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**CIMO EXPERT TEAM ON
UPPER-AIR SYSTEMS INTERCOMPARISONS**
First Session

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

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**PROCEDURES OF WMO GLOBAL AND REGIONAL
INTERCOMPARISONS OF INSTRUMENTS**

(Submitted by the Secretariat)

Summary and purpose of document

This document provides information on agreed practices as relates to WMO Intercomparisons.

Action proposed

The meeting is invited to take into account information presented in this document when discussing Intercomparisons of high quality radiosonde systems with a priority given to improved temperature and relative humidity measurements since last WMO intercomparison.

- Appendices:**
- A CIMO Guide (WMO-No. 8, Sixth edition, 1996), Part III, Chapter 5 - Testing, Calibration, and Intercomparison, Excerpt;
 - B CIMO-XII, Abridged Final Report (WMO-No. 881), Casablanca, Morocco, May 1998, Excerpt;
 - C Expert Meeting on Operational Issues for Radiosonde Applications in the Tropics and Sub-tropics, - Final Report, Geneva, Switzerland, 18-22 October 1999, Excerpt.

Procedures of WMO Global and Regional Intercomparisons of Instruments

1. Eleventh session of the Commission for Instruments and Methods of Observation (CIMO-XI), Geneva, Switzerland, 1994, agreed on the Guidance to standardize the procedures and organization for instrument intercomparisons. This Guidance had been reproduced in the *CIMO Guide*, Part III, Chapter 5. Other guidance materials on this matter was prepared by CIMO XII, Casablanca, Morocco, May 1998 and by the Expert Meeting on Operational Issues for Radiosonde Applications in the Tropics and Sub-tropics, Geneva, Switzerland, 1999. This guidance material should facilitate the work of the International Organizing Committee (IOC) in preparing and carrying out WMO intercomparisons. It could further be considered as very useful information for Members planning to host or participate in WMO intercomparisons.

2. It is expected that ET on UASI and IOC for Upper-air Systems Intercomparison will refer particularly to Annex 5.A "Procedures of WMO Global and Regional Intercomparisons of Instruments" and Annex 5.B "Guidelines for Organizing WMO Intercomparisons of Instruments" of the *CIMO Guide* (see Annex). It should also be taken into account that all intercomparisons differ from each other to some extent, therefore Annexes 5.A and 5.B contain general guidance and should, when necessary, be supplemented by a specific working rules for each comparison.

CIMO GUIDE (WMO-NO. 8)

PART III, CHAPTER 5

TESTING, CALIBRATION, AND INTERCOMPARISON

(Excerpt)

5.4 Intercomparisons

Intercomparisons of instruments and observing systems, together with agreed quality control procedures, are essential for the establishment of compatible datasets. All intercomparisons should be planned and carried out carefully in order to maintain an adequate and uniform quality level of measurements of each meteorological variable. Many meteorological quantities cannot be directly compared with metrological standards and hence to absolute references — for example, visibility, cloud-base height, and precipitation. For such quantities, intercomparisons are of primary value.

Comparisons or evaluations of instruments and observing systems can be organized and carried out at the following levels:

- (a) International comparisons, in which participants from all interested countries may attend in response to a general invitation;
- (b) Regional intercomparisons, in which participants from countries of a certain region (e.g. WMO Regions) may attend in response to a general invitation;
- (c) Multilateral and bilateral intercomparisons, in which participants from two or more countries may agree to attend without a general invitation;
- (d) National intercomparisons, within a country.

Because of the importance of international comparability of measurements, WMO, from time to time, through one of its constituent bodies, arranges for international and regional comparisons of instruments. Such intercomparisons or evaluations of instruments and observing systems may be very lengthy and expensive. Rules have therefore been established so that coordination will be effective and assured. They are reproduced in Annexes 5.A and 5.B¹. They contain general guidelines and should, when necessary, be supplemented by specific working rules for each intercomparison.

Reports of particular WMO international comparisons are referenced in other chapters in this Guide (see for instance Chapters 3, 4, 8, 9, 12 and 15, Part I). Annex 5.C provides a list of the international comparisons which have been supported by the Commission for Instruments and Methods of Observation and which have been published in the WMO technical document series.

Reports of comparisons at any level should be made known and available to the meteorological community at large.

¹ Recommendations adopted by CIMO-XI, Geneva, 1994

ANNEX 5.A

PROCEDURES OF WMO GLOBAL AND REGIONAL INTERCOMPARISONS OF INSTRUMENTS

1. A WMO intercomparison of instruments and methods of observation shall be agreed upon by the WMO constituent body concerned so that it is recognized as a WMO intercomparison.
2. The Executive Council will consider the approval of the intercomparison and its inclusion in the programme and budget of WMO.
3. In case that there is an urgent need to carry out a specific intercomparison that was not considered at the session of a constituent body, the president of the relevant body may submit a corresponding proposal to the President of WMO for approval.
4. In good time before each intercomparison, the Secretary-General, in cooperation with the president of CIMO and possibly with presidents of other technical commissions, regional associations, or heads of programmes concerned, should make inquiries as to the willingness of one or more Members to act as host country and as to the interest of Members to participate in this intercomparison.
5. In the case that at least one Member has agreed to act as host country and that a reasonable number of Members have expressed their interest in participating, an international Organizing Committee (OC) should be established by the president of CIMO in consultation with the heads of the constituent bodies concerned, if appropriate.
6. Before the intercomparison begins, the OC should agree on its organization, e.g. at least on the main objectives, place, date and duration of the intercomparison, conditions for participation, data acquisition, processing and analysis methodology, plans for the publication of results, intercomparison rules, and responsibilities of the host(s) and the participants.
7. The host should nominate a project leader (PL) who will be responsible for the proper conduct of the intercomparison, the data analysis, and the preparation of a final report of the intercomparison as agreed upon by the OC. The PL will be a member ex officio of the OC.
8. In case the OC has decided to carry out the intercomparison at sites in different host countries, each of these countries should designate a site manager (SM). The responsibilities of the SMs and the overall project management will be specified by the OC.
9. The Secretary-General is invited to announce the planned intercomparison to Members as soon as possible after the establishment of the OC. The invitation should include information on the organization and rules of the intercomparison as agreed upon by the OC. Participating Members should observe these rules.
10. All further communication between the host(s) and the participants concerning organizational matters will be handled by the PL and eventually by the SMs unless other arrangements are specified by the OC.
11. Meetings of the OC during the period of the intercomparison could be arranged, if necessary.
12. After completion of the intercomparison, the OC shall discuss and approve the main results of the data analysis of the intercomparison and shall make proposals for the utilization of the results within the meteorological community.
13. The final report of the intercomparison, prepared by the PL and approved by the OC, should be published in the WMO Instrument and Observing Methods Report series.

ANNEX 5.B

Guidelines for Organizing WMO Intercomparisons of Instruments

1. Introduction

1.1 These guidelines are complementary to the procedures of WMO global and regional intercomparisons of meteorological instruments. They assume that an international Organizing Committee (OC) has been set up for the intercomparison and provide guidance to the OC for its conduct.

1.2 However, since all intercomparisons differ to some extent from each other, these guidelines should be considered as a generalized checklist of tasks. They should be modified as situations warrant, keeping in mind that fairness and scientific validity should be criteria that govern the conduct of WMO intercomparisons and evaluations.

1.3 Final reports of other WMO intercomparisons and the reports of meetings of OCs may serve as examples of the conduct of intercomparisons. These are available from the World Weather Watch Department of the WMO Secretariat.

2. Objectives of the intercomparison

The OC should examine the achievements to be expected from the intercomparison and identify the particular problems that may be expected. It should prepare a clear and detailed statement of the main objectives of the intercomparison and agree on any criteria to be used in the evaluation of results. The OC should also investigate how best to guarantee the success of the intercomparison, making use of the accumulated experience of former intercomparisons, as appropriate.

3. Place, date, and duration

3.1 The host country should be requested by the Secretariat to provide for the OC a description of the proposed intercomparison site and facilities (location(s), environmental and climatological conditions, major topographic features, etc.). It should also nominate a project leader (PL)².

3.2 The OC should examine the suitability of the proposed site and facilities, propose any necessary changes, and agree on the site and facilities to be used. A full site and environmental description should then be prepared by the PL. The OC, in consultation with the PL, should decide on the date for the start and the duration of the intercomparison.

3.3 The PL should propose a date by which the site and its facilities will be available for the installation of equipment and its connection to the data acquisition system. The schedule should include a period of time to check and test equipment and to familiarize operators with operational and routine procedures.

4. Participation in the intercomparison

4.1 The OC should consider technical and operational aspects, desirable features and preferences, restrictions, priorities, and descriptions of different instrument types for the intercomparison.

4.2 Normally, only instruments in operational use or instruments that are considered for operational use in the near future by Members should be admitted. It is the responsibility of the participating Members to calibrate their instruments against recognized standards before shipment and to provide appropriate calibration certificates. Participants may be requested to provide two identical instruments of each type in order to achieve more confidence in the data. However, this should not be a condition for participation.

² When more than one site is involved, Site Managers (SM) shall be appointed, as required. Some tasks of the PL, as outlined in this annex, shall be delegated to the SMs.

4.3 The OC should draft a detailed questionnaire in order to obtain the required information on each instrument proposed for the intercomparison. The PL shall provide further detail and complete this questionnaire as soon as possible. Participants will be requested to specify very clearly the hardware connections and software characteristics in their reply and to supply adequate documentation (a checklist for a questionnaire is available from the WMO Secretariat).

4.4 *The chairman of the OC should then request:*

- (a) The Secretary-General to invite officially Members (who have expressed an interest) to participate in the intercomparison. The invitation shall include all necessary information on the rules of the intercomparison as prepared by the OC and the PL;
- (b) The PL to handle all further contacts with participants.

5. Data acquisition

5.1 Equipment set-up

5.1.1 The OC should evaluate a proposed layout of the instrument installation prepared by the PL and agree on a layout of instruments for the intercomparison. Special attention should be paid to fair and proper siting and exposure of instruments, taking into account criteria and standards of WMO and other international organizations. The adopted siting and exposure criteria shall be documented.

5.1.2 Specific requests of participants for equipment installation should be considered and approved, if acceptable, by the PL on behalf of the OC.

5.2 Standards and references

The host country should make every effort to include at least one reference instrument in the intercomparison. The calibration of this instrument should be traceable to national or international standards. A description and specification of the standard should be provided to the OC. If no recognized standard or reference exists for the variable(s) to be measured, then the OC should agree on a method to determine a reference for the intercomparison.

5.3 Related observations and measurements

The OC should agree on a list of meteorological and environmental variables that should be measured or observed at the intercomparison site during the whole intercomparison period. It should prepare a measuring programme for these and request the host country to execute this programme. The results of this programme should be recorded in a format suitable for the intercomparison analysis.

5.4 Data acquisition system

5.4.1 Normally the host country should provide the necessary data acquisition system capable of recording the required analogue, pulse and digital (serial and parallel) signals from all participating instruments. A description and a block diagram of the full measuring chain should be provided by the host country to the OC. The OC, in consultation with the PL, should decide whether analogue chart records and visual readings from displays will be accepted in the intercomparison for analysis purposes or only for checking of the operation.

5.4.2 The data acquisition system hardware and software should be well tested before the comparison is started and measures should be taken to prevent gaps in the data record during the intercomparison period.

5.5 Data acquisition methodology

The OC should agree on appropriate data acquisition procedures, such as frequency of measurement, data sampling, averaging, data reduction, data formats, real-time quality control, etc. When data reports have to be made by participants during the time of the intercomparison or

when data are available as chart records or visual observations, the OC should agree on the responsibility for checking these data, on the period within which the data should be submitted to the PL, and on the formats and media that would allow storage of these data in the database of the host. When possible, direct comparisons should be made against the reference instrument.

5.6 Schedule of the intercomparison

The OC should agree on an outline of a time schedule for the intercomparison, including normal and specific tasks, and prepare a time chart. Details should be further worked out by the PL and his staff.

6. Data-processing and analysis

6.1 Database and data availability

6.1.1 All essential data of the intercomparison, including related meteorological and environmental data, should be stored in a database for further analysis under the supervision of the PL. The OC, in collaboration with the PL, should propose a common format for all data, including those reported by participants during the intercomparison. The OC should agree on near-real-time monitoring and quality control checks to ensure a valid database.

6.1.2 After completion of the intercomparison, the host country should, on request, provide to each participating Member a dataset from its submitted instrument(s). This set should also contain related meteorological, environmental, and reference data.

6.2 Data analysis

6.2.1 The OC should propose a framework for data analysis and processing and for the presentation of results. It should agree on data conversion, calibration and correction algorithms, and prepare a list of terms, definitions, abbreviations and relationships (where these differ on commonly accepted and documented practice). It should elaborate and prepare a comprehensive description of statistical methods to be used that correspond with the intercomparison objectives.

6.2.2 Whenever a direct, time-synchronized, one-on-one comparison would be inappropriate (e.g. in the case of spatial separation of the instruments under test), methods of analysis based on statistical distributions should be considered. Where no reference instrument exists (as for cloud base, MOR, etc), instruments should be compared against a relative reference selected from the instruments under test, based on median or modal values, care being taken to exclude unrepresentative values from the selected subset of data.

6.2.3 Whenever a second intercomparison is established some time after the first, or in a subsequent phase of an ongoing intercomparison, the methods of analysis and the presentation should include those used in the original study. This should not preclude the addition of new methods.

6.2.4 Normally the PL should be responsible for the data processing and analysis. The PL should, as early as possible, verify the appropriateness of the selected analysis procedures and, as necessary, prepare interim reports for comment by the members of the OC. Changes should be considered, as necessary, on the basis of these reviews.

6.2.5 After completion of the intercomparison, the OC should review the results and analysis prepared by the PL. It should pay special attention to recommendations for the utilization of the results of the intercomparison and to the contents of the final report.

7. Final report of the intercomparison

7.1 The OC should draft an outline of the final report and request the PL to prepare a provisional report based on it.

7.2 The final report of the intercomparison should contain, for each instrument, a summary of key performance characteristics and operational factors. Results of statistical analysis 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.

7.3 The OC should agree on procedures to be followed for approval of the final report, such as for example:

- (a) The draft final report will be prepared by the PL and submitted to all OC members and, if appropriate, also to participating Members;
- (b) Comments and amendments should be sent back to the PL within a specified time limit, with a copy to the chairman of the OC;
- (c) In case there are only minor amendments proposed, the report can be completed by the PL and sent to the WMO Secretariat for publication;
- (d) In case of major amendments or if serious problems arise that cannot be resolved by correspondence, an additional meeting of the OC should be considered (the president of CIMO should be informed of this situation immediately).

7.4 The OC may agree that intermediate and final results may be presented only by the PL and his staff at technical conferences.

8. Responsibilities

8.1 Responsibilities of participants

8.1.1 Participants shall be fully responsible for the transportation of all submitted equipment, all import and export arrangements, and any costs arising from these. Correct import/export procedures shall be followed to ensure that no delays are attributable to this process.

8.1.2 Participants shall generally install and remove any equipment under the supervision of the PL, unless the host country has agreed to do this.

8.1.3 Each participant shall provide all necessary accessories, mounting hardware, signal and power cables and connectors (compatible with the standards of the host country), spare parts, and consumables for its equipment. A participant requiring a special or non-standard power supply shall provide his own converter or adapter. Participants shall provide all detailed instructions and manuals needed for installation, operation, calibration, and routine maintenance.

8.2 Host country support

8.2.1 The host country should provide, if asked, necessary information to participating Members on temporary and permanent (in the case of consumables) import and export procedures. It should assist with the unpacking and installation of the participants' equipment and provide rooms or cabinets to house equipment that requires protection from the weather and for storage of spare parts, manuals, consumables, etc.

8.2.2 A reasonable amount of auxiliary equipment or structures, such as towers, shelters, bases or foundations, should be provided by the host country.

8.2.3 Necessary electrical power for all instruments shall be provided. The participants should be informed of the network voltage and frequency and their stability. The connection of instruments to the data acquisition system and the power supply will be done in collaboration with the participants. The PL should agree with each participant on the provision, by the participant or the host country, of power and signal cables of adequate length (and with appropriate connectors).

8.2.4 The host country should be responsible for obtaining legal authorization related to measurements in the atmosphere, such as the use of frequencies, transmission of laser radiation, compliance with civil and aeronautical laws, etc. Each participant shall submit the necessary documents on request of the PL.

8.2.5 The host country may provide information on accommodation, travel, local transport, daily logistic support, etc.

8.3 *Host country servicing*

8.3.1 Routine operator servicing by the host country will be done only for long-term intercomparisons for which the absence of the participants or their representatives can be justified.

8.3.2 When responsible for operator servicing, the host country should:

- (a) Provide normal operator servicing for each instrument, such as cleaning, chart changing, and routine adjustments as specified in the participant's operating instructions;
- (b) Check each instrument every day of the intercomparison and inform the nominated contact person representing the participant immediately of any fault that cannot be corrected by routine maintenance;
- (c) Use its best efforts to do routine calibration checks according to the participant's specific instructions.

8.3.3 The PL should maintain in a log regular records of performance of all equipment participating in the intercomparison. This log should contain notes on everything at the site that may have an effect on the intercomparison, all events concerning participating equipment, and all events concerning equipment and facilities provided by the host country.

9. Rules during the intercomparison

9.1 The PL shall exercise general control of the intercomparison on behalf of the OC.

9.2 No changes to the equipment hardware or software shall be permitted without the concurrence of the PL.

9.3 Minor repairs, such as the replacement of fuses, will be allowed with the concurrence of the PL.

9.4 Calibration checks and equipment servicing by the participants, which requires specialist knowledge or specific equipment, will be permitted according to predefined procedures.

9.5 Any problems that arise and concern the participants' equipment shall be addressed to the PL.

9.6 The PL may select a period during the intercomparison in which equipment will be operated with extended intervals between normal routine maintenance in order to assess its susceptibility to environmental conditions. The same extended intervals will be applied to all equipment.

CIMO-XII

Casablanca, Morocco, May 1998

Abridged Final Report

WMO-No. 881

Excerpt

Annex II

Annex to paragraph 5.1.8 of the general summary

**GUIDELINES FOR ORGANIZING RADIOSONDE INTERCOMPARISONS AND
FOR THE ESTABLISHMENT OF TEST SITES**

PART I - GUIDELINES FOR ORGANIZING RADIOSONDE INTERCOMPARISONS

1. Introduction

1.1 These guidelines assume that procedures that may be established by various test facilities are consistent with procedures established by other national and international organizations. They also assume that an Organizing Committee (OC) will be formed of participants (Members) interested in comparing radiosondes and that at least one non-participant will be included with ability to provide guidance for conducting the intercomparison. The involvement of an independent non-participant is important in order to avoid bias during the planning of the intercomparison. Consideration must also be given to whether radiosonde manufacturers' personnel should actively participate or whether independent operational personnel of the host should prepare and fly such radiosondes.

1.2 All intercomparisons differ from each other to some extent, therefore, these guidelines are to be construed only as a generalized checklist of tasks needing to be accomplished. Modifications should be made by the OC, as required, but the validity of the results and scientific evaluation should not be compromised.

1.3 Final reports of previous intercomparisons and organizational meeting reports of other OCs may serve as an example of the methods that can be adopted for the intercomparison. These previous reports should be maintained and made available by the Secretariat.

2. Objectives of intercomparisons

2.1 The intercomparison objectives must be clear, must list what is expected from the intercomparisons and identify how results will be disseminated. The OC is tasked to examine the achievements to be expected from the radiosonde intercomparison and to identify and anticipate any potential problem. The OC's role is to provide guidance, but it must also prepare clear and detailed statements of the main objectives and agree on the criteria to be used in evaluating the results. The OC should also determine how best to guarantee the success of the intercomparison by drawing on background knowledge and accumulated experience from previous intercomparisons.

3. Place, date and duration of intercomparison

3.1 The host facility should provide to the OC and to the participants a description of the proposed intercomparison site and facilities (locations, etc.), environmental and climatological conditions, and site topography. The host facility should also name a Project Leader (PL) or Project Manager who will be responsible for the day-to-day operation and act as the facility point of contact.

3.2 The OC should visit the proposed site to determine the suitability of its facilities and to propose changes, as necessary. After the OC agrees that the site and facilities are adequate, a site and environmental description should be prepared by the PL for distribution to the participants. The PL, who is familiar with his facility's schedule, must decide the date for the start of the intercomparison, as well as its duration. A copy of this schedule shall be delivered to the OC.

3.3 In addition to the starting date of the intercomparisons, the PL should propose a date when his facility will be available for the installation of the participant's equipment and arrange for connections to the data acquisition system. Time should be allowed for all of the participants to check and test equipment prior to starting the intercomparison and to allow additional time to familiarize the operators with the procedures of the host facility.

4. Participation

4.1 As required, the PL and/or OC should invite, through the Secretary-General of WMO, participation of Members. However, once participants are identified, the PL should handle all further contacts.

4.2 The PL should draft a detailed questionnaire to be sent by the Secretary-General to each participant in order to obtain information on each instrument type proposed to be intercompared. Participants are expected to provide information on their space, communication, unique hardware hookup requirements, and software characteristics. They also should provide adequate documentation describing their ground and balloon-borne instrumentation.

4.3 It is important that participants provide information about their radiosonde calibration procedures against recognized standards. Although it is expected that operational radiosondes will be intercompared, this may not always be the case; new or research-type radiosondes may be considered for participation with the agreement of all of the participants, the PL, and the OC.

5. Responsibilities

5.1 Participants

5.1.1 The participants shall be responsible for the transportation of their own equipment and costs associated with this transportation.

5.1.2 The participants should install and remove their own equipment with the cognizance of the PL. The host facility shall assist with unpacking and packing, as appropriate.

5.1.3 The participants shall provide all necessary accessories, mounting hardware for ground equipment, signal and power cables, spare parts and expendables unique to their system. The participants shall have available (in the event assistance from the host facility becomes necessary) detailed instructions and manuals needed for equipment installation, operation, maintenance and, if applicable, calibration.

5.2 Host facility

5.2.1 The host facility should assist participants in the unpacking and installation of equipment as necessary, and provide storage capability to house expendables, spare parts, manuals, etc.

5.2.2 The host facility should provide auxiliary equipment as necessary, if available.

5.2.3 The host facility should assist the participants with connections to the host facility's data acquisition equipment, as necessary.

5.2.4 The host shall insure that all legal obligations relating to upper-air measurements (e.g., the host country's aviation regulations, frequency utilization, etc.) are properly met.

5.2.5 The host facility may provide information on accommodations, local transportation, daily logistics support, etc., but is not obligated to subsidize costs associated with personnel accommodations.

6. Rules during the intercomparison

6.1 The PL shall exercise control of all tests. He will keep a record of each balloon launch, together with all the relevant information on the radiosondes used in the flight and the weather conditions.

6.2 Changes in equipment or software will be permitted with the cognizance and concurrence of the PL. Notification to the other participants is necessary. The PL shall maintain a log containing a record of all the equipment participating in the comparison and any changes that occur.

6.3 Minor repairs (e.g., fuse replacement, etc.) not affecting instrumentation performance are allowed. The PL should be made aware of these minor repairs and also submit the information to the record log.

6.4 Calibration checks and equipment servicing by participants requiring a specialist or specific equipment will be permitted after notification to the PL.

6.5 Any problem that compromises the intercomparison results or the performance of any equipment shall be addressed by the PL.

7. Data acquisition

7.1 The OC should agree on appropriate data acquisition procedures such as measurement frequency, sampling intervals, data averaging, data reduction (this may be limited to individual participant's capability), data formats, real-time quality control, post-analysis quality control, data reports, etc.

7.2 All data acquisition hardware and software provided by the host facility should be well tested before commencement of the intercomparison.

7.3 The time delay between observation and delivery of data to the PL shall be established by the PL and agreed on by the participants. One hour after the end of the observation (balloon burst) should be considered to be adequate.

7.4 The responsibility for checking data prior to analysis, the quality control steps to follow, and delivery of the final data rests with the PL.

7.5 Data storage media shall be the PL's decision after taking into consideration the capability of the host facility, but the media used to return final test data to participants may vary in accordance with each of the participant's computer ability. The PL should be cognizant of these requirements.

7.6 The PL has responsibility for providing final data to all participants and, therefore, the host facility must be able to receive all individual data files from each participant.

8. Data processing and analysis

8.1 Data analysis

8.1.1 A framework for data analysis should be encouraged and decided upon even prior to beginning the actual intercomparison. This framework should be included as part of the experimental plan.

8.1.2 There must be agreement among the participants as to methods of data conversion, calibration and correction algorithms, terms and abbreviations, constants, and a comprehensive description of proposed statistical analysis methods.

8.1.3 The OC should verify the appropriateness of the analysis procedures selected.

8.1.4 The results of the intercomparisons should be reviewed by the OC, who should consider the contents and recommendations given in the final report.

8.2 Data processing and database availability

8.2.1 All essential meteorological and environmental data shall be stored in a database for further use and analysis by the participants. The PL shall exercise control of these data.

8.2.2 After completion of the intercomparison, the PL shall provide a complete set of all of the participants' data to each participant.

9. Final report of the intercomparison

9.1 The PL shall prepare the draft final report which shall be submitted to the OC and to the participating members for their comments and amendments. A time limit for reply should be specified.

9.2 Comments and amendments should be returned to the PL with copies also going to the OC.

9.3 When the amended draft final report is ready, it should be submitted to the OC, who may wish to meet for discussions, if necessary, or who may agree to the final document.

9.4 After the OC approves the final document for publication, it should then be sent to the Secretariat for publication and distribution by WMO.

10. Final comments

The OC may agree that intermediate results may be presented only by the PL, and that participants may present limited data at technical conferences, except that their own test data may be used without limitation. Once the WMO Secretariat has scheduled the final report for publication, the WMO shall make the data available to all Members who request them. The Members are then free to analyse the data and present the results at meetings and in publications.

Part II — GUIDELINES FOR THE ESTABLISHMENT OF TEST SITES

1. Introduction

1.1 In order to support the long-term stability of the global upper-air observing system, it is essential to retain the capability of performing quantitative radiosonde comparisons. Current and new operational radiosonde systems must be checked against references during flight on a regular basis. Members must ensure that a minimum number of test sites with the necessary infrastructure for performing radiosonde comparison tests are retained.

1.2 Experience with the series of WMO Radiosonde Intercomparisons since 1984 has shown that it is necessary to have a range of sites in order to compare the radiosondes over a variety of flight conditions.

1.3 Relative humidity sensor performance is particularly dependent on the conditions during a test, e.g. the amount of cloud and rain encountered during ascents, or whether surface humidity is high or low.

1.4 Daytime temperature errors depend on the solar albedo, and hence the surface albedo and cloud cover. Thus, temperature errors found at coastal sites may differ significantly from continental sites. Infrared errors on temperature sensors will not only depend on surface conditions, and cloud distribution, but also on atmospheric temperature. Thus, infrared temperature errors in the tropics (for instance near the tropopause) will be quite different from those at mid-latitudes.

1.5 The errors of many upper-wind observing systems depend on the distance the balloon travels from the launch site (and also the elevation of the balloon from the launch site). Thus, comparison tests must cover situations with weak upper winds and also strong upper winds.

2. Facilities required at locations

2.1 Locations suitable for testing should have enough buildings/office space to provide work areas to support the operations of at least four different systems.

2.2 The site should have good quality surface measurements of temperature, relative humidity, pressure and wind, measured near the radiosonde launch sites. Additional reference quality measurements of temperature pressure and relative humidity would be beneficial.

2.3 The test site should have a method of providing absolute measurements of geopotential height during test flights (either using a tracking radar or a Global Positioning System (GPS) radiosonde capable of producing accurate heights).

2.4 Supplementary observing systems, such as laser ceilometers, aerosol lidars, relative humidity lidars, ground-based radiometers and interferometers, may also prove useful.

2.5 The site must be cleared by the national air traffic control authorities for launching larger balloons (3000 g) with payloads of up to 5 kg. Balloon sheds must be able to cope with launching these large balloons.

3. Suggested geographical locations

3.1 In order to facilitate testing by the main manufacturers, it is suggested that test sites should be retained or established in mid-latitudes in North America, Europe and Asia. Ideally, each of these regions would have a minimum of two sites, one representing coastal (marine) conditions, and another representing conditions in a mid-continent location.

3.2 In addition, it is suggested that a minimum of two test locations should be identified in tropical locations, particularly for tests of relative humidity sensors.

3.3 If the main test sites noted above do not provide adequate samples of extreme conditions for relative humidity sensors (e.g. very dry low-level conditions), it may be necessary to identify further test sites in an arid area, or where surface temperatures are very cold (less than -30°C in winter).

Expert Meeting on Operational Issues for Radiosonde Applications in the Tropics and Sub-tropics³

Geneva, Switzerland, 18 - 22 October 1999

Final Report

Excerpt

Appendix H

Draft

**RECOMMENDATIONS FOR TROPICAL AND SUB-TROPICAL
INTERCOMPARISON OF RADIOSONDES**

1. Because of the variety of humidity conditions that exists in Tropical and Sub-tropical regions, it becomes necessary that a minimum of three locations (more are desirable) be chosen that allows dry and rainy season data to be obtained.
2. It is known that temperature measurements require corrections, therefore, the environmental background where the measurements are made is important and particularly influences the long-wave error of thermistors. For this reason it is recommended that a variety of surface textures be considered, i.e. tropical desert, rain forest, rain forest in dry season and rainy season, that allows maximum information to be obtained.
3. Balloons able to reach 5 hPa should be used in order to extrapolate results of the intercomparison to those balloon/radiosonde stations that do not reach 5 hPa.
4. Operational radiosondes from participating Members should be chosen without regard to special instrument selection.
5. Intercomparison measurements should be interchanged between the participants on a daily basis during the test.
6. Results of the radiosonde intercomparison should be disseminated to all Members as soon as possible after the intercomparison, but not later than 18 months.

³ The full report can be accessed through WMO/CIMO's Web-site: <http://www.wmo.ch/web/www/IMOP/reports.html>