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

COMMISSION FOR BASIC SYSTEMS

OPEN PROGRAMME AREA GROUP ON INTEGRATED OBSERVING SYSTEMS

EXPERT TEAM ON REQUIREMENTS AND IMPLEMENTATION OF AWS PLATFORMS (ET-AWS)

(Seventh Session)

Geneva, Switzerland

16-20 April 2012

FINAL REPORT

CONTENTS

AGENDA

1 ORGANIZATION OF THE SESSION

1.1 Opening of the session

1.2 Adoption of the agenda

1.3 Working arrangements

2 REPORT OF THE CHAIRMAN

3 DEVELOPMENT AND IMPLEMENTATION OF THE WIGOS CONCEPT

4 REQUIREMENTS FOR THE INTEGRATION BETWEEN AWS AND SPACE-BASED OBSERVATIONS

5 REQUIREMENTS AND SPECIFICATIONS FOR AUTOMATED OBSERVATIONS NETWORKS

6 REQUIREMENTS AND STANDARDS FOR A BASIC, ROBUST AWS SUITABLE FOR LESS DEVELOPED, REMOTE AND EXTREME CLIMATE CONDITIONS

7 GAP ANALYSIS FOR AUTOMATED OBSERVATIONS FOLLOWING THE TRANSITION FROM MANUAL OBSERVATIONS

8 AWS METADATA CATALOGUES FOR REAL-TIME EXCHANGE THROUGH WIS

9 GUIDELINES FOR THE SITING CLASSIFICATION OF SURFACE OBSERVING STATIONS

10 BUFR DESCRIPTORS RELATED TO AWS

11 ADVANCES IN AWS TECHNOLOGY

12 OTHER BUSINESS

12.1 ET-AWS input to ET-EGOS on EGOS-IP

12.2 Input to upcoming SatCom meeting (Toulouse, 23-24 April 2012)

12.3 Regulatory Material for AWS

12.4 AWS Data Quality Control

13 RECOMMENDATIONS FOR CBS-XV

14. WORK PLAN

15 CLOSURE OF THE MEETING

GENERAL SUMMARY

1. ORGANIZATION OF THE SESSION

1.1 Opening of the session

1.1.1 The Seventh Session of the CBS Expert Team on Requirements and Implementation of AWS Platforms (ET-AWS) was held in Geneva, Switzerland from 16 to 20 April 2012. The meeting was opened by Mr Karl Monnik, Chair of ET-AWS. Mr Monnik welcomed all participants (listed at Annex I); both those attending in Geneva and those participating remotely by electronic conferencing.

1.2 Adoption of the agenda

1.2.1 The Session adopted the modified Agenda for the meeting, which is reproduced on p. iii of this report.

1.3 Working arrangements

1.3.1 The tentative working hours for the meeting were agreed upon.

2. REPORT OF THE CHAIRMAN

2.1 The Chair of ET-AWS, Mr Monnik, reported on the ET's activities since 2010 and on the achievements against the approved work plan to date. Mr Monnik noted that the previous meeting of ET-AWS was held 22-25 June 2010 in Geneva (see http://www.wmo.int/pages/prog/www/OSY/Reports/ET-AWS-6_Geneva_2010_REV.doc). Since the meeting the composition of ET-AWS has changed and is currently made up of the following members:

1. MONNIK, Karl	Chair	Australia	RAV
2. MERROUCHI, Rabia	Vice-chair	Morocco	RAI
3. PATERSON, Charles		Canada	RAIV
4. FENG, Dongxia		China	RAII
5. KRISHNAIAH, Sevakula		India	RAII
6. VAN DER MEULEN, Jitze		Netherlands	Representing CIMO
7. CERVENA, Eva		Czech Republic	Representing IPET-DRC
8. SABATINI, Francesco		Italy	Representing CgAM

2.2 ET-AWS-6 considered the contribution of ET-AWS to WIGOS. The ET-AWS work plan includes elements which contribute towards WIGOS goals through facilitating interoperability, standardisation, and management of metadata and data discovery. Further progress is required before ET-AWS can contribute meaningfully to WIGOS, particularly considering the increasing role AWSs play in National networks.

2.3 It was agreed during ET-AWS-6 that AWS Functional Specifications should be continuously maintained and reviewed. To improve the process of maintaining and updating Functional Specifications, ET-AWS agreed that proposed variables should have a "mentor" on a semi-permanent basis. The Functional Requirements were accepted by ICT-IOS.

2.4 Considering the important role of data communications for AWS networks, ET-AWS-6 had endorsed a proposal originating as a recommendation from the JCOMM Pilot Project for WIGOS to establish an international forum of users of satellite data telecommunication systems to address system deficiencies, negotiate tariffs and potential improvements of the rendered services with the operators of satellite data telecommunication systems. The proposal was supported by ICT-IOS-6, agreed during CBS-Ext(2010) and presented to Cg-XVI.

2.5 Cg-XVI supported the establishment of the proposed international forum of users of satellite data telecommunication systems covering a wide user base, to address, inter alia, remote data communication requirements – including tariff negotiations as needed – for automatic environment observing systems coordinated through WMO and partner organizations such as IOC and FAO. In considering the proposal, Cg-XVI expressed concern regarding the fact that data from many Antarctic stations funded by research agencies are not available in real-time and, therefore, are not available to NWP systems. It noted that the high communication cost involved in using Iridium satellites is also a limiting factor. Congress requested the Executive Council and the Secretary-General, in collaboration with CBS and JCOMM, to investigate possible ways to reduce such costs through the proposed forum. It also expressed its desire that WIS would provide a suitable environment for collection and dissemination of data from research observing stations. The first SATCOM workshop has been scheduled for the week following ET-AWS-7 and ET-AWS will be represented at the meeting by its Chair.

2.6 Following input by both ET-AWS and ET-ST&MT, guidance material concerning the transition from manual to automated observations was presented to CIMO. This document requires some further review before it can be published.

2.7 An exploratory proposal by ET-AWS to consider the potential of surface-based AWS hosted sensors being used to validate satellite observations was considered by CBS ET-SAT and ET-SUP. Following consideration at ICT-IOS-6, and discussion at ET-SAT-6 and subsequent action taken by EUMETSAT and its Land Surface Analysis SAF, clear interest in AWS measurements of the following variables was identified:

- - DWSF (Downward Surface Shortwave Flux)
- - DSLF (Downward Surface Longwave Flux)
- - LST (Land Surface Temperature)
- - AL (Earth Surface Albedo)

ET-AWS-7 will need to consider how best to take this forward. Sites where this is already measured, or could potentially be measured, will need to be identified.

2.8 The siting classification scheme, which was proposed in ET-AWS-5 and further expanded in ET-AWS-6, was endorsed by CIMO-XV in Helsinki, 2010. CIMO-XV requested it to be included in the CIMO Guide with the following clarifications in order to ensure its appropriate use: 1) the use of the siting classification of observing stations depends on the purposes of the observations, 2) the proposed classification is the first official version of the siting classification, and will be reviewed and updated as needed at CIMO-XVI. The classification was published in Annex IV of CIMO-XV (WMO No. 1064) and is about to be published in the latest edition of the CIMO Guide, which is expected to be accessible very soon on the CIMO website.

2.9 CIMO also requested guidance material to be developed on the characterisation process for stations and advice on how to use the results obtained, indicating for which purpose stations of a specific class are appropriate.

2.10 AWSs continue to expand across the globe, including in most NHMS. The need for requirements and standards for robust AWSs suitable for less developed and remote areas is a priority for WMO. These requirements should highlight the ongoing need for site visits and skills required to manage such networks.

2.11 Cooperation with IPET-DRC has continued with further revision of some the BUFR/CREX descriptors for the functional specifications for AWS. Terminology for radiation still needs to be resolved. BUFR descriptors for all the variables defined in the AWS Functional Specifications have been developed. Where necessary IPET DRC have developed and validated new descriptors. The BUFR template for n-minute AWS data was expanded to include ground temperature over a variety of surfaces following a request made during the third meeting of IPET-DRC.

3 DEVELOPMENT AND IMPLEMENTATION OF THE WIGOS CONCEPT

3.1 Dr Atkinson provided a brief history of the development of the WIGOS concept and described recent progress in the development and implementation of the WIGOS draft Implementation Plan.

3.2 Cg-XVI (Geneva, May-June 2010), through its resolution (Res. 50 (Cg-XVI) – Implementation of the WMO Integrated Global Observing System (WIGOS), decided to implement the WMO Integrated Global Observing System. It further decided that implementation activities will be undertaken during the next financial period as one of the major efforts of the Organization with the goal that WIGOS should become operational from 2016 onwards. Cg-XVI provided overall guidance and determined responsibilities for all constituent bodies to ensure WIGOS implementation. The tasks assigned by Congress to technical commissions are of direct relevance to the ET-AWS as one of the working bodies of CBS.

3.3 Cg-XVI in particular requested the technical commissions to:

- Guide the technical aspects of WIGOS implementation;
- Incorporate WIGOS implementation activities in their operating plan and work programme;
- Provide technical guidance and advice to Members and the regional associations on WIGOS;
- Develop guidance for the design and evolution of observing components of WIGOS;
- Develop standards to support WIGOS in collaboration with partner organizations and programmes;
- Update WMO Regulatory Material, including development of the Manual on WIGOS;
- Provide the technical lead for WIGOS through the Commission for Basic Systems (CBS) and the Commission for Instruments and Methods of Observation (CIMO).

3.4 Congress emphasized that the implementation of WIGOS should build upon and add value to the existing WMO observing systems with emphasis on integration of surface- and space-based observations in an evolutionary process to satisfy requirements of WMO and WMO co-sponsored Programmes. Congress noted that, since all WMO Programmes would benefit, each should actively participate and contribute its own expertise and resources in implementing WIGOS.

3.5 Congress recognized the important role of WIS in WIGOS implementation, in relation to data exchange and discovery, and the provision of effective standards and practices for data management. Congress stressed the importance of coordination between WIGOS and WIS implementation activities.

3.6 Congress stressed the importance of the development of an implementation plan for the evolution of WIGOS beyond 2015 including technical guidance on how to design, develop and implement integrated national observing systems to provide comprehensive observations in response to the needs of all WMO Members and Programmes.

3.7 Congress agreed that the implementation of WIGOS must be reflected in the revised WMO Technical Regulations, documenting the WIGOS concept of operations and contributions of all observing components. In this regard, the Congress endorsed the inclusion of the Manual on WIGOS in the list of mandatory publications. Following the decision by Cg-XVI, EC-LXIII (May, 2011) established the Inter-Commission Coordination Group on WIGOS (ICG-WIGOS) under the chairmanship of Mr Fred R. Branski (USA), the president of CBS, with representatives of regional associations and international partner organizations during the implementation process. ICG-WIGOS was specifically tasked to develop and submit the WIGOS Implementation Plan (WIP) for approval by the EC-64.

3.8 The first session of the ICG-WIGOS was held at the WMO Secretariat in Geneva, Switzerland, from 26 to 30 September 2011.

3.9 Based on the decisions by Cg-XVI and EC-LXIII, ICG-WIGOS-1 addressed all key components of WIGOS implementation:

- WIGOS Concept of Operations - Functional Architecture;
- Manual on WIGOS;
- WIGOS Communications and Outreach Strategy;
- WIGOS Capacity Building Strategy;
- WIGOS Implementation Plan (WIP);
- Guidance on WIGOS activities to be implemented by Members.

3.10 ICG-WIGOS formulated recommendations and guidance on the above WIGOS implementation components[1] and established, inter-alia, the following Task Teams (TT): TT on WIGOS Manual, TT on WIGOS Metadata and TT on WIGOS Implementation Plan (WIP).

3.11 The Task Team on WIP (TT-WIP) met in Geneva from 27 to 30 March 2012 under the chairmanship of F. Branski and developed a draft WIP, version 0.8 (see Appendix I) which will be submitted to EC-64 for approval through the document EC-64/Doc. 4.4(1).

3.12 In elaborating the WIP, TT-WIP-1 addressed major technical issues, and made appropriate changes/edits to ensure full compliance with the guidance and recommendations made by Cg and EC. Table 4.1 of the draft WIP presents the description of implementation activities, associated deliverables, timelines, responsibilities, costs and associated risk

3.13 Particular attention of ET-AWS was invited to the Key Activity Areas for WIGOS Implementation described in the draft WIP. It was recommended that for each activity a detailed activity plan be developed by the responsible entity(s) with support of the Project Office and guidance from ICG-WIGOS. ET-AWS was invited to indicate to the WIGOS Project Office those activities to which it could contribute.

3.14 Following the task on further alignment of programme activities to support WIGOS implementation, a proposal for the possible new structure of CBS OPAG-IOS (2012-2016) was developed jointly by the Secretariat with the President of CBS and the Chair and Co-chair of OPAG IOS. The Meeting was invited to provide comment to ICT-IOC through the Chair of ET-AWS on the suggested new structure of OPAG-IOS, keeping in mind that there would be a need to focus the OPAG's limited resources during the coming inter-sessional period to assist with WIGOS Implementation whilst maintaining its priority activities at an acceptable level.

3.15 Dr Lars Peter Riishojgaard (chair of ICT-IOS) and Dr Wenjian Zhang (Director Observing and Information Systems) joined the ET meeting to discuss options for the future configuration of the ETs under IOS following CBS XV. The clear goal for all Teams will be the implementation of WIGOS. Hence it is important that the teams and work plans are reconfigured to ensure that they contribute towards this goal. Following earlier discussions between ICT-IOS chair, co-chair and the Director of Observing and Information Systems, a draft proposal which would add a Task Team (TT) on WIGOS Metadata and amalgamate ET-AWS and ET-SBROS had been presented. On the one hand, there is a clear need to reduce the number of ETs, but on the other hand there was little common ground between the members of ET-SBRSO and ET-AWS. However there was potential compatibility in areas such as metadata and meteorological coding using BUFR. The discussion emphasised that elements of all ETs that would contribute most to WIGOS were cross-cutting, such as

[1] Final report of the ICG-WIGOS-1 is available at http://www.wmo.int/pages/prog/www/WIGOS-WIS/reports.html

metadata, manuals and implementation plan. Considering the key contributions AWSs make in both current and future networks, and the important tasks for both teams in terms of WIGOS, ET-AWS suggests that AWS expertise be retained as an entity, with active contribution in the cross-cutting activties. However, the pressure on the WMO secretariat is noted.

3.16 Following a meeting with WIS TT ApMD-1, (discussed in Section 8), ET-AWS identified the value of developing a future task to enhance Volume A in support of WIS. This would contribute strongly to WIGOS through the Operational database and provide the interface to WIS Metadata for AWS and site, station and data processing related metadata.

4 REQUIREMENTS FOR THE INTEGRATION BETWEEN AWS AND SPACE-BASED OBSERVATIONS

4.1 The meeting was joined by Jerome Lafeuille (WMO Sat Program) and Mr Michael Kalb (Chair ET-SAT) for the discussion concerning the integration between surface and spaced-based observations. ET-AWS proposed using surface-based observations to contribute to the validation of remotely sensed observations, such as sensors based on satellite platforms. The Vision for the Global Observing System 2025 states that the surface-based GOS will provide data for the calibration and validation of space-based observations. This is inline with the concept of WIGOS. ET-SAT together with EUMETSAT and its Land Surface SAF expressed interest AWS measurements and suggested four variables for a pilot study.

4.2 Recognising that modern AWS platforms are able to record, process and transmit observations from a wide range of electronic sensors and these networks have a global reach which covers all continents and climates, they provide an opportunity for integration and data validation. However, comparison between the Surface-based and Space-based system is difficult due to the scale differences. Of greatest value are surface-based sites representing large homogeneous areas.

4.3 ET-AWS proposes to pursue a pilot study to identify observations sites which measure the parameters highlighted by ET-SAT and EUMETSAT. ET-AWS will develop guidelines for meteorological observations which may support spaced-based observations including functional specifications, reporting formats and message distribution requirements.

4.4 Mr Lafeuille noted that the satellite community welcomed the initiative of ET-AWS and they recognised the potential benefit to both systems. ET-SAT was interested in the location of stations which currently measure the four variables mentioned earlier. In addition, surface fluxes of CO_2, which were often spatially consistent, would also be of great value. Dr van der Meulen noted that these variables should be part of the RRR database.

5 REQUIREMENTS AND SPECIFICATIONS FOR AUTOMATED OBSERVATIONS NETWORKS

5.1 One of the tasks of the ET-AWS is to develop and maintain the requirements and specifications for automated observations networks. For this task the ET-AWS has focussed on the update of the table on Functional Specifications of ET-AWS variables (the FS table) that appears in Annex III.1 of the Guide to the GOS (WMO No. 488, 2010 ed.) and the table of observational variables, as required for a standard AWS (Annex III.2 of the Guide to the GOS). The further development of requirements and specifications for automated observations networks was not considered within the context of network design. Nevertheless it was noted that automation and standardization will provide interesting opportunities to find network design solutions, which is not possible in cases of networks based on manned stations. Alternatively, more suitable locations with better siting conditions, or remote areas can be chosen. Moreover an AWS is more flexible in replacement or relocation, in the case of modification of networks to support requests of users for temporary changes (e.g. relocation during a particular season).

5.2 The meeting considered proposed changes to the FS table. Many changes were already considered during the previous session of ET-AWS in 2010 (see Final Report of ET-AWS-6). Since then some BUFR descriptors have been tested and validated, so are now ready for operational implementation. An updated table was considered by the meeting and is now recommended for adoption by the next CBS session as a replacement in the Guide to the GOS (see Annex II).

5.3 It was noted that additions and modifications have been suggested by the satellite and radiation communities within WMO. These modifications however still have to be prepared in detail. Because no input or comments on the modifications have been received from a number of Technical Commissions, it was proposed to request input for future modifications from the other OPAG-IOS teams as well the Presidents of these Commissions. It was noted that the ET-AWS-6 recommendation to nominate mentors, each to be responsible for keeping a certain category of variables up-to-date, had not resulted in further action to date.

5.4 The ET was informed on the WMO Observing Requirements Database with variables defined for the Rolling Requirements Review process (RRR), which is under review by ET-EGOS. It was noted that the table of variables, as stated in the table of functional requirements, should be in line with the list of variables published in this database (see http://www.wmo-sat.info/db/variables).

5.5 ET-AWS agreed that the FS table should be continuously maintained and reviewed, i.e. to review the variables and requirements for measurement ranges and associated resolutions, by taking into consideration the changing needs of the various disciplines in meteorology, climatology and hydrology. Also the table in the Guide to the GOS containing the list of variables required to be measured by a Standard AWS should be maintained and reviewed in parallel.

5.6 Noting the range limitations of humidity sensors, yet the need for high quality data at the extremes of the humidity range, ET-AWS decided to request CIMO to evaluate by inter-comparison the performance of different humidity measurement systems at the extreme ends of the temperature and humidity (<5% >95%) ranges.

6 REQUIREMENTS AND STANDARDS FOR A BASIC, ROBUST AWS SUITABLE FOR LESS DEVELOPED, REMOTE AND EXTREME CLIMATE CONDITIONS

6.1 Mr Krisnaiah informed the session of India's perspective on the requirements and standards for AWSs operating in remote or under-developed regions, noting that these fall under several different broad groupings.

6.2 **Telecommunications**: GSM / GPRS mode of communication for AWS data transmission is cheaper than Satellite communication. These networks are now available almost everywhere in many less developed countries. GPRS transmission equipment (GPRS modems) and receiving systems are much cheaper as compared to satellite systems. GPRS networks may be used wherever they are available whereas satellite communications (such as FY-DCP and BEIDOU, in China's case) have been used where GSM/GPRS networks are unavailable.

6.3 **Power requirements**: Solar panels attached with a battery are a useful power source for AWS at remote areas. Solar panels and batteries are easily available and quite affordable in many less developed regions. It was noted during the meeting that China has investigated the use of wind turbines at some sites and plans to use these where there is a shortage of solar power.

6.4 **Sensors**: Mr Krisnaiah suggested that robust and high quality sensors are required for remote areas. Sensors and the platform employed should be suitable for remote diagnostics and troubleshooting in order to avoid frequent inspection visits. Sensors with integral redundant elements can also be considered so that repair trips are minimised.

6.5 **AWS equipment**: The cost of the data loggers and communication equipment has come down drastically with recent advances in electronics technologies. However equipment which can work in extended temperature ranges are still expensive. Robust data loggers and communication equipment are required which can work in extreme environments of, e.g., temperature and humidity.

6.6 **AWS cabinets**: In extreme weather areas cabinets should be rust proof and salt resistant. These enclosures should be preferably of non-metal construction so that inside temperature does not increase considerably, causing malfunction of electronic equipment or batteries. In tropical areas rain fall rates can be very high, causing water incursion. Cabinets also need to be suitably designed so that connector exposure to the environment is minimal.

6.7 **Radiation shields:** Mr Krisnaiah stated that, based on the experience of the India Meteorological Department, radiation shields should be rugged and allow representative ambient temperature to be experienced over the sensors, so wooden or plastic Stevenson screens of the size specified by WMO should be employed in place of some currently-used plastic shields.

6.7 **Maintenance free earthing**: In tropical areas AWS equipment is often damaged because of lightning strikes. Conventional earthing provided at an AWS site can become ineffective in a short period of time unless it is regularly maintained. Maintenance-free earthing (especially of the chemical type) could be very effective in the long run and does not need frequent trips to AWS site. State-of-the-art lightning arrestors together with maintenance-free earthing at the site could reduce AWS faults due to lightning.

6.8 **Calibration of sensors and maintenance of stations:** Tropical regions have peculiar problems in maintenance of AWS sensors due to dust deposition. Calibration of sensors should be performed at least once in a year. Preventive maintenance is required to be undertaken once in every quarter. Availability of manpower and funds are major constraints in accomplishing these tasks.

6.9 **Upkeep and maintenance**: Though AWS are generally unmanned by design, regular visits to a site are required to check its security, exposure conditions and for performing preventive maintenance. The costs of maintenance, calibration and running expenses for an operating AWS network far outweigh the initial purchase expense, so these expenses should be kept in mind before planning installation of an AWS network.

6.10 **Site Security:** At remote regions especially in less developed countries, security of AWS equipment at sites has become a major concern. It is seen that there are many thefts of solar panels and batteries from the AWS sites. The general public has come to know that solar panels and batteries can be used in other domestic applications. Because of this, there can be significant numbers of thefts and cases of vandalism at AWS sites. Public participation and awareness programmes can help to reduce thefts and vandalism as can involvement of the general public in safe keeping the sites, particularly once they are informed of the usefulness of these systems for their day to day lives. Other solutions to the security problem are still being sought. The participation of Non Governmental Organisations (NGO) can be considered.

7 GAP ANALYSIS FOR AUTOMATED OBSERVATIONS FOLLOWING THE TRANSITION FROM MANUAL OBSERVATIONS

7.1 There was no finalised report available on the subject of the Gap Analysis on moving from manual to automatic observations; there had been a report previously prepared that was not deemed ready for publication. The ET considered the possibility of encouraging a volunteer to complete the document, but due to the impending deadline of submission to ICT-IOS in the lead up to CBS-XV, it was decided that is now impractical. Although the modernisation and increasing automation of networks was becoming ubiquitous among many NMHSs, the preparation of such a gap analysis document could be useful in planning for the consequences of migrating to automatic observations, though this guidance may not influence their decisions to migrate. ET-AWS will therefore seek further guidance from ICT-IOS on the required focus of the document before assigning a future priority to this task.

7.2 It was noted that are two different gaps to be addressed, should the task be reassigned to ET-AWS. The first is a capability gap due to the inability of current automated observations to be able to detect human observed characteristics (e.g. cloud type). The second type is a business gap; factoring in the costs of maintaining the equipment, retraining of current staff, or dealing with site security.

8 AWS METADATA CATALOGUES FOR REAL-TIME EXCHANGE THROUGH WIS

8.1 Discussion of this topic commenced with Mr. Paterson recounting some of his experiences with metadata as part of overall data management in the Meteorological Service of Canada (MSC). This involves both static metadata (defined for this purpose as stored and generally updated manually) and more dynamic metadata that has been transmitted as part of data transmissions. An important precedent was set in the MSC in 2004-2006 when road weather metadata was initially defined in XML to transmit with each observation every 20 minutes, but eventually due to the volume of data and the redundancy of the transmissions was changed to occurring in weekly updates. This change produced much smaller files to be transmitted but there have been some metadata refresh problems since then, even with simplified metadata requirements..

8.2 Work with metadata in data transmission in MSC goes back to the mid-1990s with the use of quality assessment BUFR descriptors in a limited manner within the data transmitted from staffed and automatic surface stations. More recent work involves transmissions from a major partner using instrumentation metadata captured in BUFR Table D descriptor 3 01 091 and quality tables (Table B - 33 class). This provides a limited selection of metadata about 3rd-party stations but internal users are looking for more than that.

8.3 ET-AWS listed some required metadata, in a non-exhaustive list. These include both relatively static and more changeable values, such as:

- Instrumentation including type and model;
- Inspection types, reasons, and dates with associated sensor changes, in short a change and maintenance log of the site;
- Whether sensors were in or out of service;
- Height of instruments (generally some of this metadata is currently provided);
- Distance of sensors from datalogger (or site layout);
- Site photographs;
- Datalogger program version;
- Algorithms used for calculating derived data (whether at site or downstream) and whether data is derived or measured;
- Siting classifications;
- Quality assessment flags;
- Quantitative uncertainty.

8.4 Dr. van der Meulen pointed out that we have existing standards on AWS metadata which are referenced in the Guide to the GOS and the Manual on the GOS. It was also noted that, although it was not an encouraged practice to put a lot of metadata in transmissions on the GTS, we are obliged, as part of existing BUFR templates, to provide some metadata. A key issue noted is that even if one makes a major effort to update metadata whenever possible, it will become out-of-date unless there are ways of both providing timely updates to metadata and also refreshing all metadata, to avoid the repository becoming stale. Procedures could range from updates and periodic refreshes in observations on the GTS to periodic distribution of bundles of metadata.

8.5 To address this issue, it was raised during the joint session of ET-AWS and the first session of the WIS Task Team on Applications of Metadata (WIS TT ApMD-1), conducted on Wednesday 18 April 2012. At that session it was established that the interface between the two teams would primarily be through Volume A, and that TT ApMD would require ET-AWS to provide a specification of requirement for AWS network-related metadata.

8.6 To further address the issue, a brief review of the "Guide to GOS, section III (Surface-Based subsystem) Appendix III Automatic Station Metadata" was performed to ascertain that the document was current and provided sufficient detail. It was found to provide good detail but required some review. ET-AWS agreed to recommend to ICT-IOS that this task be pursued.

8.7 Finally, a brief examination of the gap analysis in "Space-Based GOS in 2010" (http://www.wmo.int/pages/prog/sat/gos-dossier_en.php) was performed. Similar to the AWS, the satellite is a platform with sensors attached serving multiple sets of clients. Although there are key differences, such as the much greater number of AWS platforms and their greater heterogeny, this document provided useful guidance to ET-AWS.

9 GUIDELINES FOR THE SITING CLASSIFICATION OF SURFACE OBSERVING STATIONS

9.1 The siting classification which was proposed in ET-AWS-5 and further expanded in ET-AWS-6 was endorsed by CIMO-XV in Helsinki, 2010. The Commission has requested that it be included in the CIMO Guide with the following clarifications in order to ensure its appropriate use: i) the use of the siting classification of observing stations depends on the purposes of the observations, ii) the proposed classification is the first official version of the siting classification, and will be reviewed and updated as needed at the next CIMO. The classification was published in Annex IV of CIMO-XV (WMO No. 1064). The Commission requested that guidance material on the characterisation process for stations and advice on how to use the results obtained, indicating for which purpose stations of a specific class are appropriate, needs to be developed.

9.2 The Meteorological Service of Canada (MSC) is looking to applying the Météo-France siting classifications to Canadian stations. Mr. Bill Scott (MSC) is undertaking this work during this year and is applying it to existing sites; minor modifications needed to be made since the sites were not green field sites. There is no initial intention to upgrade the siting at the time of evaluation, but MSC will build up its metadata of siting classification and may propose that certain sites be upgraded where feasible such as designated reference sites. A few minor changes have been made to the classification; the siting classification of theTipping-Bucket Rain Gauge was placed in a new section called Rainfall Intensity, and new sections have been added for Precipitation Wind (wind at precipitation sensor level) and for Snow Depth. The Maintenance Performance (A to E) part of the classification will be done at a later stage since the MSC wishes to use an internationally-accepted standard.

9.3 ET-AWS recognised that a classification regarding the level of maintenance would be valuable and supported efforts by CIMO to develop this.

10 BUFR DESCRIPTORS RELATED TO AWS

10.1 BUFR/CREX descriptors related to AWS

10.1.1 The 14th Session of the Commission for Basic Systems (Dubrovnik, Croatia, 25 March to 2 April 2009) reviewed the Functional Specifications for Automatic Weather Stations and adopted draft Recommendation 6.1/2 (CBS-XIV).

10.1.2 Dr Eva Červená submitted a document to ET-AWS-6 (Geneva, 22 to 25 June 2010), containing detailed analysis of the requirements for representation of the listed variables, a revised version of the Functional Specifications for AWS and a proposal for several new

BUFR/CREX descriptors. ET-AWS-6 examined carefully these proposals, agreed with the proposed new BUFR/CREX descriptors and procedures for representation of the listed variables, and suggested some modifications of the requirements.

10.1.3 The Second meeting of the Inter-Programme Expert Team on Data Representation and Codes (IPET-DRC) approved the proposed or modified BUFR/CREX descriptors for validation. The ET AWS members were encouraged to participate actively in the validation process of the proposed new descriptors.

10.1.4 In 2011, BUFR messages were created in the Czech Hydrometeorological Institute (CHMI) using the encoding/decoding software of CHMI and ECMWF. These messages contained extreme values of the elements as requested in the Functional Specifications for AWS, which documented the capability of the validated descriptors to meet the requirements. The validation process led to changing the specification for "Soil heat flux"; no other requirements had been expressed by the ET-AWS. Consequently the descriptors included in Annex III were submitted to the Third meeting of the IPET-DRC that recommended them for the fast-track procedure (with the implementation date of 2 May 2012).

10.1.5 The radiation terminology was discussed and the meeting decided to accept the names of BUFR/CREX descriptors Class 14 as they are, provided that they are unambiguous.

10.2 Template for n-minute data (TM 307092)

10.2.1 At the Third meeting of the IPET DRC (IPET DRC-III, Melbourne, 20 to 23 September 2011), the UKMO announced their plans to use the n-minute template (TM 307092) as a way of introducing higher temporal resolution data for ingestion into its forecast models. The existing template had had provision for only one ground temperature over the primary surface type for the station, whereas the UKMO record ground temperatures over a variety of surfaces at many of the observing stations (on grass, concrete and road/runways). A new surface type element was added to the existing Code table 0 08 010 (12 = Concrete). IPET DRC-III meeting consequently modified the existing template TM 307092 to allow reporting measurements of ground temperature at more than one point, and recommended this template for further validation.

10.2.2 The ET-AWS-7 meeting examined this version of TM 307092 and requested the possibility to report temperature and wind data at several heights above ground (mast measurements). Regarding ground temperature, the height above local ground should be considered as a variable. Dr Červená modified the template to meet these requirements as shown in Annex IV. This updated version of TM 307092 will be submitted to the IPET DRC-IV meeting (Exeter, 21 to 25 May 2012).

10.2.3 The ET-AWS-7 meeting invited members of ET AWS to participate in validation of templates TM 307092 (as well as template TM 307093 for representation of nominal values).

10.3 Specification of the station location in the CIMO Guide

10.3.1 Dr Červená pointed out different requirements for specification of station location in various WMO documents. The station location is specified in all BUFR descriptors for AWS data by latitude (0 05 001) and longitude (0 06 001) in degrees with resolution of 10^{-5} of a degree. The height of the station above mean sea level (0 07 030) is specified in meters, with a resolution of a tenth of a meter. In the Manual on the GOS (WMO-No. 544) and in WMO-No.9, Volume A, the location of stations is requested in degrees, minutes and seconds; and height of the station above mean sea level, H, is requested in meters rounded to two decimals. However, the definition of station coordinates in the Guide to the GOS (WMO-No.488) and the CIMO Guide (Seventh Edition of 6 August 2008) do not meet the current requirements for specification of station location. Moreover, the specification of the location to which the horizontal coordinates refer, is not sufficiently defined.

10.3.2 The ET AWS-7 meeting recommended unifying the reporting of station location in WMO documents so that latitude and longitude of a station are given in degrees with a resolution of 10^{-4} of a degree or better and the height of the station above mean sea level is given in metres, with a resolution one metre or better. Moreover, the specification of the location to which the horizontal coordinates refer, should be more precisely defined.

11 ADVANCES IN AWS TECHNOLOGY

11.1 Progress and Advances

11.1.1 Dr. Sabatini described how the main advance in AWS technology relates to telemetry, especially through increased flexibility of choice (radio, satellite, GSM, GPRS, LAN). Another advance includes a decrease in cost of sensors and data loggers. Either of these may lead to reduction in required battery capacity and solar panel dimensioning. However, despite the generally decreasing trend of the cost of data transmission, telecommunications services costs can remain high because cheaper options are not available in some locations. In this context Dr Sabatini remarked on the successful work of CBS and JCOMM to establish an International Forum of Users of Satellite Data Telecommunication Systems together with IOC and FAO partner international organizations. A preparatory workshop in Toulouse, France, 23-24 April 2012 has been planned to bring forward these topics.

11.1.2 The requirements for new data loggers mainly relate to high flexibility in signal input type; analogue, digital, serial RS232, serial SDI-12. Serial inputs allows data acquisition of multiple devices that normally lead also to lowering power requirements and make room for additional input sensors. Wireless technology is increasingly being exploited to build up a dense sensor network based on small data loggers with specific radio interfaces (433 MHz, 868 MHz, ZigBee 2.4 GHz). Many applications relate to precision agriculture, hydrology, monitoring systems for renewable energy.

11.1.3 Even when remote data transmission is configured, first level quality checks could be implemented, but these cannot replace local inspection. Allocation of sufficient funds for Information Technology (IT) personnel and electronics specialists is necessary to properly manage modern AWS networks. The integration between GIS and Sensor Web Enablement (SWE) approach needs to be highlighted. There are increasing numbers of online sensors. Standardization of sensors metadata is a requirement for handling observations and information for different sensors. The Open Geospatial Consortium (OGC) SWE standards meet this requirement and provide open source platforms for a series of applications. Sensor spatial location is usually a key piece of sensor or sensor data information, as well as other related information (Manufacturer, Model Type, data of installation) and SWE standards make it easy to integrate this information into geospatial applications that implement the OGC's other standards.

11.1.4 In 2009 WMO signed a Memorandum Of Understanding (MOU) with the OGC. This agreement has been promoted in order to “enhance the development and use of geospatial standards. It is anticipated that this collaboration will support the implementation of the WMO Information System (WIS) which aims at providing a single coordinated global infrastructure for the collection and sharing of information in support of all WMO and related international programmes. The MoU formalizes the partners’ planned collaboration in the development, application, and promotion of standards and best practices for the content and exchange of meteorological, climatological and hydrological data for the benefit of the worldwide scientific and operational communities of meteorologists and hydrologists”.

11.1.5 The WMO Secretariat appointed the Inter-Programme Expert Team on Metadata and Data Interoperability (IPET-MDI), to “develop a WMO core profile of the ISO 191 series of standards for metadata and data, encompassing the WMO Metadata core profile of the ISO metadata standard, including relevant feature catalogues, application schema(ta) and data product specification(s)” . One of the main tasks assigned to this ET is to create sustainable data and metadata standards that meet the needs of WMO’s stakeholder community. This should mean that the standards need to be: as simple as possible, based around standards already in use, supported by education and best practice guidance and with clear governance measures in place. This approach should facilitate the free and unrestricted exchange of data and information, products and services in real- or near-real time.

11.1.6 Another important initiative to be mentioned here relates to the activities of the International Organizing Committee for the WMO Solid Precipitation Inter-comparison Experiment (WMO IOC-SPICE coordinated by Ms Rodica Nitu (Canada) and Roy Rasmussen (USA). The Inter-comparison will focus on the performance of modern automated sensors measuring solid precipitation during the period of the year when the precipitation is expected to be solid. As a first priority, the WMO-SPICE will investigate and report on the measurement of precipitation amount as a function of precipitation phase, and of snow on the ground (snow depth), so it will be of interest to test the performance of different types of precipitation gauges, disdrometers, present weather and snow depth sensors. New models of weighing precipitation gauges have been developed in the last few years and this measuring principle is now widely accepted as the reference method, even though shielding is of primary interest. Another aspect relates to the heated versions of precipitation gauges, where the importance of the standardization of the heating algorithm should be addressed to the users.

11.1.7 ET-AWS proposed that the future work plan of the ET includes continued monitoring of technology advances for sensors, AWS technology and telemetry options, in order to promote awareness and discussion on this important topic.

11.2 Guidance on Integration

11.2.1 Mr Monnik suggested that a common problem which impacts many modern meteorological organisations is how to effectively use and integrate data from external sources. There are costs associated with ingest, archival, monitoring and communications. Issues around intellectual property rights and obligations, relationship management and contract management all create an economic impost on the organisation.

11.2.2 To make an informed decision regarding use or investment in external data there are several areas that need to be considered. Fundamentally it needs to be determined how the data source delivers value to the organisation. This includes consideration of the spatial contribution the data/information makes to the organisation and the network benefits. The quantity, quality and currency of metadata will govern the usefulness of the data. If an adequate level of metadata is not available there may be no point in continuing to consider ingesting the external data. Reaching agreement on custodianship of data is important. The accessibility of the data in terms of delivery, formats and method is a further criterion which should be considered. The final step is an agreement to manage the relationship in the long term. The steps involved in this process are discussed further in Annex V, which is based on information provided to the Chair of ET-AWS by Dr Jane Warne of the Bureau of Meteorology in Australia and further developed by the members of ET-AWS during the session.

11.2.3 ET-AWS 6 considered guidance for managing AWS networks. In addition to this, the ET proposed a series of steps to consider in integrating observations coming from different networks, particularly from third party AWS networks:

- Define a minimum set of information (range, reported accuracy, height of sensors, metadata, etc.) and procedures (regular inspections, maintenance, etc.) required to integrate observations
- Collect as much information as possible about the configuration of the third party network, such as: technical features, calibration sheets, manuals, algorithms employed, shields (i.e. for air Temperature and Humidity), in order to define the limits within which the observations of such AWSs can be roughly collocated.

- Check and report suggested corrections to third party AWS network configurations, if deficiencies are highlighted which may limit the use of those observations.
- Inter-comparison testbeds should be established at which to evaluate the performance of such systems against well proved AWSs already in use, in different weather conditions for several years
- The degree of the integration of observations is different for each variable. For example temperature sensors are generally quite robust even if they belong to low-cost systems, while relative humidity sensors are intrinsically more fragile; in this case a large source of error comes from poorly designed shields. Wind speed sensors made of poor construction tend to have perform badly especially at low wind speed.
- When we use cost-effective AWSs the general approach is to replace damaged sensors instead of opening a repair procedure. Normally the interchangeability of these sensors is not well defined, even if digital sensors nowadays offer more guarantees. In this case acceptance limits can be defined.
- Remote operational status monitoring allows early detection of failures or suspect values and should be encouraged.

11.2.4 There are other aspects of third party data capture that warrant consideration. The growing availability of external observations combined with the growing number of users of social networks and smart phone devices, suggest to the scientific community new possibilities for third party data communications. Third party sensor intercomparisons would assist in better characterizing the data from these instruments.

12 OTHER BUSINESS

12.1 ET-AWS input to ET-EGOS on EGOS-IP

12.1.1 ET-AWS welcomes the Implementation Plan for the Evolution of the Global Observing Systems considering the significant advances being made in both surfaced-based and particularly space-based systems. The surface-based systems generally provide traceable and temporally consistent observations which are an important historically consistent baseline for all observations systems.

12.1.2 ET-AWS noted that AWS networks continue to expand across many countries, including third party automated networks. These networks require an investment in data handling, technical capacity and management which should be considered when embarking on such network changes. Clear standards for the surface observing system should be upheld in the manual for the GOS so that a composite, integrated observation network is maintained.

12.2 Input to upcoming SatCom meeting (Toulouse, 23-24 April 2012)

12.2.1 Considering the important role of data communications for AWS networks, ET-AWS-6 endorsed a proposal originating as a recommendation from the JCOMM Pilot Project for WIGOS to establish an international forum of users of satellite data telecommunication systems that could to address system deficiencies, negotiate tariffs and potential improvements of the rendered services with the operators of satellite data telecommunication systems. Such a forum could partner with International Organizations such as FAO and IOC. This was supported by ICT-IOS-6, agreed during CBS-Ext(2010) and presented to Cg-XVI.

12.2.2 The first meeting of this forum is scheduled for May 2012 and ET-AWS, represented by its chair, will describe the needs for cost-effective data communication in remote area where land based telecommunications networks are unavailable.

12.3 Regulatory Material for AWS

12.3.1 It was noted that the requirements and specifications for automated observations networks, inclusive functional requirements of the specific observational variables and the table of variables to be observed by a standard AWS are published as guidelines only (i.e. in the Guide to the GOS). The Manual to the GOS, however, provides standards, inclusive of the set of variables to be reported from e.g. Synoptic AWS. The ET suggested ICT-IOS to consider moving these guidelines into the Manual, because these requirements can be considered as standard requirements.

12.4 AWS Data Quality Control

12.4.1 The following identified gaps require further attention of the ET-AWS:
With the advances of AWS，an important problem in need of addressing and therefore for the future attention of ET-AWS, is the quality control of AWS data, so a document about AWS data quality control algorithms, in particular precipitation algorithms, is required to promote reliability and consistency of data.

13 RECOMMENDATIONS FOR CBS-XV

13.1 ET-AWS-7 drafted one recommendation for consideration by the next meeting of ICT-IOS and submission to CBS-XV, concerning adoption of the updated Functional Specification for AWS and its publication in the Guide to the GOS. This draft recommendation is at Annex VI.

14 WORK PLAN

14.1 ET-AWS-7 referred to the work plan for the closing inter-sessional period, considered which items needed further attention and new times for inclusion, and proposed those items listed in Annex VII to be included in the future work plan of the group..

14.2 ET-AWS-7 also proposed modified Terms of Reference for the new group, which are contained in Annex VIII.

5 CLOSURE OF THE SESSION

10.1 The session was closed on 20 April 2012 at 1700h.

ANNEX I

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ANNEX II

Functional Specifications for Automatic Weather Stations
(NOTE: Updated table entries and notes are shown in bold text)

VARIABLE [1]	Maximum Effective Range [2]	Minimum Reported Resolution [3]	Mode of Observation [4]	BUFR / CREX [5]	Status [5]
ATMOSPHERIC PRESSURE					
Atmospheric Pressure	500 – 1080 hPa	10 Pa	I, V	0 10 004	**OP**
TEMPERATURE [9]					
Ambient air temperature (over specified surface) [14]	-80 °C – +60 °C	0.1 K	I, V	0 12 101	**OP**
Dew-point temperature [14]	-80 °C – +60 °C	0.1 K	I, V	0 12 103	**OP**
Ground (surface) temperature (over specified surface) [14]	-80 °C – +80 °C	0.1 K	I, V	**0 12 120**	**VAL**
Soil temperature [14]	-50 °C – +50 °C	0.1 K	I, V	0 12 130	**OP**
Snow temperature [14]	-80 °C – 0 °C	0.1 K	I, V	**0 12 131**	**VAL**
Water temperature - river, lake, sea, well	-2 °C – +100 °C	0.1 K	I, V	0 13 082 or **0 22 043**	**OP** **OP**
HUMIDITY [9]					
Relative humidity	0 – 100%	1%	I, V	0 13 003	**OP**
Mass mixing ratio	0 – 100%	1%	I, V	**0 13 110**	**VAL**
Soil moisture	0 – 10^3 g kg^{-1}	1 g kg^{-1}	I, V	**0 13 111**	**VAL**
Water vapour pressure	0 – 100 hPa	10 Pa	I, V	0 13 004	**OP**
Evaporation/evapotranspiration	0 – **0.25** m	0.1 kg m^{-2} 0.0001 m	T	**2 01 130** 0 13 033 **2 01 000**	**OP**
Object wetness duration	0 – 86 400 s	1 s	T	**0 13 112**	**VAL**
WIND					
Direction	0 [11,13]; 1° – 360°	1°	I, V	0 11 001	**OP**
Speed	0 – 75 m s^{-1}	0.1 m s^{-1}	I, V	0 11 002	**OP**
Gust Speed	0 – 150 m s^{-1}	0.1 m s^{-1}	I, V	0 11 041	**OP**
X,Y component of wind vector **Z component of wind vector** (horizontal and vertical profile)	**-150** – 150 m s^{-1} **-40 – 40 m s^{-1}**	0.1 m s^{-1}	I, V	**0 11 003** **0 11 004** **0 11 006**	**OP** **OP** **OP**
Turbulence type (Low levels and wake vortex) [16]	up to 15 types	BUFR Table **Not specified yet**	I, V	-	**N**
Turbulence intensity [16]	up to 15 types	BUFR Table **Not specified yet**	I, V	-	**N**
RADIATION [6]					
Sunshine duration	0 – 86 400 s	60 s	T	0 14 031	**OP**
Background luminance	**0 – 1·10^5**Cd m^{-2}	**1**Cd m^{-2}	I, V	**0 14 056**	**VAL**
Global downward solar radiation	0 – **1·10^8** J m^{-2}	**1. 10^2** J m^{-2}	I, T, V	**0 14 028**	**OP**
Global upward solar radiation	**-1·10^8 – 0** J m^{-2}	**1. 10^2** J m^{-2}	I, T, V	**0 14 052**	**VAL**
Diffuse solar radiation	**0 – 1·10^8** J m^{-2}	**1. 10^2** J m^{-2}	I, T, V	**0 14 029**	**OP**
Direct solar radiation	**0 – 1·10^8** J m^{-2}	**1. 10^2** J m^{-2}	I, T, V	**0 14 030**	**OP**
Downward long-wave radiation	**0 – 6·10^7** J m^{-2}	**1. 10^3** J m^{-2}	I, T, V	0 14 002	**OP**
Upward long-wave radiation	**-6·10^7 – 0** J m^{-2}	**1. 10^3** J m^{-2}	I, T, V	0 14 002	**OP**
Net radiation	**-1·10^8 – 1·10^8** J m^{-2}	**1. 10^2** J m^{-2}	I, T, V	**0 14 053**	**VAL**
UV-B radiation [8]	**0 – 26·10^4** J m^{-2}	**1** J m^{-2}	I, T, V	**0 14 072**	**VAL**
Photosynthetically active radiation [22]	0– **6·10^7** J m^{-2}	**1·10^3** J m^{-2}	I, T, V	**0 14 054**	**VAL**
Surface albedo	0 – 100%	1%	I, V	0 14 019	**OP**
Soil heat Flux	**-1·10^8 – 1·10^8 J m^{-2}**	**1. 10^2 J m^{-2}**	**I, T, V**	**0 14 057**	**VAL**

CLOUDS					
Cloud base height	0 – 30 km	10 m	I, V	0 20 013	**OP**
Cloud top height	0 – 30 km	10 m	I, V	0 20 014	**OP**
Cloud type, convective vs. other types	up to 30 classes	BUFR Table	I	0 20 012	**OP**
Cloud hydrometeor concentration	1 – 700 hydrometeors dm^{-3}	1 hydrometeor dm^{-3}	I, V	**0 20 130**	**VAL**
Effective radius of cloud hydrometeors	$2{\cdot}10^{-5} – 32{\cdot}10^{-5}$ m	$2{\cdot}10^{-5}$ m	I, V	**0 20 131**	**VAL**
Cloud liquid water content	$1{\cdot}10^{-5}–1.4{\cdot}10^{-2}$ kg m^{-3}	$1{\cdot}10^{-5}$ kg m^{-3}	I, V	**0 20 132**	**VAL**
Optical depth within each layer	Not specified yet	Not specified yet	I, V	-	**N**
Optical depth of fog	Not specified yet	Not specified yet	I, V	-	**N**
Height of inversion	0 – 1 000 m	10 m	I, V	**0 20 093**	**VAL**
Cloud cover	0 – 100%	1%	I, V	0 20 010	**OP**
Cloud amount	0 – 8/8	1/8	I, V	0 20 011	**OP**
PRECIPITATION					
Accumulation [7)]	0 – **1600 mm**	0.1 kg m^{-2}, 0.0001 m	T	0 13 011	**OP**
Depth of fresh snowfall	0 –1000 cm	0.001 m	T	**0 13 118**	**VAL**
Duration	up to 86 400 s	60 s	T	0 26 020	**OP**
Size of precipitating element [17)]	$1{\cdot}10^{-3}$ – **0.25** m	$1{\cdot}10^{-3}$ m	I, V	**0 13 058** **0 20 066**	**OP**
Intensity - quantitative	0 – 2000 mm h^{-1}	0.1 kg m^{-2} s^{-1}, 0.1 mm h^{-1}	I, V	**0 13 155**	**OP**
Type	up to 30 types	BUFR Table	I, V	0 20 021	**OP**
Rate of ice accretion	0 – 1 kg dm^{-2} h^{-1}	$1{\cdot}10^{-3}$ kg dm^{-2} h^{-1}	I, V	**0 13 114**	**VAL**
OBSCURATIONS					
Obscuration type	up to 30 types	BUFR Table	I, V	0 20 025	**OP**
Hydrometeor type	up to 30 types	BUFR Table	I, V	0 20 025	**OP**
Lithometeor type	up to 30 types	BUFR Table	I, V	0 20 025	**OP**
Hydrometeor radius	$2{\cdot}10^{-5} – 32{\cdot}10^{-5}$ m	$2{\cdot}10^{-5}$ m	I, V	**0 20 133**	**VAL**
Extinction coefficient	0 – 1 m^{-1}	**0.00001 m^{-1}**	I, V	**0 15 029**	**VAL**
Meteorological Optical Range [10)]	1 – 100 000 m	1 m	I, V	**0 15 051**	**VAL**
Runway visual range	1 – 4 000 m	1 m	I, V	0 20 061	**OP**
Other weather type	up to 18 types	BUFR Table	I, V	0 20 023	**OP**
LIGHTNING					
Lightning rates of discharge	0 – **4 500 000** h^{-1}	**1 h^{-1}**	I, V	**0 20 126**	**VAL**
Lightning discharge type (cloud to cloud, cloud to surface)	**3** types	BUFR **Code** Table	I, V	**0 20 023**	**OP**
Lightning discharge polarity	2 types	BUFR **Code** Table	I, V	**0 20 119**	**VAL**
Lightning discharge energy	Not specified yet	Not specified yet	I, V	-	**N**
Lightning - distance from station	0 – **$2{\cdot}10^5$** m	10^3 m	I, V	**0 20 127**	**VAL**
Lightning - direction from station	1° – 360°	1 degree	I, V	**0 20 128**	**VAL**
HYDROLOGIC AND MARINE OBSERVATIONS					
Flow discharge – river	0 – $2.5{\cdot}10^5$ m^3 s^{-1}	0.1 m^3 s^{-1}	I, V	**0 23 040**	**VAL**
Flow discharge – well	0 – 50 m^3 s^{-1}	0.001 m^3 s^{-1}	I, V	**0 23 041**	**VAL**
Ground water level	0 – 1 800 m	0.01 m	I, V	**0 13 074**	**VAL**
Ice surface temperature **[14)]**	-80 °C – +0 °C	0.5 K	I, V	**0 12 132**	**VAL**
Ice thickness - river, lake **[15)]**	0 – 50 m	0.01 m	I, V	**0 08 029** **0 13 115**	**VAL**
Ice thickness - glacier, sea **[15)]**	0 – 4 270 m	1 m	I, V	**0 08 029** **0 13 115**	**VAL**

Ice thickness [18)]	0 – 3 m	0.015 m	T	**2 01 133** **2 02 129** 0 20 031 **2 02 000** **2 01 000**	**OP**
Water level	0 – 100 m	0.01 m	I, V	0 13 071 0 13 072	**OP** **OP**
Wave height	0 – 50 m	0.1 m	V	0 22 021	**OP**
Wave period [18)]	0 – 100 s	1 s	V	**2 01 129** 0 22 011 **2 01 000**	**OP**
Wave direction	0 [13)]; **1** – 360 degrees	1 degree	V	0 22 001	**OP**
1D spectral wave energy density [18)]	0 – 5×10^5 $m^2 Hz^{-1}$	10^{-3} $m^2 Hz^{-1}$	V, T	**2 01 135** 0 22 069 **2 01 000**	**OP**
2D spectral wave energy density [18)]	0 – 5×10^5 $m^2 Hz^{-1}$	10^{-3} $m^2 Hz^{-1}$	V, T	**2 01 135** 0 22 069 **2 01 000**	**OP**
Water practical salinity [18)]	0 – 400 psu[12]	10^{-3}psu	I, V	**2 01 130** 0 22 064 **2 01 000**	**OP**
Water conductivity [18)]	0 – 600 S m^{-1}	10^{-6} S m^{-1}	I, V	**2 01 132** 0 22 066 **2 01 000**	**OP**
Water pressure [18) 19)]	0 – 11×10^7 Pa	100 Pa	I, V	**2 07 001** 0 22 065 **2 07 000**	**OP**
Ice mass	0 – 50 kg m^{-1}	0.5 kg m^{-1} (on 32 mm rod)	T	**0 20 135**	**VAL**
Snow density (liquid water content)	100 – 700 kg m^{-3}	1 kg m^{-3}	T	**0 13 117**	**VAL**
Tidal elevation with respect to local chart datum [18)]	-10 – +30 m	0.001 m	I, V	**2 01 129** 0 22 038 **2 01 000**	**OP**
Tidal elevation with respect to national land datum [18)]	-10 – +30 m	0.001 m	I, V	**2 01 129** 0 22 037 **2 01 000**	**OP**
Meteorological residual tidal elevation (surge or offset) [18) 20)]	-10 – +16m	0.001 m	I, V	0 22 040	**OP**
Ocean Current - Direction	0 [13)]; 1° – 360°	1°	I, V	0 22 004 or 0 22 005	**OP**
Ocean Current - Speed	0 – 10 m s^{-1}	0.01 m s^{-1}	I, V	0 22 031 or 0 22 032	**OP**
OTHER SURFACE VARIABLES					
Runway conditions	up to 10 types	BUFR Table	I, V	**0 20 085**	**OP**
Braking action/friction coefficient	up to 7 types	BUFR Table	I, V	**0 20 089**	**OP**
State of ground	up to 30 types	BUFR Table	I, V	0 20 062	**OP**
Type of surface specified	up to 15 types	BUFR Table	I, V	0 08 010	**OP**
Snow depth	0 – 25 m	0.01 m	T	0 13 013	**OP**
OTHER					
Gamma radiation dose rate[12)]	1 – 10^3nSv h^{-1}	**0.1** nSv h^{-1}	I, T	**0 24 014**	**VAL**
Categories of stability	9 types	BUFR Table	I, V	0 13 041	**OP**

Notes:

1. Name of variable, in line with WMO vocabulary and Technical Regulations.
2. Maximum Effective Range - Maximum range of measuring capability; units traceable to SI.
3. Minimum Reported Resolution – Lower resolution of reporting is not permitted.
4. Mode of Observation – Type of data being reported:

I: Instantaneous – 1-minute value (instantaneous as defined in WMO-No. 8, **Appendix VI.2**);

V: Variability – Average (mean), Standard Deviation, Maximum, Minimum, Range, Median, etc. of samples – those reported depend upon meteorological variable;

T: Total – Integrated value over defined period; maximum 24 hours for all parameters except radiation which requires a maximum of one hour (exception, see note 6), and precipitation accumulation (6 hours maximum). **The relevant element descriptor shall be preceded by a time period descriptor 0 04 024 (in hours) or 0 04 025 (in minutes)**.

A: Average (mean) value.

5. **BUFR/CREX descriptors for representation of the listed variables;**

   OP: Operational descriptors of BUFR/CREX Table B, <u>Version Number 14 and subsequent versions</u>.

   VAL: Descriptors which became operational on 2 May 2012 (BUFR/CREX Table B. Version Number 18).

   N: Not yet specified requirements.

6. Radiation energy amounts are given over a 24-hour period.
7. **Liquid water equivalent**. Maximum interval: 6 hours.
8. Definition of UV-B according to WMO-No. 8 (Vol. 1, Chapter on Radiation). **Descriptor 0 14 072 (Global UV irradiation) was recommended for validation in September 2008, revised in July 2010.**
9. Humidity related variables (*i.e.* dew point temperature) expressed as temperature are collected under temperature.
10. MOR uniquely related to "extinction coefficient",σ, by MOR = -ln(5%)/σ.
11. Direction to indicate 0 (zero) if speed = 0.
12. **Absolute Salinity (kg.kg^{-1}) is now being used for ocean applications (IOC Res XXV-7). However, salinity that is reported to national oceanographic data centres remains the Practical Salinity (psu). Ocean water is about 35 psu. Lake Assal (Djibouti) is the most saline body of water on earth with 348 psu salt concentration.**
13. Calm.
14. **Temperature data represented by 0 12 101, 0 12 103, 0 12 113, 0 12 120, 0 12 130, 0 12 131 and 0 12 132 shall be reported with precision in hundredths of a degree even if they are measured with the accuracy in tenths of a degree. This requirement is based on the fact that conversion from the Kelvin to the Celsius scale has often resulted into distortion of the data values. Temperature t (in degrees Celsius) shall be converted into temperature T (in degrees Kelvin) using equation: T = t + 273.15.**
15. **Ice thickness 0 13 115 shall be preceded by 0 08 029 (Surface type) set to 11, 12, 13 or 14 to specify river, lake, sea or glacier, respectively.**
16. **If the UNIT is specified as "BUFR Table", the BUFR descriptor cannot be proposed without the content of the table being available.**
17. **0 13 058 (Size of precipitation element) is capable to express size of any precipitation element, apart from hailstones. Size of hailstones shall be represented by 0 20 066.**
18. **These requirements being confirmed, it has to be noted that the selected descriptors are suitable for the normal operating conditions and shall be combined with appropriate operator descriptors to allow representation of the extreme values or the requested high precision.**
19. **Operator 2 07 Y is recommended to be used with Water pressure 0 22 065 (Pa, -3, 0, 17), if the data are produced in BUFR, Edition 4. The same result, i.e. change to (Pa, -2, 0, 21) would be obtained by the combined use of the less sophisticated operators 201Y and 202Y:**

    2 01 132
    2 02 129
    0 22 065 Reported value of "Water pressure"
    2 02 000
    2 01 000

20. **The following sequence is to be used to change data width and reference value of 0 22 040 (m, 3, -5000, 14) to become (m, 3, -10000, 15):**

    2 01 129
    2 03 015
    0 22 040 New reference value = -10000
    2 03 255

0 22 040 Reported value of "Meteorological residual tidal elevation"
2 01 000
2 03 000

21. **Gamma radiation dose rate 0 24 014 is intended to be used for reporting of this element under normal conditions, nuclear accidents excluded.**

22. **Photosynthetically active radiation (PAR). Various forms of the electromagnetic energy flux in the 400 – 700 nm wavelength range, either as integrated spectra or using different weighting functions. For example converted to the photosynthetic photon flux (PPF) in quanta per second per square meter, or mole of quanta per second per square meter or microeinsteins per second per square meter. Approximate conversion is 1 J m^{-2} s^{-1} equivalent to 5 µE m^{-2} s^{-1} based on a mean wavelength of 550 nm.**

ANNEX III

BUFR/CREX to become operational on 2 May 2012

For Temperature

Table reference		BUFR				CREX		
F X Y	Element name	Unit	Scale	Reference value	Data width	Unit	Scale	Data width
0 12 120	Ground temperature	K	2	0	16	˚C	2	4
0 12 131	Snow temperature	K	2	0	16	˚C	2	4

For Humidity

Table reference		BUFR				CREX		
F X Y	Element name	Unit	Scale	Reference value	Data width	Unit	Scale	Data width
0 13 110	Mass mixing ratio	%	0	0	7	%	0	3
0 13 111	Soil moisture	$g\ kg^{-1}$	0	0	10	$g\ kg^{-1}$	0	4
0 13 112	Object wetness duration	s	0	0	17	s	0	5

For Radiation

Table reference		BUFR				CREX		
F X Y	Element name	Unit	Scale	Reference value	Data width	Unit	Scale	Data width
0 14 052	Global upward solar radiation, integrated over period specified	$J\ m^{-2}$	-2	–1048574	20	$J\ m^{-2}$	-2	7
0 14 053	Net radiation (high accuracy), integrated over period specified	$J\ m^{-2}$	-2	–1048574	21	$J\ m^{-2}$	-2	7
0 14 054	Photosynthetically active radiation, integrated over period specified	$J\ m^{-2}$	–3	0	16	$J\ m^{-2}$	–3	5
0 14 056	Background luminance	$Cd\ m^{-2}$	0	0	18	$Cd\ m^{-2}$	0	6
0 14 057	Soil heat flux	$J\ m^{-2}$	–2	–1048574	21	$J\ m^{-2}$	–2	7
0 14 072	Global UV irradiation	$J\ m^{-2}$	0	–4000000	23	$J\ m^{-2}$	0	7
0 02 072	Spectrographic width	m	13	0	30	m	13	10

With a Note under Class 14:

(8) Global UV irradiation (0 14 072) is UV energy integrated over period specified for spectral band specified. 0 14 072 shall be preceded by a time period descriptor and by 0 02 071 (Spectrographic

wavelength) and 0 02 072 (Spectrographic width). E.g. If 0 14 072 is used for Global UV-B irradiation, 0 02 071 and 0 02 072 shall specify spectral band 280 to 315 nm.

For Clouds

Table reference		BUFR				CREX		
F X Y	Element name	Unit	Scale	Reference value	Data width	Unit	Scale	Data width
0 20 130	Cloud hydrometeor concentration	Numeric	0	0	10	Numeric	0	3
0 20 131	Effective radius of cloud hydrometeors	m	5	0	6	m	5	2
0 20 132	Cloud liquid water content	kg m^{-3}	5	0	11	kg m^{-3}	5	4
0 20 093	Height of inversion	m	-1	0	8	m	-1	3

With a Note under Class 20:

Cloud hydrometeor concentration 0 20 130 represents the number of hydrometeors in 1 dm^3.

For Precipitation

Table reference		BUFR				CREX		
F X Y	Element name	Unit	Scale	Reference value	Data width	Unit	Scale	Data width
0 13 114	Rate of ice accretion	kg m^{-2} h^{-1}	1	0	11	kg m^{-2} h^{-1}	1	4
0 13 118	Depth of freshsnow (high accuracy)	m	3	**-2**	14	m	3	5

With a Note under Class 13:

Depth of fresh snow (0 13 118) set to –0.001 before scaling (–1 after scaling or in CREX) shall indicate a little snow (less than 0.0005 m). Depth of fresh snow (0 13 118) set to –0.002 before scaling (–2 after scaling or in CREX) shall indicate “snow cover not continuous”.

The name of 0 20 032 is requested to be changed from the current “Rate of ice accretion” to “***Rate of ice accretion (estimated)***".

For Obscuration

Table reference		BUFR				CREX		
F X Y	Element name	Unit	Scale	Reference value	Data width	Unit	Scale	Data width
0 20 133	Hydrometeor radius	m	5	0	6	m	5	2
0 15 029	Extinction coefficient	m^{-1}	9	0	30	m^{-1}	9	10
0 15 051	Meteorological Optical Range	m	0	0	18	m	0	6

For Lightning

Table reference		BUFR				CREX		
F X Y	Element name	Unit	Scale	Reference value	Data width	Unit	Scale	Data width
0 20 126	Lightning rate of discharge	h^{-1}	0	0	23	h^{-1}	0	7
0 20 127	Lightning - distance from station	m	-3	0	8	m	-3	3
0 20 128	Lightning - direction from station	Degree true	1	0	12	Degree true	1	4
0 20 119	Lightning discharge polarity	Code table	0	0	2	Code table	0	1

0 20 119 - ***Lightning discharge polarity:***

Code figure	
0	Not defined
1	Positive
2	Negative
3	Missing value

For Hydrologic and marine data

Table reference		BUFR				CREX		
F X Y	Element name	Unit	Scale	Reference value	Data width	Unit	Scale	Data width
0 23 040	Flow discharge – river	$m^3 s^{-1}$	1	0	22	$m^3 s^{-1}$	1	7
0 23 041	Flow discharge – well	$m^3 s^{-1}$	3	0	16	$m^3 s^{-1}$	3	5
0 13 074	Ground water level	m	2	0	18	m	2	6
0 12 132	Ice surface temperature	K	2	0	16	˚C	2	4
0 13 115	Ice thickness	m	2	0	19	m	2	6
0 20 135	Ice mass (on a rod)	$kg\ m^{-1}$	1	0	10	$kg\ m^{-1}$	1	3
0 13 117	Snow density (liquid water content)	$kg\ m^{-3}$	0	0	10	$kg\ m^{-3}$	0	3

With a Note under Class 13:

Ice thickness 0 13 115 shall be preceded by 0 08 029 (Surface type) set to 11, 12, 13 or 14 to specify river, lake, sea or glacier, respectively.

The name of 0 08 029 has been changed to "***Surface type***" and the following code figures introduced:

0 08 029 - *Surface type*:

Code figure

Code figure	
11	river
12	lake
13	sea
14	glacier

For Other

Table reference		BUFR				CREX		
F X Y	Element name	Unit	Scale	Reference value	Data width	Unit	Scale	Data width
0 24 014	Gamma radiation dose rate	nSv h^{-1}	1	0	14	nSv h^{-1}	1	4

With a Note under Class 24:

Gamma radiation dose rate 0 24 014 is intended to be used for reporting of this element under normal conditions, nuclear accidents excluded.

ANNEX IV

BUFR template for surface observations from n-minute period

TM 307092

			Unit, scale
3 01 089		National station identification	
	0 01 101	State identifier (1)	Code table, 0
	0 01 102	National station number (1)	Numeric, 0
3 01 090		**Fixed surface station identification; time, horizontal and vertical co-ordinates**	
	3 01 004	Surface station identification	
		WMO block number	Numeric, 0
		WMO station number	Numeric, 0
		Station or site name	CCITT IA5, 0
		Type of station	Code table, 0
	3 01 011	Year(2)	Year, 0
		Month(2)	Month, 0
		Day(2)	Day, 0
	3 01 012	Hour(2)	Hour, 0
		Minute(2)	Minute, 0
	3 01 021	Latitude (high accuracy)	Degree, 5
		Longitude (high accuracy)	Degree, 5
	0 07 030	Height of station ground above mean sea level	m, 1
	0 07 031	Height of barometer above mean sea level	m, 1
0 08 010		Surface qualifier (for temperature data)	Code table, 0
3 01 091		**Surface station instrumentation**	
	0 02 180	Main present weather detecting system	Code table, 0
	0 02 181	Supplementary present weather sensor	Flag table, 0
	0 02 182	Visibility measurement system	Code table, 0
	0 02 183	Cloud detection system	Code table, 0
	0 02 184	Type of lightning detection sensor	Code table, 0
	0 02 179	Type of sky condition algorithm	Code table, 0
	0 02 186	Capability to detect precipitation phenomena	Flag table, 0
	0 02 187	Capability to detect other weather phenomena	Flag table, 0
	0 02 188	Capability to detect obscuration	Flag table, 0
	0 02 189	Capability to discriminate lightning strikes	Flag table, 0
0 04 015		Time increment (= - n minutes)	Minute, 0
0 04 065		Short time increment (= 1 minute)	Minute, 0
1 32 000		**Delayed replication of 32 descriptors**	
0 31 001		Delayed descriptor replication factor (= n)	Numeric, 0
0 10 004		Pressure	Pa, –1
1 02 000		**Delayed replication of 2 descriptors**	
0 31 001		**Delayed descriptor replication factor**	**Numeric, 0**
3 02 070		**Wind data**	
	0 07 032	Height of sensor above local ground	m, 2
	0 07 033	Height of sensor above water surface	m, 1
	0 11 001	Wind direction	Degree true, 0
	0 11 002	Wind speed	m s^{-1}, 1
	0 11 043	Maximum wind gust direction	Degree true, 0
	0 11 041	Maximum wind gust speed	m s^{-1}, 1
	0 11 016	Extreme counterclockwise wind direction of a variable wind	Degree true, 0

	0 11 017	Extreme clockwise wind direction of a variable wind	Degree true, 0
3 02 072		**Temperature and humidity data**	
	0 07 032	Height of sensor above local ground	m, 2
	0 07 033	Height of sensor above water surface	m, 1
	0 12 101	Temperature/Air-temperature (scale 2)	K, 2
	0 12 103	Dew-point temperature (scale 2)	K, 2
	0 13 003	Relative humidity	%, 0
1 03 000		Delayed replication of 3 descriptors	
0 31 001		Delayed descriptor replication factor	Numeric, 0
0 07 032		Height of sensor above local ground (6)	m, 2
0 08 010		Surface qualifier	Code table, 0
0 12 120		Ground temperature	K, 2
0 07 032		Height of sensor above local ground (set to missing to cancel the previous value)	m, 2
0 08 010		Surface qualifier (set to missing to cancel the previous value)	Code table, 0
1 03 000		Delayed replication of 3 descriptors	
0 31 000		Short delayed descriptor replication factor	Numeric, 0
1 01 005		Replicate 1 descriptor five times	
3 07 063	0 07 061	Depth below land surface	m, 2
	0 12 130	Soil temperature (scale 2)	K, 2
0 07 061		Depth below land surface (set to missing to cancel the previous value)	m, 2
1 01 000		Delayed replication of 1 descriptor	
0 31 000		Short delayed descriptor replication factor	Numeric, 0
3 02 069		**Visibility data**	
	0 07 032	Height of sensor above local ground	m, 2
	0 07 033	Height of sensor above water surface	m, 1
	0 33 041	Attribute of following value	***Code table, 0***
	0 20 001	Horizontal visibility	m, –1
0 07 032		Height of sensor above local ground (set to missing to cancel the previous value)	m, 2
0 07 033		Height of sensor above water surface (set to missing to cancel the previous value)	m, 1
1 01 000		Delayed replication of 1 descriptor	
0 31 000		Short delayed descriptor replication factor	Numeric, 0
3 02 073		**Cloud data**	
	0 20 010	Cloud cover (total)	%, 0
	1 05 004	Replicate 5 descriptors four times	
	0 08 002	Vertical significance	Code table, 0
	0 20 011	Cloud amount	Code table, 0
	0 20 012	Cloud type	Code table, 0
	0 33 041	Attribute of following value	Code table, 0
	0 20 013	Height of base of cloud	m, –1
1 01 000		Delayed replication of 1 descriptor	
0 31 000		Short delayed descriptor replication factor	Numeric, 0
3 02 076		**Precipitation, obscuration and other phenomena**	
	0 20 021	Type of precipitation	Flag table, 0
	0 20 022	Character of precipitation	***Code table, 0***
	0 26 020	Duration of precipitation(3)	Minute, 0
	0 20 023	Other weather phenomena	Flag table, 0
	0 20 024	Intensity of phenomena	Code table, 0
	0 20 025	Obscuration	Flag table, 0
	0 20 026	Character of obscuration	Code table, 0
1 02 000		Delayed replication of 2 descriptors	

0 31 000		Short delayed descriptor replication factor	Numeric, 0
0 13 155		Intensity of precipitation	$kgm^{-2}s^{-1}$, 4
0 13 058		Size of precipitation element	m, 4
		(end of the replicated sequence)	
1 02 000		Delayed replication of 2 descriptors	
0 31 000		Short delayed descriptor replication factor	Numeric, 0
0 20 031		Ice deposit (thickness)	m, 2
0 20 032		Rate of ice accretion	Code table, 0
1 01 000		Delayed replication of 1 descriptor	
0 31 000		Short delayed descriptor replication factor	Numeric, 0
3 02 078		**State of ground and snow depth measurement**	
	0 02 176	Method of state of ground measurement	Code table, 0
	0 20 062	State of ground (with or without snow)	Code table, 0
	0 02 177	Method of snow depth measurement	Code table, 0
	0 13 013	Total snow depth	m, 2
1 02 000		Delayed replication of 2 descriptors	
0 31 000		Short delayed descriptor replication factor	Numeric, 0
3 02 079		**Precipitation measurement**	
	0 07 032	Height of sensor above local ground	m, 2
	0 02 175	***Method of precipitation measurement***	Code table, 0
	0 02 178	Method of liquid water content measurement of precipitation	Code table, 0
	0 04 025	Time period (= - n minutes)	Minute, 0
	0 13 011	Total precipitation / total water equivalent of snow	kg m^{-2}, 1
0 07 032		Height of sensor above local ground (set to missing to cancel the previous value)	m, 2
1 01 000		Delayed replication of 1 descriptor	
0 31 000		Short delayed descriptor replication factor	Numeric, 0
3 02 080		**Evaporation measurement**	
	0 02 185	***Method of evaporation measurement***	Code table, 0
	0 04 025	Time period or displacement (= - n minutes)	Minute, 0
	0 13 033	Evaporation /evapotranspiration	kg m^{-2}, 1
1 01 000		Delayed replication of 1 descriptor	
0 31 000		Short delayed descriptor replication factor	Numeric, 0
3 02 081		**Total sunshine data**	
	0 04 025	Time period (= - n minutes)	Minute, 0
	0 14 031	Total sunshine	Minute, 0
1 01 000		Delayed replication of 1 descriptor	
0 31 000		Short delayed descriptor replication factor	Numeric, 0
3 02 082		**Radiation data**	
	0 04 025	Time period (= - n minutes)	Minute, 0
	0 14 002	Long-wave radiation, integrated over period specified	J m^{-2}, -3
	0 14 004	Short-wave radiation, integrated over period specified	J m^{-2}, -3
	0 14 016	Net radiation, integrated over period specified	J m^{-2}, -4
	0 14 028	Global solar radiation (high accuracy), integrated over period specified	J m^{-2}, -2
	0 14 029	Diffuse solar radiation (high accuracy), integrated over period specified	J m^{-2}, -2
	0 14 030	Direct solar radiation (high accuracy), integrated over period specified	J m^{-2}, -2
1 02 000		Delayed replication of 2 descriptors	
0 31 000		Short delayed descriptor replication factor	Numeric, 0
0 04 025		Time period (= - n minutes)	Minute

0 13 059		Number of flashes	Numeric
1 01 000		Delayed replication of 1 descriptor	
0 31 000		Short delayed descriptor replication factor	Numeric, 0
3 02 083		**First order statistics of P, W, T, U data**	
	0 04 025	Time period (= - n minutes)	Minute, 0
	0 08 023	First order statistics (= 9; best estimate of standard deviation) (4)	Code table, 0
	0 10 004	Pressure	Pa, –1
	0 11 001	Wind direction	Degree true, 0
	0 11 002	Wind speed	$m\ s^{-1}$, 1
	0 12 101	Temperature/dry-bulb temperature (scale 2)	K, 2
	0 13 003	Relative humidity	%, 0
	0 08 023	First order statistics (= missing value)	Code table, 0
0 33 005		Quality information (AWS data)	Flag table, 0
0 33 006		Internal measurement status information (AWS)	Code table, 0

Notes:

1) 0 01 101 (WMO Member State identifier) and 0 01 102 (National AWS number) shall be used to identify a station within the national numbering system that is completely independent of the WMO international numbering system. The WMO international identification 0 01 001 (WMO block number) and 0 01 002 (WMO station number) shall be reported if available for the particular station.

2) The time identification refers to the end of the n-minute period.

3) Duration of precipitation (in minutes) represents number of minutes in which any precipitation was registered.

4) Best estimate of standard deviation is counted out of a set of samples (signal measurements) recorded within the period specified; it should be reported as a missing value, if the measurements of the relevant element are not available from a part of the period specified by 0 04 025.

5) If reporting nominal values is required, the template shall be supplemented with 3 07 093.

6) **The height above local ground 0 07 032 referring to ground temperature shall be considered as a variable. After a snowfall, the sensor is placed at the top of the snow layer and the changed value of 0 07 032 shall indicate this procedure (the depth of the snow is reported in 0 13 013)**.

ANNEX V

Advances in AWS Technology
Review progress and advances in AWS technologies - Develop guidance to deal with integration of third party AWS networks

Submitted by Dr Jane Warne (Australia)

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DECISION PROCESS FOR THE INTEGRATION OF EXTERNAL DATA SOURCES INTO NATIONAL METEOROLOGICAL ORGANISATIONS

A common problem which impacts many modern meteorological organisations is how to effectively use and integrate data from external sources. Historically the decisions to use this data may have been made on an *ad hoc* basis and not necessarily considered the operational cost of using and maintaining such sources of data. It is sometimes assumed that data provided at nominally no cost to meteorological organisation is free, however, this is seldom case. There are costs associated with ingest and potential archival of the data. If the data is critical to operations then monitoring of both the quality and the availability of the data becomes critical. Issues around intellectual property rights and obligations, relationship management and contract management all create an economic impost on the organisation. As a consequence, "free data." is seldom free. It is therefore important to be able to determine the value of the data source and hence whether investment in its management is justified.

To make an informed decision regarding use or investment in external data there are several areas that need to be considered. They can be summarised as:-

- Value - What does this data or arrangement deliver to the organisation?
- Metadata - Do you know enough about the data to make effective use of it?
- Intellectual property - Can you use the data in the way we want?
- Implementation – Can you access and manage the data?
- Agreement – Do you have the mutual ability to manage the relationship in the future?

A decision process to address these five issues is given in Figure 1. This provides a logical flow decision-making which progresses through each of the above areas. If for any reason the source fails to meet the needs of the process, then no more energy and resource need be invested. Having this process should therefore limit negative economic, risk and resource impacts of ingesting external data. It is important to note this is a decision process not an implementation process.

Value

Ingestion of data, its management, archival and dissemination, are all costly process unless data is adding value to an operational research outcome. There is little point in making the investment associated with managing that data if we're not deriving value. With this in mind the following decision process commences with an assessment of value in three different areas; relationship, network contribution and quality of the data.

Questions that could be asked at this stage are:-

- Is maintaining a healthy relationship with this provider critical to the broader goals of the organisation?
- Why do you want particular data or information?
- What do you need to know to judge the value of the information?
- How do you know that the information is adding value i.e. that is what is the KPI (Key Performance Index)?
- Spatially is the data filling a gap in a network or providing redundancy?
- What is the quality of the data?
- Are there risks or costs in having too much data?

Fundamentally it needs to be determined how this data source delivers value to the organisation.

Is the relationship with the supplier sufficiently important that despite minor issues with the data it is worth engaging for the relationship alone? An example of this would be the acceptance of AWS data that is over sampling an area or which is of lower quality to ensure delivery of critical remote sensing data to another program. In this situation concerns about the quality (which may be managed in a tier structure) are secondary to shoring up the relationship. This is fundamentally the most subjective measure of value, and will need to be considered on site by site and supplier basis.

A second consideration is the spatial contribution the data/information makes to the organisation. This is often a balance between the quality and usefulness aspects of the data and is driven by end user. Critical to the ultimate decision is a detailed understanding of the user needs (potentially via a Rolling Review of Requirements process).

Another critical input to this decision is an integrated a network design. Network designs need to be a balance of various user needs, an understanding of meteorological and environmental threats, and ideally an understanding of national infrastructure, societal and environmental priorities. Integrated GIS tools that draw on National economic and societal data along with value estimates from meteorological model outputs, such as adjoint based sensitivity and ensemble analysis, are useful tools in determining the value of individual data sources.

The next stage in assessing the value of new data sources is its quality and utility. Criteria such as the frequency of data delivery, reliability of delivery, longevity and the quality of information supplied should be assessed. If the data does not satisfy the requirements of particular users then there is no sense in its collection, archival or quality control unless the relationship is paramount.

Having considered and determined there is some merit or value in the delivered data. The final stage of value assessment is to make a preliminary determination of the tier the data belongs to. This will assist with related decisions on data requirements, the nature of an agreement and intellectual property rights. Clearly this step assumes implementation of a "Tiered network"[2] that incorporates and rates sources of data based on the quality and all usefulness. Such a system will allow the organisation to better manage data of varied quality, but is not essential to the operation of a decision process.

There are, five key tools needed to aid in this stage of the decision process (Fig. 1a).

- A set of principles or guidelines for deciding value of relationships

[2] Note from this point forward you should assume the use of a tier system within the operation of networks. In general, this does not negate any of the stages of the decision process, however minor modifications may be needed if implementing in a non-tiered network.

- A list or policy regarding critical relationships

- User requirements that articulate the quality, frequency, reliability and the spatial distribution of data needed.

- A network design which reflects the user's spatial requirements for a particular data type.

- Quality standards and criteria for the data for tiers, if implemented.

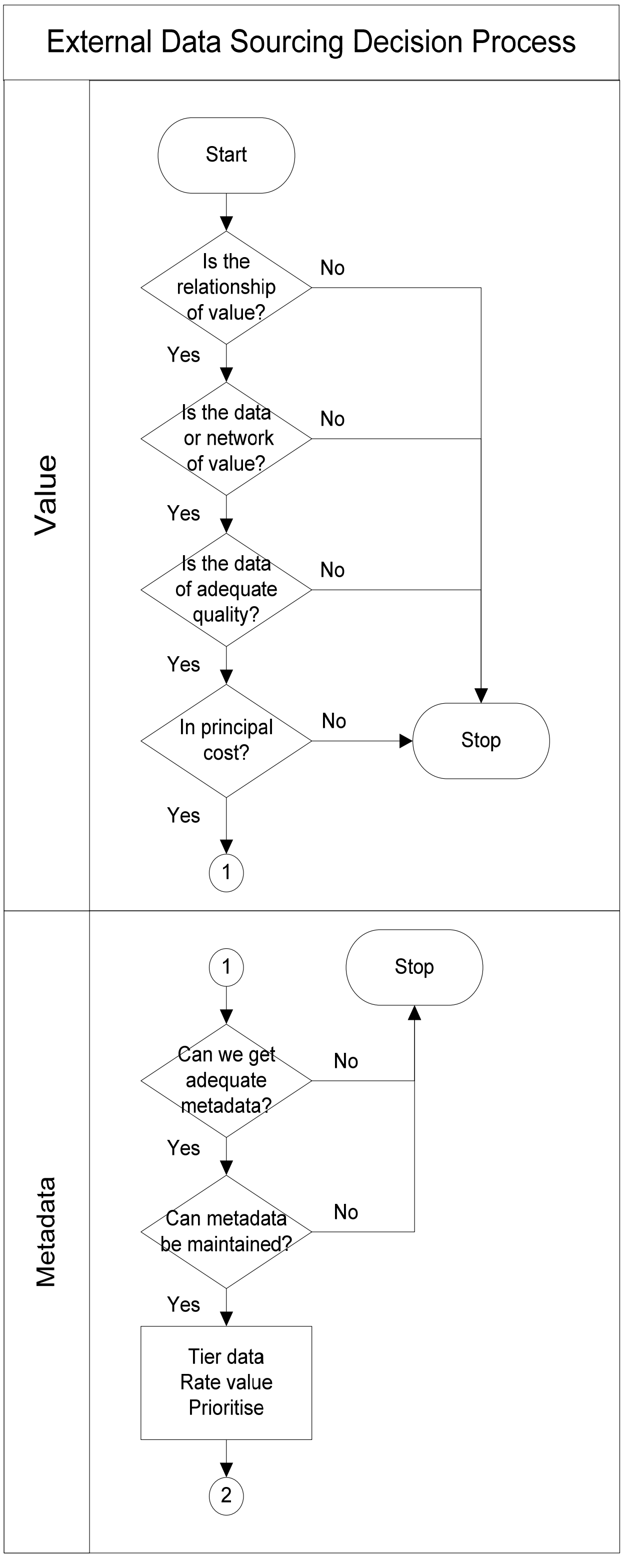

Figure 1a. External data is sourcing decision process flow diagram – Determining Value

Metadata

The second stage in this process is to assess the metadata needs. What metadata is essential to make the data useful? How do we gather metadata? What resources are needed to maintain the data? (Fig. 1a).

Metadata falls into several categories:-

- ownership and management (e.g. infrastructure owner, property owner, operating contact, leasing arrangements, length of tenure);
- geographic (e.g. Latitude, longitude, elevation);
- measurement infrastructure (e.g. sensors, age of infrastructure);
- siting (e.g. photographs, skyline surveys, plans, land type);
- communications and reporting (e.g. frequency of reporting, format, the method of reporting);
- algorithms and software (e.g. sampling methods, processing);
- standards and calibration (e.g., traceability, uncertainty estimates, compliance certification, maintenance schedule);
- quality control (e.g. post-processing, flags);
    - Date, record coverage period;
    - Archive information; (Electronic/paper) access to historical data.

The quantity, quality and currency of metadata will govern the usefulness of the data and hence the tier to which the data will contribute. As a result if an adequate level of metadata is not available there may be no point in continuing to consider ingesting the external data.

A further consideration is whether the metadata can be maintained on a regular basis. To minimise costs and maximise value this should be a task undertaken by the supplier of the data. In most data formats a minimum metadata of time and location or site number are provided which links the data to the more detailed site, quality and ownership metadata. To update the metadata related to a site there needs to be a separate process which provides details on the sensors used calibrations and maintenance etc. Model transfer formats such as BUFR and XML tend to carry more detailed metadata on a message by message basis. Meteorological Service Canada are taking this approach to what might be considered “routine” metadata. Such methods cater for some, not all metadata requirements. As a consequence, organisations need to consider developing simple access paths for external organisations to maintain more detailed metadata e.g. via Web interface.

To progress this aspect of process will require:-

- Metadata for each tier level, and an assessment of the risks associated with not having metadata.
- A mechanism for external agencies to submit and update metadata records.

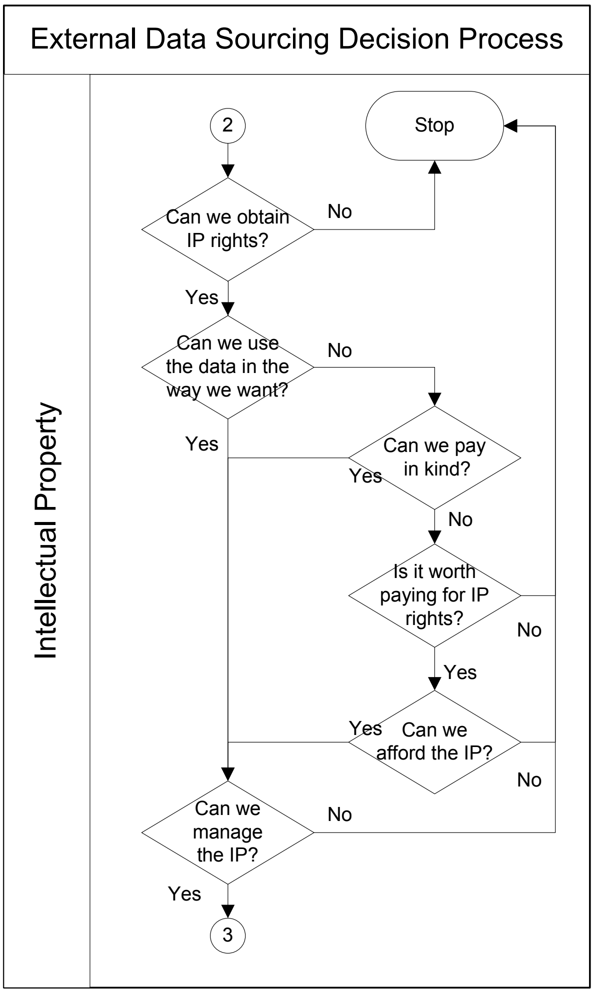

Figure 1b. External data is sourcing decision process flow diagram – Intellectual Property

Intellectual property (IP)

The next issue to be addressed is that of IP rights. Reaching agreement on custodianship of data is important. There needs to be an understanding of how the data can be used so that incumbent limitations can be efficiently managed. Some providers of data may wish to place restrictions on redistribution and/or internal use of the data. Where possible these should be avoided as they increase significantly the cost and risk associated with the use of the data. For example, without adequate controls over the release of data it is very easy for individual members of the organisation to unwittingly redistribute data which has limitations on it. Managing those controls can also add significantly to the overhead costs.

In some rare cases the value contributed by the data may be so high that purchasing the data directly or contributing in-kind to ensure access may be considered. This may take the form of providing access to meta-databases, archival of data or shared maintenance. These sorts of arrangements need careful consideration as they imply a legacy commitment internally to the organisation.

IP agreements will be easiest to manage if they are consistent across suppliers, and ideally Open Source. The specific nature of any licence its pros and cons are complex. A common form of licensing created originally for the arts community is Creative Commons (Creative Commons 2012) and its variants. This is a commonly used in New Zealand, UK, Russia and Australia.

Creative Commons is an enormously useful tool however, there are some questions around:-

- managing attribution;

- irrevocability of distributed information under the licence;
- the ability to terminate the license where misuse of the information has occurred;
- duty of care as an executive agency;
- on- selling of unchanged material.

Many of these concerns relates to impacts on the originator of the data rather than the user, however they are considerations which can complicate use and redistribution of data. Creative Commons has been commonly used in the UK government, but more recently they have developed their own open access license agreement. The UK Meteorological Office are now using this alternate license. The Canadian Metrological Service has also taken this approach.

One of the most important considerations in dealing with external agencies is that the licence chosen is generally accepted across that nation's government. This is because a large percentage of the organisations that are likely to provide data of a desirable quality and longevity, will be government owned. Hence the licence needs to be commonly accepted if efficiencies in negotiations are to be achieved.

Secondly, the licence should have an open source or open access basis to ensure that public are not paying multiple times for taxpayer funded data.

Key requirements (Fig. 1b):

- standard open source agreement;
- priority rating on the value of the data.

Implementation

Once the value and the usefulness of the data have been determined in the next consideration is its accessibility. The first decision is whether the data it can be delivered reliably and efficiently. The preference is for electronic delivery in a known format. If this is not possible, then consideration may be given to the development of specific decoders; if the data is valuable enough to warrant to the cost. It is a decision that needs to be made with some caution as ongoing management of changes in codes may be expensive, and the ability to retrieve archived data compromised.

Can the data be displayed? Can you afford to develop the display? In general if it is standard AWS data this would not be a consideration, but for new technologies or measurements this may require extensive work adequately displayed and archive. The other two considerations are the archival and quality control of the data. Do we have the capacity to archive the data? Do we have sufficient information and tools for adequate quality control of data?

Individually none of these considerations is a "deal breaker", but understanding the journey of the information is critical to getting the best value out of it. Within organisations the gathering, display, archival and quality control of data may be undertaken by a variety of different areas. Decisions in any one area may have significant impacts on another. It is therefore important that throughout this process but particularly at implementation all areas are consulted and informed.

Key information needs (Fig. 1c):

- the format, volumes and information content of the data;
- estimates of communications costs;
- estimates of integration costs including quality control, display and archival.

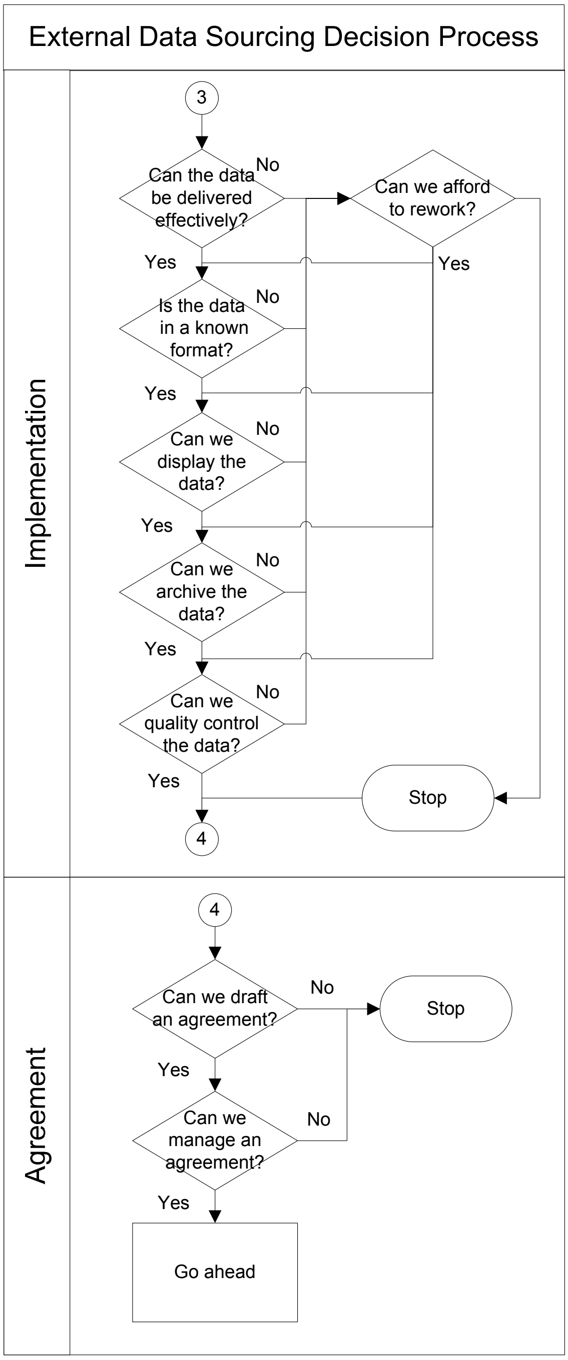

Figure 1c. External data is sourcing decision process flow diagram – Implementation and Agreement.

Agreement

This is the point at which everything comes together. We should by this stage have an understanding of:-

- what value the data can deliver;
- what priority it has for operations;
- if you can access and maintain the associated information (metadata);
- whether you have the right to use the data in the way we want;

- whether in practice, you can manage the data flow and quality;
- whether you can manage the relationship in a positive and productive manner;
- what in-kind commitments are needed;
- what the general cost of incorporating the data is;
- the likely reliability and longevity of the relationship and the data supply.

If at any point along this chain the answer is a considered no, then the value of the data source must be questioned and hence any investment should be carefully considered (Fig. 1c).

It is important that both parties understand the mutual commitments and the impacts this will have on each party. Most importantly the agreement should include review points and renewal to ensure regular contact between the organisation and the supplier to maintain a healthy working relationship.

External data are not free data. There is a lot of internal work required to utilise data effectively. Every dollar invested in external data is a dollar not spent on the internal operations. While this may be valid decision, it needs to be made strategically not by process of small cuts.

ANNEX VI

DRAFT RECOMMENDATION TO CBS-XV: REVISED FUNCTIONAL SPECIFICATIONS FOR AUTOMATIC WEATHER STATIONS

THE COMMISSION FOR BASIC SYSTEMS,

Noting:

(1) The request of CBS-Ext.(06) to revise automatic weather station (AWS) functional specifications,

(2) The Expert Team on Requirements for Data from Automatic Weather Stations (ET-AWS) Work Plan 2009-2012 to revise AWS functional specifications,

Considering that the AWS functional specifications have been reviewed and updated based on the inputs and proposals of other technical commissions,

Recommends that the revised Functional Specifications for Automatic Weather Stations (see Annex) be approved,

Requests the Secretary-General to make arrangements for publication of the revised functional specifications in the *Guide to the Global Observing System* (WMO-No. 488).

Annex to Recommendation No. XXX (CBS-XV)

Functional Specifications for Automatic Weather Stations

See Annex II for table.

ANNEX VII

Proposed ET-AWS WORKPLAN FOR THE PERIOD 2012 TO 2014

(i) Contribute to the implementation of the WIGOS Implementation Plan (WIP) in terms of AWS networks;

(ii) Develop standards and methods for integrating observations data (including BUFR) and metadata (static and dynamic) into WIGOS.

(iii) Liaise with relevant ICT-IOS and ICT –ISS ETs and TTs to develop requirements for an expanded Volume A to support WIP, using WMO 488 Appendix III.3 as a basis.

(iv) Monitor and review advances in AWS technology and networks for developed, less developed countries, and in extreme environmental conditions.

(v) Review and update AWS Requirements and Functional Specifications, including ET-EGOS RRR database and liaison with technical experts.

(vi) Through mutual cooperation with other ETs, develop guidance for the integration of AWS observations in support of other observing systems (e.g. space-based).

(vii) Considering the observations and business gaps when transitioning to automated surface networks, develop guidance material suitable for NMHS. *(lowest priority*)

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ANNEX VIII

ET-AWS 2012-2014

***Proposed* TERMS OF REFERENCE**

Expert Team on Requirements and Implementation of AWS Platforms (ET-AWS)

(a) Provide advice and support to the Chairperson of OPAG-IOS on development and implementation of WIGOS concept;

(b) Address requirements for integration, interoperability, standardization and homogeneity of the WIGOS Implementation Plan (WIP);

(c) Review and update the *Manual* and the *Guide on the GOS* in the context of WIP;

(d) Address the evolution of the AWS observing networks;

(e) Provide advice to ET-EGOS and OPAG-IOS on surface in situ contributions to the GOS to address the identified requirements and overcome known deficiencies and gaps;

(f) Monitor advances in AWS technology.