EXPERT TEAM ON OBSERVING REQUIREMENTS AND STANDARDS FOR CLIMATE

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TABLE OF CONTENTS

1	ORGANIZATION OF THE SESSION	1
1.1	*Opening of the meeting*	*1*
2.	REPORTS AND TORS	1
2.1	*Report of the OPAG.1 Chair*	*1*
2.2	*Report of the ET leader*	*2*
2.3	*Terms of Reference (Ref. CCl-XIV, November 2005)*	*2*
3.	IMPLICATION OF IPCC REPORTS	3
4.	LINKS TO OTHERS WMO AND INTERNATIONAL PROGRAMME	3
4.1	*GCOS*	*3*
4.2	*GEOSS*	*4*
4.3	*UNFCC (WMO involvement in)*	*4*
4.4	*CBS (ET on EGOS)*	*4*
4.5	*CIMO*	*5*
4.6	*Space Programme*	*5*
4.7	*JCOMM*	*6*
5.	CURRENT KNOWLEDGE ON SELECTED TOPICS	6
5.2	*AWS in developing countries*	*6*
6.	FRAMING WORK-TASKS	7
6.1	*TASK 1 on Automatic Weather Stations*	*7*
6.2	*TASK 2. Develop, or contribute to, a Guidelines document for climate observational standards in developing countries*	*9*
6.3	*TASK 3: Guidelines on Quality Assurance/Quality Control of surface meteorological data"*	*10*
7.	SUMMARY OF RECOMMENDATIONS	11

APPENDIX A - IPCC

ANNEX 1 - PROVISIONAL LIST OF PARTICIPANTS
ANNEX 2 - AGENDA

EXPERT TEAM ON OBSERVING REQUIREMENTS AND STANDARDS FOR CLIMATE
(Geneva, 28-30 March 2007)

1 ORGANIZATION OF THE SESSION

1.1 Opening of the meeting

1.1.1 The meeting of the Expert Team on Observing Requirements and Standards for Climate (ET-ORSC- ET1.2), of the Commission for Climatology (CCl); Open Programme Area Group on Climate Data and Data Management was opened by its Leader, Dr William Wright, at 9h45 on Wednesday 28 March 200 at WMO Headquarters in Geneva, Switzerland. The list of participants is attached in Annex 1.

1.1.2 Following the opening of the session, Prof. Hong YAN, Deputy Secretary-General (DSG) of WMO, welcomed the participants to Geneva. In his statement he highlighted the most important topics related to the meeting. He specifically recalled the issues related to the role of climate observation, its quality and standards in conducting climate analysis and prediction and carrying out robust and consistent assessments needed for climate change studies. He also outlined some challenges for WMO in climate data and monitoring. These ranged from implementing modern climate data base systems, helping Members with advice on best practices for climate networks, data exchanges, and best use of Automatic Weather Stations, and defining the role of Satellite data in climate monitoring. He considered very important the role of the Expert team in taking up these challenges along with other WMO programmes, technical commissions such CBS, CIMO and other WMO sponsored programmes such as GCOS.

1.1.3 Dr William Wright thanked DSG for his participation at the opening and welcomed the participants to the meeting. He pointed out some key issues relevant to the work of the meeting with emphasis on climate data continuity and homogeneity as well as the increasing use of AWS. He recalled his recent participation at the meeting of JCOMM Expert Team for Marine Climatology which addressed homogeneity and Ships observation problems. He stressed the need to look for stronger links and synergies with CIMO, CBS, GCOS and GEO. He concluded that the work should continue by email and asked the ET members to continue their work for the ET in their institutions.

1.1.4 Mr Pierre Bessemoulin, President of CCl extended his thanks to the participants, to the ET leader and to the OPAG1 Chair as well as to the WMO secretariat. He highlighted the importance of having ET meetings as early as possible within the CCl Intersessional Period. He stressed the need to clearly define priorities, establish a work-plan with Simple, Measurable, Achievable and Time bound (SMART) objectives. He suggested setting up as is being done by other CCl ETs a web based information exchange among the experts. He concluded with various priorities for the ET works including issues related to CIMO work and its Guidelines, CCl Guidelines and providing links with other WMO programmes.

1.1.5 Dr Raino Heino provided remarks on his role within GCOS as a Member of the GCOS Atmospheric Observing Panel (AOPC) and his active role within IPCC scientific groups. After the Opening ceremony, participants reviewed and adopted the meeting agenda (Annex 2)

2. REPORTS AND ToRs

2.1 Report of the OPAG.1 Chair

Dr Raino Heino presented his report including various activities in which he is involved with emphasis on the European Climate Support network (ECSN) of which Dr Aryan Engelen from KNMI (The Netherlands) leads the coordination. ET1.2 could promote this work, problems related to the declining observation network, problems with inhomogeneity in Data with example illustrated by Helsinki station time series 1844-2005. He provided examples of changes in observations linked mainly to changing sites, methods and instrument practices and made several remarks and outlined major problems that face climate communities in particular:

- Changes in national networks with increasing implementation of AWS to replace classical manual stations;
- The problem of Data availability and existing Gaps in the time series;
- The need for daily data for climate extreme studies;
- The importance of quality control and homogenization in climate studies;
- The Role of Data archaeology and data rescue to complement the length of available time series,

2.2 Report of the ET leader

In his Report, Dr William Wright The report defined three major tasks for the ET work: Task 1: Investigate and make recommendations from a CCl viewpoint on requirements and standards of AWS observations for climate work; Task 2: Develop guidelines documents in particular for developing countries including Climate Data Management Systems, communication infrastructure problems, maintenance and training issues for observation networks and cost-benefit analysis for AWS and Task 3: Accomplishment of the Guidelines on QC/QA which commenced in 2005. He also emphasized the desirability of an "end to end" approach in climate data management, with effective feedback processes to observation network managers.

Dr Wright elaborated on the theme of AWSs, providing information on the Australian experience (Australia now has almost 600 AWSs, many of them "stand-alone" observational platforms). He reported some negative impacts related to AWSs such as the loss of visual observations, problems with inhomogeneity (and the resultant impacts on assessing climate change), and problems at times in attaining a sufficient overlap period when transitioning from manual to automated systems. Rainfall monitoring was identified as a particular problem, as apart from introducing inhomogeneities into rainfall time-series used for climate change and variability monitoring, in Australia there are possible financial implications. (For example, drought relief payments to farmers are sensitive to rainfall amounts received in relation to the long-term historical record. If amounts are being artificially under-read because of changes in instrumentation, this has the potential to provide misleading input into decisions worth millions of dollars). The report concluded by exhorting all team members to work as one team with ultimate goal to benefit NMHSs and assist them in carrying out their climate role and activities.

2.3 Terms of Reference (Ref. CCl-XIV, November 2005)

The meeting reviewed the Expert Terms of References as defined by CCl in its fourteenth session, Beijing, 3-10 November 2005. These are:

(a) To review and make recommendations regarding the adequacy and choice of observing instruments and sensors to meet climate needs, including *in situ,* remote-sensing systems and automated methods;

(b) To review and develop recommendations on procedures and practices necessary to support the long-term homogeneity of climate data, including:

(i) Procedures to be carried out in the migration from man-made to automated measurements, and during changes to sensors and site;
(ii) Procedures to be carried out during instrument maintenance and calibration;
(iii) Instrument comparisons to identify biases, drift and sensitivity;
(iv) Maintenance, monitoring and reporting on observing environments including instrument exposure;

(c)	To specify the basic characteristics and standards of national and regional climate networks and their observations, including AWSs and remote sensing platforms, needed in support of climate activities;
(d)	To help ensure that guidance and procedures are developed to assist with improved data exchange, particularly with regard to satisfying the requirements of the Reference Climate Stations, RBCN and the relevant GCOS networks;
(e)	To coordinate and collaborate with the OPAG Rapporteurs, CBS, JCOMM, CIMO, GEOSS, GCOS, WCRP (e.g. on polar data for the IPY) and other groups as required or as opportunities arise;
(f)	To explore, document and make recommendations for addressing the needs for capacity building in each region, pertinent to this topic;
(g)	To submit reports in accordance with timetables established by the OPAG chair and/or Management Group.

During the discussion of ET ToRs, several issues were raised. These included: the level requirement in the measurement accuracy to be met by the instrument industry, data spikes due to maintenance and calibration procedures, remote sensing and reference climate basic stations, their inventory and the issue of CLIMAT messages. It was suggested that ET should work on recommending an intermediate approach in addressing accuracy standards, by setting minimum-level and high-level standards for accuracy in the measurement of climate parameters. As for solid precipitation measurement by AWS, the ET feels that this measurement still needs major improvement and that precipitation estimation from Radar is not a very accurate guide to precipitation amount.

3. IMPLICATION OF IPCC REPORTS

Dr Raino Heino made a presentation (see summary in appendix A) on the IPCC process, work group structure and its Fourth Assessment Report (FAR) which was released in February 2006. The IPCC Fourth Assessment report concluded that the understanding of anthropogenic warming and cooling influences on climate has improved since the TAR, leading to *very high confidence* that the globally averaged net effect of human activities since 1750 has been one of warming. In 21st century the warming is expected to be greatest over land and at most high northern latitudes and least over the Southern Ocean and parts of the North Atlantic Ocean. Precipitation increases *very likely* in high latitudes and decreases *likely* in most subtropical land regions.

4. LINKS TO OTHERS WMO AND INTERNATIONAL PROGRAMME

4.1 GCOS

4.1.1 Dr Hans Teunissen and Mr William Westermeyer provided two presentations on GCOS including its goals and strategy based on promoting the scientific requirements for climate observations. The overall science leadership is provided through various GCOS panels such as AOPC for atmospheric observations, OOPC for Ocean observations and TOPC for Terrestrial Observations. GCOS interacts closely with CGMS, CEOS, IGOS and GEOSS. The meeting was also informed on the GCOS monitoring principles and various GCOS Baseline Networks including GSN, GUAN, GRUAN, and BSRN. Four primary strategies for GCOS were also identified, these being: (a) identify observational requirements for climate applications; (b) desirability of building on existing systems to the extent possible; (c) engage as required intergovernmental, regional and national bodies (including links to UNFCCC); (d) resource mobilization. The GCOS second adequacy report (2AR) issued in April 2003 identified 44 Essential climate variables 16 Atmospheric, 15 oceanic and 13 terrestrial. The GCOS Implementation plan (October 2004) identified 131 actions for the five years period and the agent for their implementation including WMO, CGMS, CEOS, Panels. The ‘’satellite supplement’’ to the requirements for climate products provided detailed specifications for satellite-observed products in support of climate programme objectives, in conjunction with in situ observations (CEOS/WMO Data base).

An item that arose during discussions, of relevance to the work programme of this ET, was the possibility of engaging the UNFCCC/COP process to impose high-level leverage on signatory countries to improve their observational networks. Later discussions highlighted the key role OPAGS 1 and 2 can play in the UNFCCC process.

4.1.2 Mr William Westermeyer provided information on the GCOS workshop programme, which aims to assess baseline networks, national and regional needs, and deficiencies in climate data. The meeting was also informed on the CLIM-DEV Africa project aiming at promoting the use of climate data and services in meeting the Millennium Development Goals in Africa with emphasis on Climate Risk Management. Essentially, CLIM DEV aims to "mainstream" climate information into decision-making and planning processes, with the aim of improving management of climate-sensitive activities. The project objectives are structured around four Key Result Areas: Policy Awareness; Climate Risk Management; Climate support services with priority for MDGs and, Observations; Data Management and infrastructure upgrade. During the discussion on this item, it was emphasized that there is a need for closer liaison with the WCP for the implementation of climate services in CLIM DEV project.

4.2 GEOSS

4.2.1 Mr Brian O'Donnell informed the meeting on GEO. Since its formal constitution 2 years ago, GEO encompasses now 65 nations at ministry level and 43 agencies. Its goal is to provide a better link among all existing observations systems through the establishment of Global Earth Observation System of Systems, GEOSS. The GEO 10 year implementation plan defined 9 benefit areas, (e.g., disaster management, energy, water, and including climate). WMO participation in GEO is important; it is involved in 46 tasks out of 92 tasks identified for 2006 and 23 out of 46 identified for the period of 2007-2009. The WMO role was defined as: enhancing the use of existing National Meteorological Service (NMS) data and systems; bringing observational capacity to other areas; and exploring how to better integrate meteorological/climate activities in the areas of health, energy, etc. The meeting was also informed on various climate tasks established for this period, including sustained reprocessing and re-analysis of the climate record; securing provision of key satellite data for climate studies; and better integration of climate and weather forecasts into a more seamless prediction system.

4.3 UNFCC (WMO involvement in)

Mr Amir Delju, from the WCP department, provided a presentation on ''Climate Data for adaptation to climate change'', which included background information on the UNFCCC process since COP1 in 1995 through COP 12 in 2006, and its work programme (the Nairobi Work Programme). He provided the definition of the nine areas of activity of this programme and WCP/CCI contributions in providing expertise and organizing workshops. He outlined the main challenges in coping with climate variability and change, such as those issues related to CCI work in Data quality and climate Networks. These included: obtaining sustainable high quality data for climate change detection, etc; and supporting climate observation networks, especially in Least-Developed countries. With regard to the latter, the issue of resource mobilization was raised, with the comment that there is a need to improve our ability to do this. Regional Climate Centres were described as having a role to play in facilitating understanding of local and regional impacts to climate change.

4.4 CBS (ET on EGOS)

Dr Raino Heino provided a presentation on the CBS Expert Team on Evolution of the Global Observing System ET-EGOS. He described activities of EGOS, including: expanding the User Requirements Database to include "break-through" values via its Rolling Requirements Review Process, and expand to new observational types as required; implementation and recommendations of the Evolution; work on AWSs and for redesigning GOS.

Two Statements of Guidance (SoGs) for climate applications were developed by the GCOS-AOPC in 2003-2004 with input from some expert members of the climate community. It has also been noted that the CCl might develop additional SoGs for climate applications. It was also recommended that the formal ownership of these SoGs reside within the CCl structure.

The CCl structure was, however, changed since November 2005 and organizing the work of the new Expert Teams has delayed the process. In 2006 GCOS SoGs, however, were finally accepted, and possible new CCl-related SoGs were requested.

ET-ORSC discussed the item on the SoGs and its inclusion in the Work plan. It was concluded that any possible new SoG-information would be for now elaborated by the OPAG1 chair only. - More specifically, SoGs on possible new climate applications, when agreed in co-operation with the OPAG4 ETs in the first place, will be prepared and complemented by the full RRR-process.

4.5 CIMO

4.5.1 Mr Bessemoulin Informed the meeting about the CIMO mission and the new CIMO guide which will provide guidance on the measurement accuracy. This can be found on the CIMO Web-site. The new CIMO guide will include a chapter on extreme events such as tornadoes. Mr Bessemoulin also informed that the forthcoming CCl guide on Climatological practices will make reference to the CIMO guide in its relevant chapters.

4.5.2 Mr Bruce Sumner described how the Hydro-Meteorological Equipment Industry Association (HEMI) works closely with CIMO, and provided information on various inter-comparison experiments held and planned in various areas such as in Mauritius, where 36 manufacturers were involved during three weeks for GPS- RS inter-comparison. Other CIMO/WMO inter-comparison experiments are planned in Italy and Algeria. There was a convergence among participant views on the usefulness and the need for continuing these inter-comparison experiments.

4.6 Space Programme

4.6.1 Mr Jerôme Lafeuille provided an in-depth presentation on the Rolling Requirement Review (RRR) process, and the CEOS-WMO Database on User Requirements. The aim of these is to generate and maintain specified User Requirements for the observing systems of WMO and other organizations. This process started in 1994. The formulation of WMO requirements is being now handled by the CBS ET-EGOS and the database itself (which is relevant to both surface- and space-based observations) is maintained by the WMO Space Programme. On a regular basis, a gap analysis is performed and results in a “Statement of guidance” (See: http://www.wmo.int/pages/prog/sat/Refdocuments.html). The purpose is to define how present, planned and proposed observation systems meet User Requirements (URs) for different application areas within WMO.
The key points developed through his presentation deal with how URs are specified within RRR for every required geophysical variable (level2) through 5 dimensions: Horizontal resolution, vertical resolution, observing cycle, timeliness and accuracy. For each of these 5 dimensions of the requirement for a geophysical variable, the users shall define a “threshold” (= the least demanding value below which the measurement would not be useful), a “goal” (=the most demanding value above which further improvement are not necessary), and the ‘’ breakthrough’’, an intermediate concept which was introduced in 2006, and defined as an optimum value that lies between the threshold and the goal. The breakthrough is expected to allow significant progress in the applications with a good cost/benefit ratio.

4.6.2 Mr Lafeuille informed as well on a forthcoming workshop in Geneva, 21-22 June on Redesign and Optimization of the space based component of GOS, following a request from CBS (Ext.06) to initiate such a re-design in order to better address the observation needs of climate monitoring.

4.7 JCOMM

4.7.1 Dr W. Wright reported on his participation in the meeting of the JCOMM Expert Team on Marine Climatology (ET-MC) which was held in Geneva 26-27 March 2007, back to back to the ET-ORSC meeting. Some points of likely interest to the ET-ORSC (and possibly other CCI ET's) included:

- The ET-MC aim to develop an extreme wind wave Climatology (SWH > 14 meters);
- The importance of developing a reliable Sea Ice climatology;
- The issue of data management and acquiring access to marine data-sets through devices such as interoperable data-sharing portals was regarded as very important;
- Observation availability from Voluntary Observing ships (VOS) have been negatively impacted by security and commercial concerns (ship owners are not prepared to divulge their identify, meaning metadata is essentially unavailable); urgent efforts are underway to find a solution;
- The need to standardize electronic log books;
- International efforts are underway to find and digitize historical SHIP log books and metadata, under the RECLAIM project;
- On-board AWS capability has led to a decline in the availability of visual observations from VOS;
- The experience of ET-MC is similar to other climate groups: the needs of climate tend to be subordinated to those of other programmes.

An action item arising from the meeting was that CCI would be asked to participate in a new cross-cutting Task Team on Marine and Oceanographic Climate Summaries (TT-MOCS). Among other things, this Task Team would be responsible for advising on marine meteorological products; and advising on the collaborative development of climate change monitoring indices (e.g., indices of the North Atlantic Thermohaline Circulation intensity).

5. CURRENT KNOWLEDGE ON SELECTED TOPICS

5.1 Dr W. Wright **expanded upon his earlier comments with regard to AWS impacts on** climate-related issues in the context of the 10 climate monitoring principles. He outlined the AWS benefits such as: high frequency in the records, better ability to measure extremes, ability to be deployed in remote areas; general cost-effectiveness; potential use as a quality control tool; and consistency in measurements. On the other side, he listed some of their shortcomings including data losses; inhomogeneity issues when migrating from conventional(manual observations) to AWS; management and maintenance problems; data spikes; rainfall accuracy problems; and loss of visual observations. These negative aspects have implications that include making them generally unsuitable for climate change studies, and constructing climatologies of several parameters, with phenomena and visual parameters especially affected. In Australia, the accuracy of rainfall measurements has implications for financial decisions, including the provision of relief payments to farmers during drought periods. He concluded with the existing recommended Australian standards for AWS network including:

- Data availability greater than 99 %;
- Need for Visual observation sensors;
- Need for an alert system for failure, and adequate data backup ;
- Consider redundant sensors (Us reference Network);
- High precision measurements meeting Wmo standards;
- Regular inspection and maintenance;
- Preferably intersperse with conventional stations to provide a mutual check;
- Quality control procedures (Guidelines)

5.2 AWS in developing countries

5.2.1.1 Dr Wright described as well some findings on the cost effectiveness of AWS deployment in developing countries such as in the RA.V Region. In general, AWS deployment is not widespread, in these countries, due to: lack of funding, inadequate expertise to manage maintenance problems, and the problem of vandalism affecting AWS located in remote areas. There is as well the fact that relatively low labor costs encourage continuing with conventional network. At regional level the RA.V Working Group on Climate Related Matters is involved in the CIMO/WMO guidelines on AWS specifications.

5.2.1.2 Mr Bruce Sumner provided further information on facts related to AWS such as the increase in total number of AWS among WMO RBSN with a proportion of 23 %. He stated that with the current AWS technology the accuracy has increased and the costs are decreased.

5.2.1.3 Dr C. Boroneant gave an extensive presentation of the present status of AWS in Romania with a comparative study providing comparison between AWS and conventional stations. Romania Network has 162 stations among which 99 are AWS. Parallel measurements were conducted in some areas including 15 stations to compute monthly bias in the main climate parameters hourly T, P, H. She noted significant differences: in particular, AWS tend to overestimate Min T and underestimate Max T. The differences appear almost in all time-ranges (including hourly, daily and monthly mean values). The causes of these differences are related to both human and technical (sensors) factors.

6. FRAMING WORK-TASKS

Participants agreed to focus on three main tasks as proposed by the ET leader (item 2.1.2 above) and that for all assignments, the first draft for exchange is due in November 2007.

In view of the substantial number of tasks, the Meeting assigned priority rankings to each of the sub-tasks, with greatest emphasis to be placed on achieving so-called "Priority 1" Tasks.

6.1 TASK 1 on Automatic Weather Stations

The meeting recognized that AWS are increasing in numbers (23% of GBSN of WMO in 2006) and already a very major part of the world's network is automated. This will only increase. AWSs have the capacity to increase the availability, accessibility, density and the management of climate records, and there is a trend for the sensors to become more accurate. In principle they can meet any desired level of precision, and the costs of providing this accuracy are getting proportionately lower. However it is important that the climate community set standards to ensure AWS readings are compliant with the needs of the climate programme. Several sub-tasks were assigned to the Task Team (TT) composed of Demircan, Boroneant, Hassan, Kruger, and Wright. The following actions were agreed:

6.1.1 The outline of the task was originally specified as:

Develop an updated list of standards for AWSs for climate purposes including:
6.1.1.1 Revising, and where necessary amending, the existing recommendations for sensor precision/network spacing;
6.1.1.2 Develop recommended standards for climate work for non-instrumental observations, such as visibility, cloud type and amount, phenomena, and sea state; and provide options and advice on cost-effective means of establishing this capacity within AWS;
6.1.1.3 Standards for data back-up and transmission, sensor redundancy, and possibly also inspection and maintenance; Guidance on network design, including the relative location of AWSs and manual stations for optimizing complementary aspects of the two data types and for AWS data QC;
6.1.1.4 Any other factors pertinent to the objective of ensuring AWSs provide data that best fits climate needs.

6.1.2 Addresses Part 6.1.1.1 above: Work on the required precision of climate-related variables Priority 1 (C. Boroneant, W. Wright);

6.1.2.1 CBS have requested CCl to revisit the standards required for AWS. Ideally this should be done for all variables, but at least the team should concentrate on ECVs.
6.1.2.2 Several sources of advice on this matter could be found available on WMO web site. These include: the CIMO guide, guide for marine meteorology, N. Plummer publications on the subject, Ernest Rudel publications on AWS, and various publications from GCOS, IGBP, ICSU, and UNEP etc.). The Task Team will investigate these sources of advice;
6.1.2.3 First step is to identify the key parameters to be measured for climate purposes. (Priority 1: C. Boroneant, W. Wright);
6.1.2.4 Task team to provide guidelines on a set of ECVs and other phenomena to be measured (how is this arrived at?). Are there "essential" versus "desirable" variables? (Temperature, precipitations, humidity, pressure, surface wind). TT to define whether any extra variables are needed such as SST. Also good to read document making original recommendations as to reasoning behind why these were set as they were;
6.1.2.5 Are the current suggested precisions and network spacing variables too stringent? If so, can we define a "breakpoint" which indicates the most cost-effective values that are acceptable to the climate programme (consider RRR). Priority 2 /3;
6.1.2.6 Precipitation is a particularly important variable that poses problems for AWSs (e.g., frequently reads low). More significant problem with solid precipitation: is there a case for specific instrumentation or additives (e.g., heating elements on all stations regularly exposed to extreme cold?) Priority 3;
6.1.2.7 Is there a case for "tiered" networks? – i.e., where a certain subset of AWSs has considerably enhanced capacity – e.g., being equipped with visual/phenomena sensors such as lightning detectors. Priority 1 (W. Wright, in consultation with NCDC);
6.1.2.8 Noting the continual conflict between meeting the needs for the climate programme and resource limitations in most countries, this ET would like to seek Policy guidance from WMO on question of cost-effectiveness versus high standards – is there a policy? Priority 2/3

6.1.3 Address 6.1.1.2: The issue of loss of visual observations Priority 1 (R. Hassan)

6.1.3.1 Need for specialized observational sensors; options include: tiered stations, some with high-end capacity; or else intersperse with conventional stations with capacity to observe phenomena, visual obs, etc.

6.1.4 Addresses Part 6.1.1.3: Develop guidance and advices continuity and homogeneity issues [M. Demircan]

AWS can potentially lead to a loss of continuity of the climate record through problems such as data losses, introduction of inhomogeneities (e.g., migration from manual to AWS), and existence of data spikes. The Task Team will investigate, and make recommendations on:

6.1.4.1 Inspection frequency, mechanism for data back-ups (e.g. should all AWSs be fitted with loggers, and with what characteristics (e.g., how many days data?), system alarms on failure, whether to have redundant sensors. How to avoid data spikes and data corruption. Priority 1 (M. Demircan).
6.1.4.2 Investigate the sources of information, such as CIMO (guide), CBS publications, manufacturers' guides, and the requirements for completeness of data. (Australian requirements of 99% - check general applicability). These will inform recommendations
6.1.4.3 Provide advices on AWS Network management for climate needs.

6.1.5 Change management: Parallel observations and comparison Priority1 (C. Boroneant, M. Demircan)
6.1.5.1 Ideally it is necessary to do this for a minimum period of two years at each station, but this is not affordable or practical in all cases. For instance, given budgetary constraints some

NMHS try to minimize "overlap" between two representative sensors. One option is to make this a formal requirement rather than just a recommendation to NMHSs;

6.1.5.2 Two types of measurements: Conventional Weather Station (CWS) to AWS, and when moving one station from one site to another. Task Team (TT) will look at the period of overlap and the number of stations for the comparison noting, e.g., Constanta's presentation showing significant differences in the intercomparison between different regions, and determine whether the inter comparison could be done at only selected stations;

6.1.5.3 Investigate existing differences in AWS/CWS for hourly, daily and monthly Data, to assess the non systematic causes: human and technical**,** and to determine in general the various reasons for differences between AWS/CWS (response time, etc.). Visit CIMO Guide (policy management) and provide recommendations on how to reduce these differences, including: greater QC, greater consistency in instrument sitting, Calibration/overlap, etc. TT will look as well at other experiences where parallel comparisons were successful.

6.2 TASK 2. Develop, or contribute to, a Guidelines document for climate observational standards in developing countries

This task involves, inter alia, collaboration with GCOS Lead Centres. The Task Team (TT) is composed of (Howe, Isobe, Wright, and Kruger). TT will address several issues, and the special problems of lack of funding, limited expertise, lack of maintenance, vandalism, and it will investigate potential solutions. There is also a need to establish a case for defining where AWS would be of particular benefit. Existing works will be considered, such as studies undertaken by Neil Plummer (Australia) *et al* on cost/effectiveness of AWS. The GCOS concern about having AWS as GSN stations is to be addressed with GCOS appropriate panel to see how will this be supported by the international community to ensure a high quality and systematic climate records

6.2.1 Topics to be covered by the guidelines document

6.2.1.1 Outline of WMO recommended standards (B. Howe)

Includes identifying which variables are key – temp, precip, other ECVs; and what the standards are for these stations. Who might be able to help define these standards? Use existing CCl standards. Do the GCOS Adequacy reports prepared for the UNFCCC provide guidance?

6.2.1.2 Identification of key stations and strategies for ensuring at least minimum number of observations are taken at those stations. (Isobe)

It should include the definition of what is meant by key stations – GCOS, major population centres, stations representative of major climate zones, or all of the above, what criteria to be used to define "key stations"? Does this vary from country to country? and what are the strategies for a combination of a careful network planning, resource mobilisation, mitigating observation-related problems, etc.)

6.2.1.3 Training and capacity-building activities in observations. (B. Howe)

Develop best practices for in-country visits and suggestions for hands-on training, training to more staff, etc. Training may need to be provided by staff from developed countries – example of PNG where staff has lost ability to do radio-sonde flights. Provide list of examples of successful experiences e.g., a couple of Australian projects. The guidelines might also include recommendations for succession planning and training for trainers, the role of workshops, and utilization of WMO RMTCs. TT will seek guidance from CIMO/OPAG on capacity building in developing this part of the guidelines.

6.2.1.4 Strategies for mitigating observation-related problems (W. Wright)

Recommend strategies for mitigating the effects of communications, difficulty in maintenance, remoteness, vandalism/security issues such as use of and workshops on Climate data management software.

6.2.2 Network issues including AWS in developing countries (B. Howe)

Consider the issue of blended Network (CWS-AWS) and look at defining a process to determine minimum/maximum number and advice on how to get access to high-end maintenance needed and whether we can use stations established by private companies.

6.2.2.1 Issues related to climate programme needs (Isobe)
Define the needs of climate programme, in particular their requirements in terms of homogeneity, continuity with minimal data loss and adequate quality control. Review the synergies, if any, that exists between needs of climate programme observations needs and real-time observations?
6.2.2.2 Profile-raising activities in-country (Kruger)
Suggest ways in which NMHSs can be helped to emphasize the benefits of robust and reliable observations to their countries' governments, especially pointing to the potential economic benefits. (refer to WMO socio economic benefit of Met services conferences reports, website) and examine the leverage that could be provided by UNFCCC bodies. TT to investigate links to UNFCCC (refer to GCOS and GOS presentations of 29 March 2007).
6.2.2.3 Strategies for resource mobilization (W. Wright)
TT will Identify the major potential funding sources – own Government, Aid Agencies, World Bank (?), UNFCCC-related, etc. If successful in in-country profile-raising efforts, this will lead to some funding from countries' own Governments. Even then, there is likely to be a need for funding supplementation from elsewhere. TT will also investigate whether there already exists a WMO-linked mechanism for funding/support for countries that need it, and if not, we could recommend that consideration be given to establishing such a fund.

In terms of staffing/training: is a "buddy" system an option – i.e. where certain countries within a Region provide temporary support to others? Example in Pacific where Fiji has capacity to support some of its smaller island neighbours. Review the role of Regional centres CIIFEN, ACMAD, ICPAC, DMCs etc.

6.2.2.4 Suggestions for further activities/investigations (W. Wright)

Investigate whether satellite imagery holds any potential here – perhaps for estimating wind speed and solar energy.

Thinking outside square: e.g., does carbon trading schemes have potential to support activities in developing countries?

6.2.2.5 Liaison with other Technical commissions (All)

The Task Team should consult with other technical commissions whose work involves Least-Developed Countries – e.g., CIMO, CBS – there may be existing documents, policies and practices. Also, GCOS Lead Centre surveys into why countries are having trouble meeting requirements for CLIMAT messages.

6.3 TASK 3: Guidelines on Quality Assurance/Quality Control of surface meteorological data"

The Task Team is composed of (Boroneant, Kruger, Howe, Wright, Heino, and NCDC). Its task is to complete the Guidelines document on Quality Control/Quality Assurance commenced in 2005. This task is relatively straightforward (but not necessarily easy), in that the task is already started, with a proposed outline of the document already established and some writing already done. The history was that, in the previous Inter-sessional period, it was recommended that CCl produce a guidance document on QA/QC that was relatively short (around 50 pages or so, and including specific examples, including illustrations)

6.3.1 The existing outline was accepted as basically adequate, with minor amendments, taking into consideration:

6.3.1.1. Extension of basic variables to include MSLP, and possibly other ECVs. These latter would be the subject of "Chapter 6" of existing structure. This is one area where NCDC might be willing to contribute;
6.3.1.2. The experts in the current team might not have the statistical expertise to address this task. However, Dr Wright has reported that NCDC have indicated a willingness to assist with this

document. Therefore it was suggested that Chapter 4 be referred back to NCDC with request that they do this (and perhaps provide detail on other techniques, such as MISH;
6.3.1.3. Other sources: reference to the CCl Guide on Climatological Practices;
6.3.1.4. Additions: It was decided to include a section on techniques for homogenizing daily data;
6.3.1.5. Additions: Investigation on whether QC should be incorporated at the instrument/software level, or in delayed mode QC, or both.

6.3.2 The Guidelines document should fit within the overall Data Quality "strategy" of the WMO, and the Team was informed that there was already abundant guidance on QC/QA from existing sources within other technical commissions and programmes (e.g., WWW Guide; CIMO guide, guide to GOS). The Task Team should, within the confines of the existing proposed framework, assess what's in these existing sources, and assess what is relevant to climate applications (in which case they might be cross-referenced), and what needs separate treatment to meet climate needs. A recommendation concerning the availability and use of generic QC software packages should be included within the Guide. Bruce Sumner has agreed to make copies of the relevant publications for Task Team members engaged in this task.

6.3.3 The proposed Structure of the Guidelines on Quality Assurance/Quality Control of surface meteorological data will now consist of Eight (8) chapters:

Chapter I: [To be defined, but essentially an Introduction] NCDC (W. Wright)

Chapter II: [To be defined, but along lines of basic concepts] (W.Wright)

Chapter III: Basic QC (B. Howe)

Chapter IV: Single Stations Checks (NCDC)

Chapter V: Spatial checks (W. Wright)

Chapter VI: Other parameters (R. Heino)

Chapter VII: Inhomogeneities (C. Boroneant)

Chapter VIII: Evaluation (B. Howe)

And three appendices:

A.1 The Australian approach (W. Wright)
A.2 Potential applications to AWS/QC (C. Boroneant)
A.3 End to end approach (collecting statistics on network health) [W.Wright]

7. SUMMARY OF RECOMMENDATIONS

I. Automatic Weather Stations (AWS)

Recommendation 1: In any observing network it is important for climate purposes that at least some manual stations be retained for optimizing the complementary aspects of AWS and manual stations.
Recommendation 2: The Task Team should investigate the various sources of advice already current (e.g., comparative studies under CIMO), and match these with needs of the climate programme, to arrive at an acceptable, and achievable, statement on observational standards and practices (including maintenance, continuity of observations, etc) that AWS should meet to satisfy climate needs.

Recommendation 3: Noting the improving standards of instrumentation, the Task Team should establish a “High accuracy” standard based on existing guidelines, and recommend a second set of minimum standards. Task Team should define “minimum standards”.
Recommendation 4: Task Team should look at examples of tiered networks (in which a selection of stations have higher-end capabilities for climate purposes), such as the US Reference Climate Network. Recommend whether tiered networks are effective ways of meeting climate needs.
Recommendation 5: Task Team to liaise with CIMO and consult also with CBS, GCOS, instrument manufacturers, and others?
Recommendation 6: Climate programme needs to define what QC including metadata issue should be built into AWSs to complement existing delayed-mode QC, and that there is agreement between instrument manufacturers and the climate programme on how to assign quality flags, etc. To achieve this, a dialogue is needed with Manufacturers for them to provide QC/QA description in the operational manuals.

II. Observational Standards in Developing Countries

Recommendation 8: Recognising the crucial importance of climate observations from developing countries for climate variability and prediction, and climate change monitoring and adaptation work, the Task team to assess strategies for achieving and maintaining the best possible standards of observations from developing countries taking into consideration the existing RBCN standards. This will involve, *inter alia*, optimising the use of existing stations and their equipment, an assessment of whether AWS can provide the required data, and recommendations for addressing problems such as lack of funding, maintenance, and expertise in developing countries.
Recommendation 9: The Task Team should investigate and recommend options for resource mobilisation and other means of support for the observational programmes in developing countries. This includes in-country profile-raising of the NMHS, and a variety of possible external fund-raising strategies, including investigating the potential role of the UNFCCC and World Bank.

III. Quality Assurance/Quality Control of surface meteorological data

Recommendation 10: The Climate programme should provide a definitive statement on QC techniques for climate data
Recommendation 11: Climate programmes should build dialogue with instrument manufacturers on QC/QA, and manufacturers should provide details of QC/QA functionality in the operational manuals.

IV. Results Delivery

Participants agreed that for all assignments, the first draft text for exchange is due in November 2007.

APPENDIX A

The Intergovernmental Panel on Climate Change (IPCC) was established by WMO and UNEP in1988 to assess scientific, technical and socio-economic information relevant for the understanding of climate change, its potential impacts and options for adaptation and mitigation. Main activity of the IPCC is to provide in regular intervals Assessment Reports of the state of knowledge on climate change. The IPCC also prepares Special Reports and Technical Papers on topics where independent scientific information and advice is deemed necessary and it supports the UN Framework Convention on Climate Change (UNFCCC). A number of IPCC reports are published commercially. Summaries, CD ROMs and Technical Papers can be obtained free of charge. The reports have a 5-year cycle: 1990 (1992), 1995, 2001 and 2007.

The IPCC has three Working Groups:

- Working Group I assesses the scientific aspects of the climate system and climate change,
- Working Group II assesses the vulnerability of socio-economic and natural systems to climate change, negative and positive consequences of climate change, and options for adapting to it (Impacts…),
- Working Group III assesses options for limiting greenhouse gas emissions and otherwise mitigating climate change.

Since the Third Assessment Report (TAR) progress in understanding how climate is changing in space and in time has been gained through:

- Improvements and extensions of numerous datasets and data analyses,
- Broader geographical coverage,
- Better understanding of uncertainties,
- A wider variety of measurements.

Direct Observations of Recent Climate Change

- Global mean temperatures are rising faster with time,
- Warming in the Arctic is double that for the globe from 19th to 21st century and from late 1960s to present,
- Warm nights are increasing; cold nights decreasing,
- Heat waves are increasing,
- Significantly increased precipitation in eastern parts of North and South America, northern Europe and northern and central Asia,
- The frequency of heavy precipitation events has increased over most land areas - consistent with warming and increases of atmospheric water vapor,
- Drying in the Sahel, the Mediterranean, southern Africa and parts of southern Asia,
- More intense and longer droughts observed since the 1970s, particularly in the tropics and subtropics,
- Climate change is affecting storm tracks, winds and temperature patterns,
- Anthropogenic forcing has likely contributed North Atlantic hurricanes have increased with SSTs,
- Snow cover and Arctic sea ice are decreasing,
- Glaciers and frozen ground are receding,
- Some aspects of climate have not been observed to change: Tornadoes, Dust-storms, Hail, Lightning, Antarctic sea ice,
- Paleoclimate information supports the interpretation that the warmth of the last half century is unusual in at least the previous 1300 years.

Attribution

The understanding of anthropogenic warming and cooling influences on climate has improved since the TAR, leading to *very high confidence* that the globally averaged net effect of human activities since 1750 has been one of warming

Projected warming

• 21st century expected to be greatest over land and at most high northern latitudes and least over the

• Southern Ocean and parts of the North Atlantic Ocean,

• Precipitation increases *very likely* in high latitudes and decreases *likely* in most subtropical land regions.

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ANNEX 2

AGENDA

DAY 1: 28 March

1. ORGANISATION OF THE SESSION

0945-1030 Welcome, Introductions and official opening of the meeting
1030-1045 Tea/Coffee Break
1045-1130 Adoption of the Agenda and working arrangements

2. REPORTS and TORs

1130-1200 Commission for Climatology (CCl) - Structure and Challenges
1200-1230 Report of the OPAG1 Chair
1230-1400 Lunch
1400-1430 Report of the Team Leader (1400-1430)
1430-1500 Review of TORs – ORSC

3. IMPLICATION OF IPCC REPORTS

1500-1545 IPCC WG 1 Recent Report + implications
1545-1600 Tea/Coffee Break
1600-1630 IPCC Report (Cont'd)

4. LINKS TO OTHER WMO + INTERNATIONAL PROGRAMMES

1630 -1715 JCOMM, CIMO, CBS, GCOS, GEOSS, UNFCC

DAY 2: 29 March

0845-1030 JCOMM, CIMO, CBS, GCOS, GEOSS (Cntd)
1030-1045 Tea/Coffee Break

5. CURRENT KNOWLEDGE on SELECTED TOPICS

1045–1230 Current Knowledge on Selected Topics

- AWS Standards for Climate purposes
- Guidelines on QA/QC of surface meteorological variables
- Guidelines for observational standards in developing countries

1239-1400 Lunch
1400-1545 Current Knowledge on Selected Topics (Cntd)
1545-1600 Tea/Coffee Break
1600-1630 Current Knowledge on Selected Topics (Cntd)

6. FRAMING WORK-TASKS

1630-1730 Framing Work-Tasks

DAY 3: 30 March

0845-1030 Framing Work-Tasks (Cntd)
1030-1045 Tea/Coffee Break

7. RECOMMENDATIONS + FUTURE PLANS

1045-1230 Recommendations and work-plan
1230-1400 Lunch
1400-1515 Recommendations and work-plan (Cntd)

8. **OTHER BUSINESS**

1515-1545 Other Business

CLOSURE OF THE MEETING