P3.2 Testing Radiosonde Replacement System (RRS) Radiosondes – Part 2

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1. INTRODUCTION

The National Weather Service (NWS) has developed the Radiosonde Replacement System (RRS) to replace its antiquated Micro-ART system, which has been in operation since the late 1980s. Although the NWS tested and qualified two1680-MHz GPS radiosondes for use with the RRS, they are currently only procuring one of the two radiosondes tested.

Over the course of the last two years the NWS has conducted a series of tests to understand the measurement characteristics of the radiosondes qualified for use with the RRS. This paper will discuss some recent updates to techniques developed for these tests. Test procedures discussed are the use of the Global Positioning Satellite-derived Integrated Precipitable Water (GPS-IPW) to evaluate the total moisture, evaluating atmospheric profiles and derived parameters using the RAOB[1] program, inter-comparison test with the NASA developed reference radiosonde for evaluating the temperature's radiation correction, and the use of benchmarks to test software. Examples of the types of data acquired during each of these tests will also be presented.

2. GPS-IPW

NWS is just beginning to use this technique and will be developing the analysis capability for its next set of tests. In Figure 1, the RRS GPS-radiosonde, the Sippican Mark IIA, seems to agree well with the GPS-IPW; however, note the two disagreements with radiosonde IPW values.

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[1] RAOB, *the complete rawinsonde observation program*, is produced by Environmental Research Services, ©, 1994-2004.

Additional tests with the final configuration of the test radiosonde will need to be conducted both at Sterling and at Caribou, Maine, before NWS begins field operations.

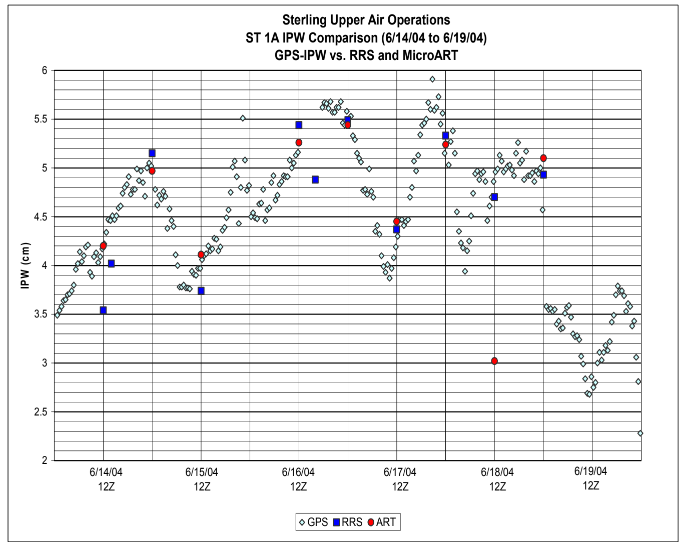


Figure 1. Example of GPS vs Radiosonde IPW.

3. USE OF RAOB

Below are some examples of RAOB* comparisons showing interesting cases from a flight series conducted at Caribou, Maine in January and February 2004.

3.1 Temperature Jitter

Figure 2 illustrates the problem of excessive temperature jitter encountered with the Sippican Mark IIA radiosonde during the tests at Caribou last winter. The cause of the jitter is still under investigation by NWS and the vendor.

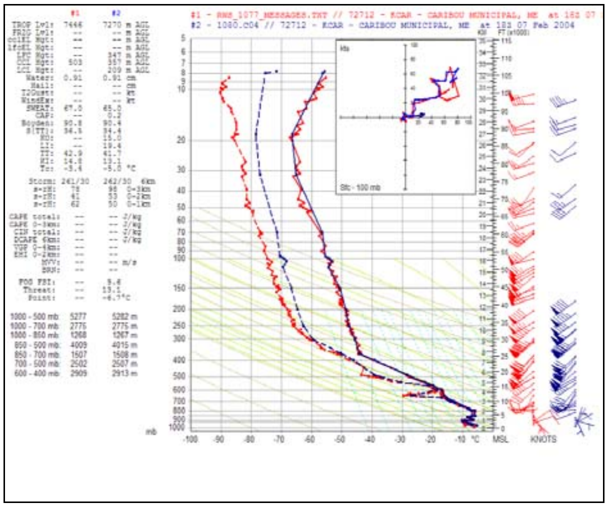


Figure 2. Example of Temperature Jitter.

3.2 Missing or Erroneous Winds

Figure 3 illustrates some cases encountered at Caribou with missing or erroneous GPS-derived winds. The cause was traced to the radiosonde not communicating with the ground system properly causing the winds to not be processed correctly within the software. Notice the two very high winds in the stratosphere not consistent with the legacy system winds. This problem has since been corrected.

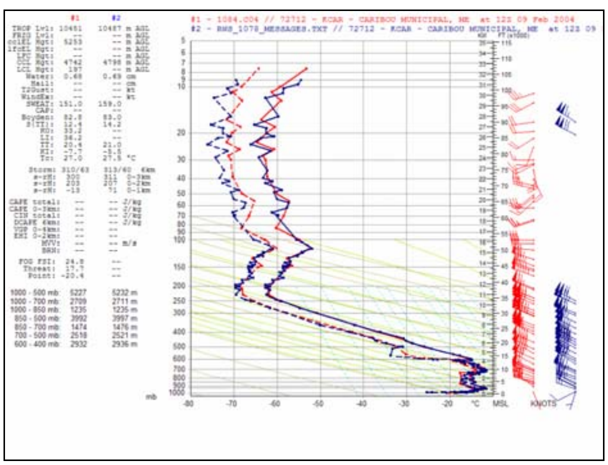


Figure 3. Example of Missing/Erroneous GPS winds.

3.3 Dry-RH Bias

In some cases during the Caribou tests, a dry RH bias would be exhibited with the Sippican radiosonde. Further tests in other seasons indicated the problem was still there and needed to be addressed. The vendor investigated the problem and has determined a corrective action, which NWS will be evaluating throughout the upcoming fall and winter months.

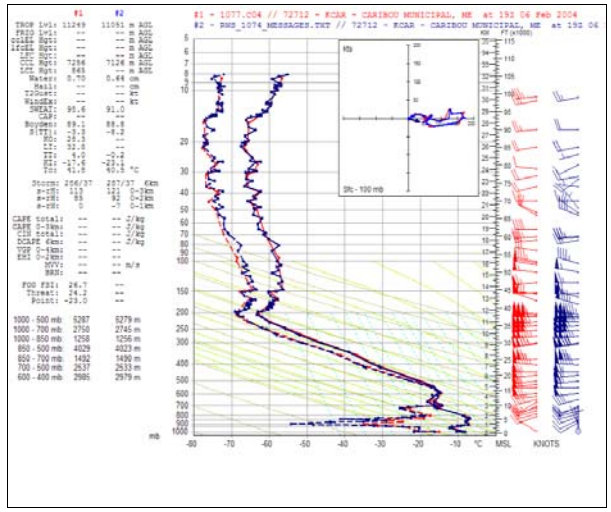


Figure 4. Example of Dry RH bias.

4. INTERCOMPARISON WITH NASA ATM

The NWS conducted a series of radiosonde inter-comparison flights with the NASA Accurate Temperature Measuring (ATM) radiosonde and RRS radiosondes. This type test is conducted to evaluate radiosonde temperature sensor performance and vendor supplied temperature radiation correction schemes.

4.1 Methodology

For this type of test the ATM radiosonde and the RRS radiosonde were flown on the same balloon using a six-foot spreader bar assembly. Figure 5 is an illustration of this assembly. The ATM 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.

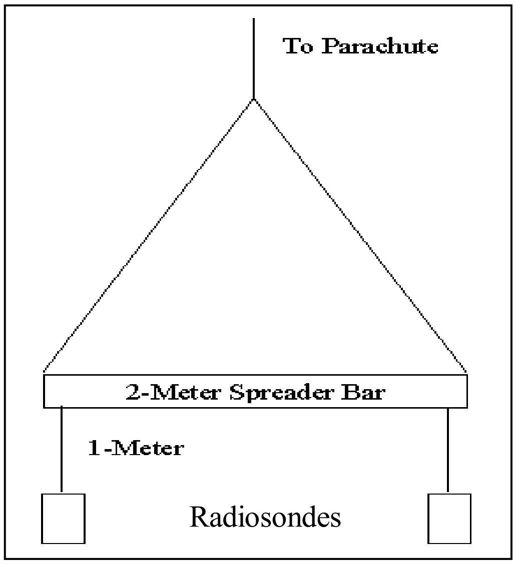


Figure 5. Spreader Bar Assembly.

4.2 Data Analysis

For this test the data were analyzed on a flight-by-flight basis. Figure 6 and 7 are examples of this analysis. Figure 6 is a plot of the ATM temperature, and the corrected and uncorrected temperatures for the RRS radiosonde.

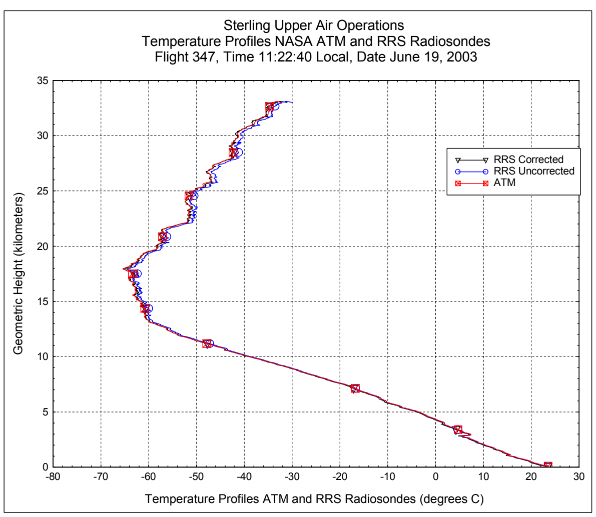


Figure 6. Temperature plots for ATM and RRS Radiosonde

This was a day flight released from Sterling VA. at 11:22 local time. As expected the plot shows the uncorrected RRS temperature is warmer than the ATM radiosonde at high altitudes due to the solar radiation. The plot also shows that once the solar radiation correction is applied to the RRS radiosonde it's temperature is nearly identical to the ATM.

Although the NWS has become quite proficient in conducting the ATM intercomparisons, there is still quite a bite to learn and understand about producing quality data. Figure 7 is an example of one of the lessons learned. This flight was released at night from Sterling VA. at 21:28 local time. At the time of release it was not raining, but there were rain showers in the area. As the radiosondes ascended into the dense low clouds, the ATM and/or RRS temperatures became somewhat erratic and diverged. It is suspected that liquid water droplets impacting on the sensors had an adverse impact on the temperature readings. Looking at Figure 7, this becomes very apparent in the data between 1 and 7 kilometers (km). After 7km the data appears to return to normal, however, agreement between the two measurements at high altitudes was not as good as expected for a night flight. Although there was much learned from this flight, it was not considered valid for the purposes of the test.

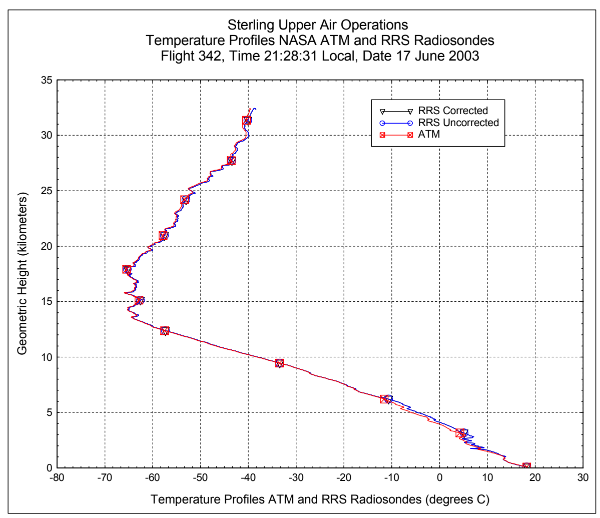


Figure 7. Degraded Temperature plots for ATM and RRS Radiosonde.

5 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 measure the same environment at the same time. When a test is conducted in this manner, the functional precision is defined as the root mean square of differences (RMSD).

5.1 Comparison for the Temperature Jitter

In Section 3.1 above, there was temperature jitter being exhibited in the Sippican Mark IIA radiosonde when compared to its older model, the B2 radiosonde. Figure 8 illustrates the jitter more clearly in the functional precision diagram generated from two identical Mark IIA radiosondes. Smoothing can eliminate much of this jitter, but there must not be too much smoothing or the information content could be lost.

5.2 Pressure

Another example of the benefit of functional precision diagrams is with comparing the same pressure sensor on two identical radiosondes. Figure 9 shows two different dual flights, one having good pressure agreement (top diagram) and one having poor agreement (bottom one). The number of times the latter case occurs will determine whether the radiosonde sensor in question is deemed repeatable or not. During a lengthy test, it is expected that an occasional poor comparison will be evident; however, if too many of these occur, this will lead to field problems, because two identical radiosondes will produce different data at nearby upper air locations. In this case, heights will be impacted, which could affect numerical models and forecasts.

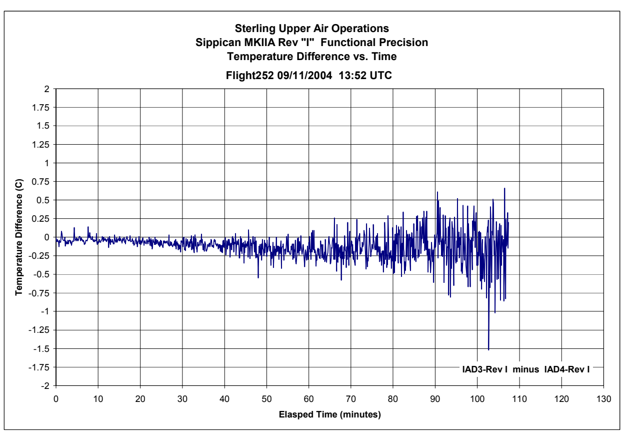
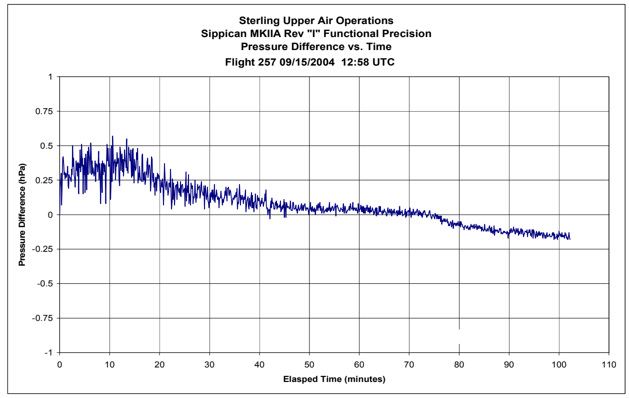


Figure 8. Example of Temperature Jitter in a Functional Precision Comparison.



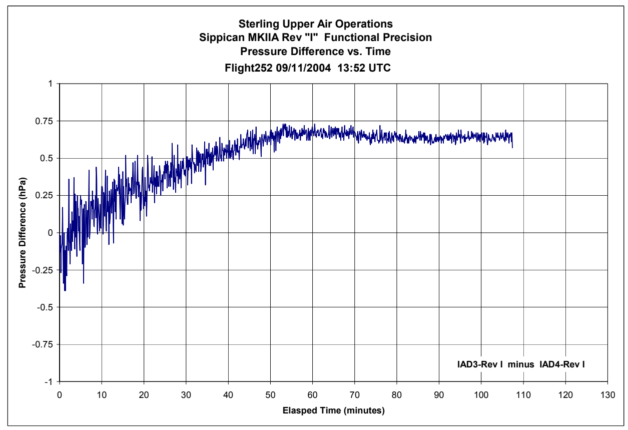


Figure 9. Two examples of Pressure Functional Precision Diagrams.

6 Conclusions

The purpose of this paper was to inform the meteorological community about the types of tests being performed on radiosondes and some issues that have resulted from them. Once the tests discussed in this paper has been completed, reports will be generated summarizing each of the tests conducted.

In addition to the test discussed in this paper, the NWS will be conducting operational comparability tests. This test will compare the performance of the new RRS radiosonde against the current operational radiosondes used in the NWS upper air network. This test is expected to last at least one year in order to span all four seasons.

7. References

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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.

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