknown errors in the radiosonde data. The comparisons confirmed errors caused by radiation, cold bias, and lack of response of the VIZ RH sensor, and also brought to light that RS90 are significantly drier than the RS80-H radiosondes. Comparisons made in Barrow between the RS80-H and VIZ-B2 radiosondes and the RS90 and VIZ-B2 may indicate a systematic dry bias of the RS80-H and RS90 radiosondes, as was described in Oklahoma however, given the variability and small sample sizes these results are inconclusive and further evaluation of additional sounding pairs needs to be made. Future plans include comparing additional radiosonde pairs collected in Barrow, and also comparing those soundings with microwave radiometer data to further evaluate the performance of both temperature and RH sensors on different radiosonde types.

VI. References

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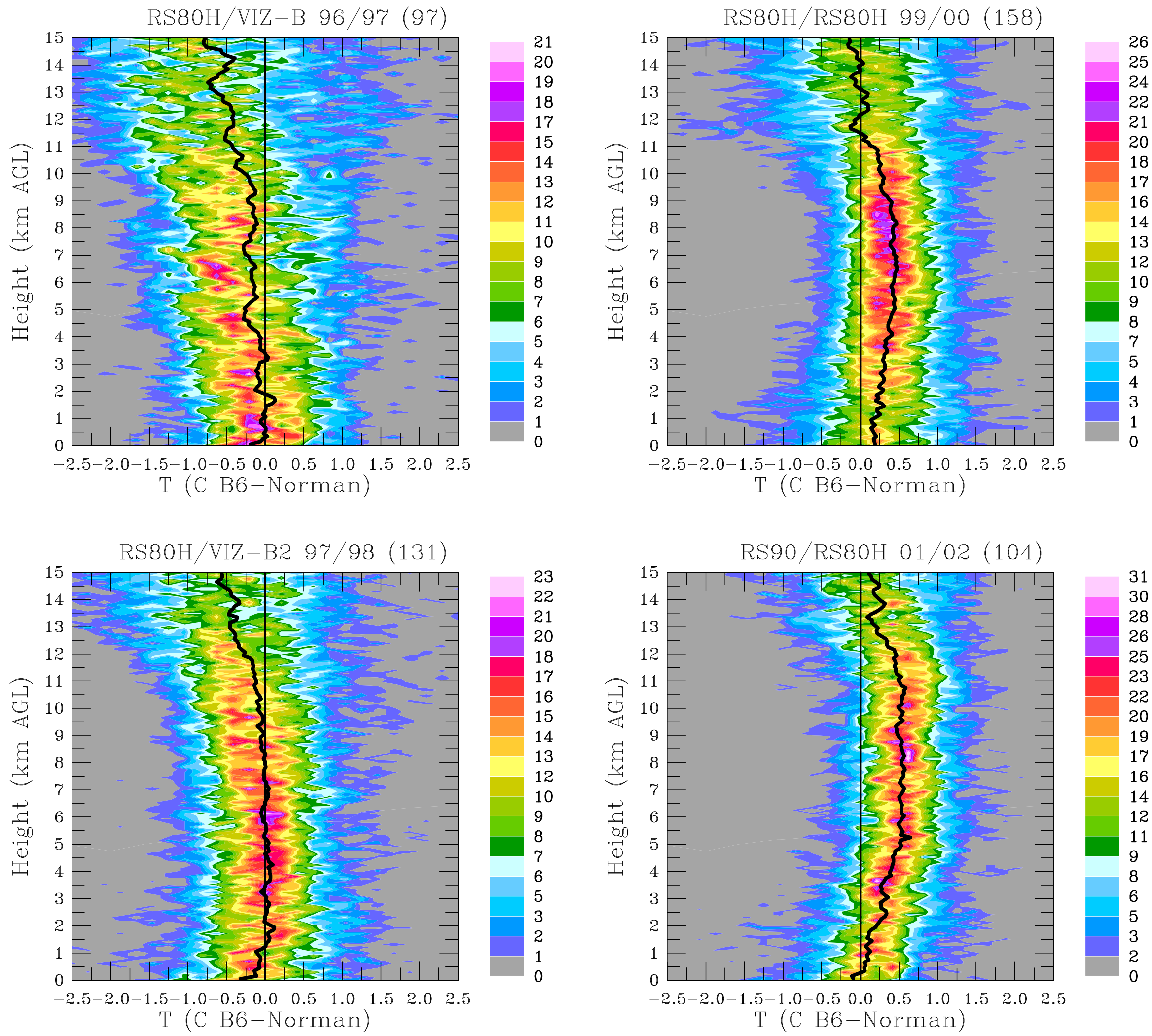

Figure 1.Frequency distributions of temperature differences (ARM-B6 - Norman) as a function of heights (km AGL). The frequency is calculated in 0.2°C and 1 km intervals and sums up to 100% for each 1 km layer. The thick solid black lines are mean difference profiles. The sonde types used at ARM-B6 and Norman are given in the titles and are separated by "/". Years of data and number of matched pairs are also given in the titles.

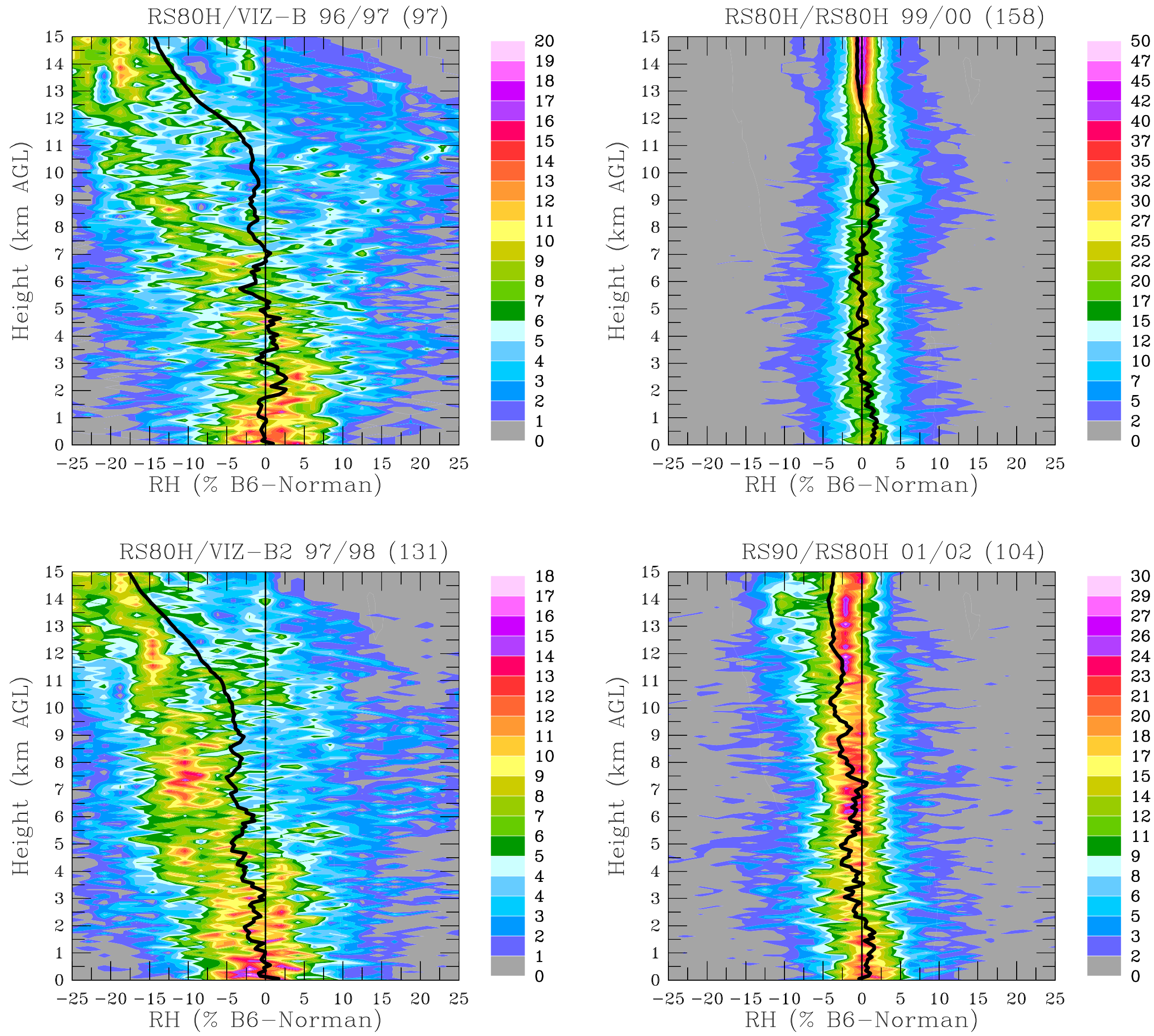

Figure 2 Frequency distributions of RH differences (ARM-B6 - Norman) as a function of heights (km AGL). The frequency is calculated in 2.5% and 1 km intervals and sums up to 100% for each 1 km layer. The thick solid black lines are mean difference profiles. The sonde types used at ARM-B6 and Norman are given in the titles and are separated by "/". Years of data and number of matched pairs are also given in the titles

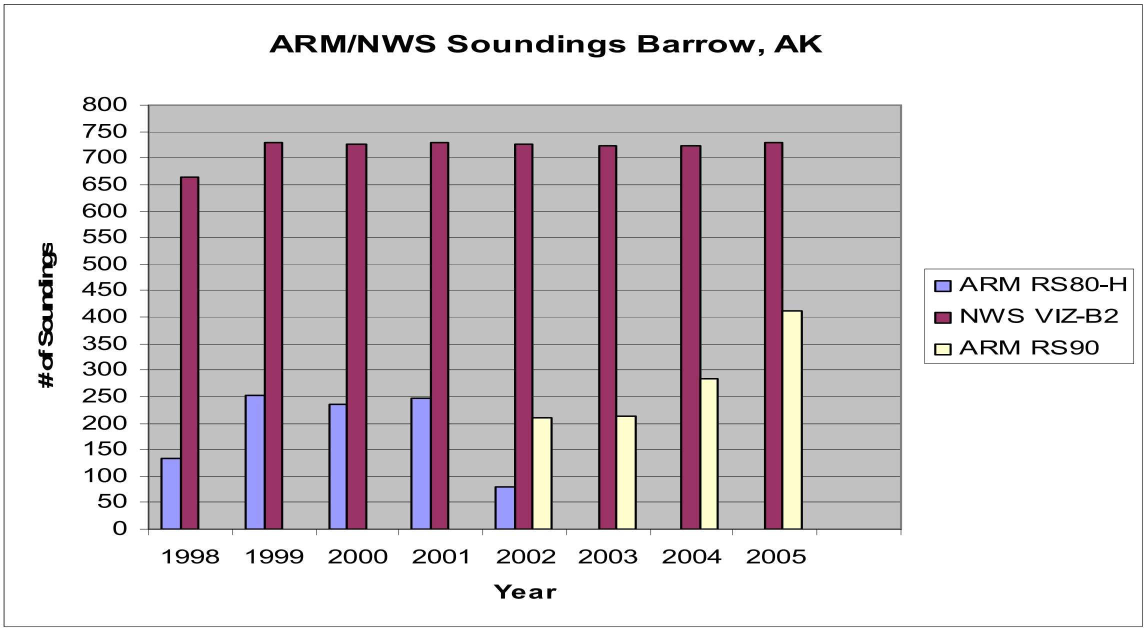

Figure 3 Total number of soundings launched between the NWS and ARM facilities between 1998 and 2005. Radiosonde types are differentiated by color.

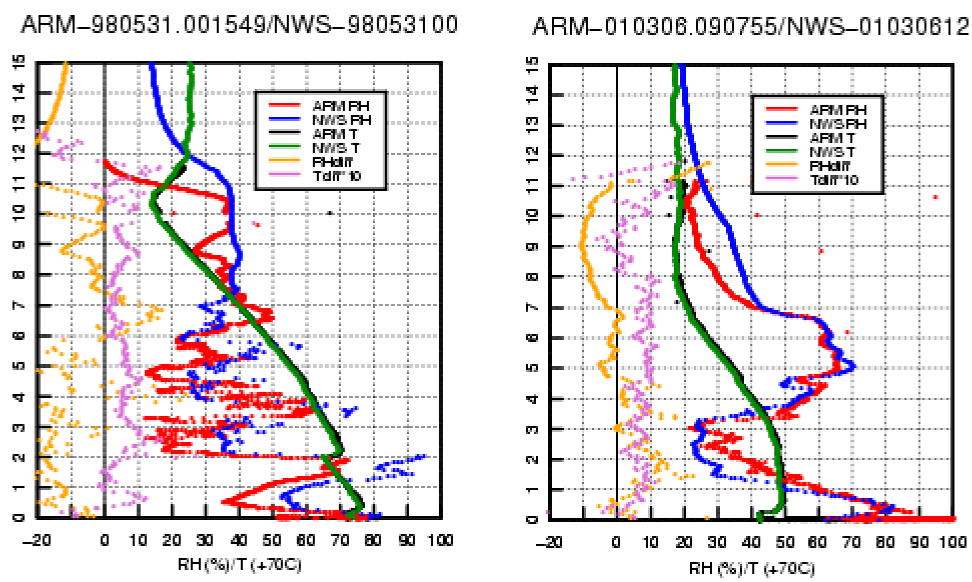

Figure 4. Profiles of NWS VIZ-B2 and ARM RS80-H soundings matched within three hours. Black lines indicate RS80-H temperature profiles, green line show temperature from the VIZ radiosondes. Relative Humidity profiles from RS80-H are shown in red and VIZ are shown in blue. Differences calculated between the temperature profiles, multiplied by 10, are shown in pink. RH differences are shown in orange.

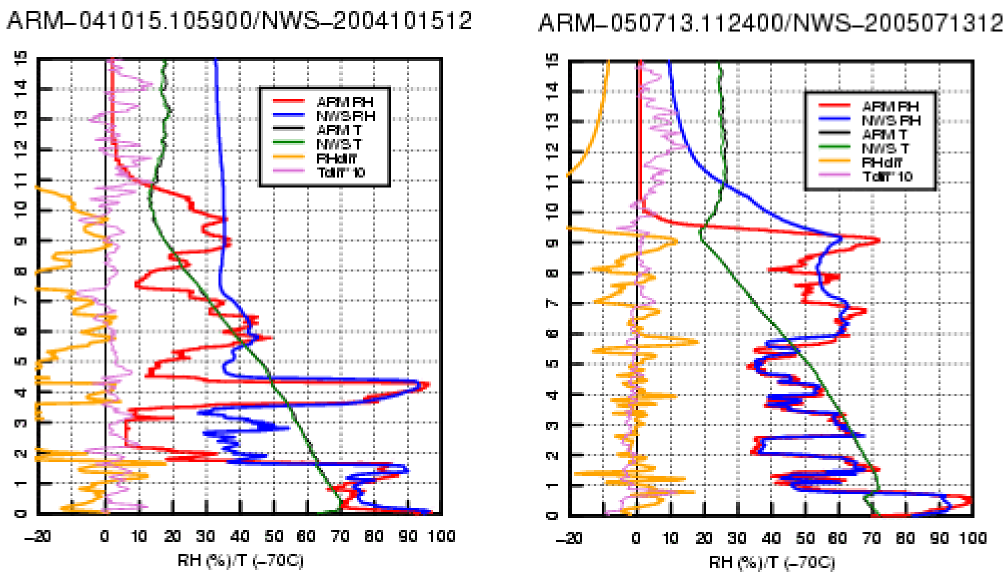

Figure 5. Profiles of NWS VIZ-B2 and ARM RS90 soundings matched within three hours. Black lines indicate RS90 temperature profiles, green line show temperature from the VIZ radiosondes. Relative Humidity profiles from RS90 are shown in red and VIZ are shown in blue. Differences calculated between the temperature profiles, multiplied by 10, are shown in pink. RH differences are shown in orange.