3.3 TESTING THE RADIOSONDE REPLACEMENT SYSTEM (RRS) RADIOSONDES

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1. INTRODUCTION

The National Weather Service (NWS) is developing the Radiosonde Replacement System (RRS) to replace its antiquated Micro-ART system, which has been in operation since the late 1980s. Currently there are two radiosonde vendors who will be producing 1680-MHz GPS radiosondes for the RRS.

Before fielding the RRS in 2004, the NWS is conducting a series of tests to understand the measurement characteristics of the RRS radiosondes and ground station. This paper will discuss some of these tests. Test procedures discussed are the functional repeatability, functional precision, and the inter-comparison test with the NASA developed reference radiosonde. Examples of the types of data acquired during each of these tests will also be presented

2. FUNCTIONAL REPEATABILITY

The functional repeatability tests are conducted to verify that the vendor supplied radiosonde and associated Signal Processing System (SPS) were compatible with the Telemetry Receiver System (TRS). Additionally, these tests are used to determine the amount of variability the RRS ground equipment induces into the upper air data.

2.1 Methodology

The functional repeatability test requires a minimum of 10 flights be made in which two production TRS ground stations and two SPS units are used to simultaneously track one radiosonde. The test procedures discussed in this paper were conducted using the Sippican, Inc. SPS and radiosondes. The data acquisition systems were Windows 2000 workstations running Protocol Interface Test Suite (PITS).

PITS is an NWS developed software suite that is used to record the data from the TRS and SPS units.

For each test the flight trains were prepared in accordance with NWS standard procedures and were typically between 25 and 35 meters long. To initiate the start of the flight, a manual release was used to simultaneously start both systems at the same time.

2.2 Data Analysis

For the functional repeatability test the flight data was analyzed on an individual flight-by-flight basis and as a flight series. For the individual flight analysis, time and pressure paired thermodynamic data (pressure, temperature, relative humidity) and the u and v wind components were plotted. In addition to the actual data plots, the differences between the two systems were also plotted for each parameter. These plots were used to review the data for anomalies on a flight-by-flight basis.

For a flight series, a statistical analysis was conducted. For this part of the data analysis, summary statistics were generated for the differences between systems for the thermodynamic and wind data. This includes minimum, maximum, mean, and standard deviation for the differences between the systems for the entire data set. This was performed for time and pressure paired data. Additionally, the data were stratified into pressure ranges, and the summary statistics were again calculated. An example of the time-paired difference statistics for the entire data set is in Table 1.

Table 1. Functional repeatability summary statistics.

Parameter	N	Mean	Std. Deviation
Pressure	11320	.00	.03
Temperature	11320	.00	.01
Relative Humidity	11320	.00	.04
v Wind Component	11324	.00	.15
u Wind Componet	11324	-.01	.16

In addition to the summary statistics, a graphical analysis was also completed for the test series. For each of the measured parameters a histogram and a scatter plot were created. Figure 1 is a sample of a histogram for the time paired temperature differences.

For the repeatability test, the system and radiosonde performance were excellent for all measured parameters. This indicates good compatibility with little or no measurement variability induced by the ground equipment

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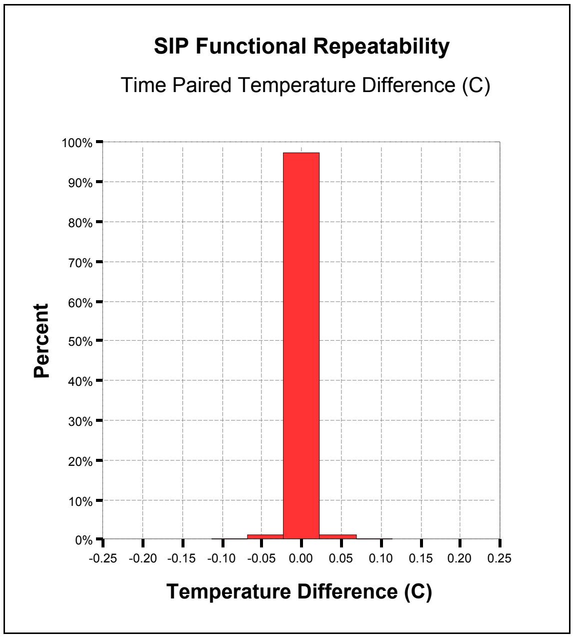

Figure 1. Histogram of time paired temperature measurement differences.

3. FUNCTIONAL PRECISION

Functional precision tests are conducted to determine the amount of measurement variability that exists between two identical instruments. For this test, the two instruments must simultaneously measure the same environment. When a test is conducted in this manner, the functional precision is defined as the root mean square of the differences (RMSD).

3.1 Methodology

For a complete functional precision test series, the NWS typically flies 50 dual radiosonde flights. For each flight two radiosondes were suspended between 25 and 35 meters below the balloon on a two-meter spreader bar. Figure 2 illustrates the spreader bar assembly with radiosondes. With the radiosondes set on different frequencies, two identical RRS systems were set up to track in such a manner that each system tracked one radiosonde.

To initiate the start of the flight, a manual release was made which simultaneously started both systems. For this test PITS was used as the data acquisition system.

3.2 Data Analysis

As was discussed in the data analysis section for the functional repeatability test, the flight data for the functional precision test were analyzed on an individual flight-by-flight basis and as a flight series. The only difference was that the RMSD was included in the calculation of the summary statistics. At the time this paper was written only 22 flights of the desired 50 had been completed. Table 2 is a sample of the summary statistics for these 22 flights

Table 2. Functional Precision Summary Statistics.

Parameter	N	Mean	Std. Dev	RMSD
Pressure	22517	.04	.55	.55
Temperature	22517	.02	.31	.31
Relative Humidity	22517	.40	4.26	4.27
v Wind Component	22254	.00	.11	.11
u Wind Component	22254	.00	.12	.12

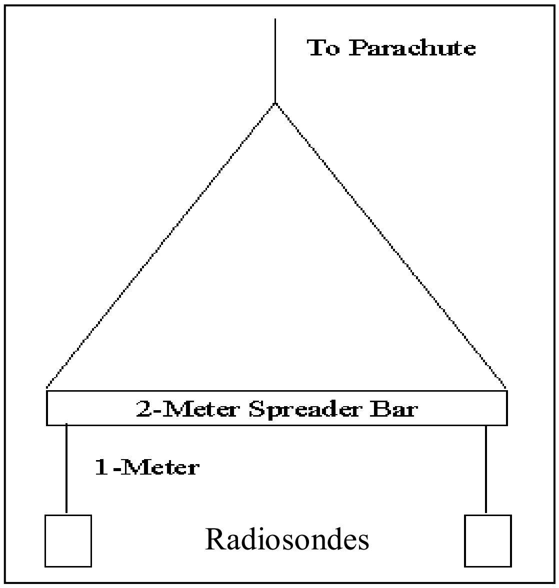

Figure 2. Spreader bar assembly.

Statistics similar to those listed in Table 2, were also generated for all meteorological parameters, however, the data was organized into pressure ranges. This was completed for both the time and pressure paired data sets.

In addition to the tabular data, a graphical analysis was also completed. An example of this is presented in Figure 3. Figure 3 is a scatter plot of the GPS v wind component for the entire test series. Plots of this type as well as histograms are normally generated for each of the measured parameters.

4. REFERENCE RADIOSONDE COMPARISON

Radiosonde inter-comparisons with reference radiosondes are conducted to determine temperature sensor accuracy. The NWS is conducting a series of radiosonde inter-comparisons with the NASA Accurate Temperature Measuring (ATM) reference radiosonde and RRS radiosondes. These tests are also used to validate radiation correction algorithms.

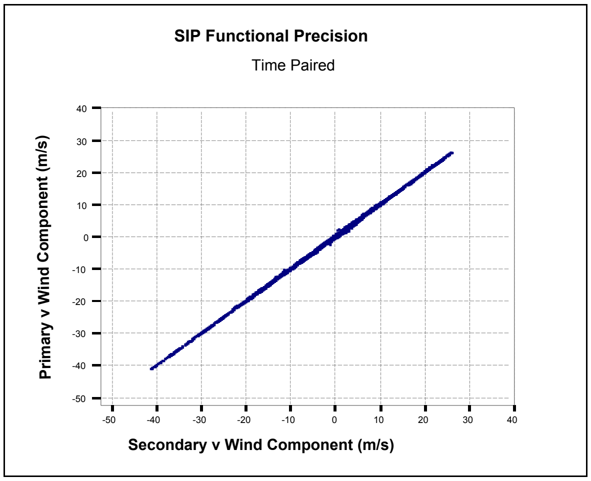

Figure 3. Scatter plot of v wind components for each system.

4.1 Methodology

For this test the ATM reference radiosonde and the Sippican Mark IIA were flown on the same balloon using the spreader bar assembly in Figure 2. The reference radiosonde used in this test is the Sippican Mark II radiosonde equipped with two white, two aluminum and one black thermistor. For the solution only one of each color sensor was used. For each of the three different colored sensors the emissivity and absorptivity of the coatings have been determined. This information was then used to solve simultaneous equations to determine the true temperature. Therefore the effects of the solar radiation were eliminated. This true temperature was then compared against the RRS Radiosonde.

4.2 Data Analysis

For this test the data were again analyzed on a flight-by-flight basis. Figures 4 and 5 are examples of this analysis. Figure 4 is a plot of the true temperature and the uncorrected temperature from the RRS Mark IIA radiosonde. As indicated the Mark IIA radiosonde is warmer than the ATM reference radiosonde due to the solar radiation effects on the Mark IIA radiosonde.

Once 20 of these flights are completed, the data will be analyzed as a test series, and group statistics generated for the ATM temperature minus the RRS radiosonde. From the group statistics, the overall accuracy of the RRS radiosonde will be determined. This test can also be used to refine RRS radiation correction schemes. For additional analysis the temperature differences are also plotted. Figure 5 is an example of this.

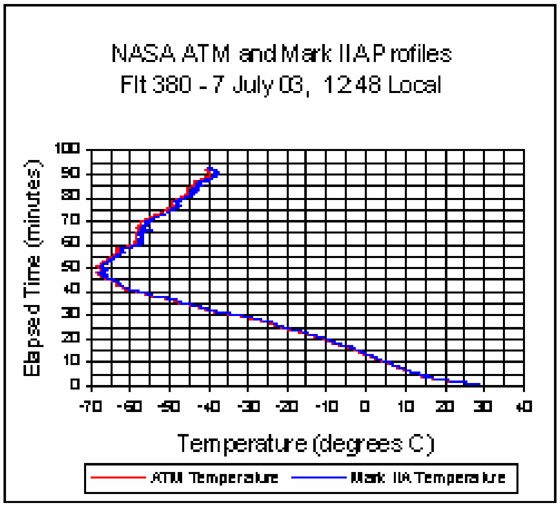

Figure 4. Temperature profiles for the NASA reference radiosonde and the Sippican Mark IIA radiosonde.

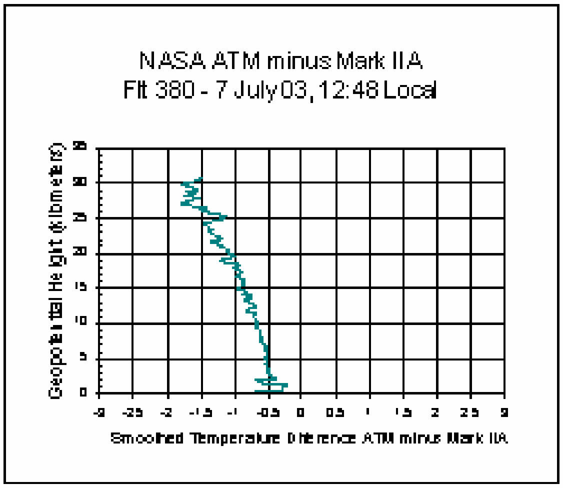

Figure 5. Plot of the Temperature difference for ATM reference radiosonde minus the Mark IIA radiosonde.

5 CONCLUSIONS

The purpose of this paper was to inform the meteorology community about the types of tests performed on radiosondes that will be introduced into the upper air network. Once the tests discussed in this paper have been completed, reports will be generated summarizing each of the test conducted.

In addition to the test discussed in this paper, the NWS will be conducting operational comparability tests between the new and old radiosondes.

6. REFERENCES

World Meteorological Organization 1996: Guide to Meteorological Instruments and Methods of observation. Sixth Edition WMO-No. 8, Geneva.

Schmidlin,F.J., Luers, J.K., and Huffman, P.D. 1986: Preliminary Estimates of Radiosonde Thermistor Errors. NASA Technical Paper 2637. Wallops Island, Virginia

NOAA Technical Report, NWS 44: Functional Precision of National Weather Service Upper-Air measurements Using VIZ Manufacturing Co. “A” Radiosonde (Model 1492-510)

ASTM Standard, E 177, Standard Practice for Use of the Terms Precision and Bias in Test Methods.
ASTM Standard, D 4430, Standard practice for Determining the Operational Comparability of Meteorological Measurements.