W O R L D   M E T E O R O L O G I C A L   O R G A N I Z A T I O N

COMMISSION FOR INSTRUMENTS AND METHODS OF OBSERVATION

OPAG ON UPPER-AIR OBSERVATION TECHNOLOGY

JOINT

CIMO EXPERT TEAM ON
UPPER-AIR SYSTEMS INTERCOMPARISONS (ET-UASI)
Third Session

and

INTERNATIONAL ORGANIZING COMMITTEE (IOC) ON
UPPER-AIR SYSTEMS INTERCOMPARISONS
Third Session

FINAL REPORT

(Payerne, Switzerland, 2-6 June 2008)

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WMO General Regulations 42 and 43

Regulation 42

Recommendations of working groups shall have no status within the Organization until they have been approved by the responsible constituent body. In the case of joint working groups the recommendations must be concurred with by the presidents of the constituent bodies concerned before being submitted to the designated constituent body.

Regulation 43

In the case of a recommendation made by a working group between sessions of the responsible constituent body, either in a session of a working group or by correspondence, the president of the body may, as an exceptional measure, approve the recommendation on behalf of the constituent body when the matter is, in his opinion, urgent, and does not appear to imply new obligations for Members. He may then submit this recommendation for adoption by the Executive Council or to the President of the Organization for action in accordance with Regulation 9(5).

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EXECUTIVE SUMMARY

This report provides a summary of the joint third session of the Expert Team on Upper-Air Systems Intercomparisons (ET) and International Organizing Committee on Upper-Air Systems Intercomparisons (IOC) that was held at the Aerological Station Payerne, Switzerland, 2–6 June 2008.

The manufacturers' representatives presented changes made in their radiosondes after the WMO Intercomparison of High Quality Radiosonde Systems, (Vacoas, Mauritius, 2005) and explained details of functional tests made on new designs. The changes in radiosonde designs/sensors are listed in Annex 2. The ET/IOC reviewed the positive changes in the designs of radiosondes of all manufactures since 2005 and discussed their impact on global radiosonde data compatibility and the need for a new global radiosonde intercomparison (see Item 3.1).

The results of several recent international and national radiosondes tests as well as progress on testing interoperable upper-air systems were presented and discussed. Presentations on progress in the further development of other upper-air measurement systems and related planned projects were also given, namely: UKMO FUND Project, COST Action ES0702 EG-CLIMET, CN-MET Project of MeteoSwiss and LUAMI Campaign (see Item 3.5). In this context, the ET/IOC considered the requirements for future tests/intercomparisons of upper-air systems and updated its Work Plan (see Annex7).

The attention was given to the testing requirements for the GRUAN network considering the outcomes of the Initiation GCOS Reference Upper-Air Network Meeting (GRUAN), (Germany, February, 2008). The ET/IOC noted that the ET should assist the GRUAN in developing the best operational practices. The results of the discussion were reflected in the updated ET Work Plan (see Annex 7).

The ET/IOC focussed mainly on elaboration of both operational and organizational aspects for the 8th WMO Intercomparison of Radiosonde Systems, China, 2010. In planning for future WMO global and regional radiosonde intercomparisons, the ET/IOC took into account the need for global intercomparison driven by changes made in the designs of the High Quality Operational Radiosondes. It was decided to organize the 8th WMO Intercomparison of Radiosonde Systems (WMO-RSO-8) in early 2010, followed by the WMO Regional Intercomparison within 2 years, if required. The planned WMO Regional Intercomparison in China in 2009 would, therefore, be organized at a later stage, if China would not be able to join the WMO-RSO-8. In addition to the general rules and procedures for WMO Intercomparisons as defined in the Guide to Instruments and Methods of Observation (WMO-No. 8), Part III, Chapter 5, Annex 5.A and 5.B, and Part I, Chapter 12, Annex 12.C, the ET/IOC agreed on all the rules and procedures for the 8th WMO Intercomparison of Radiosonde Systems (see Item 7 provides all details).

Based on the discussion during the meeting and taking into account requirements for the future intercomparisons, the ET/IOC Work Plan was reviewed and updated (see Annex 7).

The Final report of the session is available at:
http://www.wmo.int/pages/prog/www/IMOP/reports.html

GENERAL SUMMARY

1. ORGANIZATION OF THE SESSION

1.1 Opening of the session

1.1.1 The joint third session of the CIMO/OPAG-UPPER-AIR Expert Team on Upper-Air Systems Intercomparisons (ET) and the International Organizing Committee on Upper-Air Systems Intercomparisons (IOC) was held at the Aerological Station Payerne, Switzerland, 2–6 June 2008.

1.1.2 T. Oakley, Chairperson of the ET and IOC, opened the session and welcomed the participants. He wished everyone a fruitful and productive meeting. The list of participants is given in Annex 1.

1.1.3 Bertrand Calpini, Chief, Aerological Station Payerne, also welcomed the participants and wished everyone a fruitful and productive meeting and pleasant stay in Payerne.

1.1.4 M. Ondráš, Chief, Observing System Division, (OBS Dept., WMO) highlighted the important deliverables of the ET/IOC achieved so far and the role of the ET/IOC in the development of high quality radiosondes. He also stressed that intercomparisons of radiosondes were essential for high quality upper-air observations, their compatibility, and their long-term stability and a new need for a “reference” system for the GCOS Reference Upper-Air Network (GRUAN).

1.2 Adoption of the agenda

The ET/IOC adopted the Agenda for the meeting, which is reproduced at the beginning of this report.

1.3 Working arrangements for the session

The ET/IOC agreed on working hours and tentative timetable for the session.

2. REPORT OF THE CHAIRPERSON

2.1 The ET/IOC Chairperson recalled the objectives of the ET/IOC and the activities carried out since CIMO-XIV (2006) in accordance with the Terms of Reference (TOR) and the Work Plan of the ET. He highlighted the difficulties in constructing the Work Plan in a situation of a significant change in the ET/IOC membership and stressed the role of CIMO OPAG-UPPER-AIR and WMO Secretariat for the continuity of ET/IOC work.

2.2 In his report, he further emphasized the fact that design modifications happen much more often now than it was in the past and these frequent changes cause problems and difficulties in keeping track of performance of upper-air measurement. Therefore, there is a need to develop a realistic method for overlapping radiosonde flight periods to generate transform procedures between old and new equipments as well as performance measures to demonstrate the improvement in the upper-air measurement quality.

2.3 In his report, he also mentioned activities related to testbed experiments that require collaboration between this Expert Team and Expert Team on Remote Sensing Upper-Air Technology and Techniques (ET-RSUT&T) as well as between CIMO and relevant scientific community.

3. REVIEW OF PREVIOUS INTERCOMPARISONS AND TESTS AND REQUIREMENTS FOR FUTURE INTERCOMPARISONS

3.1 Review of previous WMO intercomparison and resulting changes to systems

3.1.1 The ET/IOC reviewed the changes in the design of radiosondes following the 7th WMO Intercomparison of Radiosondes (Mauritius, 2005), their impact on global radiosonde data compatibility and the need for a new global radiosonde intercomparison.

3.1.2 The manufacturers' representatives presented changes made to their radiosondes following the Mauritius intercomparison and explained details of functional tests made on new designs. It was noted that all manufacturers that participated in Mauritius had made significant changes as a result of the intercomparison and their new versions of radiosondes are already in use or will soon be used in the Global Observing System (GOS). This is also true for manufacturers that did not participate in the Mauritius intercomparison and have candidate systems for the next global intercomparison. The changes in radiosonde designs/sensors are listed in Annex 2.

3.1.3 The ET/IOC noted positive changes in radiosonde performance resulting from improvements in radiosondes design/sensors. However, the ET/IOC was of the opinion that manufactures should inform WMO Members about the changes in the radiosonde, as well as on the results of the conducted tests. It was agreed that manufacturers would provide relevant information to the WMO Secretariat which would be posted on its CIMO website.

3.1.4 It was noted that:

- The design and characteristics of radiosondes in use has been changing radically since Mauritius intercomparison and there is a need for a new global WMO intercomparison of radiosonde systems (see Item 7). All manufacturers indicated their preparedness to participate in the next global radiosonde intercomparison;
- Significant progress was noted in some countries, such as China, as shown by the long-term quality assessment using the ECMWF OB-FG statistics. These new radiosondes need to be linked to the high quality radiosondes through regional intercomparison;
- However, in some countries, relatively poor systems still remain, so that not all of the upper-air measurements have the same error characteristics;
- The improved radiosondes meet user requirements for operational use and scientific studies, apart from the very high accuracy requested for relative humidity in the upper troposphere and lower stratosphere for climate trend studies;
- Knowledge of radiosonde errors is essential when using radiosondes to compare with remote sensing measurements. This includes an understanding of the representativeness errors from the rapid ascent of the balloon through the vertical structure of the atmosphere, usually 1 km in the vertical in about 3 minutes.

3.1.5 A major advantage of the radiosonde measurement is that it provides simultaneous measurement of vertical structure of temperature, relative humidity and wind direction/speed.

3.1.6 A suitable combination of radiosondes providing accurate profiles with remote sensing and AMDAR measurements would provide the optimum mix of observing techniques; this has to be explored further by collaborative efforts through the national and international (CIMO) testbeds experiments.

3.1.7 Obtaining an accurate representation of 3-D water vapour distribution requires a combination of measurements from different types of systems; radiosondes offer a cost-effective method of making measurements at targeted locations. The main benefit is using the information from the radiosonde and remote sensing to understand the nature of the changes in the atmospheric profiles during the day.

3.2 Presentations on recent International/National radiosonde tests/comparisons

3.2.1 The ET/IOC reviewed the recent international as well as national intercomparisons and tests. It considered the test results and the consequent of changes to the systems.

3.2.2 UKMO presented recent tests on the effects of changes in the radiosondes (mainly changes in sensor design) with regards upper-air measurement and their negative impacts on the homogeneity of data.

3.2.3 C. A. Bower, NOAA NWS, presented the activities of NOAA NWS radiosonde replacement programme and related activities such as radiosonde acquisitions, radiosonde test and qualification activities and operational issues. He also addressed the GCOS requirement for overlapping measurements to determinate biases between the old and new radiosonde measurements.

3.2.4 The purpose for development of the Accurate Temperature Measuring (ATM) radiosonde and early results using rod thermistors were presented by F.J. Schmidlin, NASA. Early results gathered from nine upper-air sites indicated that thermistor errors were sensitive to the background radiative environment suggesting that fixed corrections may not work. Comparison of ATM with operational radiosondes showed that even after manufacturer's corrections were applied to the measurements, the radiosonde errors may have been larger than suggested by the manufacturers values applied operationally.

3.2.5 In addition, a discussion was given about the Snow White chilled mirror sensor. Comparison between the Snow White and the Frost Point Hygrometer gives comparable results up to the tropopause and occasionally to the lower stratosphere. Further comparisons of relative humidity measurements were made. The utility of the Snow White sensor was shown in relation to cirrus clouds. A caution was raised concerning rain and heavy wet-clouds on Snow White operations.

3.2.6 Dr J. Nash, President of CIMO briefed the ET/IOC on the results of the InterMet Systems GPS Radiosonde test, (Namibia, October 2007). The ET/IOC was informed that the final results would be available by July 2008.

3.3 Progress of testing interoperable upper-air systems

3.3.1 The progress of testing interoperable upper-air systems was discussed.

3.3.2 The NOAA National Weather Service has been using an interoperable radiosonde for 20 years. The development of the new 1680 MHz GPS ground receiver evolved through the interfacing of different vendor's radiosondes with the RDF systems in use for the past 45 years. Qualification activities continue to increase the number of potential providers of the interoperable 1680 MHz GPS radiosonde and to improve the performance of existing radiosondes. Preparation is underway for a multiple award contract for radiosonde units.

3.3.3 Interoperable systems have been installed in several countries. These systems use six different radiosonde models manufactured by InterMet, InterMet Africa, LM Sippican, Vaisala and the India Meteorological Department.

3.3.4 The experiences show that the concept of interoperable system is adaptable and such a system is commercial available.

3.4 Presentations on recent tests / work on wind profiler systems

3.4.1 S. Y. Lee, Korea Meteorological Administration, briefed on the current KMA network of ten wind profilers as complementary to radiosonde network installed mainly for severe weather monitoring.

3.4.2 Presentation on WINPROF-II activities was given by the ET/IOC Chair. In his presentation, he emphasized the need for defining wind profiler operational standards and for improving future quality monitoring. He also stressed the fact that continuous 'real-time' monitoring involves significant operating costs if they are to be effective in delivering quality measurements.

3.5 Presentations on recent tests / work on integrated profiling systems and review of requirements for further tests / intercomparison

3.5.1 Some results of the tests made by UKMO and MeteoSwiss were presented.

3.5.2 With reference to the Provisional Programme of CIMO Upper-Air Instrument Intercomparisons (2006–2010) approved by CIMO-XIV and with the recommendation of EC-LIX to identify a Centre(s) of excellence that would serve as the CIMO Lead Centre(s) for Instrument Development and Testing, and the EC request to CIMO to extend its intercomparison activities to testbeds, the ET/IOC reviewed the requirements for further tests / intercomparisons / testbeds which as follows:

- ***UKMO FUND*** (Future Upper-Air Network Development) project for 2010-2020 with the aim to optimize and integrate the current network with surface measurement, weather radar, AMDAR, in-situ remote sensing focusing mainly on the Planetary Boundary Layer including its variability. This Testbed was proposed by the ET/IOC to become a WIGOS Demonstration Project (see Item 9.3.3).
- ***COST Action ES0702 EG-CLIMET*** (European Ground-based observations of essential variables for CLImate and operational METeorology) as a coordinated development of upper-air measurements and in-situ remote sensing with the aim to design a new integrated observing network in RA VI.
- ***CN-MET*** (Centrales Nucléaires et METéorologie) project of MeteoSwiss that will combine operational surface and upper-air networks data with a high resolution NWP model (COSMO-CH 2.2km). The upper-air network includes one radiosounding station (Payerne), three low-tropospheric wind profilers, and three microwave radiometers for temperature profiling. Observational data will be assimilated into the NWP model. High quality weather forecast will be available for the meteorological surveillance of the power plants. It is planned that the entire system will be operational in January 2010.
- ***LUAMI*** (Lindenberg Upper Air Methods Intercomparison campaign): The Richard-Aßmann Observatory at Lindenberg, Germany is planning for LUAMI in the period of 3-30 November 2008 with the emphasis to remote sensing techniques. The assessment of remote sensing measurement will be supported by in-situ reference sounding techniques. Apart from these, the opportunity will be given to manufacturers of standard radiosonde systems to participate in the LUAMI campaign in order to prepare their systems for the next WMO intercomparison of radiosonde systems, China, 2010.

  The main objectives of the LUAMI campaign are as follows:

(1) To preliminary assess and intercompare both up-to-date active & passive in situ remote sensing systems for meteorological parameters in view of their potential to supply in operational networks, as well as for high-quality reference, and ground-truth of satellite measurements (e.g. water vapour, wind and temperature);

(2) To demonstrate the capabilities of passive microwave profiler systems for their use in operational meteorological networks by means of a test network of profilers supplying quality-proven data in real time to a network hub in Lindenberg;

(3) To address the requirement of the GCOS Global Reference Upper-Air Network GRUAN for development of reference sounding techniques for climate monitoring;

(4) To provide a 3-week reference data set of the Central-European atmosphere in late fall by compiling measurements of the WMO-GUAN reference site "Lindenberg" supplying 6-hours interval data of humidity and temperature profiles for comparison with ground-based and air-/space-borne remote sensing techniques and in-situ sensors;

(5) To compare European Lidar sites for water-vapour sounding by independent air-borne reference techniques enabling an assessment of the absolute accuracy of water-vapour remote sensing.

3.5.3 The ET/IOC considered all these requirements for further tests and reflected them in the Work Plan (see Annex 7).

4. TESTING REQUIREMENTS FOR THE GRUAN NETWORK

4.1 F. Berger, DWD, briefed the ET/IOC on the outcomes of the initiation of the GCOS Reference Upper-Air Network Meeting (GRUAN), (Germany, February, 2008). The basic documents summarizing the justifications and requirements for GRUAN and the outcome of the meeting are GCOS reports GCOS-112 and GCOS-121.

4.2 The ET/IOC noted the outcomes of the meeting, mainly that:

- It had been proposed that a major intercomparison be held under the auspices of GCOS and CIMO, managed by the WG-ARO and Lead Centre, at one or more GRUAN or other appropriate sites to try to ascertain a best set of instrumentation and practices specifically for GRUAN operations in 2010 and that this should involve both operational and research radiosondes;
- Definition of best operational practices for GRUAN, priority list of additional ground-based instrumentation, and recommendations for a set of ground-based instrumentation types has to be defined;
- Manual/Guideline on the observing practices to ensure standardization, comparability and high-quality of measurements at all sites has to be developed.

4.3 The proposal for the first-priority instrumentation (routine radiosondes, a reference sounding together with a GPS receiver) and the second-priority instrumentation (active and/or passive remote sensing systems) of a GRUAN site were presented and discussed.

4.4 It was pointed out that some GRUAN activities were related to CIMO activities, such as a common intercomparison strategy, and assistance in selecting appropriate reference sounding systems. The GRUAN Lead Centre, Meteorological Observatory Lindenberg – Richard-Aßmann Observatory, could ensure the close link to WMO/CIMO.

4.5 The ET/IOC noted that the ET should assist the GRUAN in developing the best operational practices, which was reflected in the updated Work Plan of the ET (see Annex 7).

4.6 C. A. Bower presented the GCOS requirement for overlapping climate continuity flight series for up to one year for the purpose of maintaining climate data continuity anytime radiosonde sensor siting and/or design are changed at GUAN sites.

4.7 He also noted the difficulties in meeting this requirement internationally as well as nationally and proposed a potential mechanism by which the GRUAN could fulfil this requirement.

4.8 The ET/IOC discussed how to address those GCOS and GRUAN requirements in the future intercomparisons as it is difficult to achieve them in some cases. The ET/IOC felt that its role was to provide advice how to keep continuity addressing the requirement of the climate community. The results of the discussion were reflected in the updated ET Work Plan (see Annex 7).

5. REQUIREMENTS FOR TESTING AMDAR MEASUREMENTS

5.1 The ET/IOC Chair briefed on E-AMDAR data evaluation. The purpose of this preliminary study was to use data from operational radiosonde ascents to examine whether those data would provide a good comparison for AMDAR data. The study results are positive and promising for the future.

5.2 The ET addressed this issue in the updated Work Plan (see Annex 7).

6. REVIEW OF RELEVANT GUIDANCE MATERIAL FOR NECESSARY UPDATES

C.A. Bower presented a proposal for the update of the Guide to Meteorological Instruments and Methods of Observation (WMO-No. 8) related to publication of the WMO upper-air intercomparison results. The ET/IOC discussed briefly the submitted proposal (reproduced in Annex 3) and updated its Work Plan accordingly (see Annex 7).

7. 8th WMO INTERCOMPARISON OF RADIOSONDE SYSTEMS

In the preparation of planning for a future WMO global and regional radiosonde intercomparison, the ET/IOC took into account the need for global intercomparison driven by the changes made in the designs of the High Quality Operational Radiosondes (HQOR). There is a need to advise GCOS on the suitable radiosondes for use in the GRUAN network and to develop the use of Best Quality Research Sounding Systems (BQRSS) to supplement the operational radiosondes in the GRUAN network. F. Li, China Meteorological Administration, proposed to postpone the planned WMO Regional Intercomparison to 2010 at the earliest. When considering the date of the intercomparison, it was stressed that CIMO experts will be unavailable before and during the CIMO-XV session (1st Q. 2011) and also before the Sixteenth WMO Congress (Cg-XVI, 2nd Q. 2011). Thus, it was decided to organize the 8th WMO Intercomparison of Radiosonde Systems (WMO-RSO-8) in early 2010, followed by the WMO Regional Intercomparison within two years, if required. The planned WMO Regional Intercomparison in China in 2009 would, therefore, be organized at a later stage, if China would not be able to join the WMO-RSO-8.

In addition to the general rules and procedures for WMO Intercomparisons as defined in the Guide to Instruments and Methods of Observation (WMO-No. 8), Part III, Chapter 5, Annex 5.A and 5.B, and Part I, Chapter 12, Annex 12.C, the ET/IOC agreed on the following rules and procedures for the 8th WMO Intercomparison of Radiosonde Systems:

7.1 Objectives

7.1.1 The main objective of this intercomparison is to test in the tropical / subtropical moist conditions the relative performances of HQOR in conjunction with the BQRSS. The results will be used to advise Members on a selection of HQOR suitable for RBSN/RBCN and its GUAN sub-network as well as advise GCOS on a selection of systems suitable for GCOS Reference Upper-Air Network (GRUAN).

7.1.2 The ET/IOC agreed on further objectives as follows:

a) To improve the accuracy of daytime HQOR measurements and the associated correction procedures to provide temperature and relative humidity accuracies currently possible with night time measurements.

b) To assess the accuracy and availability of the GPS wind measuring systems.

c) To evaluate the performance of geometric and geopotential height values obtained from GPS radiosondes (with a possibility to check the associated algorithms).

d) To evaluate the quality and reliability of BQRSS, and to use this information to evaluate the quality of the working references for the radiosonde test.

e) To recommend suitable HQOR systems to be used in the RBSN/RBCN and GUAN.

f) To assess the magnitude of changes introduced by new radiosonde designs.

g) To identify the best practices used in the preparation of HQOR radiosondes for launch.

h) To evaluate the added value of using remote sensing equipment in radiosonde systems intercomparisons as recommended by ET-RSUT&T experts (following testbed evaluations).

i) To evaluate the day-night differences of temperature, relative humidity of HQOR and BQRSS against available remote sensing observations; and to identify, as far as possible, the origins of differences.

j) To publish the Executive Summary within three months, the draft Final Report within six months and the approved Final Report within nine months after the Intercomparison in the *WMO Instruments and Observing Methods Report* (IOM) series.

7.2 Qualification

The ET/IOC agreed on the tentative qualification procedure for participation in the 8th WMO Intercomparison of Radiosonde Systems, which prompt the respective manufacturers to take part in national test prior the WMO-RSO-8, namely:

a) The candidate HQOR should preferably pass through the national intercomparisons organized in the CIMO recognized intercomparison sites/testbeds, list of which is in the Annex 4, or

b) The candidate HQOR should pass through the Regional WMO Radiosonde Intercomparison.

7.3 Project Team

7.3.1 The ET/IOC agreed on the composition and duties of the Project Team (PT). The PT will be responsible for preparing the intercomparison in liaison with the WMO Secretariat. The PT will organise the conduct of the intercomparison, the quality control and analysis of the results, and preparation of Executive Summary, draft Final and Final Reports. It will take part in the whole period of the intercomparison and the financial support for their participation should be equally shared among the WMO, GCOS and relevant COST Actions.

7.3.2 The WMO-RSO-8 Project Team will consists of:

- Project Leader (PL), to be nominated by the UK Met Office out of the IOC members;
- The Radiosonde Test Expert, to be nominated by the UK Met Office;

- The Data Manager; proposed Sergey Kurnosenko, as he is the owner of the reference data processing software for WMO intercomparisons (RSKOMP, Annex 5); 2nd option is an expert nominated by the MeteoSwiss;
- The data-processing expert for HQOR, to be nominated by the UK Met Office;
- Holger Voemel as the data-processing expert for BQRSS;
- Dirk Engelbart as the data-processing expert for the remote sensing instruments.

7.4 Place, date and duration

Place

7.4.1 The ET/IOC agreed on the potential sites for holding the WMO-RSO-8. Those are, in the order of priorities: Guilin (China), Hawaii (USA), and Darwin (Australia).

Date and Duration

7.4.2 The WMO-RSO-8 will last for no more than 3 weeks. It should preferably start in the 1st quarter of 2010.

7.5 Participation

7.5.1 The following manufacturers expressed their firm commitments to participate in the WMO-RSO-8 with their radiosonde systems:

a) GRAW with DFM-06 GPS radiosonde, (400-406 MHz);

b) INTERMET with the iMet-1GPS radiosonde, (400-406 MHz);

c) LOCKHEED MARTIN SIPPICAN INC with LMS6 GPS radiosonde, (400-406 MHz);

d) MODEM with M2K2-DC GPS radiosonde, (400-406 MHz);

e) MEISEI ELECTRONIC CO., LTD with RS-06G GPS Radiosonde, (400-406 MHz);

f) METEOLABOR AG with SRS-C34, (400-406 MHz);

g) VAISALA OYJ with RS92 SGP GPS radiosonde, (400-406 MHz).

7.5.2 China will decide on the participation with the Shanghai-GTS Radiosonde with Secondary WindFinding Radar 1680 MHz and/or GPS radiosondes (400-406 MHz).

7.5.3 The manufacturers of HQOR will provide their radiosonde systems with 40 pieces of radiosondes for the intercomparison on their own account.

7.5.4 The following BQRSS should be developed to participate in the WMO-RSO-8; this list might be updated as a result of the LUAMI campaign:

a) METEOLABOR SnowWhite, (400-406);

b) Cryogenic Frost-point Hygrometer (CFH), (works with one of the Radiosondes above);

c) A multi-thermistor radiosonde (ATM), (400-406 MHz).

7.5.5 Funding for the participation of the BQRSS will be shared between providers and GCOS. There is a need for 60 pieces of BQRSS measurement of temperature and 60 pieces for water-vapour measurement. As there is more than one potential BQRSS system for a water-vapour measurement, the Project Leader and data processing expert for BQRSS will need to agree on the numbers to be used.

7.5.6 The following remote sensing instruments may participate in the WMO-RSO-8:

a) GPS-MET,

b) Cloud Radar,

c) Ceilometer,

d) Microwave Profiler,

e) LIDAR,

f) Doppler weather radar,

g) Wind profiler.

7.5.7 Remote sensing instruments will be provided by volunteered NMHSs or manufacturers who will also arrange for the transport to the host country and for the installation. Funding for the participation of the remote sensing instruments will also be requested from relevant COST Actions. Systems need to be established at the test site well in advance of the test.

7.6 Responsibilities

Participants

7.6.1 Participants (manufacturers of HQOR and providers of BQRSS) will be responsible for timely delivery of instruments to the intercomparison site according to the custom procedures for the respective country.

7.6.2 Participants will run their systems in a near continuous mode (day and night) and will provide data according to a format to be agreed by the Data Manager.

7.6.3 Participants will share the cost of supplies of consumables, such as: balloons, gas, parachutes, un-winders, etc. They will also provide funding for the participation of Data Manager (one month of salary and travel expenses).

Host country

7.6.4 Host country will be responsible for all preparations relevant to the infrastructure needed for the intercomparison, offices for the international participants and WMO PT and for the logistic support during the intercomparison (installation of instruments, internet connection, production of gas and filling of balloons, production of bamboo rigs, etc).

7.7 Rules during the intercomparison

7.7.1 It was agreed that participants in the test would provide both fully processed and raw data from each radiosonde test flight.

7.7.2 Data formats would be similar to those used during the 7th WMO Radiosonde Intercomparison and would be finalised well in advance of the test with the agreement of the Data Manager. Care should be taken to avoid mistakes made during the 7th WMO Radiosonde Intercomparison (see Annex 6).

7.7.3 A uniform method of time stamping the data samples would be agreed to by the participants, utilising an agreed method of exploiting GPS timing.

7.7.4 Data samples need to be submitted to the Data Manager within 1-hour after the completion of the test flight.

7.7.5 The Project Team will take responsibility for resolving disputes between participants (e.g. potential radio frequency interference between some radiosonde types).

7.7.6 The Project Team will attempt to identify systematic problems in measurements with a given radiosonde type early in the test, and then will judge whether it is appropriate to rectify this problem.

7.7.7 Regular data meetings will be held with relevant participants to quantify progress in building up the comparison data bases.

7.7.8 The Data Manager or remote sensing data-processing expert will also have to arrange for archiving of relevant remote sensing observations, in a database that can be accessed by the other participants as appropriate.

7.8 Data Policy

The following are the guidance principles for data policy of the intercomparison agreed by the ET/IOC:

- The complete intercomparison database is kept by the WMO Secretariat, the ET/IOC Chair, the Project Leader and Site Manager. WMO may, if requested by the ET/IOC, export whole or part of the comparison database on the CIMO/IMOP website, or other website controlled by the ET/IOC members, as soon as the Final Report is published.
- After the Intercomparison, every participant could get a copy of the comparison database, containing any further raw data obtained during the tests, related to its own instruments.
- The WMO authorizes the Project Leader (in collaboration with Site Manager and data-processing experts), with the agreement of the ET/IOC Chair (following an IOC members consensus), to publish full results in a Final Report of the intercomparison on behalf of the ET/IOC.
- The ET/IOC members may publish their partial scientific results if demanded by the scientific community before the end of the intercomparison, provided the publication was authorized by the Project Leader and that the participating instruments remain anonymous in that publication.
- The comparison database may be provided to other parties for the purpose of scientific studies on the subject. This requires an approval of the ET/IOC Chair, and is possible only after the full results of the intercomparison have been published.
- For the publication and for the third parties, the participants are only allowed to use data from their own instrument. In doing so, they will avoid qualitative assessment of their instruments in comparison with other participating instruments.

7.9 Radiofrequency issues

7.9.1 The radiofrequency environment at the intercomparison site needs to be checked for potential interference well in advance of the intercomparison by the host.

7.9.2 If radiosondes are flown which use L-Band secondary radars, then other participants will have to be checked for radiofrequency compatibility with this system in advance of the test.

7.9.3 Transmissions from 403 MHz radiosonde systems need to be tuneable to designated frequency, of narrow bandwidth (100 kHz) and stable frequency (less than 10 kHz drift in flight).

7.10 Potential sampling problem

7.10.1 The method of suspending the radiosondes from the support rig must allow for the motion of the radiosondes during the ascent to be similar to that experienced in an individual radiosonde flight.

7.10.2 Operational radiosondes are not designed to measure accurately during descent, so either the BQRSS chosen must function reliably during ascent, or a method be agreed to for comparing between HQOR ascent data and BQRSS descent data.

7.10.3 It should be considered whether GPS signals should be used to track the motion of the test rig and radiosondes during each comparison flight.

7.11 Data-processing and analysis

7.11.1 The three data processing experts in the Project Team will be responsible for organizing the data analysis in consultation with the Project Leader.

7.11.2 In particular, comparisons between the different types of data will require that the individual databases need to be compatible with the RSKOMP database.

7.12 Data processing and database availability

7.12.1 Each HQOR participant will only be able to access their own measurements until the data analysis is completed.

7.12.2 When the final report is published the full data sets (both raw and processed high resolution data) should be made available to the general scientific community.

7.13 Schedule of the intercomparison

7.13.1 Before the intercomparison schedule is finalized, tests will have to be performed to identify the safe radiofrequency separation between individual radiosonde types that is practical. For instance if 500 KHz Separation were possible, then it might be possible to fly nine radiosondes at 401.5, 402, 402.5, 403, 403.5, 404, 404.5, 405 and 405.5, and it would also be necessary to establish the physical separation necessary between the radiosondes to avoid spurious interaction between the systems. However, this does not seem to be very practical when relatively long radiosonde suspensions from the support rig are required to ensure that the ventilation of the radiosondes in the test is similar to that of an individual radiosonde.

7.13.2 Thus, a practical schedule for test could be obtained by splitting the nine radiosondes into two groups so that at most 6 radiosonde types were flown together. The link between the two groups would have to be agreed by the Project Leader/IOC but would sensibly be based on a multi-thermistor radiosonde for temperature and suitable BQRSS for relative humidity/water vapour. Time separation between test flights needs to be about 4-hours, so launches at 10.00, 14.00, 19.00 and 23.00 would allow a test flight for each radiosonde in daytime and night-time conditions each day.

7.13.3 The schedule needs to be prepared well in advance of the test in coordination between the Project Leader and the experts responsible for HQOR and BQRSS.

7.13.4 Approximately equal numbers of day and night comparison flights need to be completed.

7.13.5 The number of flights that can be attempted will depend on the availability of lifting gas, with an individual test flight taking at least 3-hours to complete, start to finish. With possibly another hour for the data-processing staff to complete their activities, so that more than four test flights in 24 hours is difficult to sustain over any lengthy period.

8. WORK PLAN

Based on the discussion during the meeting, the ET/IOC reviewed and updated its Work Plan which is reproduced in Annex 7.

9. ANY OTHER BUSINESS

9.1 Vision for the GOS in 2025

The ET/IOC discussed the draft Vision for the GOS in 2025 approved by CBS/OPAG-IOS ET-AWS-5, May 2008 with special emphasis on upper-air and remote sensing measurements. The ET/IOC provided the WMO Secretariat its comments that will be submitted to CBS/OPAG-IOS ET-EGOS for further consideration.

9.2 Training Workshop on Upper-Air observations in parallel with Intercomparison between RDF a GPS systems

9.2.1 The ET/IOC considered the request from the Egyptian Meteorological Authority to organize a training workshop on upper-air measurements in parallel with intercomparison between Radio Direction Finding (RDF) and GPS systems.

9.2.2 The ET/IOC noted that a similar training workshop combined with intercomparison was conducted in Namibia in 2007.

9.2.3 Taking into account priorities and available resources in this intersessional period, the ET/IOC was of the opinion that it would not be possible to conduct such a training workshop and intercomparison in RA I in this WMO financial period.

9.3 WIGOS and WIS

9.3.1 M. Ondráš briefed the session on the WMO activities related to WIGOS and WIS. In his presentation, he underlined standardization and the role IMOP and CIMO will play in it. He also explained principles and objectives of new WMO Secretariat structure and organizational change.

9.3.2 The ET/IOC agreed that standardization is a key integration issue between observing systems within WIGOS and proposed that standardization of GRUAN be addressed through the WIGOS Pilot Project (PP). The objective of this PP would be to coordinate activities related to a selection of “reference” systems for GRUAN and the development of operational practices for GRUAN. The ET/IOC agreed that this has to be done in close collaboration among CBS, CIMO and GCOS. Therefore, it proposed that a ad-hoc steering group of the WIGOS PP for GRUAN would be composed of:

- T. Oakley, Chairperson of ET/IOC UASI,
- C. Gaffard, Vice-chairperson of ET/IOC UASI,
- D. Engelbart, Chairperson of ET-RSUT&T and GRUAN remote sensing expert,
- F. Berger, representative of the GCOS Lead Centre for GRUAN,
- CBS representative,
- CIMO representative.

9.3.3 The ET/IOC considered the need of a WIGOS Demonstration Project aimed at demonstrating integration approach taken by CIMO testbeds in integration of ground-based in-situ and remote-sensing systems to best meet user requirements for increased temporal and spatial resolution of upper-air measurements. In this regard, the ET/IOC agreed to propose the UK Met Office Test bed (FUND) as a WIGOS Demonstration Project and requested the Secretariat to send an official invitation to UK.

10. CLOSURE OF THE SESSION

The session was closed on 6 June 2008 at 14:00 hours.

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CHANGES IN RADIOSONDES AFTER THE WMO INTERCOMPARISON OFHIGH QUALITY RADIOSONDE SYSTEMS, (VACOAS, MAURITIUS, 2005)

1. GRAW RADIOSONDES GMBH & CO. KG

- Temperature measurement:
  - A new type of thermistor (tiny glass bulb),
  - New position on top of a sensor boom to avoid wet bulbs,
  - Removal of thin wires to avoid damages;
- Humidity measurement:
  - Manufacturer of Polymer changed,
  - Calibration completely done in house;
- GPS:
  - Implementation of latest chipset,
  - Number of channels increased from12 channels to 20 channels;
- General:
  - Obsolete components replaced by latest technology,
  - Power reduced from 9V to 6V (2 Lithium cells now),
  - Size and Weight reduced;
- Receiving Software:
  - Completely reprogrammed to meet latest requirements for modern user-interface,
  - New remote access features,
  - Google Earth support,
  - Implementation of BUFR code.

2. INTERNATIONAL MET SYSTEMS (InterMet)

InterMet did not participate in the Mauritius global intercomparison; however, InterMet participated with the InterMet BAT 16G 1680 MHz GPS radiosonde in a regional intercomparison in Windhoek, Namibia organized by the UK Met Office, October of 2007 (dual flights between the BAT 16G and the Vaisala RS92, which served as the link sonde to the intercomparison).

The changes after the Namibia tests are as follows:

- a new humidity sensor;
- software modifications (the solar radiation corrections).

3. LOCKHEED MARTIN SIPPICAN INC.

- A new Model – LMS6 GPS Radiosonde;
- No change in temperature sensor – same sensor, mounting, processing;
- The same relative humidity sensor; change in its exposure (removed from duct, deployed on an arm extended from radiosonde case and mounted below a protective cap);
- The second temperature sensor measures the air temperature at the RH sensor location;
- A new GPS receiver;
- Change to ETSI Standards-Compliant 403 MHz Transmitter;
- Change of the batteries;
- Weight reduction.

4. MEISEI ELECTRONIC CO., LTD.

- Development of a new sonde RS-06G GPS radiosonde;
- Comparison of a new and old TU sensor:

	RS-06G GPS	RS-01G GPS
T sensor Surface	Aluminized	Aluminized
T sensor Volume	1.4x10E-10 m^3	8.6x10E-9 m^3
Response（1000 hPa）	0.37 s	1.8 s
Response（10 hPa）	2.4 s	10.8 s
Solar error（10 hPa）	1.8 ‘C	2.5 ‘C
Humidity cap dir	15mm	10mm
Humidity cap Surface	Aluminized	Non
Material	Plastic	Aluminium

Other changes:

Battery	AA Battery x 2	Water Battery
Life time	240min or more	120 min
Weight (with battery)	150 g	210g

5. METEOLAB AG

- Modification of electronic circuits,
- Modification of the algorithm for thermocouple signal computing,
- Snow white sensor: change of sensor housing.

6. MODEM

Model flown at Mauritius: M2K2, Current version: M2K2-DC (Dual core):

- Temperature sensor:
  - Replacement of the white paint by a varnish coating and vacuum metallization of the boom end;
  - Modification of the boom end shape in order to reduce solar radiation influence close to the temperature sensor;
- Humidity sensor:
  - Addition of a second thermistor under the cap;
  - Different positioning of the cap allowing a better ventilation of the sensor;
- Dual core processor;
- External On/Off power switch;
- Infrared link for operation with automatic launch system (RobotSonde):
  - On/Off power control;
  - Frequency setting possible during the procedure.

7. VAISALA OYJ

- The RS92 radiosonde temperature sensor is currently reinforced with strong quartz fibber.
- Additional boom frame has been removed in order to ensure sensor ventilation at low pressure levels in heavy multi-radiosonde soundings.

- RS92-SGP radiosonde is currently available with dry cell batteries.
- RS92 radiosondes are equipped with a UV-degradable unwinder string.
- BUFR available in DigiCORA MW31 and MW21 Sounding System (the software version 3.52).

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PROCEDURES FOR PUBLICATION OF WMO INTERCOMPARISON RADIOSONDE SYSTEMS RESULTS

1. Introduction

Publication of the radiosonde intercomparison report should include results from the intercomparison and particular problems. The report should also include detailed statements on the main objectives of the intercomparison and criteria used in the evaluation of results. The criteria would include results of statistical analysis and should be presented in tables and graphs, as appropriate. Time series plots should be considered for selected periods containing events of particular significance. The host country should be invited to prepare a chapter describing the database and facilities used for data-processing, analysis and storage. An overview of participating radiosondes and systems, particularly sensor technology, correction, accuracy, precision, resolution, data frequency, smoothing etc. should be included. The final report of the intercomparison should contain, for each instrument, a summary of key performance characteristics and operational factors. Results of the radiosonde intercomparisons may be used to partially satisfy GUAN requirements for overlapping periods of radiosonde flights when changes of instrumentation occur within the GUAN network. For this reason, detailed metadata should also be included in the report results. Information such as station location, elevation, instruments used as well as the data output from the radiosondes both corrected and uncorrected should be archived. The report should include provisions for permanent archival of the intercomparison results for permanent archival at the WDC-Asheville for GUAN data or a recognized established centre if possible. These data and products should be available to all potential users on a free and unrestricted basis.

2. Radiosonde Systems Intercomparison Report Format

A draft outline for the report should be provided by the International Organizing Committee (IOC) to the Project Leader (PL) for drafting a provisional report and the final report. The format of the report and the data analysis should enable easy comparison of data results with previous international radiosonde intercomparisons. The outline of the final report should include as appropriate the following:

EXECUTIVE SUMMARY

1. INTRODUCTION

1.1 Objectives
1.2 Relevance of the test for weather forecast and climate monitoring operations
1.3 Relationships with previous intercomparisons
1.4 Relationships with recent scientific studies

2. SUMMARY OF INTERCOMPARISON ORGANIZATION

3. RADIOSONDES TESTED

4. PREPARATIONS FOR LAUNCH

4.1 GPS initiation issues
4.2 Radiofrequency issues
4.3 Pressure sensor check
4.4 Temperature and relative humidity check
4.5 Battery preparation
4.6 Launch procedure

5. DATA-PROCESSING, INCLUDING DATA EDITING

13.1.2 The most significant test results
13.2 Recommendations
13.2.1 Organization of Intercomparison and Associated Activities
13.2.2 Technical Considerations

14. ACKNOWLEDGEMENTS

15. REFERENCES

16. ANNEXES

ANNEX A Project Team on duty during WMO Radiosonde Intercomparison,
ANNEX B List of Participants,
ANNEX C Pictures of systems and testing,
ANNEX D Radiosonde Comparison Software,
ANNEX E Data format recommendations.

3. IOM Report Series and IOC Approval Process

This section is a guideline for the WMO publication of radiosonde intercomparison reports. It concerns the successive reports which have to be written at different steps after the analysis of the field radiosonde intercomparison and the approval process to include timeliness of each part of the process. Timeliness for delivering the different reports are very important. The provision of the intercomparison reports in a timely manner to the meteorological community, manufacturers, and to the WMO Secretariat is a high priority for the PL and the IOC. This timely provision of the reports enables a return on investment to the manufacturers who had participated in the intercomparison tests. They fully fund their participation in the testing and have every expectation that the results from the testing will published in a timely manner. The timely provision of data and test results benefits them, in that they have a point of reference from which to make adjustments to their radiosonde systems to correct noted deficiencies identified when compared with recognized references and link radiosondes. Additionally, it provides information to the data using community on adjustments that may be required to sustain long-term continuity in upper air records. The timely provision of the information also ensures that internationally, measurements are better and the spread in the differences between different radiosonde measurements are reduced. The IOC should agree on procedures to be followed for approval of the various levels of reports. The reports will be prepared by the PL who is the lead writer for each report and submitted to all IOC members and, if appropriate, to participating members.

The four reports associated with an intercomparison are as follows:

- Preliminary report
- Provisional report
- Project draft final report
- Project final report

Each report builds on the previous report and includes more detail on accomplishments and findings of the intercomparison. The review and the validation process for each report is specific and consequently treated separately. The reviewers and those approving the documents may be different in the process from report to the next. However, the publication processes of the preliminary and the provisional reports are similar; as are the final draft report and the final report.

3.1 Preliminary report

This report is the first document written following the field test with elements observed or derived during each radiosonde flight. This report shall be done within a few days, and consequently is a short document. The PL is the main writer. The reviewers are the IOC members. The Chairperson of the IOC is responsible for final approval. This document contains information useful for the future interpretation of trials. This report should be completed in no more than 3 successive versions: Version 0, Version 1, and Version 2. The preliminary report has to be produced in a short time just after the end of the intercomparison series, whereas the provisional report can be delivered 9-months after completion of the field series.

Moreover, this report can be used as a publication at the WMO-TECO Conference.

3.2 Provisional report

This report is written by using the main content of the preliminary report. After the end of the campaign and the writing of the preliminary report, 6-months can be spent analyzing intercomparison database sets. After the data sets analyses, the provisional report should be prepared within three months. This report is a more complete document than the preliminary report and can be elaborated in 3 successive versions: Version 0 deduced from the preliminary report Version 2 and written by the PL, Version 1 at the level of participating members and the Version 2 at the level of the IOC Chair. The reviewers and the approval levels are the same as the preliminary report.

3.3. Project draft final report

This report is written within 2-months after the provisional report. The organization and the text should be very close to that of the final report. The reviewers are the participating members and the IOC members. They receive the document at the same time and provide their comments to the Project Leader. The approval step is then at the IOC chair level. As previous, this report is in fact elaborated in three successive versions: Version zero written by the Project Leader, Version one after inclusion of reviewers comments, and Version two after review by the IOC Chair. The Project draft final report will be delivered in two months after the provisional report and the definitive final report in three months after the project draft final report.

3.4. Final report

The final report is the final step of the publication process. Its content has been developed by carrying out the main parts of previous reports. As for other reports, the PL is the main writer. This document has to be completed within three months. The reviewer steps are organized for the final approval by the IOC members and the IOC Chair. This document can be elaborated in three steps: Version 0, Version 1, and Version 2.

4. Publications, Conference Presentations and Data Disposition

4.1 Publications and Conferences

After validation of these reports by the IOC and/or the IOC chair, they can be published or presented at a technical conference like WMO TECO after final approval by the WMO Secretariat.

4.2 Data Disposition

Data from the Intercomparison may have use for helping to understanding biases between different radiosonde systems and for further application to the GUAN archive. As such, these intercomparison data sets should be co-located with the GCOS upper air archive at World Data Center (Asheville, North Carolina). This would help satisfy the GCOS requirement that changes by bias caused, by changes in instrumentation should be evaluated by a sufficient overlapping period of observation (perhaps as much as a year) or by making use of the results of instrument intercomparisons made at designated test sites (WMO/TD No. 1106 September 2002). Detailed metadata should be from the intercomparison that should be provided to the GUAN archive so that users of the data can make appropriate comparisons from the intercomparisons. The metadata should include detailed information about the site of the intercomparison such as location, elevation, operating instruments to include the sensor types, their accuracies, resolution, time response and any impacts by the environment on their performance. Correction procedures used on the data should be provided. Both corrected and corrected data for all flights as well as data from reference systems used in the comparison should also be archived.

5. References

Guide to Meteorological Instruments and Methods of Observation (WMO-No. 8)

Manual on the Global Observing System (WMO-No. 544)

GCOS Guide to the GCOS Surface and Upper-air Networks: GSN and GUAN, Version 1.1,
GCOS-73 (WMO/TD No. 1106), September 2002

WMO Joint CIMO Expert Team on Upper-air Systems Intercomparisons (ET- UASI) and International Organizing Committee (IOC) on Upper-air Systems Intercomparisons, (Final Report), Geneva, Switzerland, 17-20 March 2004

WMO Intercomparison of High Quality Radiosonde Systems, Vacoas, Mauritius, 2-25 February 2005 (Final Report)

CIMO RECOGNIZED INTERCOMPARISON SITES / TEST BEDS

a) Lindenberg, Germany

b) Camborne, UK

c) Payerne, Switzerland

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RADIOSONDE COMPARISON SOFTWARE (RSKOMP ©) FOR WIN32 PLATFORM

The Radiosonde Comparison Software (RSKOMP) has been regularly used in radiosonde intercomparisons since 1990. It implements the well-established comparison methodology and provides multiple important features that make RSKOMP a powerful and complete tool for radiosonde data analysis. In these comparisons, RSKOMP was used for the following tasks:

- To create a common database of all intercomparison flights;
- To reconcile different entry data standards from different participants;
- To perform post-flight data quality analysis;
- To detect and eliminate mis-synchronizations;
- To hide data where measurements were judged atypical;
- To calculate and analyze statistical results;
- To produce other relevant reference materials for the report.

During its existence, the RSKOMP has been thoroughly verified. History of major applications of RSKOMP includes:

- 4th WMO Radiosonde Intercomparison (1989, USSR)
- Potential Reference Radiosonde Test (1992, UK)
- 5th WMO Radiosonde Intercomparison (1993, Japan)
- WMO Intercomparison of Humidity Sensors (1995, USA)
- Flight Phase of Ozonesonde Intercomparison (1996, Switzerland)
- 6th WMO Radiosonde Intercomparison (2001, Brazil)
- 7th WMO Radiosonde Intercomparison (Mauritius, 2005).

and many other tests / experiments of the smaller scale.

It should be noted that WRSKOMP applicability is not limited to radiosonde data neither to any particular manufacturer standard. **Practically any data that are represented in a form of vertical profiles may be analyzed with WRSKOMP**. So, the data set may include radiosondes, ozonesondes, remote soundings data, theoretical models or combination of the above data sources.

The readers who are interested in more details may refer to the Web site: www.rskomp.net

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DATA FORMAT RECOMMENDATIONS

One of the problems the Expert Team has faced during the 7th WMO Radiosonde Intercomparison was the substantial difference in the entry data standards. This problem was anticipated and solved; however, it created extra significant workload and clearly increased the time needed to complete the post-flight analysis.

There were several sources of inconsistencies:

- Different units of measure and data reporting standards adopted by different manufacturers. For example:
  - (i) Wind speed in knots and m/s.
  - (ii) Standard and opposite wind direction conventions.
  - (iii) Height above sea-level and above surface.
  - (iv) Geopotential and geometric height.
  - (v) Time since start, time of day (in the both forms HH:MM:SS.hh and "seconds since midnight").
- Numerous data separators, such as space, tab, comma, <, >, +;
- Including pre-flight data;
- Too many data columns (up to 80) most of which did not contain any information.

All of the above inconsistencies increase the risk of misinterpretation of the data and must be removed by the participants before the data are submitted to the common database.

It is understood that modern radiosondes have multiple channels with the specific housekeeping parameters, so we do not suggest that all data sources follow the same strictly defined data format. Nevertheless, based on the Expert Team experience, the following general requirements were strongly recommended:

1. Participants should negotiate use of the same units of measure and interpretation of variables.
2. All data files from the same data source should have same number of header lines (which may be different for different data sources, of course).
3. Same variable is always reported in the same column (which may be different for different data sources, of course).
4. Clearly defined convention for the representation of the missed data. It is recommended that all data sources follow the same method.
5. There is no limitation imposed on the data precision but it is recommended to keep it reasonable (we sometimes observe precision of 0.001 in reporting, for example, relative humidity).
6. Pre-flight data should be removed; otherwise it creates additional synchronization problems.
7. Use the most common data separators such as Space and Tab characters to ensure readability by any software package.

These requirements will be helpful no matter what software is used to evaluate the combined dataset. If participants will choose to use RSKOMP software, they can further benefit by following rather flexible RSKOMP data formatting rules and using some optional possibilities (such as metadata), implemented in this package.

WORK PLAN

No	Task description	Person responsible	Action	Deadline for action	Deliverables	Deadline for deliverables
1	**Radiosonde Intercomparison: 8th WMO intercomparison of radiosonde systems CHINA 2010** **Alternative: (Darwin, Hawaii)**	Feng Li, J. Nash, & T. Oakley	1. Define and agree on the organisation of the intercomparison, namely: main objective, place, date, duration, conditions for participation, data acquisition, processing and analysis methodology, publication of results, intercomparison rules, responsibility of the host(s) and responsibility of participants.	Q1 2008	Implementation Plan	***Q2 2008 Complete***
		Feng Li	2. Provide description of proposed intercomparison site and facility (location, environmental and climatological conditions, etc.).	Q2 2008	Description of intercomparison site	***Q2 2008 Complete***
		IOC	3. Confirm the location and finalise the participants & arrangements for the intercomparison (necessary to implement plans to develop the proposal for an alternative location).	Q4 2008	List of participating instruments	XI. 2008 (TECO)
		J. Nash, T. Oakley & Feng Li	4. Overall supervision and coordination of the field intercomparison.	X. 2010	Distribute statistics and executive summary	I. 2011
		J. Nash, T. Oakley & Feng Li	5. Evaluation of the results and preparation of the final report (maybe merge with 4 if same person is responsible)	2011	Draft final report	X. 2011
		IOC	6. Review and approval of final report	2011	Published results of the intercomparison	XII. 2011
		PL	7. Provide data of intercomparison to International Data Centre	2011	Deliver Data to relevant Centres	XII. 2011
		J. Nash & T. Oakley	8. Provide recommendations for user community (e.g. update of CIMO Guide)	2011	Document providing recommendations and CIMO guide revision proposal	XII. 2011

2	**Radiosonde Intercomparison – NAMIBIA (INTERMET System test)**	J. Nash, R. Smout & C. Gaffard	1. Produce specification of intercomparison (Trial Spec.).	IX. 2007	Guidelines (trial spec. & planning) for conducting national radiosonde tests	***X. 2207 Complete***
		M.Smees, J.Nash & C.Gaffard	2. Overall supervision and coordination of the field intercomparison.	X. 2007		***X. 2207 Complete***
		J.Nash	3. Evaluation of the results and preparation of the final report.		Published results of the intercomparison	VIII. 2008
3	**Radiosonde & Remote Sensing Intercomparison – National Plans/Work**	C. Bower & All Members	1. Provide information to the Expert Team on national results or planned tests of Radiosonde & Remote Sensing Intercomparisons.	Ongoing	Report and/or presentation to Expert Team	ET meetings
3a	**National Tests at Camborne, UK (ET-UASI Recognised test site)**	T. Oakley	2. Report to ET-UASI with regards National tests conducted at Camborne, UK. Results submitted to ET-UASI will be 'peer' reviewed and if test meets agreed standards will be recognised by CIMO.	2008-2010	Report and/or presentation to Expert Team	ET meetings or as submitted
3b	**National Tests at Lindenberg, Germany (ET-UASI Recognised test site)**	F. Berger	3. Report to ET-UASI with regards National tests conducted at Lindenberg, Germany. Results submitted to ET-UASI will be 'peer' reviewed and if test meets agreed standards will be recognised by CIMO.	2008-2010	Report and/or presentation to Expert Team	ET meetings or as submitted
3c	**National Tests at Payerne, Switz. (ET-UASI Recognised test site)**	R. Philippona	4. Report to ET-UASI with regards National tests conducted at Payerne,Switzerland. Results submitted to ET-UASI will be 'peer' reviewed and if test meets agreed standards will be recognised by CIMO.	2008-2010	Report and/or presentation to Expert Team	ET meetings or as submitted
3d	**National Tests in USA. (ET-UASI Recognised test site)**	C. Bower	5. Report to ET-UASI with regards National tests conducted in USA. Mainly with respects the replacement of radiosonde project. Results submitted to ET-UASI will be 'peer' reviewed and if test meets agreed standards will be recognised by CIMO.	2008-2010	Report and/or presentation to Expert Team	ET meetings or as submitted

4	**Ground Based Remote Sensing Intercomparisons (TESTBED) with in-situ and remote sensing UA measurements, in collaboration with ET-RSUT&T**	C. Gaffard H. Klein Baltink F. Berger A. Ivanov	1. Prepare proposals for WMO involvement in 'TESTBED' experiments. 2. Monitor, review and document testing on Regional and National levels. 3. Assess need to, and develop, up-date for relevant part of CIMO Guide, as necessary	Q1 2008 2010 2010	Presentation / Document at 1st meeting Summary reports on results and tests Document providing revision proposal	***Q2 2008 Complete*** 2010 2010
4a	**LUAMI test at Lindenberg (Co-supported by COST actions)**	F. Berger C.Gaffard D. Englebart & J. Nash	1. Provide advice and guidance to the LUAMI experiment, in particular with regards the high quality radiosonde systems. 2. Assist with the data processing and interpretation of the results. 3. Report back to the ET-UASI and advise on remote sensing systems to be used in 8th WMO Radiosonde Intercomparison.	XI. 2008 III. 2009 XII. 2009	Guidance for Radiosonde intercomparisons and assistance during campaign Workshop in Lindenberg Document the progress, results of the LUAMI project.	XI. 2008 III. 2009 XII. 2009
4b	**Review and document testing at Lindenberg 'test-bed' site**	F. Berger & D.Englebart	Provide updates and results from the Lindenberg integrated profiling site.	Ongoing	Document the progress and results of the 'test-bed' project.	XII. 2010
4c	**Review and document testing of UK FUND 'test-bed' network**	C. Gaffard & T.Oakley	Provide updates and results from the FUND UK S/E England integrated profiling network.	2009-2010	Document the progress and results of the 'test-bed' project.	XII. 2010
4d	**Review and document testing of MeteoSwiss CN-NET network**	D. Ruffieux	Provide updates and results from the CN-NET integrated profiling network in Switzerland.	2008-2010	Document the progress and results of the 'test-bed' project.	XII. 2010
4e	**Review and document testing of Cabauw, Netherlands 'test-bed' site**	Henk Klein Baltink	Provide updates and results from the Cabauw integrated profiling site.	Ongoing	Document the progress and results of the 'test-bed' project.	XII. 2010

5	**AMDAR measurements Intercomparison of water-vapour sensor**	T. Oakley C. Bower AMDAR Panel	1. Prepare proposals for WMO involvement in intercomparison tests. 2. Request AMDAR to provide data 3. Monitor, review and document testing on Regional and National levels. 4. Assess need to, and develop, up-date for relevant part of CIMO Guide, as necessary.	Q1 2008 Q2 2008 2010 2010	Presentation/Document at 1st meeting Summary reports on results and tests Document providing revision proposal	***Q2 2008 Complete*** 2010 2010
5a	**UK Comparison of E-AMDAR data with collocated Radiosondes**	T. Oakley	Report back on 2nd phase of UK Met Office comparison of E-AMDAR measurements with collocated radiosonde.	2008-2010	Report	XII. 2010
6	**Wind Profiler Intercomparisons (Quality Assessment), in collaboration with ET-RSUT&T**	T. Oakley B. Heo Henk Klein Baltink	1. Prepare proposals for WMO involvement in intercomparison tests. 2. Monitor, review and document testing on Regional and National levels. 3. Assess need to, and develop, update for relevant part of CIMO Guide, as necessary.	Q1 2008 2010 2010	Presentation/Document at 1st meeting Summary reports on results and tests Document providing revision proposal	***Q2 2008 Complete*** 2010 2010
7	**Procedures for publication of WMO intercomparison radiosonde systems results**	C. Bower	Finalize the draft.	209	Draft for CIMO Guide update	2010

LIST OF ABBREVIATIONS

AMDAR	Aircraft Meteorological Data Relay
ATM	Accurate Temperature Measuring
BQRSS	Best Quality Research Sounding Systems
ECMWF	European Centre for Medium-range Weather Forecasts
CFH	Cryogenic Frost-point Hygrometer
GCOS	Global Climate Observing System
GOS	Global Observing System
GPS	Global Positioning System
GRUAN	Global Reference Upper-Air Network
GUAN	Global Upper-Air Network
HQOR	High Quality Operational Radiosondes
IOC	International Organizing Committee
LUAMI	Lindenberg Upper Air Methods Intercomparison
NASA	National Aeronautical and Space Administration
NOAA	National Oceanic and Atmospheric Administration
NWS	National Weather Service USA
OPAG	Open Program Area Group
RBCN	Regional Basic Climate Network
RBSN	Regional Basic Synoptic Network
RDF	Radio Direction Finding
UKMO	United Kingdom Met Office
WG-ARO	Working Group on Atmospheric Reference Observations
WIGOS	WMO Integrated Global Observing Network
WIS	WMO Information System
WMO-RSO-8	8^{th} WMO Intercomparison of Radiosonde Systems

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