P1.2 THE IMPORTANCE OF RECORDING PRE-LAUNCH RADIOSONDE DATA

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1. Introduction

Collecting high quality, accurate radiosonde data from the field is of significant importance for a number of reasons. Globally, there are roughly 900 operational radiosonde stations and about fourteen different radiosonde types in use. Global radiosonde data are required by meteorological analysis centers for initializing numerical prediction models for forecasting. They represent an increasingly valuable resource for studies of climate change and in the development, calibration and validation of retrieval techniques for atmospheric temperature and water vapor profiles from satellites.

The best way to ensure precision of radiosonde data measurements is to have both high quality surface reference, and radiosonde pre-launch data available for comparison. Unlike many other sounding systems in use, ATD's GPS, Loran Atmospheric Sounding System (GLASS) is among a few radiosonde systems which collect, and integrate the pre-launch radiosonde data into the sounding file. The practice of collecting surface meteorological (surface met) data has been in use by the National Center for Atmospheric Research's (NCAR's) Atmospheric Technology Division (ATD) since their launching of balloon borne radiosondes began. The data is collected by several independent sensors and is then integrated into the radiosonde data where it can either be used as a reference in determining the accuracy of pre-launch surface radiosonde data, or in some cases it reveals errors in the surface met data. Comparison between the data sets has helped us to identify problems such as sensor arm heating, humidity sensor contamination, and relative humidity bias errors. In this paper we will (1) briefly describe the instruments used to collect data in the field, (2) describe the errors found by comparing surface met and pre-launch radiosonde data, (3) explain current methods, and future plans for correcting such errors.

2. Instrumentation and Data Collection

The sounding system currently used by ATD is a standard GLASS that typically uses Vaisala RS-80 GH sondes. The GLASS system has been deployed in approximately 30 field experiments since 1998 and for each of those experiments, radiosonde pre-launch data were collected. Prior to launch, the sonde sensors are ventilated by a fan pulling ambient air across the sensor arm or, by natural wind. Every attempt is made to shield the sonde sensors from direct sunlight, as they are susceptible to solar heating. These measures help ensure the collection of accurate, high quality data.

Collection of surface met data is done by several independent sensors that measure temperature, humidity, pressure, wind velocity, and wind direction. These are connected to a Campbell CR-10 data logger. The temperature and humidity sensors are aspirated by a fan pulling ambient air across the sensor and the sensor is also protected with a radiation shield. The temperature sensors accuracy is +/- 0.4 degrees C over the range of -33 to +48 degrees. The accuracy of the humidity sensor against field references is approximately +/- 2% with long term stability of better than 1% RH per year (Chamberlain, 2000).

3. Results

Data quality control, after completion of a project, is a three step process which includes: (1) running the data through Atmospheric Sounding Processing Environment (ASPEN), (2) visually evaluating the data by observing skew-t diagrams, and (3) comparing the pre-launch PTU radiosonde data with the surface data to check for problems that may have gone undetected by the first two quality control procedures. We began to pay more attention to the third quality control step this year and it has helped us to identify several problems

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associated with pre-launch data, and/or surface met data. These are described below. Table 1 lists a few of the projects in which comparison of surface met and pre-launch radiosonde data revealed significant errors in the data.

Table 1 – Projects conducted by ATD where data errors became apparent.

Project	Year	Location	Errors Found
TOGA COARE	1992 - 1993	Western Pacific	SAH/ Sensor Contamination
INDOEX	1999	Sagar Kenya	SAH/ Sensor Contamination
STEPS	2001	Eastern Colorado	Surface Met Sensor Heating
ISPA02	2002	Steamboat Springs, CO	SAH
IHOP	2002	Kansas/ Oklahoma	SAH

3.1 Sensor Arm Heating Error

To some degree sensor arm heating is present in almost all data sets. It occurs when the temperature and humidity sensors on the sonde sensor boom absorb heat from exposure to sunlight, and/or lack proper ventilation. SAH negatively affects radiosonde measurements in two ways: a warm bias appears in the temperature measurement, and a dry bias appears in the RH measurement. The dry bias occurs because the humidity sensor gives a reading of the humidity relative to the temperature of the sensor surface itself. In a situation where the sensor surface is warmer than the surroundings, the humidity reading will be lower than ambient (Chamberlain, 2000). IHOP 2002 data show SAH errors very clearly (Fig.1). The pre-launch data are drier than the surface by more than 5% during the day, and the mean RH difference is 3.34%. SAH errors appear to correspond with warmer temperatures, increase with the solar angle, and reach their maximum around noon time when shielding the sonde from direct sunlight is more difficult.

The SAH effect on the RH measurement diminishes as ventilation occurs with the ascension of the sonde after launch. It typically takes about 40-60 seconds to reach equilibrium with the environment. Fortunately, due to the thermal mass of the temperature sensor, the effect of SAH is short lived, and the sensor equilibrates shortly after launch (~2 s). Figure 2 shows a sounding from the project INDOEX that contains SAH errors. The prelaunch data are warmer than the surface data by 2.3^{o}C but drier by 11%. The temperature recovers approximately 10 seconds after launch where as the recovery time of the humidity sensor is longer but consistent with it's time constant.

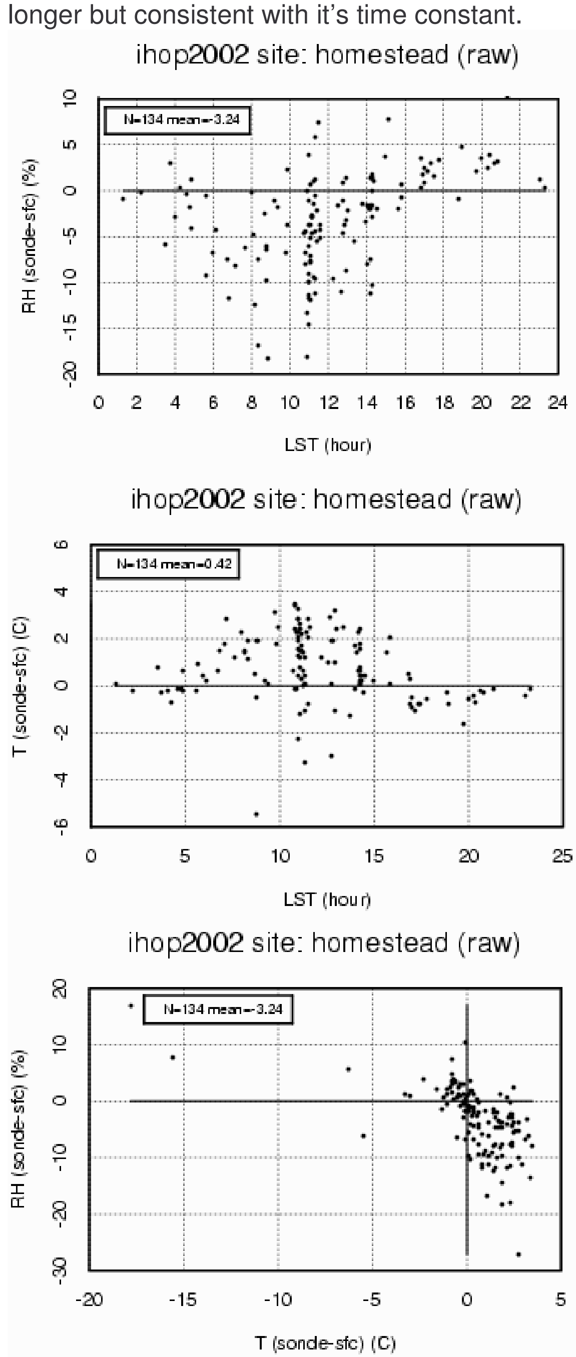

Figure 1. Differences between sonde and surface RH and Temperature measurements as a function of Local Standard

Time. A scatter plot of correlations between RH and temperature differences is also shown.

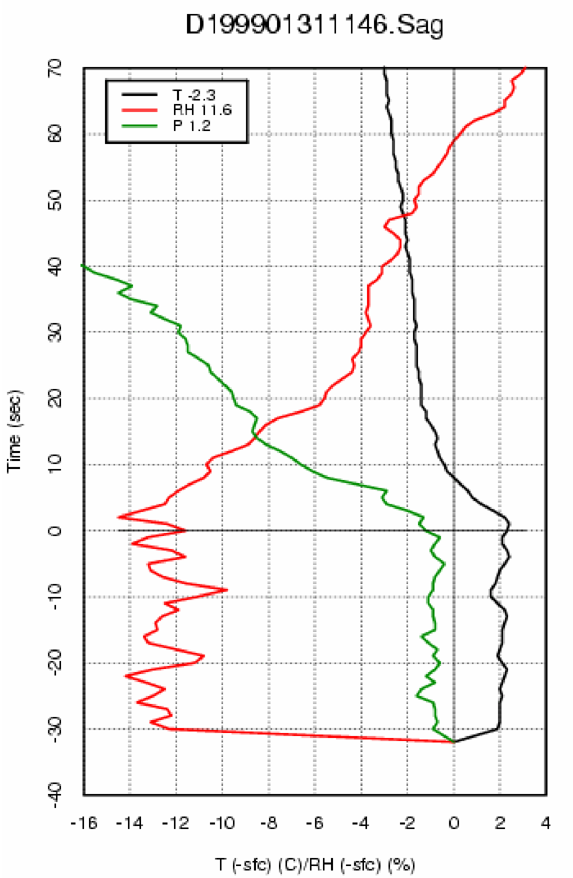

Figure 2. Profiles of temperature, RH and pressure. The surface data is at -32 sec and pre-launch sonde data is between -32 and 0 sec.

3.2 RH Sensor Contamination

While analyzing data from the Tropical Ocean Global Atmosphere-Coupled Ocean Atmosphere Response Experiment (TOGA COARE), it became apparent that there was a significant, and systematic dry bias of the relative humidity sensors contained within the Vaisala radiosondes. The dry bias was a result of contamination of the RH sensor from a polymer contained in the packaging material that the sondes were shipped in. Non-water molecules had occupied polymer binding sites, reducing the ability of the polymer to absorb water molecules resulting in lower humidity values. ATD worked closely with Vaisala to correct the error however, even with physically-based reproducible correction schemes ATD found that correction methods using surface data as an independent reference worked better than methods derived solely from laboratory tests (Wang, 2002). These errors also surfaced in data collected from a 1998 project called INDOEX. Figure 3 shows data containing the dry bias error. The sonde RH is lower than that measured by the surface sensor by as much as 20%, with a mean of 5% for most of the soundings. After applying the contamination dry bias correction schemes to the INDOEX data, the improvement was significant, with a change in mean RH difference from 4.1 % to 1.4%.

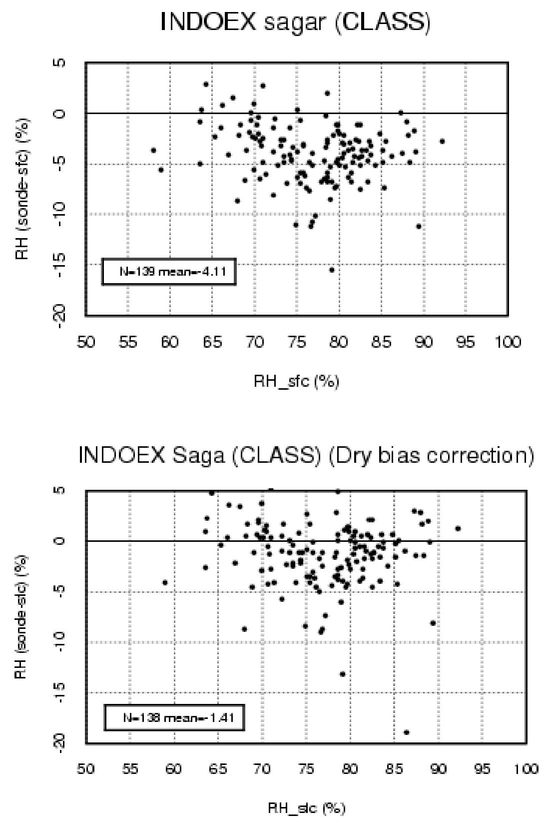

Figure 3. RH differences between pre-launch and surface data, before and after correction, from the STEPS project.

As a result of the joint effort between ATD and Vaisala, in September 1998, Vaisala changed the desiccant type in the sonde packaging, and in May 2000 they introduced a new type of protective shield over the sonde sensor boom to further help prevent the contamination errors.

3.3 Ventilation Problem with Surface Sensor

While performing quality control measures on the STEPS project, conducted in the spring/summer of 2001 in Eastern Colorado, it came to our attention that there were consistent errors with the surface met data. By looking at PTU graphs and skew-t diagrams, it became obvious that for approximately 65 of the 89 STEPS soundings, the temperatures from the sondes were much colder than those from the surface met sensors (figures 4 and 5). When comparing the pre-launch data, between soundings, the data were consistent so it became apparent that the problem was with the surface met data. After a thorough investigation, the surface sensor heating was attributed to improper ventilation of the surface met instruments.

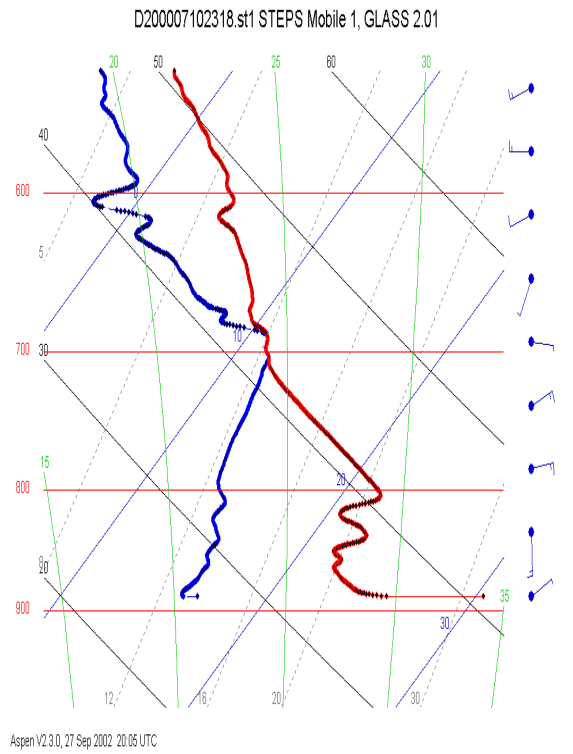

Figure 4 - Skew-t diagram from July 10, 2001. Shows heating of the surface met sensor.

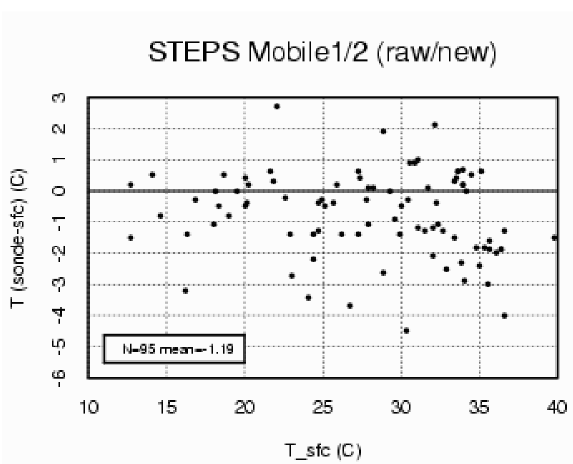

Figure 5. Temperature differences between pre-launch and surface data during STEPS.

4. Conclusions

In recent years, radiosonde data has received increased attention in climate research because it provides the longest record (the last four or five decades) of upper-air temperature, humidity and wind, has near-global coverage (best in the Northern Hemisphere), and has high vertical resolution (Wang, 2002). In several experiments, when comparing the data, we found the pre-launch radiosonde data was warmer and drier as a result of sensor arm heating, as described earlier in this paper. In another experiment, it was found that the surface met data was warmer due to poor ventilation of the surface temperature and humidity sensors. These comparisons also revealed the humidity sensors contamination and resulting dry bias in the Vaisala RS 80 humidity sensor. Our response to such errors has been to either correct the data sets, or simply to warn users about the presence of errors and or bias found. The latter is normally the case because these errors are generally small, and only affect a small percentage of the soundings in the dataset. The comparison of pre-launch radiosonde and surface met data has shown us the importance of recording pre-launch data, and has prompted us to improve system operations and performance in the field.

5. References

Edward Chamberlain, 2000: GPS/Loran Atmospheric Sounding System (GLASS). http://www.atd.ucar.edu/rtf/facilities/class/class.html (accessed Sept 2002).

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