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First Session

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PRESENTATION ON RECENT NATIONAL TESTS/COMPARISONS

United States National Weather Service
Recent Tests and Comparisons

(Submitted by Carl A.Bower, USA)

Summary and purpose of document

This document, presented by Dr Carl Bower (USA), provides information on the United States National Weather Service recent tests and comparisons of new radiosondes and requirements for further tests and/or intercomparisons.

Action proposed

The meeting is invited to note and comment on the information contained in the report and take actions on the issues raised in the report, as appropriate.

The United States National Weather Service recent tests and comparisons

1. Introduction

The development of the NWS Radiosonde Replacement System (RWS) including the Telemetry Receiver System (TRS), Signal Processing System (SPS), Radiosonde Workstation (RWS), and the Radiosonde Surface Observing Instrument System required significant testing and evaluation by the NWS Test and Evaluation Facility. In addition to testing of the individual hardware, firmware, and software components, full system test activities including the new 1680 MHz, four-channel, circular polarized GPS radiosonde is being performed. In addition to the testing of the new RWS, test activities continue on radiosondes in operational use. Four major test and evaluation areas include:

Functional Repeatability — Functional Reference Comparison

Functional Precision — Functional Comparison

2. Functional Repeatability

The NWS uses functional repeatability tests to help ensure that identical radiosondes, and associated signal processing systems are compatible with the RRS ground receiver. The repeatability tests require two complete identical ground systems tracking one compatible radiosonde. The results from the tests are used to determine the amount of variability (systematic bias) the RWS ground equipment introduces into the upper air data. A minimum of ten flights was conducted using Mark IIA radiosondes and associated signal processing systems with the TRS. Pressure, Temperature, Relative Humidity and GPS U and V wind components for each flight were analyzed both by time and pressure-paired thermodynamic and wind data. Data for each flight are plotted as well as the differences between the two systems for each thermodynamic and wind parameter. This includes minimum, maximum, mean, and standard deviation for the differences between the systems for the entire flight series. Data are also stratified into pressure ranges and summary statistics generated. Table 1 shows an example of statistics generated for the ten-flight series data set for the time-paired measurement differences.

Table 1. Functional repeatability Summary Statistics for the Mark IIA Radiosonde and TRS

Parameter	Number of Points	Mean	Standard Deviation
Pressure	11320	0.00	0.03
Temperature	11320	0.00	0.01
Relative Humidity	11320	0.00	0.04
U Wind Component	11324	-0.01	0.16
V Wind Component	11324	0.00	0.15

Table 2 is an example of Pressure-paired Temperature Differences for the Series.

Table 2. Pressure-paired Temperature differences for Pressure Intervals.

Pressure hPa	N	Minimum	Maximum	Mean	Standard Deviation
1070 to 850	1729	-0.16	0.24	0.00	0.02
850 to 500	3850	-0.03	0.04	0.00	0.00
500 to 300	2200	-0.01	0.01	0.00	0.00
300 to 200	1100	-0.01	0.01	0.00	0.00
200 to 100	1100	-0.01	0.01	0.00	0.00
100 to 50	546	-0.01	0.01	0.00	0.00
50 to 20	275	0.00	0.00	0.00	0.00
20 to 00	72	0.00	0.00	0.00	0.00
All	10872	-0.16	0.24	0.00	0.01

3. Functional Precision

The NWS uses functional precision testing to determine variability between data sets of atmospheric measurements made by two separate radiosonde instruments exposed to the same environment at the same time. A series of balloon ascents are made with two of the same radiosonde types attached to a flight train. The functional precision of the radiosonde's measurements is determined from the time-paired differences between pressure, temperature, and relative humidity conditions. Data sets from equivalent systems have root mean square of the differences as a measure of variability. For upper-air flight-testing, the data can be compared not only by time but also by pressure. A series of flights were made under various weather conditions over the measurement range to determine the radiosonde sensor suite precision and operates reliably in an operational environment. These test series are not considered as accuracy tests but are a measure on manufacturing repeatability. Two test series have been completed. One is for the RS80-57H radiosonde currently in operational use and the other on the Mark IIA, a pre-production prototype yet in operational use.

RS80-57H Radiosonde

A flight series of 45 flights covering both day and night flights over four seasons were conducted for this radiosonde. The statistics for the flight series for all levels from surface to flight termination are included in Table 3. More stratified information will be provided in the presentation.

Table 3. RS80-57H Radiosonde Functional Precision Statistics by Element.

	N	Minimum	Maximum	Mean	Std Deviation
	Statistic	Statistic	Statistic	Statistic	Statistic
Pressure Differences (hPa)	4476	-3.50	3.60	-0.02	0.45
GPH Difference (meters)	4476	-687.00	1460.00	1.89	91.64
Temperature Difference (C)	4476	-4.00	2.60	-0.01	0.41
RH Difference (%)	4476	-38.00	49.0	0.67	5.69

Mark IIA Radiosonde

A flight series covering both day and night flights over four seasons were conducted for this pre-production prototype radiosonde. The summaries statistics for the flight series include all levels from surface to flight termination are included in Table 4. More stratified information by meteorological parameter and pressure ranges will be provided in the presentation. The wind information for this table from the GPS measurements obtained from the radiosonde.

Table 4. Mark IIA Radiosonde Functional Precision Statistics by Element

	N	Minimum	Maximum	Mean	Std Deviation
	Statistic	Statistic	Statistic	Statistic	Statistic
Pressure Differences (hPa)	40040	-3.55	4.75	0.04	0.97
GPH Difference (meters)	40040	-2639.00	1562.00	-7.89	209.35
Temperature Difference(C)	40040	-5.93	7.17	-0.02	0.35
RH Difference (%)	40040	-22.10	23.10	0.29	3.66
U Component Difference (m/s)	39768	-2.30	1.90	0.00	0.12
V Component Difference (m/s)	39768	-3.30	1.40	0.00	0.12

4. Functional Reference Comparison (NASA Accurate Temperature Measuring (ATM) Reference Radiosonde Comparison)

Radiosonde in-situ accuracy comparisons are obtained through flight series using operational radiosondes against reference radiosondes. The NWS has conducted preliminary flight series against the Mark IIA prototype radiosonde and the IMS 3010 prototype radiosonde using the NASA ATM as the reference. A complete series would consist of 25 flights conducted during different solar angles and for day and night conditions. These tests are critical for determining radiosonde biases against a reference and also enable validation of radiation correction algorithms provided by the radiosonde manufacturers for their respective radiosondes.

The ATM radiosonde is a specialized MARK II radiosonde with spare channels used to support data gathering from five discrete thermistors. Two white-coated, two aluminum-coated, and one black-coated thermistor are flown on the reference. The emissivity and absorptivity of each sensor coating is known from laboratory measurement of coated samples. For solving for true temperature, only one white and one aluminum-coated sensor are used in solving set of simultaneous equations to determine the true in-situ temperature.

Radiosonde flight data are analyzed on a flight-by-flight basis against the ATM and differences are determined. Examples of the flight series will be shown in the briefing.

5. Functional Comparison

The NWS uses functional comparison testing to determine variability between data sets of atmospheric measurements made by two separate radiosonde instruments exposed to the same environment at the same time. A series of balloon ascents are made with two different radiosonde types attached to a flight train. The functional comparison of the radiosonde measurements is determined from the time-paired differences between pressure, temperature, and relative humidity conditions. Data sets from different radiosondes have root mean square of the differences as a measure of variability. For upper-air flight-testing, the data can be compared not only by time but also by pressure. A series of flights made under various weather conditions over the measurement range are used to determine the radiosonde sensor suite precision and operational reliably. These test series enable the determination of biases between different radiosonde types.

The deployment of the NWS Radiosonde Replacement System will include different sensor suites from those in current operational use. These changes in sensors will have an impact on long-term data continuity. In order to assess the bias caused by the transition to different sensors it has been recommended that approximately 200 dual radiosonde flight comparisons be performed at each of 13 to 19 sites in the NWS Upper Air network. These flights will be conducted to help identify biases that will enable the construction of transfer functions to convert between climatic data taken before and after the change to new sensor technology. This activity is anticipated to begin in 2006.