

**WORLD METEOROLOGICAL ORGANIZATION
COMMISSION FOR INSTRUMENTS AND METHODS OF OBSERVATION**

**CIMO EXPERT TEAM ON
SURFACE TECHNOLOGY AND MEASUREMENT TECHNIQUES
(ET-ST&MT)**

Second Session

Geneva, Switzerland

22-26 September 2008



FINAL REPORT

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EXECUTIVE SUMMARY

This report provides a summary of the second session of the Expert Team on Surface Technology and Measurement Techniques held in Geneva from 22 to 26 September 2008.

The expert team addressed the topic of metadata that are crucial information to exploit the full potential of observations. In view of the development of WIS, the expert team recognized the urgent need to develop metadata catalogues and agreed to start working on the instrumental aspects of such catalogues.

The expert team addressed standard observing methods for automatic measurement of clouds, present weather and other subjective observations and suggested that an intercomparison on cloud amount should be considered.

Algorithms used in AWS were discussed and a number of recommendations were made for inclusion of specific formulas in the CIMO Guide, such as formula for automatic snow depth measurement correction for ultrasonic devices, air pressure calculations, sunrise and sunset. As far as quality checks for data of subjective quantities measured automatically were concerned, the expert team agreed that existing algorithms couldn't be considered as a standard, but that skill factors could be developed and later used as requirements for the manufacturers. The expert team also reviewed and made proposals for amendments of the CIMO Guide table on Operational Uncertainty Requirements and Instrument Performance, which combines the requirements of all WMO Programmes and which is regularly used for the preparation of tenders and bids.

Standardization for the interoperability of instruments hardware and software of meteorological instruments would simplify the exchange of information making it more efficient and reducing the need for specific sensor-specific arrangements. Presently there is a lack of sensor compatibility even within one manufacturer. It was recognized that the existence of an interoperability standard would be advantageous to both users and manufacturers though it was clear that present interfaces/protocols would still exist for a long time. The expert team and HMEI agreed to collaborate to investigate the need and interest of manufacturers to work on the development of such an interoperability standard.

The expert team decided to develop Guidelines and procedures for the transition from manual to Automatic Weather Stations intended for users who do not have detailed knowledge of such transitions, in particular developing countries. Such transitions require a high level of preparation across a wide range of topics, such as installations, measurements and management of systems and imply having skilled staff available to deliver the project and run the mature systems after the transition.

The expert team addressed surface measurements in extreme weather conditions with particular focus to icing phenomena, wind and precipitations in cold climates. In extreme climate conditions, reliability of the electronics, data transfers and electricity supply is at least as critical as the reliability of the sensors themselves.

The expert team reviewed a proposal for siting classification of automatic weather stations providing a characterization of the area surrounding the station. This classification provides a very good starting point to develop guidelines for the Siting classification of Surface Observing Stations (not only of AWS). ET-ST&MT supported this proposal and recommended that a wide consultation of WMO Members be done for its further development to generate consensus.

GENERAL SUMMARY

1. ORGANIZATION OF THE SESSION

1.1 Opening of the meeting

1.1.1 The second session of the Expert Team on Surface Technology and Measurement Techniques (ET-ST&MT) was held in Geneva, Switzerland, 22-26 September 2008. Mr Karl-Heinz Klapheck, Chairperson of the ET-ST&MT, opened the session. The list of participants is given in Annex I.

1.1.2 Dr. A. Karpov, representing Wenjian Zhang, the Director of the WMO Observing and Information Systems Department, welcomed the participants to Geneva and highlighted the importance of the work of this ET for the development of WIGOS, in particular due to the importance of standardization. He also highlighted the working arrangements with ISO, that were just signed and that opened new possibilities for the publication of meteorological standards.

1.2 Adoption of the agenda

1.2.1 The ET adopted the agenda for the meeting, which is reproduced at the beginning of this report.

1.3 Working arrangements for the session

1.3.1 The working hours and tentative timetable for the meeting were agreed upon¹.

2. REPORT OF THE CHAIRMAN

2.1 The Chairman recalled the history of ET-ST&MT. He recalled that CIMO-XIV had decided to continue the work of this ET. The Terms of Reference (TOR) of the teams had been defined and prioritized. He highlighted the large variety of tasks to be addressed by the ET and stressed that the strength of the team was the variety of expertise of its members.

2.2 The Chairman noted the fact that there were some similarities between the tasks that ET-ST&MT had to address and those of ET-AWS and that the team should keep this in mind to avoid any duplication of activities. It was recognized that ET-ST&MT is responsible for instrument issues, while ET-AWS is responsible for issues dealing with the network implementations and the determination of user requirements. As far as user requirements are concerned, ET-ST&MT's role is to make recommendation on how to achieve those user requirements from the instrumental point of view.

2.3 The OPAG-Surface Co-Chair, Dr Jitze van der Meulen, recalled that ET-ST&MT needed to work towards deliverables prior to CIMO XV and that it should keep to the agreed deadlines to complete the work deliverables. The Chairman reminded the session that the main person listed as responsible for an item should incorporate the inputs from the other contributors listed in the final deliverables.

¹ The working documents of the meeting can be found under <http://www.wmo.int/pages/prog/www/IMOP/meetings/Surface/ET-STMT-2/Doc.Plan.htm> .

3. REPORTS ON PROGRESS IN ADDRESSING THE WORK PLAN OF THE EXPERT TEAM

3.1 Standardization in instrumentation and observations

Identification of siting, performance, classifications and metadata standards for systems and sensors

3.1.1 ET-ST&MT addressed the topic of metadata standards for instruments and considered a proposal by Mr Wei Li. ET-ST&MT was also informed that other expert teams, in particular ET-AWS and the Inter-Programme Expert Team on Metadata Implementation (IPET-MI) were also working on the subject. It was stressed that there is no duplication in the work of the different teams, but that they are complementing each other. IPET-MI is coordinating the development of the metadata catalogues that should be made available in the context of WIS and that would be stored in WIS Information Centers. ET-AWS is addressing the operational point of view. ET-ST&MT should address the instrumental aspects, such as information on the sensor used for each type of meteorological measurement.

3.1.2 The metadata can be considered as being composed of 2 types of information: metadata required from a real-time point of view and on the other hand, metadata necessary for archiving. The metadata must of course document any change in the instrumentation.

3.1.3 ET-ST&MT recommended that Mr Li ensures that all the parameters that he included in his proposal were also present in the metadata catalogues developed by ET-AWS and published in the Guide on the GOS (WMO-No. 488, Appendix III) that have to be used as basis for this work.

3.1.4 In view of the development of WIS, there is an urgent need to develop metadata catalogues. ET-ST&MT agreed to start developing the instrumental aspects of the metadata catalogue, but recognized that it was an open and long-term job. The task should be accomplished by taking the catalogues mentioned above that were developed by ET-AWS and for each item of Tables 1.2 and 2.2 (as published in the Guide on the GOS, WMO-No. 488, Appendix III) develop a list of observing techniques. ET-ST&MT requested Mr Li to fill in those tables according to the information published in the CIMO-Guide (type of instruments, method used for such measurements, etc...) for each of the basic meteorological variables (temperature, humidity, ...) and each type of instrument used for its measurement and to submit them to IPET-MI and ET-AWS for consideration. ET-ST&MT requested that IPET-MI provides feed-back on the tables that Mr Li will submit to allow for the continuation of this work in an appropriate manner.

3.1.5 ET-ST&MT recognized that it was useful for the user if the metadata information (such as software version, last calibration, etc...) could be pulled from the sensors and recommended that manufacturers ensure that such features are included in the instrumentation they propose. The meeting noted that the instrumental part of the metadata catalogue would provide guidance to the manufacturers, as to which metadata are necessary to be provided by the sensors. ET-ST&MT noted the software version does not necessarily give information on the capabilities of the instrument.

Recommendation for standard observing methods for automatic measurement of clouds, present weather and other subjective observations

3.1.6 Mrs Hannelore Bloemink gave a summary of the paper on automatic observation of clouds, present weather and state of the ground summarizing and analyzing the methods in use.

3.1.7 The last intercomparison of present weather sensors took place 15 years ago. The problem with carrying out such an intercomparison is the lack of clear procedures to evaluate it, since it is difficult to quantify the performance of such sensors. This would need to be achieved using for example skill scores. The last intercomparison on ceilometers (1986) had shown that the definition of the cloud base was not well defined, since it was only qualitatively defined as a significant change of extinction coefficient or of AOD, and this definition has not changed yet.

3.1.8 ET-ST&MT agreed that in view of giving guidance to Members on the most suitable technology to use, the CIMO Guide should give the most appropriate technology in the first place and requested Mrs Bloemink reformat the relevant chapters of the CIMO Guide accordingly. All technologies that are still being used by Members should be kept in the Guide, even if they are not manufactured anymore. In the case of cloud-base height the laser-base ceilometer have great advantages relative to other technologies and should be considered as the most appropriate technique. In the case of precipitation type 3 methods of observation should be considered as the most appropriate techniques (scatter sensor, disdrometer and radar). It was suggested that the manufacturers could be contacted to gather information on present technologies and HMEI offered to transmit a set of questions to its Members.

3.1.9 Various automatic methods (including camera methods) exist to determine cloud amount. ET-ST&MT suggested that an intercomparison on cloud amount should be considered in the future.

Review algorithms used in AWOS/AWS and proposal for their standardization

3.1.10 ET-ST&MT addressed the topic of algorithms used in AWS and recognized there were 2 different kinds of algorithms: algorithms based on well-known scientific formulas and manufacturers proprietary sensor-specific algorithms. In the first case, manufacturers have no problem to provide the information. For the case of manufacturers' proprietary algorithms, HMEI recognized that manufacturers normally agree to supply information about the algorithm if a customer asks for it but they consider this information as proprietary information.

3.1.11 ET-ST&MT noted that astronomical formulas (see WMO No 8, Part I, Chapter 7) should be complemented by formulas for sunrise and sunset and recommended that it should be addressed by CIMO ET A.3.

3.1.12 ET-ST&MT agreed that the formula for automatic snow depth measurement correction for ultrasonic devices should be provided in the CIMO guide.

3.1.13 Air pressure calculations were published in the International Meteorological Tables, WMO-No. 188. The English version of this document being out of print, ET-ST&MT recommended that the relevant Tables should be published as an Annex to the CIMO Guide. This recommendation was supported by HMEI.

3.1.14 The discussion about standard quality checks algorithms like range check, variability check etc. resulted in the statement that they should be mentioned only in general (they are already published in the CIMO Guide) and no details can be given on certain parameters because they depend on the individual conditions of the stations.

3.1.15 ET-ST&MT addressed the topic of quality checks for data of subjective quantities measured automatically, especially for the PW data. Existing algorithms cannot be considered as a standard. Skill factors could be developed and used as a requirement for the manufacturers. Also some subjectivity is to be noted: many users have only interest in specific PW data, for example snowfall yes/no.

3.1.16 HMEI showed interest in such skill-factor requirements. Presently, they are not mature enough to be included in the CIMO guide. The OPAG-Surface Co-Chair offered to develop a document that could be published as a IOM report and that could be used for further elaboration in view of inclusion in the CIMO Guide.

Development of standards for the interoperability of instruments hardware and software

3.1.17 Mr Stefan Waas presented a proposal to introduce standardization into future meteorological instruments. Interoperability is the "ability of independent heterogeneous systems to cooperate as far as possible for the exchange of information in an efficient way without any specific arrangement". Keeping standards is advantageous for users as well as for manufacturers.

3.1.18 After listing examples of current and successful standards such as CAN-bus in automotive industry a sensor interface and new protocol was presented based on the OSI layer model of data transmission. A scheme for the network structure of a future automatic weather station based on these approaches was explained.

3.1.19 ET-ST&MT discussed advantages and disadvantages with the use of a standard for the different ranges of applications of sensors. It was stated that there are standard protocols that work well but there is a need for standardization in the way they are used. Presently there is a lack of compatibility even within one manufacturer, so that it would be even much more difficult between different manufacturers. As an example of the difficulties that emerge from non-existing standards the present intercomparison of rain gauges in Vigna di Valle was referred to, where it was very expensive to integrate all the different interfaces and protocols into the data acquisition system.

3.1.20 The marine community is also looking at this issue, partly in the context of metadata and favor XML.

3.1.21 It was a concern, to get the many small companies together that work in the field. Present interfaces/protocols would still exist for a long time but a standard for new sensors was seen as advantageous. For a transition period separate interface boxes could be used to connect sensors with non-standard data transmission. It was seen as important that there would be no sensor specific software for the communication with the sensors. A problem was seen with the operation of sensors/systems in extreme conditions (such as -60°C) and where telecommunication was not readily available which would still keep up the need for special interfaces and protocols.

3.1.22 It was widely agreed that all would benefit from an interoperability standard. HMEI stated that it would be a great success story if WMO and HMEI could develop such a standard.

3.1.23 ET-ST&MT members agreed to send comments by end of October 2008 to Mr Waas who would develop a revised version of the paper. This paper will then be sent – together with a questionnaire that Mr Waas will develop – to HMEI who should redistribute it to its members. HMEI agreed to contact also marine manufacturers that are not members of HMEI.

3.2 Automation of surface observations

Guidelines and procedures for the transition from manual to Automatic Weather Stations

3.2.1 A paper on “Development of guidelines and procedures for the transition from manual to Automatic Weather Stations” was presented by Mike Molyneux. ET-ST&MT reviewed and agreed with the draft content of the document provided in Annex II to this report. The focus for the document should be Users who do not have detailed knowledge of these transitions, in particular developing countries.

3.2.2 In order to make the transition successful, it is necessary to prepare well, in terms of installations, measurements and management of systems. There are many issues to plan for, across a wide range of topics. This will involve having skilled staff available to deliver projects and run the mature systems after the transition.

3.2.3 ET-ST&MT agreed that the guidance document should be readable, not too long, but also comprehensive, covering key points. A template or outline project plan would be a useful inclusion, as well as information on preparing the specification to be included in the tender and on the cost that such a transition may imply. A round table discussion was used to prepare a table for the next version of the paper. This being a list of parameters commonly measured at AWS sites and some of the key issues associated with each. This can be used to guide planning for the measurement part of a successful transition. The specific recommendations for the duration of the overlap between the 2 observing systems are already specified in the CIMO Guide and therefore do not need to be included in this document.

3.2.4 Dr Igor Zahumensky informed the ET-ST&MT that similar work, focusing on the operational aspects, was being carried out by ET-AWS and that ET-AWS had recommended that the two teams work together in view of developing one single document covering the details of instrument and process change issues with input from both teams. Dr Zahumensky recommended that the final document be submitted for consideration within both teams.

3.2.5 ET-ST&MT recommended that these guidelines be published as an IOM report, since the presently available training material is out-dated (in particular WMO-No. 622, I and II as stated by CIMO XIII). However, they could also be considered for later publication as an annex to the AWS Chapter of the CIMO Guide, for example.

Instrument Development Inquiry

3.2.6 ET-ST&MT was informed on the historic background of the Instrument Development Inquiry (IDI). It was explained that CIMO has continued to endorse the need to be informed on new instruments and observation techniques. Because for a decade the IDI became more and more an instrument catalogue, CIMO has decided that the IDI should report only on newly developed instruments and instruments under development. Other instruments can be found in the World Instruments Catalogue (WIC), which has a comparable structure, or on the HMEI website for example. Because the IDI is updated approximately only every four years and therefore not always up-to-date, it was suggested and approved to start up an IDI-website to be refreshed e.g. every year. This website should contain recent developments submitted using the standard IDI questionnaire (see IOM Report 93, Appendix A). It was recommended to withdraw in due course those entries, which will become out-of-date. The website should either be hosted on the CIMO/IMOP website or a link from the CIMO website should be made to the IDI website. ET-ST&MT recognized that manufacturers may not be willing to provide information on instruments under development, but felt that research institutions may be interested to communicate such work as in the past and was therefore in favor of continuing the IDI.

3.2.7 Representatives of HMEI informed ET-ST&MT they would welcome information from the users on which particular technologies should be improved and on the needs for development of specific instrument types. In the past there was close collaboration between manufacturers and NMHSs, which enabled the manufacturers to be well aware of NMHSs needs and to develop products specially fitting their requirements. Nowadays, NMHSs are increasingly purchasing off-the-shelf systems and the collaboration is not as tight as in the past. The WMO-HMEI relationship could help close this communication gap. ET-ST&MT recognized there was a lot of sensitivity in gathering the precise needs of Members for new instrumentation. The OPAG-Surface Co-Chair offered to gather information at TECO-2008 and develop a paper summarizing his personal findings on the needs of Members and present tendencies that could be shared with manufacturers.

3.3 Surface measurements in extreme weather conditions

COST 727 Measuring and Forecasting Atmospheric Icing on Structures

3.3.1 Mr Alain Heimo, as COST representative, presented the preliminary results of the COST 727 action on "Measuring and Forecasting Atmospheric Icing on Structures". Atmospheric icing causes severe financial losses and reduces security and human safety, for example in the fields of power lines, forests and wind power production. The goals of the action are to develop the understanding of icing and to improve the potential to observe, monitor and forecast icing.

3.3.2 Mr Heimo recalled that CIMO XIV had adopted Recommendation 1 to expand the CIMO Guide by including a definition of the siting characteristics of Automatic Weather Stations in terms of local icing conditions and requirements for measurements in severe icing conditions.

3.3.3 CIMO had organized a wind instrument intercomparison on Mt Aigoual (France) in 1992-93 that showed that the formation of ice makes almost all the calculated parameters incoherent and that had not been able to characterize the icing phenomena from ice detectors. At present, CIMO

still has no guidelines for measurements of icing, though there is a requirement for such specifications. One of the objective of the COST 727 Action is precisely to fulfill the WMO/CIMO request to provide guidance for performing measurements under harsh icing conditions.

3.3.4 Mr Heimo mentioned the lack of adequate ice detectors. It had been challenging to identify and obtain “reference” sensors. Adequate instruments for the detection of ice accretion and for the measurement of ice loads were identified. Such pairs of sensors were deployed at 6 stations (4 of them belonging to NMHSs) throughout Europe, after calibration in a dedicated icing wind tunnel facility.

3.3.5 Preliminary results of COST 727 on icing event modeling were presented. Models can simulate the icing rate, the total amount and the duration of the icing. A major limitation of the simulation is due to the lack of instruments capable of measuring the Liquid Water content and Droplet Size Distribution at the stations that are needed for the modeling. It was requested that ET-ST&MT provides Mr Heimo with information on drop size distribution measurement technologies.

3.3.6 COST 727 will stop in September 2009 and it is not sure whether there will be a follow-up action and whether the 6 experimental stations will be maintained after the end of the action. ET-ST&MT agreed that it would be of great benefit to the community if this network would remain operational after the end of the action to increase our knowledge of the phenomena and to have stations where the influence of icing on other instruments could be measured and studied, which would be fully in line with WMO’s interest to support severe weather phenomena. ET-ST&MT recommended to the Management Group to encourage NMHSs to maintain those stations after completion of the action.

3.3.7 ET-ST&MT agreed that CIMO should closely collaborate with COST on this topic and would welcome the joint WMO/COST publication of the COST 727 Report as an IOM Report. This report would provide important information to WMO Members and would be a good base for the further development of guidelines on icing to be later published in the CIMO Guide.

3.3.8 Mr Heimo invited the President of CIMO to provide the opening address of the Final Workshop of the action that will be held together with the International Workshop on Atmospheric Icing on Structures IWAIS XIII in Andermatt (Switzerland), 8-11 September 2009.

Specification of measurement practices for different extreme climates

3.3.9 ET-ST&MT recommended that a new chapter on Extreme Weather should be published in the CIMO Guide. This chapter would contain recommendation for use of instruments under Mountain/Arctic Climate, Maritime Climate, Desert Climate, Tropical and Sub-tropical Climate. The OPAG-Surface Co-Chair recalled that a preliminary document had been developed for the previous session of ET-ST&MT, but that the expertise had been lost due to the unavailability of the experts who had drafted it. This document should have served as the base to develop an IOM report and later a chapter of the CIMO Guide. At present, the necessary expertise is not available in the team. ET-ST&MT recommended to invite the Permanent Representatives of countries of the authors of the above-mentioned paper to consider nominating experts to continue this work. The part of this chapter on icing should be mainly based on the findings of the COST 727 action.

Specification of sensor techniques for the measurement of extreme values of wind and precipitation

3.3.10 Under extreme conditions the difficulty is not only to provide accurate information, but also to survive the extreme climate. The mounting structure is also a critical element that should not be underestimated.

3.3.11 ET-ST&MT recognized that in extreme climate conditions the difficulty of operating instruments is more linked to the reliability of the electronics, data transfers and electricity supply than on the reliability of the sensors themselves. The industry has responded to this requirement with instruments for extreme conditions. Now it is possible to pick up from the industry a set of

sensor controls for any climatic conditions, but their price is much higher than standard sensors. At very low temperatures it is necessary to use special electronic components or to warm the devices and requires increased power supply. ET-ST&MT recommended that manufacturers should develop instruments with low power consumption for remote and extreme weather locations.

3.3.12 HMEI representative highlighted the importance of intercomparisons for the development of instruments to be used in extreme conditions, since it enables manufacturers to learn more about their instruments and their short-comings. A number of manufacturers made modifications to improve their instruments following the results of intercomparisons.

3.3.13 ET-ST&MT considered the possibility to organize the next present weather sensor intercomparison in a tropical area or in desartic area facing dust and sand.

4. PROPOSAL FOR UPDATE OF THE GUIDE TO METEOROLOGICAL INSTRUMENTS AND METHODS OF OBSERVATION (WMO-No. 8)

4.1 ET-ST&MT reviewed a proposal to update the Table on Operational Uncertainty Requirements and Instrument Performance that is published in the Guide to Meteorological Instruments and Methods of Observation (WMO-No. 8, Part I, Chapter 1, Annex 1B) which combines the requirements of all WMO Programmes. It is the basic table summarizing the WMO instrumental requirements.

4.2 ET-ST&MT recognized the importance of this table since it serves as a base for many meteorological services for stating their requirements when preparing tenders and to evaluate bids. It is therefore of utmost importance that the table be up-to-date, clear and easily understandable. Adding too much information in the table may render it more difficult to understand and reduce its use.

4.3 ET-ST&MT recommended to improve the general layout of the table, by highlighting the existence of the explanatory notes that are laid down at the end of the table, possibly by highlighting the column numbers in a separate row and using footnotes referring to the content of the notes.

4.4 ET-ST&MT requested the CIMO Rapporteur to submit the revised table (Annex III of this report) to CIMO XV for approval.

4.5 ET-ST&MT was of the opinion that the item 1.2 "Extremes of air temperature" was not necessary anymore and recommended to CBS to advise whether it was still necessary to keep it in the table. ET-ST&MT also recognized the need to update part 7 "Radiation" and recommended that ET-A3 addresses the issue. Additional variables could be considered for inclusion in the table in line with the table of functional specifications for AWS.

5. ACTIVITIES RELATED TO CBS/OPAG-IOS ET-AWS

5.1 Requirements for a robust, low power, continuous communications platform for AWS

5.1.1 The ET-ST&MT was briefed on the draft Guidelines for Requirements for a robust, low power, continuous communications platform for AWS suitable for remote locations elaborated by the CBS/OPAG-IOS ET-AWS-5 and considered the Guidelines from development of surface technology and measurement techniques points of view.

5.1.2 The ET-ST&MT agreed that the robustness of power supply and communication platforms implemented on an AWS is critical to the continuous, timely, and reliable operation and retrieval of data from AWS. This is a key issue in particular for those AWS installed in remote locations.

5.1.3 HMEI welcomed and very much appreciated development of such guidelines as it well expressed the need of the manufactures to be informed on the requirements of equipment users.

5.1.4 The ET-ST&MT made several comments on the draft regarding power management, internal technical monitoring of AWS and sensors performance, etc.

5.1.5 ET-ST&MT members agreed to review the document and to send detailed proposals for changes/inclusions to the ET-AWS member (Mrs Rodica Nitu, rodica.nitu @ ec.gc.ca) in charge of the further development of this document, with copy to ET-ST&MT Chair (karl-heinz.klapheck @ dwd.de) and the Secretariat (iruedi @ wmo.int). The proposal should include the precise text to be included and must clearly indicate where it is proposed to be included in the document and shall be sent by 15 November 2008.

5.2 Requirements for new sensors or the integration of sensors to overcome the deficiencies of AWS following the migration from manual observations

5.2.1 The ET-ST&MT considered the draft Requirements for new sensors or the integration of sensors to overcome the deficiencies of AWS following the migration from manual observations developed by the CBS/OPAG-IOE ET-AWS-5 as well as the Guidelines and procedures to assist in the transition from manual to automatic surface observing stations elaborated by the CBS/OPAG-IOE ET-AWS-5 from development of surface technology and measurement techniques points of view and made several proposals.

5.2.2 The ET-ST&MT suggested that it would be beneficial for both Members as well as for HMEI to combine these two guidelines with the guidelines presented under the Item 3.2 (Guidelines and procedures for the transition from manual to Automatic Weather Stations) as they dealt with the same topic and that it should preferably be published as an IOM report.

5.2.3 ET-ST&MT members agreed to review the document and to send detailed proposals for changes/inclusions to the ET-AWS member (Mrs Rodica Nitu, rodica.nitu @ ec.gc.ca) in charge of the further development of this document, with copy to ET-ST&MT Chair (karl-heinz.klapheck @ dwd.de) and the Secretariat (iruedi @ wmo.int). The proposal should include the precise text to be included and must clearly indicate where it is proposed to be included in the document and shall be sent by 15 November 2008.

5.3 Guidelines and procedures to assist in the transition from manual to automatic surface observing stations

5.3.1 This item was discussed in combination with agenda item 3.2 and is reported above in the corresponding section.

5.4 Siting classification of AWS

5.4.1 Mr Leroy, presented a proposal for siting classification of surface observing stations that was developed by Météo-France. Météo-France has been applying this classification to about 4000 stations for a number of years. This provides a characterization of the area surrounding the station, but doesn't allow any correction of the data. Ideally, correction methods could be applied for some parameters accounting for the characteristics of the surroundings of the station. Though such methods do exist for some parameters they require a detailed knowledge of the site environment and sometimes additional parameters and may not be a practicable procedure in the real world. The overall site classification is based on the specific classification obtained for the various instruments (temperature, humidity, precipitation, wind, radiation). The classification of any site should be updated regularly, typically every 5 years, to account for any change in the surroundings.

5.4.2 Mr Leroy proposed that this classification could be further developed with the view of preparing an international standard, possibly a WMO-ISO standard. ET-ST&MT was consulted on the content of this siting classification, in view of generating common agreement on how it should be further developed for its later adoption as international standard.

5.4.3 This classification provides a very good starting point to develop guidelines for the Siting classification of Surface Observing Stations (not only of AWS). Therefore, the CBS ET-AWS had recommended that further work be done on the Siting Classification, reproduced in the appendix in close collaboration with CIMO, with the objective to be validated by CBS and then included in the Manual of the Global Observing System (WMO-No. 544) and Guide to Meteorological Instruments and Methods of Observation (WMO-No. 8).

5.4.4 ET-ST&MT supported this proposal of a siting classification as presented by Mr Leroy and recommended that wide consultation of WMO Members should be done for its further development and to generate consensus. ET-ST&MT welcomed the offer of Mr Leroy to act as focal point (for both ET-ST&MT and ET-AWS) for the further development of this classification and agreed that he could also mention this role at the occasion of his presentation on the subject at TECO-2008 or other similar relevant events, while asking for feed-back. ET-ST&MT members agreed to review the proposal and to send their comments and suggestions to Mr Leroy by 15 November 2008.

6. WORKPLAN

6.1 ET-ST&MT reviewed its work plan in view of the outcome of the discussions on the above agenda items and adopted the workplan provided in Annex IV.

7. ANY OTHER BUSINESS

Calibration requirements for satellite sensing of surface variables

7.1 ET-ST&MT addressed the topic of the calibration requirements for satellite sensing of surface variables. In particular, ET-ST&MT reviewed the document that had been developed by ET-AWS and submitted to ET-SAT and ET-SUP. ET-ST&MT agreed with the content of the document. ET-ST&MT decided that no further action from CIMO was necessary at the moment, but that it would reconsider the issue when the satellite community would show a clear interest for calibration (or validation) of their products using surface variables.

WMO Integrated Global Observing Systems (WIGOS)

7.2 Dr Zahumensky introduced a WIGOS concept of Cg-XV and follow-up activities by the EC Working Group (WG) on WIGOS-WIS and EC-LX. The ET-ST&MT was informed that EC-LX adopted the draft of WIGOS Development and Implementation Plan (WDIP) and urged Members, Regional Associations and Technical Commissions to actively collaborate in the implementation of WDIP. The EC-LX also agreed with the WIGOS Concept of Operations (CONOPS), developed by the EC WG on WIGOS-WIS, which contains goals, objectives, major characteristics, operational framework, data policy and benefits of WIGOS.

7.3 The ET-ST&MT was briefed on CIMO Pilot Projects concerning the underpinning / crosscutting role and responsibilities of the Instruments and Methods of Observation Programme and CIMO in the context of WIGOS.

7.4 ET-ST&MT reviewed the proposed "Role and Responsibilities of the Commission for Instruments and Methods of Observation (CIMO) within the Framework of WIGOS" and made proposals for change as given in Annex V that should be submitted to the CIMO Ad-hoc Working Group on the WIGOS Pilot Project.

COST

7.5 ET-ST&MT was informed that CIMO was involved in another COST action: COST ES0702 European Ground based observations of essential variables for climate and operational

meteorology (EG-CLIMET). This action was just started and consists of 4 working groups on Instrumentation, Assimilation, Observing Experiments and Data Evaluation. It will cover the topic of the standardization of remote sensing observing systems, such as wind profilers, lidars and microwave radiometers, and their integration with *in-situ* observing systems that was assigned to CIMO by Congress XV.

8. CLOSURE OF THE SESSION

8.1 The session was closed on 26 September 2008 at 14h30.

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Guidelines and procedures for the transition from manual to automatic weather stations

Draft Outline

Section Plan

1. Introduction
2. How to plan the specification of the stations and system
3. Audit of the site
 - 3.1 Measurements
 - 3.2 Records
 - 3.3 Activities and processes
 - 3.4 Staffing levels
 - 3.5 Infrastructure
 - 3.6 People Issues
4. Off-site processes
 - 4.1 Interfaces to other hardware systems owned by the NMS
 - 4.2 Interfaces to customer hardware systems
 - 4.3 System and site management
5. Future Proofing
6. Planning and documenting Instrument change
7. Agreeing the completion of the change
8. Lessons Learnt by other Met Services
9. References

Note: Timeframe Complete write up in 08-09

1. Introduction

Weather stations simply produce data. However, the detailed uses of that data are complex and the properties of the data are key concerns to paying customers and users. The properties can vary in terms of:

- Uncertainty of measurement (WMO Guide No 8);
- Exposure;
- Availability (Amount of data missing);
- Timeliness (Delay before data is available);
- Quality (Processes used to reduce overall measurements uncertainty); and
- Maintenance (Processes used to keep hardware within specification).

The properties are often linked to the use of the data, for example:

- Climatological temperature measurements - key properties: low uncertainty, unbroken long time series;
- Safety critical at aerodromes – key properties: high quality, low delay, and low uncertainty; and
 - NWP and very short-range forecasting – key properties: timeliness.

However, it should be noted there are often several users and this increases the need for high performance in several properties.

When making any changes to a station the customers and users will be most concerned that the data output and key properties are maintained. This should be considered at all times.

Meteorological data from a station also varies considerably in subjectivity, for example the air pressure can be measured with little uncertainty with a calibrated barometer. However, the observation of cloud amount by skilled staff is much more subjective. Therefore the changes introduced by automation can be small for highly objective measurements, but significant for subjective observations of cloud amount, visibility and weather.

At an early stage the change process must link changes to the WMO agreed Karl or GCOS Principles. These have been developed by Climate data users but can be applied to all changes. These ensure the change process considers all aspects. These rules are important and stated in full here.

GCOS/GOOS/GTOS CLIMATE MONITORING PRINCIPLES

1. Effective monitoring systems for climate should adhere as closely as possible to the following principles.
2. The impact of new systems or changes to existing systems should be assessed prior to implementation.
3. A suitable period of overlap of new and old observing systems should be required.
4. The results of calibration, validation and data homogeneity assessments and assessments of algorithm changes should be treated with the same care as data.
5. A capability to routinely assess the quality and homogeneity of data on extreme events, including high-resolution data and related descriptive information, should be ensured.
6. Consideration of environmental climate-monitoring products and assessments, such as IPCC assessments, should be integrated into national, regional and global observing priorities.
7. Uninterrupted station operations and observing systems should be maintained.
8. A high priority should be given to additional observations in data-poor regions and regions sensitive to change.
9. Long-term requirements should be specified to network designers, operators and instrument engineers at the outset of new system design and implementation.
10. The carefully planned conversion of research observing systems to long-term operations should be promoted.
11. Data management systems that facilitate access, use and interpretation should be included as essential elements of climate monitoring systems.

2. How to plan the specification of the new stations and system

It is suggested that all work of this nature is carried out using the principles of "Project Management". These are well known and well documented techniques that have been shown to deliver outcomes in a predictable way. Techniques can be found in "PRINCE II" (add reference).

Met stations only exist to supply users with data. It cannot be overstressed that during the process of changing stations the users' requirements must be central. Requirement capture is familiar in WMO under Rolling Requirement Review process (link to be added). However, that system may need to be examined to extend it to all the features that may differ between manned and unmanned sites.

A well developed system to draw out user needs and existing processes can be found in "Business Analysis" methods. These can be used to plan the changes. The techniques were initially developed to work with IT systems. However, AWS systems can increasingly be considered IT data systems and techniques transfer well. Overall, the main aim is to use a systematic approach to ensure that our customers' needs are satisfied in a complete and competent manner. The exact system used is not important; but using one that is widely used, has well prepared methods and pools of skilled staff has considerable advantage. For an introduction see Business Analysis (Paul and Yates).

New business processes will be needed when the new site is installed. For example, fault identification and resolution. Where possible these should be incorporated into systems that already exist. These processes may lead to staff skills changing.

3. Audit of the site

3.1 Measurements

What measurements are made?
What instruments are there?

3.2 Records

What records are there on sites that are not duplicated elsewhere?

3.3 Activities and processes

What activities are underpinned by the staff? These may not be clear; staffs are resourceful, skilled and good at quality control. These items are not easy to automate. Interviews can be used to document these processes in detail.

3.4 Staffing levels

These are examples of site issues that will need to be considered in future. They are likely to change with automation.

Measurement quality checking
Maintenance
Grass cutting
Service Restoration

3.5 Infrastructure

New infrastructure should be considered so that it is suitable for future use. - For example, using a well designed instrument enclosure may be expensive initially. However, the infrastructure may last for more than one generation of AWS and prove less expensive in the long-term.

Security - What needs to be kept out of the site? For example, animals or vandals. Levels of protection need to be installed according to the threat.

Ownership - Who owns the site? Will changes impact on any contracts or arrangements with the Landowners?

Power supply – what power is required for the AWS and sensors. Checks on continuity of supply may be needed

3.6 People Issues

People issues may need to be considered. Levels of staffing and shift patterns may change. Skills required may change considerably.

4. Off-site processes

Offsite processes can be grouped into 3 main areas:

- Interfaces to other hardware systems owned by the NMS;
- Interfaces to customer hardware systems; and
- Management.

It should be noted that off-site changes can be considerable and often may result in increased costs to set up or run. These costs should be considered when planning changes.

4.1 Interfaces to other hardware systems owned by the NMS

In simple terms the existing data from a station is delivered to customers in an agreed format using a hardware mechanism. For example, at an existing station the data may be transmitted in SYNOP format from a PC via a modem. It is vital that some customers or users can access the data without interruption. NMS downstream systems may need to be:

- Modified to accept new data or formats; and
- Unmodified retaining data and formats but this needs considerable testing to ensure service is continued.

4.2 Interfaces to customer hardware systems

If dataflow is modified - customers will be impacted by the changes. These impacts can be mitigated by early communication and help with change planning. New systems often have additional benefits to customers and these benefits should be stressed.

4.3 System and site management

A new system will change existing structures. Early planning is required to ensure that the impacts are minimal. It may be that other processes need to expand to accommodate the changes. For example, QA Lab activities and replacement systems for sensors may need to be increased. Often greater staff skill levels will be needed in these systems.

List of Functions or teams needed to run an Automated AWS system:

- Calibration
- Stores
- Repair and service
- IT support
- Comms
- Site Management
- Sensor and Measurement development planning and procurement
- Meteorological Coding and formatting development and planning
- Post measurement quality checking – data and coded output
- Databases for measurement and metadata

5. Future Proofing

The system above is largely designed to continue the service of the existing site or system. However, it is not intended to limit the changes being when a station is automated.

For example, additional items to be considered can include:

- Ability to duplicate sensors of existing type
- Ability to add new type of sensors
- Higher frequency sampling
- Adding or modifying algorithms

For the project to run on time it is vital to identify all the areas of impact so that clear decisions can be made.

6. Planning and documenting instrument change

It is important from the Karl Principles above that measurement changes documented. However, the risk of change varies considerably. Below is a Table of parameters and an assessment of the risk of change.

Examples:

- Temperature measurement Low risk
- Cloud cover High risk

Examples of non-ideal performance should be considered here. For example, sensors at manned stations can be checked daily. This may change at unmanned stations and data quality be changed.

Parameter	Key issues	Time for documenting change	CIMO guide ref	
Temperature	<ul style="list-style-type: none"> • Siting and exposure • Scrutiny by Climate users • High quality interfaces required • Includes soil temp and grass min • Determination of max and min temp 			
Humidity	<ul style="list-style-type: none"> • Siting and exposure • Calibration interval • Contamination • Temperature dependant calibration • Time constant at high humidities • Recovery from high U and low T • Filtering 			
Wind speed and dir	<ul style="list-style-type: none"> • Siting and exposure (alignment) • Time constant (sampling freq) • Icing problem (and power) • Max survivable windspeed • Contamination • Range (high speed) • Starting speed 			
Pressure	<ul style="list-style-type: none"> • Stability (temperature) • Reduction formula (see refs) • Use of static pressure head (water trap) 		Align parameters with CIMO guide order...	
Precipitation	<ul style="list-style-type: none"> • Siting and exposure • Wind inducing Catch LOSS • Calibration Techniques (match to expected intensities) • Evaporation and wetting • Contamination and blocking (maintenance) • Impact of phase of precipitation 			

	<ul style="list-style-type: none"> and time response • Averaging interval 			
Radiation	<ul style="list-style-type: none"> • Specialist staff required • Regular cleaning 		Seek input	ET
Sunshine duration	<ul style="list-style-type: none"> • Regular cleaning • (C S not recommended) 		Seek input	ET
Visibility	<ul style="list-style-type: none"> • Regular cleaning • Subjective comparison • Point measurement • Precipitation events • Calibration • Altitude of observer (continuity) • Representivity 			
Evaporation	<ul style="list-style-type: none"> • Technology for automatic measurement • Formula to derive from other variables but may not be well followed 			
Soil moisture	<ul style="list-style-type: none"> • Diverse technology • Long Time to settle for installation 		Seek input	ET
Upper air	Not applicable			
Cloud base and coverage	<ul style="list-style-type: none"> • Regular cleaning • Range • Determination of coverage • Cloud type 			
Present Weather and state of ground	<ul style="list-style-type: none"> • Variable technology • Constrained by complexity • Subjective comparison • Unclear user requirements • Regular cleaning 			

Notes:

- Measurement of ozone and atmospheric composition may be required seek special guidance
- Urban meteorological measurements may be required
- Road meteorological measurements may be required
- Specialist sites may be located in a marine environment (oil platforms) to be considered later. Issues include access, contamination, corrosion, intrinsic safety
- Some sites (offshore and aerodrome) may have high EMC environment
- All equipment (sensors and Data acquisition needs to work in a wide range of environments
- Date and time synchronization must be considered over a remote network
- A wide-range of locations and environments imposes constraints on power availability and continuity

7. Agreeing the completion of the change

A formal testing system should be agreed and carried out as part of the system change. This should be a sign-off process to show the new system or site is acceptable. The stakeholders should be involved in the development and approval of the plan.

8. Lessons Learnt by other National Met Services

During the process of change under Project Management two key documents are suggested. These are titled “Issues Log” and “Risk Log”. If used, they can add significant value by capturing and enabling planning to deal with problems as they arise and preparing against risks outside immediate control. In order to propagate these lessons the following key issues have been noted by NMSs who have automated sites in the past or are undergoing that process.

Issues log: Examples are provided – *to be completed by discussion with ET members*

Risk log: Examples are provided – *to be completed by discussion with ET members*

9. References

(To be completed by discussion and questionnaire to ET members)

Business Analysis – Paul and Yates – British Computer Society ISBN 978-1-902505-70-1

Recent work - Parallel Expert Team document

See Expert Team on Requirements for Data from Automatic Weather Stations. Final Report of ET-AWS, Fifth Session, Annex 7 (Geneva, Switzerland, 5-9 May 2008)
http://www.wmo.ch/pages/prog/www/OSY/Reports/ET-AWS-5_Geneva_2008.pdf

There has been recent activity on this topic documented in “Transition to automated systems”.

This has been checked against the work above with few key differences noted.

OPERATIONAL MEASUREMENT UNCERTAINTY REQUIREMENTS AND INSTRUMENT PERFORMANCE

SEE EXPLANATORY NOTES BELOW THIS TABLE; FIRST ROW INDICATES COLUMN NUMBERS

(1) Variable	(2) Range	(3) Reported resolution	(4) Mode of measurement/observation	(5) Required measurement uncertainty	(6) Sensor time constant	(7) Output averaging time	(8) Achievable measurement uncertainty	(9) Remarks
<u>Variable</u>	<u>Range</u>	<u>Reported resolution</u>	<u>Mode of measurement/observation</u>	<u>Required measurement uncertainty</u>	<u>Sensor time constant</u>	<u>Output averaging time</u>	<u>Achievable measurement uncertainty</u>	<u>Remarks</u>
1. Temperature								
1.1 Air temperature	-80 – +60°C	0.1 K	I	0.3 K for ≤ -40°C 0.1 K for > -40°C and ≤ +40°C 0.3 K for > +40°C	20 s	1 min	0.2 K	Achievable uncertainty and effective time-constant may be affected by the design of the thermometer solar radiation screen. Time-constant depends on the air-flow over the sensor.
1.2 Extremes of air temperature	-80 – +60°C	0.1 K	I	0.5 K for ≤ -40°C 0.3 K for > -40°C and ≤ +40°C 0.5 K for > +40°C	20 s	1 min	0.2 K	
1.3 Sea surface temperature	-2 – +40°C	0.1 K	I	0.1 K	20 s	1 min	0.2 K	
<u>1.4 Soil Temperature</u>	<u>-50 - +50°</u>	<u>0.1K</u>	<u>I</u>		<u>20 s</u>	<u>1 min</u>	<u>0.2 K</u>	

2. Humidity 2.1 Dewpoint temperature	-80 – +35°C	0.1 K	I	0.1 K	20 s	1 min	0.25 K	Measurement uncertainty depends on the deviation from air temperature
Wet-bulb temperature (psychrometer)								
2.2 Relative humidity	0 – 100%	1%	I	1%	20 s	1 min	0.2 K	If measured directly and in combination with air temperature (dry bulb) Large errors are possible due to aspiration and cleanliness problems (see also note 11) Threshold of 0°C to be noticed for wet bulb
Solid state and others								
					40 s	1 min	3%	Time constant and achievable uncertainty of s Solid state sensors may show significant temperature and humidity dependence
3. Atmospheric pressure								

CIMO/OPAG-SURFACE/ET-ST&MT-2, ANNEX III, p. 3

3.1	Pressure	500 – 1080 hPa	0.1 hPa	I	0.1 hPa	20 s	1 min	0.1 3 hPa	Both station pressure and MSL pressure Measurement uncertainty is seriously affected by dynamic pressure due to wind if no precautions are taken Inadequate temperature compensation of the transducer may affect the measurement uncertainty significantly MSL pressure is affected by the uncertainty in altitude of the barometer for measurements onboard ships
3.2	Tendency	Not specified	0.1 hPa	I	0.2 hPa			0.2 hPa	Difference between instantaneous values
4.	Clouds								
4.1	Cloud amount	0/8 – 8/8	1/8	I	1/8	n/a		2/8	Period (30 s) clustering algorithms may be used to estimate low cloud amount automatically

4.2 Height of cloud base	0 m – 30 km	10 m	I	10 m for ≤ 100 m 10% for > 100 m	n/a		~10 m	Achievable measurement uncertainty is can be determined with a hard target . undetermined because No clear definition exists for instrumentally measured cloud-base height (e.g. based on penetration depth or significant discontinuity in the extinction profile) Significant bias during precipitation
4.3 Height of cloud top	Not available							
5. Wind								
5.1 Speed	0 – 75 m s ⁻¹	0.5 m s ⁻¹	A	0.5 m s ⁻¹ for ≤ 5 m s ⁻¹ 10% for > 5 m s ⁻¹	Distance constant 2 – 5 m	2 and/or 10 min	0.5 m s ⁻¹ for ≤ 5 m s ⁻¹ 10% for > 5 m s ⁻¹	Average over 2 and/or 10 min Non-linear devices. Care needed in design of averaging process Distance constant is usually expressed as response length Averages computed over Cartesian components (see Part III, Chapter 3, section 3.6 of this Guide) When using ultrasonic anemometers no distance constant or time constant is needed. For moving mobile stations, the movement of the station needs to be taken into account, inclusive of its uncertainty.
5.2 Direction	0 – 360°	1°	A	5°	1 s	2 and/or 10 min	5°	

5.3	Gusts	0.1 – 150 m s ⁻¹	0.1 m s ⁻¹	A	10%		3 s	0.5 m s ⁻¹ for ≤ 5 m s ⁻¹ 10% for > 5 m s ⁻¹	Highest 3 s average should be recorded
6.	Precipitation								
6.1	Amount (daily)	0 – 500 mm	0.1 mm	T	0.1 mm for ≤ 5 mm 2% for > 5 mm	n/a	n/a	The larger of 5% or 0.1 mm	Quantity based on daily amounts Measurement uncertainty depends on aerodynamic collection efficiency of gauges and evaporation losses in heated gauges
6.2	Depth of snow	0 – 25 m	1 cm	<u>A</u>	1 cm for ≤ 20 cm 5% for > 20 cm	<u>< 10 s</u>	<u>1 min</u>	<u>1 cm</u>	Average depth over an area representative of the observing site
6.3	Thickness of ice accretion on ships	Not specified	1 cm	I	1 cm for ≤ 10 cm 10% for > 10 cm				
6.4	Precipitation intensity	0.02 mm h ⁻¹ – 2000 mm h ⁻¹	0.1 mm h ⁻¹	I	(trace): n/a for 0.02 – 0.2 mm h ⁻¹ 0.1 mm h ⁻¹ for 0.2 – 2 mm h ⁻¹ 5% for > 2 mm h ⁻¹	< 30 s	1 min		Uncertainty values for liquid precipitation only Uncertainty is seriously affected by wind Sensors may show significant non-linear behaviour For < 0.2 mm h ⁻¹ : detection only (yes/no) sensor time constant is significantly affected during solid precipitation using catchment type of gauges

6.5 Precipitation duration (daily)	0-24 h	60 s	I	n/a	60s			Threshold value of 0.02 mm/h
7. Radiation								
7.1 Sunshine duration (daily)	0 – 24 h	60 s	T	0.1 h	20 s	n/a	The larger of 0.1 h or 2%	Radiant exposure expressed as daily sums (amount) of (net) radiation
7.2 Net radiation, radiant exposure (daily)	Not specified	1 J m ⁻²	T	0.4 MJ m ⁻² for ≤ 8 MJ m ⁻² 5% for > 8 MJ m ⁻²	20 s	n/a	0.4 MJ m ⁻² for ≤ 8 MJ m ⁻² 5% for > 8 MJ m ⁻²	
8. Visibility								
8.1 Meteorological optical range (MOR)	10 m – 100 km	1 m	I	50 m for ≤ 600 m 10% for > 600 m – ≤ 1500 m 20% for > 1500 m	< 30 s	1 and 10 min	The larger of 20 m or 20%	Achievable measurement uncertainty may depend on the cause of obscuration Quantity to be averaged: extinction coefficient (see Part III, Chapter 3, section 3.6, of this Guide). Preference for averaging logarithmic values
8.2 Runway visual range (RVR)	10 m – 1520 2000 m	1 m	A	10 m for ≤ 400 m 25 m for > 400 m – ≤ 800 m 10% for > 800 m	< 30 s	1 and 10 min	The larger of 20 m or 20%	In accordance with WMO-No. 49, Volume II, Attachment A (2004 ed.) and ICAO Doc 9328-AN/908 (second ed., 2000) New versions of these documents may exist specifying other values

8.3 Background luminance	0 - 40000 cd m⁻²	1 cd m⁻²	I		30 s	1 min	10%	Related to 8.2 RVR
9 Waves								
9.1 Significant wave height	0 – 50 m	0.1 m	A	0.5 m for ≤ 5 m 10% for > 5 m	0.5 s	20 min	0.5 m for ≤ 5 m 10% for > 5 m	Average over 20 min for instrumental measurements
9.2 Wave period	0 – 100 s	1 s	A	0.5 s	0.5 s	20 min	0.5 s	Average over 20 min for instrumental measurements
9.3 Wave direction	0 – 360°	1°	A	10°	0.5 s	20 min	20°	Average over 20 min for instrumental measurements
10. Evaporation								
10.1 Amount of pan evaporation	0 – 100 mm	0.1 mm	T	0.1 mm for ≤ 5 mm 2% for > 5 mm	n/a			

- Notes:
- Column 1 gives the basic variable.
 - Column 2 gives the common range for most variables; limits depend on local climatological conditions.
 - Column 3 gives the most stringent resolution as determined by the *Manual on Codes* (WMO-No. 306).
 - In column 4:
 - I = Instantaneous: In order to exclude the natural small-scale variability and the noise, an average value over a period of 1 min is considered as a minimum and most suitable; averages over periods of up to 10 min are acceptable.
 - A: = Averaging: Average values over a fixed period, as specified by the coding requirements.
 - T: = Totals: Totals over a fixed period, as specified by coding requirements.
 - Column 5 gives the recommended measurement uncertainty requirements for general operational use, i.e. of Level II data according to FM 12, 13, 14, 15 and its BUFR equivalents. They have been adopted by all

eight technical commissions and are applicable for synoptic, aeronautical, agricultural and marine meteorology, hydrology, climatology, etc. These requirements are applicable for both manned and automatic weather stations as defined in the *Manual on the Global Observing System* (WMO-No. 544). Individual applications may have less stringent requirements. The stated value of required measurement uncertainty represents the uncertainty of the reported value with respect to the true value and indicates the interval in which the true value lies with a stated probability. The recommended probability level is 95 per cent ($k = 2$), which corresponds to the 2σ level for a normal (Gaussian) distribution of the variable. The assumption that all known corrections are taken into account implies that the errors in reported values will have a mean value (or bias) close to zero. Any residual bias should be small compared with the stated measurement uncertainty requirement. The true value is the value which, under operational conditions, perfectly characterizes the variable to be measured/observed over the representative time interval, area and/or volume required, taking into account siting and exposure.

6. Columns 2 to 5 refer to the requirements established by the CBS Expert Team on Requirements for Data from Automatic Weather Stations in 2004.

7. Columns 6 to 8 refer to the typical operational performance established by the CIMO Expert Team on Surface Technology and Measurement Techniques in 2004.

8. Achievable measurement uncertainty (column 8) is based on sensor performance under nominal and recommended exposure that can be achieved in operational practice. It should be regarded as a practical aid to users in defining achievable and affordable requirements.

9. n/a = not applicable.

10. The term *uncertainty* has preference over *accuracy* (i.e. uncertainty is in accordance with ISO standards on the uncertainty of measurements (ISO, 1995)).

11. Dewpoint temperature, relative humidity and air temperature are linked, and thus their uncertainties are linked. When averaging, preference is given to absolute humidity as the principal variable.

**Workplan of ET-ST&MT
(2008-2010)**

No.	Task description	Person responsible	Action	Deadline	Deliverables	Deadline
1	Standardization in instrumentation and observations					
1a	Identify siting, performance, classifications and metadata standards for systems and sensors	LI Wei Contributions: K. Klapheck	In collaboration with CBS-ETs: 1. Compare keywords with "official" keywords given in Guide on the GOS for WMO Metadata core profile relative to instruments 2. Develop metadata catalogues for stations , sensors, data handling	Jul 2008	Task report to CIMO-XV 1 catalogue Catalogues	Jul 2010 Jul 2009 Jul 2010
1b	Recommend standard observing methods for automatic measurement of clouds, present weather etc	H. Bloemink Contributions: Wei Li K. Klapheck	1. Review and list methods in use 2. Analyze methods and recommend standards Update Chapters of the CIMO Guide	Jul 2008	Task report to CIMO-XV Update of CIMO-Guide chapters Update of CIMO-Guide chapters	Jul 2010 End 2009 Nov 2008
1c	Review algorithms in AWOSs and make proposal for their standardization	J. van den Meulen	1. Verify availability of snow depth correction formula in CIMO Guide Inclusion of air-reduction tables in CIMO Guide IOM report on skill factor requirements	Nov 2008	Update of CIMO-Guide chapters IOM Report	Nov 2008 July 2010
1d	Develop standards for the interoperability of instruments' hardware and software	St. Waas Contributions: K. Klapheck	1. Review standards in use in met. instrumentation 2. Recommend and give reasons for new standards 3. Collaborate with HMEI (questionnaire) and analyze replies	Jul 2008	Task report to CIMO-XV and HMEI Document	Jul 2010

2 Automatization of surface observations

2a	Develop guidelines and procedures for the transition from manual to automatic weather stations	M. Molyneux Contributions: All	1. Review existing material 2. Search and describe new procedures Collaborate with ET-AWS to finalize guidelines	Jul 2008	Task report to CIMO-XV IOM Report	Jul 2010
2b	Instrument Development Inquiry - Report on progress in new surface technologies and techniques	J. van der Meulen Contributions: S. Waas	1. Review IDI 2. In coop. with HMEI look for new techniques 3. Develop website and update IDI	Jul 2008	IOM Report Website with update of IDI	Jul 2010 2009

3 Surface measurements in extreme weather conditions

3a	Describe requirements on instruments on meteorological icing	A. Heimo	Joint COST/WMO Publication of COST 727 Action, containing: 1. Analyze and describe the problem 2. Investigate into tests experiences etc of icing 3. Recommend best practices	Jul 2008	COST/IOM Report	Jul 2010
3b	Specify measurement practices for different extreme climates	M. Novitsky Contributions: TBD	1. Review practices of measurement 2. Analyze and recommend best practices	Jul 2008	Task report to CIMO-XV Document	Jul 2010
3c	Find sensor techniques for the measurement of extreme values of wind and precipitation	S. Waas Contributions: Wei Li	1. In coop. with HMEI investigate about appropriate sensors 2. Prompting HMEI to instrument adaptations	Jul 2008	Task report to CIMO-XV Update of CIMO-Guide chapters	End 2009

4 Miscellaneous tasks

4a	In cooperation with CBS: Report on calibration requirements for satellite sensing of surface variables	N. N.	1. List variables to be considered 2. Discuss requirements on surface datasets	Jul 2008	on hold
4b	Review uncertainty requirements and operational instrument performance	Klapheck	1. Review existing CIMO table 2. Actualize specifications	Jul 2008	Update of CIMO-Guide chapter Done

Comments of CIMO ET MT&ST on the
Role and Responsibilities of the Commission for Instruments and
Methods of Observation (CIMO) within the framework of the WMO
Integrated Global Observing Systems (WIGOS)

(Extract from the final report of the CIMO Ad-Hoc Working Group on WIGOS, First Session)

Within the framework of the WMO Integrated Global Observing Systems (WIGOS).

The Commission shall be responsible for matters relating to international standardization, compatibility and sustainability of instruments and methods of observation of meteorological, climatological, hydrological, oceanographic, and related geophysical and environmental variables.

This responsibility underpins all observations within WIGOS, and will be carried out in close consultation with relevant WMO partner organizations that co-sponsor, own and/or operate some of the observing systems.

This shall include in particular (priority to be defined at later stage):

- (a) Addressing the requirements across all elements of WIGOS for standardized and compatible observations, including data content, quality and metadata;
- (b) Providing advice, studies and recommendations concerning effective and sustainable use of instruments and methods of observation consistent with DRR/NDPM, including methods for ~~testing~~ intercomparisons, calibration and quality management consistent with the WMO Quality Management Framework ;
- (c) Conducting and/or coordinating global and regional field intercomparisons and functional ~~testing checks~~ of instruments and methods of observation;
- (d) Promoting the development of measurement traceability to recognized international standards, including reference instruments and effective hierarchy of world, regional, national and lead centres for instrument calibration, development and testing**;
- (e) Promoting compatibility, inter-calibration, integration and inter-operability with respect to both, and between, space-based and surface-based (*in situ* and remote sensing) observations, including conducting testbed observing experiments;
- (f) Encouraging research and development of new approaches in the field of instruments and methods of observation of meteorological, climatological, hydrological, oceanographic, and related geophysical and environmental variables;
- (g) Promoting the appropriate and economical production and use of instruments and methods of observation with particular attention to the needs of developing countries; and
- (h) Supporting training and capacity building activities in the area of instruments and methods of observation.

** It is not known whether CIMO can provide guidelines for instrument development and test.
