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

AND

COMMISSION FOR INSTRUMENTS AND METHODS OF OBSERVATION

JOINT MEETING OF

CBS EXPERT TEAM ON SURFACE-BASED REMOTELY-SENSED OBSERVATIONS

AND

CIMO EXPERT TEAM ON REMOTE SENSING UPPER-AIR TECHNOLOGY AND TECHNIQUES

Geneva, Switzerland

23-27 November 2009

FINAL REPORT

WMO General Regulations 42 and 43

Regulation 42

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

Regulation 43

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

CONTENTS

	PAGES
Agenda	p. iii
Executive Summary	p. iv
General Summary	p. 1 – p. 21
List of Participants	Annex I, p. 1 – p. 4
WMO Guidance Statement on Weather Radar/Wind Turbine Siting	Annex II, p. 1 – p. 2
WMO Guidance Statement on Weather Radar/Radio-Frequency Shared Spectrum Use (Draft)	Annex III, p. 1 – p. 2
Work Plans	Annex IV, p. 1 – p. 7

AGENDA

1. ORGANIZATION OF THE MEETING

1.1. Opening of the session
1.2. Adoption of the agenda
1.3. Working arrangements for the session

2. ASSESS THE CURRENT AND POTENTIAL CAPABILITIES OF WEATHER RADARS FOR THEIR USE IN THE WMO INTEGRATED GLOBAL OBSERVING SYSTEM (WIGOS)

2.1 Develop guidance and standards on weather radar siting, data exchange and operation
2.2 Preparation for weather radar intercomparison
2.3 Develop database of weather radars
2.4 Asses the status/plans of implementation for weather radars by WMO Members in relation to meeting user requirements for all application areas and provide updates to the WMO CEOS of observations systems capabilities database as necessary

3. ASSESS THE CURRENT AND POTENTIAL CAPABILITIES OF WIND PROFILERS FOR THEIR USE IN WIGOS

3.1 Develop guidance and standards on wind profiler siting, data exchange and operation
3.2 Results from the Lindenberg Campaign Regarding an Upper-Air Methods Intercomparison (LUAMI)/2008 campaign
3.3 Asses the status/plans of implementation for wind profilers by WMO Members in relation to meeting user requirements for all application areas and provide updates to the WMO CEOS of observations systems capabilities database as necessary

4. ASSESS THE CURRENT AND POTENTIAL CAPABILITIES OF OTHER SURFACE BASED REMOTE SENSING SYSTEMS (SUCH AS GPS, MICROWAVE AND INFRARED RADIOMETERS, LIDARS, ETC.) FOR THEIR USE IN WIGOS

4.1 Develop guidance and standards on other surface based remote sensing systems siting, data exchange and operation
4.2 Asses the status/plans of implementation for other surface based remote sensing systems by WMO Members in relation to meeting user requirements for all application areas and provide updates to the WMO CEOS of observations systems capabilities database as necessary

5. REVIEW THE IMPLEMENTATION PLAN FOR THE EVOLUTION OF THE GOS

6. DEVELOP GUIDANCE AND METHODOLOGY FOR SURFACED BASED REMOTE SENSOR MONITORING

7. WORK PLAN

8. OTHER BUSINESS

9. CLOSURE OF THE MEETING

EXECUTIVE SUMMARY

This report provides a summary of the joint meeting of the CBS Expert Team on Surface-Based Remotely-Sensed Observations and of the CIMO Expert Team on Remote Sensing Upper-Air Technology and Techniques (Joint Meeting).

The Joint Meeting recognized that the impact of wind turbines on weather radars and the coping strategies to reduce this impact needed to be well described in the CIMO Guide so that all WMO Members can be made aware of this problem when selecting sites for their weather radars. A guidance statement on weather radar/wind turbine siting was prepared for WMO review which includes these siting recommendations.

The Joint Meeting noted that an essential recommendation from the guidance on weather radar data exchange would be to examine the possibility of exchanging raw radar data. The Joint Meeting also noted that developing a common radar data format would be difficult and that it would be more appropriate to look towards building a better understanding of the radar decoding software, metadata and uncertainty in measurement.

The Joint Meeting noted that there will be significant pressures placed on the use of C-Band radars by the operators of unlicensed Radio Local Area Networks (RLAN) once the density of these system increases. The Joint Meeting agreed that strong leadership from WMO through the Steering Group on Radio Frequency (SG-RFC) had occurred and continued to be required to monitor and provide guidance on the use of Meteorological spectrum in all application areas, including weather radars. The Joint Meeting developed a WMO Guidance Statement on Weather Radar/Radio Frequency Shared Spectrum Use that would be provided to CBS through SG-RFC for its consideration.

As remote sensing instruments like weather radars have to go through a number of steps to provide the geophysical parameters of interest, their actual calibration is a real challenge. In view of the importance of weather radars in forecasting severe weather events and their widespread use, the Joint Meeting recommended to address the calibration of weather radars with a view of obtaining comparable data from different radar manufacturers. This should be addressed by carrying out a series of inter-comparison workshops to understand, evaluate and document the various quality control algorithms and adjustment algorithms for quantitative precipitation estimation (QPE). The first workshop would address the first two steps of the process - ground clutter removal and calibrating the reflectivity values.

The Joint Meeting noted that lightning detection systems help add value to other observation systems such as weather radar and satellites through composite observation products from integrated networks that meet the end user requirements more effectively. The Joint Meeting encouraged WMO Members to exchange lightning data on the GTS to allow interested entities to intercompare lightning data and those WMO Members that have carried out lightning detection system intercomparisons to publish their results for the benefit of all WMO Members. The Joint Meeting reviewed a full revision of the CIMO Guide chapter on Lightning Detection to provide up-to-date guidance to Members on these systems. The Joint Meeting also noted the need to develop appropriate guidance material on the use of a number of other remote-sensing observing systems, such as laser ceilometers, microwave radiometry, integrated water vapor measurements from Global Navigation Satellite System.

The Joint Meeting discussed the general trend and issues for the Global Observing System (GOS) including the response to user needs and requirements and how the GOS will become part of the WMO Integrated Global Observing System (WIGOS), which will integrate current GOS functionalities, that are intended primarily to support operational weather forecasting, with those of other applications: climate monitoring, oceanography, atmospheric composition, hydrology, and weather and climate research. The Joint Meeting agreed on a number of recommendations on how the integration of such surface-based remote sensing (SBRS) observing systems within the GOS

might be taken forward, including making proposed changes and some additions for SBRS observing systems in the Implementation Plan for the Evolution of the GOS.

GENERAL SUMMARY

1. ORGANIZATION OF THE SESSION

1.1 Opening of the session

1.1 The Joint Meeting of the CBS Expert Team on Surface-Based Remotely-Sensed Observations (ET-SBRSO) and of the CIMO Expert Team on Remote Sensing Upper-Air Technology and Techniques (ET-RSUATT) was held in Geneva, Switzerland, 23-27 November 2009. The participants were welcomed by Mr Miroslav Ondráš, Chief of the Observing System Division. The list of participants is given in Annex I.

1.2 Mr Ondráš recalled that Congress-XV decided to work towards the development of the WMO Integrated Observing System (WIGOS) that aims at making observing networks more cost-effective through better management and governance. This development will also require improved standardization in three areas: instruments, communications, including metadata, and quality of data and products. The mandate of the Joint Meeting lies with all 3 areas of standardization and its advice is consequently sought for all WIGOS matters addressing remote-sensing systems.

1.3 As the participants from both teams have expertise that cover both instrumentation and networking issues and in view of avoiding duplication and overlap between the work of the two teams, as well as utilizing the available remote-sensing experts, it was decided to organize a Joint Meeting of both expert teams.

1.2 Adoption of the agenda

1.2.1 The Joint Meeting adopted the Agenda for the meeting, which is reproduced at the beginning of this report.

1.3 Working arrangements for the session

1.3.1 It was agreed that Mr Stewart Goldstraw, Chairperson of ET-SBRSO and Mr Seth Gutman, Chairperson of ET-RSUATT would co-chair the meeting.

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

2. ASSESS THE CURRENT AND POTENTIAL CAPABILITIES OF WEATHER RADARS FOR THEIR USE IN THE WMO INTEGRATED GLOBAL OBSERVING SYSTEM (WIGOS)

2.1 Develop guidance and standards on weather radar siting, data exchange and operation

Wind turbine siting and weather radar

2.1.1 Wind turbine farms are nationally supported clean energy sources that are quickly proliferating. Wind turbines are tall structures with large propellers that reflect microwaves. They are deployed in localized networks (also called wind farms or wind parks) and can be deployed as single or hundreds of turbines. There is generally no regulatory requirement for mutual sharing of unobstructed space with weather radars since they are similar to other structures. Therefore, over time, the mutual effective operation of wind turbines and weather radars could have significant impacts. They can impact weather radar data depending on their location and local terrain. Generally, the closer the turbine, the larger the impact. Close to the radar, the individual turbines can create blockage (complete or partial) to completely obscure the weather or affect the Doppler measurements significantly by generating air motion within radar coverage. At very far distances, the wind farm will not be seen as it will be beyond the line of sight of the radar. In between, the microwave signal will be scattered, reflected and create confounding false echoes.

2.1.2 Since radar data is used for public safety and security and wind turbine farms are in the national interest, cooperation in weather radar and wind turbine siting is of mutual interest. Various ranges/distances from the radar are generally defined to describe the impact of wind turbines on radar data quality. It is proposed that these be used as general guidelines for mutual siting of wind turbines and weather radars. It should be noted that these are general guidelines and for flat terrain situations and may require modification for specific situations. At less than about 5 km, complete or partial blockage will occur and cannot be overcome, so that siting wind turbines is not recommended. At up to 20 km, multi-path, multi-elevation and side lobe effects are quite significant, terrain can obscure or enhance its presence and viewing aspects affect the quantitative impact. Mitigation of impact on weather data is very difficult to overcome and early consultation is recommended as potential simple viewing aspect or siting changes of individual turbines in the wind farm can be effective to reduce the impact. Beyond 20km and less than about 45 km, ground clutter-like echoes are experienced and can confound the user and applications. At present there is no demonstrated signal processing or other mitigation techniques available. However, with appropriate training and knowledge of the wind farm locations, human usage is possible and masking (with data loss) is possible for automated hydrological applications. Beyond 45km the wind turbines are generally below the radar beam and it is therefore unlikely that the weather radar would be significantly impacted. However, wind turbines can still be visible in anomalous propagation situation. A guidance statement on weather radar/wind turbine siting has been prepared for WMO review which includes these siting recommendations, see Annex II.

2.1.3 The Joint Meeting recognized that the impact of wind turbines on weather radars and coping strategies to reduce this impact needed to be described in the CIMO Guide so that Members are aware of this problem in selecting their weather radars site. It should be noted that some NMHSs have had very positive experience resulting from early discussions with the wind farm industry; in some cases this has even lead to the relocation of planned wind turbines.

2.1.4 As the national legislation applicable to wind turbines vary strongly from country to country, the Joint Meeting recognized that it was valuable to raise the awareness of the environment agencies and wind industry companies on the impact that wind turbines can have on weather radar data and to develop draft recommendations on the siting of wind turbines with respect to weather radars that could be used by NMHSs in their negotiations with authorities. The Joint Meeting agreed with the statement reproduced in Annex II and strongly recommended that it be widely distributed and also published as an annex to the chapter of the CIMO Guide addressing weather radars. In this context, the Joint Meeting recognized that it would be valuable to publish the location of weather radars to help the wind energy industry in the planning of future turbines to mitigate their impact on weather radars.

Data exchange

2.1.5 The value of exchanging Weather Radar based products between members has long been recognized and a number of bi-lateral and multi-lateral exchange agreements are in place. Bi-lateral agreements tend to be between neighboring members whilst multi-lateral agreements tend to be among members in one region. As application area requirements become more demanding and the use of Weather Radar data by global and regional NWP centers becomes more common, the need to exchange more data, more widely will become the norm. Whilst some application areas will be satisfied by the exchange of surface integrated precipitation total composites, others such as the NWP community will require access to more basic Weather Radar outputs, such as radial velocity and reflectivity.

2.1.6 An understanding of the different requirements of each application area for Weather Radar data needs to be better understood but generally the Joint Meeting accepted the proposal that in future raw data, in the form of radar reflectivity and radial winds, should be exchanged by Members. The Joint Meeting highlighted that to manage data volumes there would need to be some form of data reduction, probably at the regional level, with global exchange being delivered by Regional Data Centers.

2.1.7 The Joint Meeting noted that an essential recommendation from the guidance on weather radar data exchange would be to examine the possibility of exchanging raw radar data. The Joint Meeting also noted that developing a common radar data format would be difficult and that it would be more appropriate to look towards building a better understanding of the radar decoding software, metadata and uncertainty in measurement.

2.1.8 The Joint Meeting felt that a clear definition of raw data is required, as there are many steps in the processing chain where the output from the Weather Radar is still classed as raw, to ensure a consistent level of national processing before exchange. The Joint Meeting requested clarification from the document author. This clarification will be made and an improved version of the document will be circulated to the Joint Meeting participants for review before the end of January 2010.

2.1.9 The Joint Meeting agreed with the urgent need to develop a consistent and comprehensive set of quality descriptors associated with the data exchanged and agreed to establish a task team to develop options for a set of 'standard' data quality descriptors that could be considered by the Joint Meeting and subsequently refined into a recommendation. The Joint Meeting agreed that there was a requirement to establish the requirements for data quality and Metadata.

2.1.10 It was noted that radar sampling intervals should be more aligned to the requirements of end user application areas. For example in the UK, 4D-VAR assimilation and flash flood forecasting may require a data exchange of 5 minutes, however there are other application areas were the requirements for sampling intervals and latency were not as stringent as that of NWP. The Joint Meeting agreed that there should be a strategy for the exchange of radar data and that if the requirements for radar sampling intervals were to satisfy the wider Meteorological Community then these would have to be provided to CBS. The Joint Meeting also agreed that Mr. Malcolm Kitchen would continue to work on developing the guidance and recommendations for the weather radar data exchange, with an appropriate definition required for sampling interval.

2.1.11 It was noted that the other NMHS from other regions as well as weather radar manufacturers will need to be engaged to better develop the overall requirements for the guidance on weather radar data exchange.

Radio-frequency spectrum

At the World Radio Conference In 2003, the ITU-R Resolution 229 states that the bands 5150-5350MHz and 5470-5725MHz were allocated on a primary basis to mobile service for wireless access systems including radio local area networks. The radiolocation service was upgraded to primary status in 5350-5650MHz band and radiodetermination service (radar) was allocated primary status in 5250-5725MHz. There is a need to protect the existing primary services in the 5150-5350 MHz and 5470-5725MHz (radar bands). That studies have show that sharing between the radiodetermination (radar) and mobile services. In the bands 5250-5350 and 5470 5725 MHz (radar bands) is only possible with the application techniques such as dynamic frequency selection.

2.1.12 In the past few years, there have been considerable strategic discussions with the telecommunications industry and national radio-frequency agencies and have reversed some of the practices. This has resulted in substantial progress in the protection of the weather radar particularly in Europe where EUMETFREQ/WMO has been successful in lobbying and changing European practices that will be implemented in the next few years. Radio Local Area Networks (RLANs) and Dynamic Frequency Selection (DFS) devices will be unlicensed, massively deployed and able to cross borders. So the problem of protecting weather radars requires a global solution. However, there are still significant deficiencies and, among other things, include: a comprehensive test plan of the DFS with weather radars, particularly for a massively deployed network of RLAN devices and in various (anomalous, reflection) propagation scenarios and in mountainous terrain. There is no consideration of mobile applications - aircraft, trains, cars, buses, etc. Considerable care is required to provide radar specifications to the telecommunication industry as future considerations must be carefully considered, particularly following deployment when remedial solutions are simply not available. Co-operation and collaboration is encouraged between weather radar and telecommunication as the telecommunications Industry could provide considerable resources to investigate possible solutions.

2.1.13 The Joint Meeting noted that there will be significant pressures placed on the use of C-Band radars by the operators of unlicensed RLAN once the density of these system increases. The Joint Meeting also noted that use of DFS by RLANs to mitigate the impact on the primary user of this band, Meteorological C-band Radars has not so far proven effective at sufficiently protecting C-band radars from the potential interface caused by RLANs. The Joint Meeting also noted that the clutter suppression tools currently available to NMHSs are not adequate in removing interference caused by RLANs.

2.1.14 The Joint Meeting agreed that strong leadership from WMO through the Steering Group on Radio Frequency (SG-RFC) has occurred and continues to be required to monitor and provide guidance on the use of Meteorological spectrum in all application areas, including weather radars. The Joint Meeting developed and agreed on a WMO Guidance Statement on Weather Radar/Radio Frequency Shared Spectrum Use provided in Annex III. The Joint meeting also agreed that the statement would be provided to CBS through SG-RFC for their consideration.

2.2 **Preparation for weather radar software intercomparison**

2.2.1 Remote-sensing observing systems cannot be compared directly to in-situ observations to assess their capabilities as they are not measuring the same thing. Also, remote sensing instrument have to go through a number of steps to provide the geophysical parameters of interest. Therefore, the actual calibration of remote-sensing systems is a real challenge.

2.2.2 Chains of processing steps are required to quality control and convert weather radar data to precipitation rate estimates. These include ground clutter rejection, vertical profile corrections, target classification, multi-radar merging algorithms just to indicate a few steps. A series of inter-comparison workshops are proposed to understand, evaluate and document the various quality control algorithms and adjustment algorithms for quantitative precipitation estimation. The first workshop would address the first two steps of the process - ground clutter removal and calibrating the reflectivity values.

2.2.3 A critical path item was defining success criteria. Successful ground clutter removal will result in smoother reflectivity integration. Proposed metrics to describe this include two-dimensional correlation statistics, variograms or structure functions. A series of test cases with different types of ground clutter (urban, rural, mountain, anomalous propagation, sea clutter, etc) are proposed to be collated as the test set: (i) without weather and only ground clutter, (ii) 24 hour datasets with widespread precipitation and ground clutter, (iii) simulation data sets where the ground clutter only data sets will be manipulated with known or simulated weather and (iv) special cases. An ad hoc group of participants has been formed who will provide data sets or run their algorithms. The first workshop is planned for Exeter, U.K. in spring of 2011. The workshop will be by invitation only and limited to about 30 or so participants in order to promote discussion. Data sets have been identified and will be collated and held on a server at the Bureau of Meteorology (Australia). Decode software will be provided and/or the data will be converted to a single format (netCDF) if participants requests this. Results are required to be prepared 2 months in advance so that the results can be collated, compared and analyzed. The workshop will present the results of the inter-comparisons (in an anonymous manner) and participants will be invited to make available and describe their algorithms according to the proposed rules agreed by the workshop organizing committee. The Joint Meeting noted that deliverables will be documentation that will be peer reviewed and published in a scientific journal or as a CIMO report or both. It is expected that this would be available within 9 months following the workshop.

2.2.4 The goal of the project presented above is to assess whether the software of the different groups retrieve the quantitative precipitation in a comparable manner. This should enable to provide recommendation on how the weather data treatment should be done to obtain best results. The end goal of the overall project is to have comparable data from different radar manufacturers, much as obtained now in the case of radiosondes. However, it should be noted that this intercomparison project addresses more the software then the actual hardware.

2.2.5 The Joint meeting strongly supported the proposal to embark on an intercomparison of weather radar algorithms in view of identifying the best quality control algorithms and to specify the quality of the radar products, such as Quantitative Precipitation Estimation (QPE). The Joint meeting agreed that not all aspects of radar calibration could be addressed at once and that one would need to go through a series of steps to understand/quantify the performance of the algorithms used. Therefore this first workshop would consist in the evaluation of the first step of the radar signal processing chain and address ground clutter removal and calibration. Following steps of the projects could address comparisons with rain gauge, NWP and satellite data, but this would not be included in the first step proposed here.

2.2.6 The Joint Meeting was pleased to note that the issue of the metrics used to evaluate the performances has been solved and that data collection has already started and that numerous groups have shown interest to participate in the project. The Joint Meeting recognized with great appreciation the efforts of Paul Joe and Alan Seed with the organization and preparation of the weather radar software intercomparison.

2.2.7 The timeframe for the project would encompass the following milestones:

- Collection of the data (3-4 months, already started)
- Preparation of the data (3-4 months)
- Mid term meeting (kick off meeting) for data analysis
- Analysis of the data by the participants (4-5 months)
- Preparation of a summary of the participants results (2 months)
- Workshop to present results and agree on main conclusions/recommendations
- Final report of the intercomparison (9 months)

2.2.8 The Joint Meeting recommended that this project be handled in a way similar to an instrument intercomparison with the establishment of an international organizing committee that would have the responsibility to ensure the unbiased presentation of the results. Furthermore, the Joint Meeting tasked Paul Joe to develop a detailed plan for the workshop, so that the Secretariat could follow-up and identify the funding needed for the workshop. The Joint Meeting agreed that in view of ensuring fruitful discussions, the workshop would be mainly restricted to the people who analyzed the data and/or provided data so as not to exceed 30 to 40 participants and that it should be organized as soon as possible, but preferably early 2011. The Joint Meeting also agreed that, where appropriate, weather radar vendors should be invited to participate in the intercomparison. The Joint Meeting agreed that the organizing committee should develop a clear definition of the participants that may take part in the intercomparison.

2.3 **Develop database of weather radars**

2.3.1 A survey on weather radars had been prepared for establishing a comprehensive web-based weather radar database in the scope of the work plan of CIMO/ET-RSUATT. This database could in particular be used to address issues like radio-frequency protection, planning of the deployment of wind-farm as well as NWP data assimilation. The survey was distributed to WMO Members in August 2009. The Joint Meeting was presented with an overview of the responses. The replies to the questionnaire are very encouraging as approximately one third of the Members responded. The process of gathering replies from countries which have not responded to the questionnaire and of the countries which replied to the questionnaire but did not complete the associated spread sheet with the radar details will be continued by the expert team member in charge of this task. Methods for collecting the required data from operators of weather radars other than NMHSs (such as universities, airports, TV stations) will be searched and applied. It is expected that the collected information will be presented on a webpage which will be hosted by WMO or a volunteer WMO member country or interested institute/organization.

2.3.2 The Joint Meeting requested the members of ET-SBRSO and ET-RSUATT to provide support in passing the request for information to people who would be likely to provide additional replies to the questionnaire and in particular to the list of weather radars to achieve a representative database. The deadline for final submission would be towards the end of January 2010.

2.3.3 It was recognized that a questionnaire like this one provides an instantaneous snapshot of the situation, but that it would be much better to be able to update the information on a continual basis to maintain its potential for use. The Joint meeting recommended that the first analysis of the questionnaire and radar database as obtained from this survey be published as an IOM report, so that Members can see the value of this information. Furthermore, the Joint Meeting recommended Members should be encouraged to volunteer to develop and host an interactive website, linked to the WMO website, on which this data could be made available and maintained up-to-date.

2.4 **Asses the status/plans of implementation for weather radars by WMO Members in relation to meeting user requirements for all application areas and provide updates to the WMO CEOS of observations systems capabilities database as necessary**

2.4.1 Weather radars have been in operational use by WMO members since 1950 with a dramatic increase in the number and variety of types based on the purposes of the use as well as the number of the WMO members operating weather radars. C-Band, S-Band and X-Band radars are the mostly used radars respectively.

2.4.2 In line with the development in Doppler technology for radial velocity measurements after 1990s and innovations in polarimetry since 2000 for hydrometeor classification and accurate precipitation measurements have made weather radars very capable of meeting the increasing needs of the meteorological services. It can be concluded that weather radars, at least for today, are essential and indispensable instruments for collecting the real time and high resolution weather data from large scale areas for nowcasting and early warnings against severe weather phenomena such as heavy rain, flash flood, hail, strong wind, tornado, hurricane, etc. This is why most of the WMO Members intend to install weather radars or upgrade their existing systems with the features and capabilities newly developed.

2.4.3 By considering the great importance of weather radar data for providing efficient high quality meteorological products and services to the users, these data should be exchanged on bilateral or multilateral basis and regional networks should be established by improving the international cooperation activities.

2.4.4 Furthermore, it is also important to organize training workshops on weather radars and to develop guidelines for the basic features and products of weather radars.

2.4.5 The main finding revealed by a study of WMO Members, complimented by information provided in reference documentation provided by manufacturers, are summarized below :

a) As a result of unique features of the weather radars, most of the meteorological services that replied (80 out of 182 WMO members) have been either installing or upgrading the Doppler weather radars (C-Band, S-Band and X-Band in the order of the majority) increasingly to improve the capabilities of their early warning systems against the severe weather phenomena such as heavy rain, strong wind, tornado, hail, etc.

b) Since early 1990s Doppler capability has become a standard feature for all weather radars. Similar to the process for Doppler capability, it seems that dual polarization which has come up as a new and useful feature of hydrometeor identification and more accurate quantitative precipitation estimation for weather radars will become also a standard feature for weather radars. The upgrade plans include hardware and software upgrade for having Doppler capability, dual polarization, advanced signal and data processing tools and methods, developed application software for product generation and dissemination, networking, remote monitoring and maintenance function, etc.

c) It has been observed that weather radars have been used mainly by developed countries due to the high investment and operating cost of the radars. Developing countries have shown a high interest for making weather radar investments. Because of the high cost of weather radars, some countries may not be in a position from financial aspect to make such investments due to the lack of sufficient resources. Less developed and developing countries may need funding from international organizations or developed countries to be able to execute radar investments. Consequently, international cooperation and funding mechanism should support them to have required systems.

d) Generally, rain gauge data have been used for the validation and calibration of weather radars. Recently, disdrometers have been proposed to use for the validation and calibration studies with a view that disdrometers will allow real time measurement of rainfall drop size distributions for calibration of the Z-R relationship between radar reflectivity and rain rate. A guideline including common standards for the basic requirements of weather radars, methods and algorithms for validation and calibration of weather radar data should be developed by WMO, and could possibly be an outcome of the intercomparison workshop.

e) Maintenance of the systems, impact of lightning, supplying required spare parts cost and timeliness point of view, lack of qualified staff for maintenance, operation and product interpretation are the problems encountered for the operation of weather radars.

f) In addition, by considering sharing the frequency bands with other users, electromagnetic compatibility (EMC) analysis should be performed to determine the suitability of the site on the basis of interference between the radar and other types of radio/radar services, and human exposure to the transmitted radar beam. Such analysis should identify the operating frequency and the power of the radar.

g) WMO members should take into consideration that well trained operators and engineers are needed for operating the weather radars as well as well trained meteorologists for interpreting the radar products to provide required meteorological services. This is why national and international capacity building activities such as workshops, seminars and trainings should be organized to improve the capabilities of member countries.

h) Another important issue to be considered and studied to benefit from weather radars is assimilation of weather radar data for numerical weather prediction models to have more accurate products from these models. Trainings and seminars on this subject should be organized for the counties which have no expertise on this subject.

i) By considering the importance of weather radar observations for many purposes, particularly for weather forecasting and early warnings, Members should exchange the weather radar data on a bilateral and multilateral basis. On the other hand regional and sub-regional collaborations should be encouraged and supported by WMO.

2.4.6 The Joint Meeting agreed that in order to gauge the status of the implementation of weather radars by WMO Members it was important that users of radar weather data be requested to provide detailed information on which data sets they consider critical to their operations. The Joint Meeting noted that this information could then be used to assist NMHSs with building better observing networks that could not only meet national requirements but also regional and NWP requirements.

3. ASSESS THE CURRENT AND POTENTIAL CAPABILITIES OF WIND PROFILERS FOR THEIR USE IN WIGOS

3.1 Develop guidance and standards on wind profiler siting, data exchange and operation

3.1.1 There are three groups of wind profiler data on the GTS (Global Telecommunication Network): NOAA profiler network, European wind profiler network, and Japanese wind profiler network. To develop guidance and standards on wind profiler siting, data exchange and operation on the basis of the experience in the Japan Meteorological Agency, operational use of wind profilers in the JMA, the Wind profiler Network and Data Acquisition System (WINDAS), were demonstrated.

3.1.2 A brief history of JMA's wind profiler network was explained. An operational network of twenty-five 1.3 GHz wind profilers was implemented in 2001, and 6 wind profilers were added in 2003. The characteristics of wind profilers: frequency, antenna, beam scanning, pulse length, vertical resolution, observation interval, height range, distributed data, were shown. The procedures in the signal processing and the functions of the data processing were explained. Data from the wind profilers: horizontal and vertical component of wind and signal intensity are used in the forecast made with the meso-scale numerical model (MSM) and the hourly analysis. These profiler data are then put on the GTS for distribution to the world in real-time.

3.1.3 The performance of the WINDAS data availability, height coverage and data accuracy were presented. The ground echo rejection to prevent data contamination of ground echoes and migrating-bird echo removal to eliminate bird-contaminated data were also explained. Data display of the WINDAS for public use, application of the wind profiler data to the hourly analysis and to the weather analysis were demonstrated. Upper-air observations with wind profiler, radiosonde, and Doppler radar are compared in the items of weather condition, accuracy, maximum height, vertical resolution, horizontal spacing, time between observations, and delay in delivery to user.

3.1.4 In summary, the WINDAS, 1.3 GHz-band operational wind profilers of the JMA, is characterized with horizontal spacing of 120 km on the average over the main islands of Japan, height coverage of about 5 km, high-accuracy, and high-availability data. The wind data from the WINDAS has contributed to improve accuracy of the numerical weather prediction (NWP) model and to analyze atmospheric conditions.

3.1.5 Current issues and future plans were as follows:

- Data collection and distribution every 10 minutes to provide real-time wind data for aviation applications.
- Estimation of humidity profiles with the WINDAS to improve accuracy of NWP models for heavy rainfall events.
- Planning of the next generation WINDAS to improve height coverage and to resolve sharing issues concerning frequency bands used by wind profiler systems.

3.1.6 The Joint Meeting recommended that the procedures used by JMA for wind-profiles be developed into a guidance material that could be made available to Members, together with similar procedures used by other NMHSs.

3.1.7 Wind profilers are affected by wind turbines and other moving objects in a manner similar to weather radars. In view of minimizing this impact, the Joint Meeting recommended that a guidance statement similar to the statement on the effect of weather radars be developed for wind profilers and agreed to work on the development of this statement. The Joint Meeting welcomed the offer from Dominique Ruffieux to develop this statement of guidance.

3.1.8 The Joint Meeting noted that there is a requirement to reinvestigate the calibration techniques used in particular the traceability of surface based remote sensing systems, in particular wind profilers, to international standards, such as linking wind profiler data uncertainty to that of radiosondes.

3.1.9 The Joint Meeting recognized that guidance material was also required with respect to the optimal distribution of wind profilers with respect to other systems and that CIMO and CBS consider addressing this issue. The Joint Meeting agreed that this particular issue would be brought to the attention of ET-EGOS.

3.2 Results from the Lindenberg Campaign Regarding an Upper-Air Methods Intercomparison (LUAMI)/2008 campaign

3.2.1 A brief report on outcomes of the LUAMI campaign was provided to the Joint Meeting. Unfortunately, no expert team member or representative could participate in the Joint Meeting to provide more detailed information. The Joint Meeting was of the understanding that at present only limited results of the LUAMI campaign had been published and that it was therefore too early to enable to draw guidance material for the Members from these publications.

3.3 **Asses the status/plans of implementation for wind profilers by WMO Members in relation to meeting user requirements for all application areas and provide updates to the WMO CEOS of observations systems capabilities database as necessary**

3.3.1 The requirements for wind profiles, both horizontal and vertical, are articulated by a number of application areas, although it should be noted that some are outside the ET-EGOS area of responsibility. The areas identified in the Committee on Earth Observation Satellites (CEOS) WMO Database of observational requirements were: Global NWP; Regional NWP; Nowcasting (including VSR Forecasting); Synoptic Meteorology; Aeronautical Meteorology; Climate (as defined both by the WCRP and GCOS) and the Global Analysis, Integration and Modeling (GAIM, as defined by the International Geosphere-Biosphere Programme (IGBP)).

3.3.2 The range of requirements stated in the CEOS-WMO database is broadly consistent but it was noted that aeronautical meteorology was generally the most demanding application area for observational requirements. There may be some inconsistencies in the content of the database and this will be investigated by the Chair of the ET in conjunction with the Chair of ET-EGOS.

3.3.3 In addition, the need to capture requirements on measurement integration period was also important. Historically this has not been important as most observing systems produced near instantaneous data. However Wind Profilers generally require a measurement integration period to obtain an observation of acceptable quality. Therefore clarification of the technology free statement of acceptable measurement integration period is required to confirm the need of the application area.

3.3.4 Although confirmation of operational wind profiler network performance will be required via the ET-SBRSO work plan tasks relating to the request of information from the Members, via a questionnaire and subsequent analysis, it was felt that operational Wind Profiler Networks could meet most of the requirements of most of the application areas, at least in the Lower Troposphere.

3.3.5 The Joint Meeting agreed that there are many demands being placed on improving observation systems to meet the current and future requirements of users, with certain application areas, such as aeronautical meteorology, climate and NWP having some of the most challenging requirements. The Joint meeting was made aware that currently under the framework of ET-EGOS there are ten application areas covering requirements of WMO Programmes. It was also noted that as we progress into a WIGOS environment there will be more application areas that will be included. The Joint Meeting noted that there were potential problems with the monitoring threshold levels and that currently there were no meteorological significance to these threshold values. The Joint Meeting agreed that as part of the evaluation process the Joint Meeting would undertake the evaluation of these requirements and provide constructive feedback to the appropriate ET-EGOS focal points.

3.3.6 The Joint Meeting noted that there is a definite need to have specific items in the requirements statement left open for discussion, such as the required vertical resolution. The Joint Meeting also noted that guidance material on the required distribution of surface based remote systems, such as wind profilers, should be developed that would provide valuable guidance to NMHSs in developing observing networks. The Joint Meeting agreed that as part of the work plan it would collect and review the current suite of available national and/or regional guidance material, such as the recent EUCOS upper-air network redesign study, in order to develop some basic guidance material for network managers.

4. ASSESS THE CURRENT AND POTENTIAL CAPABILITIES OF OTHER SURFACE BASED REMOTE SENSING SYSTEMS (SUCH AS GPS, MICROWAVE AND INFRARED RADIOMETERS, LIDARS, ETC.) FOR THEIR USE IN WIGOS

4.1 Develop guidance and standards on other surface based remote sensing systems siting, data exchange and operation

4.1.1 In general, recent observing system developments are best characterized as incremental improvements in data acquisition techniques and data processing, assimilation, analysis and interpretation. A driving force for this comes from attempts to reconcile the results of field campaigns or intensive observing periods over the years at international facilities such as Lindenberg and the U.S. Department of Energy Atmospheric Radiation Monitoring (ARM) Sites respectively over the years.

4.1.2 These campaigns have resulted in a better understanding of the strengths and limitations of existing in situ and remote sensing observing systems. This in turn has helped us to identify gaps in our ability to describe and monitor the dominant atmospheric state variables (winds, temperature and moisture) in the upper atmosphere and propose ways to address them.

4.1.3 In the process, the atmospheric remote sensing community has gained a better appreciation for the need to integrate various observations that improve our ability to characterize and monitor changes in the characteristics of the upper atmosphere at high temporal and spatial resolutions. Another factor that compels us to move in this direction is the understanding that improvements in weather prediction, building or extending long-term climate records, or verifying climate predictions requires upper-air observations to meet the same standards of accuracy and homogeneity that have always been required of terrestrial observations.

4.1.4 To accomplish this, we must focus on identifying and then implementing tools and techniques that allow us to verify that remote sensing observations meet certain (but as yet to be determined) criteria that insure conformance and traceability to international measurement (SI) standards. To maximize the global impact of these tools and techniques on weather forecasting and climate monitoring/prediction, they must be readily implementable in the developing nations on an operational basis.

4.1.5 The Joint Meeting recommended to consider holding a workshop (in collaboration with the Satellite and GRUAN communities) to evaluate which Remote Sensing tools and techniques are likely to have success in tying Upper-Air observations to SI standards. The outputs of such a workshop could include:

- Output: report with recommendations and supporting documents
- Follow-on: Plan on how to verify this?
- Follow-on: Plan on how to implement it?
- Carry out international demonstration project.

4.1.6 The Joint Meeting had intense discussion on the work that needed to be done to provide appropriate guidance to Members on those new systems that are at the transition between research and operation. The Joint Meeting agreed that CIMO should aim at providing information on when new observing technologies are sufficiently developed and reliable so that they can be deployed on an operational basis and be of interest to NMHSs. Priority should be given to describing those systems that are most relevant to user requirements.

4.1.7 As far as guidance concerning the optimal distribution of the deployment of new observing systems and the best mix of instruments is concerned, the Joint Meeting recognized that it is a very complex topic that depends strongly on the local situation and needs. The Joint Meeting agreed that this topic could only be addressed by first making best use of the outcomes of the national testbed activities assessing the capabilities of remote-sensing upper-air technologies. Therefore the Joint Meeting decided to formalize the concept of testbeds for remote-sensing upper-air technologies. In that effect, the Joint Meeting requested Prof. Bertrand Calpini to develop in collaboration with the WMO Secretariat the draft Terms of Reference of these testbeds. The participants of the Joint Meeting will then be invited to provide proposals of testbed sites that should be invited to provide a submission that would be evaluated and formalized at next CIMO Session in 2010.

Questionnaire on lightning detection systems

4.1.8 A survey on lightning detection systems was conducted by CIMO to evaluate the current operation of lightning detection systems. It aimed to report on the strengths and weaknesses of existing systems, including coverage, accuracy, reliability and cost effectiveness. This was undertaken as a preliminary step to the assessment of the need to carry out an intercomparison of lightning detection systems. A document providing the analysis of this survey was presented to the Joint Meeting.

4.1.9 The Joint Meeting recognized that this was an excellent document providing very valuable information that should be published as an IOM Report and thanked Mr Dahoui for his work. The Joint Meeting was pleased to note that HMEI representatives also welcomed this report that also provided them with valuable market information.

4.1.10 The Joint Meeting recognized that an intercomparison of lightning detection systems would be welcome, but noted that it would be a very complex project that would first require defining how to compare systems that have so different capabilities and that do not measure exactly the same thing. The Joint Meeting recognized that it would be timely to embark on such an intercomparison and recommended that WMO Members that have carried out intercomparison publish their results. It was noted that some NMHSs may not, for legal reasons, even be allowed to publish such results as the lightning data is frequently obtained from commercial providers. The Joint Meeting also encouraged Members to exchange lightning data on the GTS to allow interested entities to intercompare them as they want. The Joint Meeting recognized that there was a need to provide guidance to Members on methods to evaluate the performances and intercompare lightning detection systems.

4.1.11 One of the reasons for the non-use of the lightning data is the misconception of its necessity while some other systems, e.g. weather radars, satellites, are available and sufficient to provide the required products and services for the users. It must be shown to WMO Members that each system contributes, but does not substitute, to other observing systems by filling identified gaps and compensating for weaknesses. The Joint Meeting also noted that these systems help add value to other observations by generating composite products from integrated networks that meet the end user requirements more effectively. For example, it should be demonstrated how the integration of weather radar data, lightning data and satellite data can improve the observing and forecasting capabilities of meteorological services.

Chapter of the CIMO Guide on lightning detection systems

4.1.12 A document presenting a fully revised version of the CIMO Guide Part II, Chapter 7 on “Locating the source of lightning events” that was developed by Prof. H.-D. Betz was submitted to the Joint Meeting for review. The Joint Meeting was very pleased with the new chapter and recognized the high quality of the document, which provides a valuable major revision of the chapter. HMEI representatives also appreciated this contribution. The Joint Meeting expressed its thanks to Mr Betz for carrying out this important work.

4.1.13 Some of the participants in the Joint Meeting expressed the desire to consult their colleagues specialized in lightning detection systems to provide support in the review/approval of this chapter. The Joint Meeting requested the participants in the Joint Meeting to carry out consultations within their services and to provide their feedback (comments/requests for changes) to the ET-RSUATT Chair (Seth.I.Gutman@noaa.gov) with copy to the WMO Secretariat (iruedi@wmo.int) by the end of the year. Those comments should be provided in track change mode. Any request for insertion of new material should be accompanied with a quotation of the evidence. The Secretariat was requested to transmit those comments to Prof. Betz and to request him to provide an updated version of the chapter that would be submitted to the next session of

CIMO for final approval, following the official procedures. The chair of the CIMO ET-RSUATT was requested by the Joint Meeting to arbitrate any divergence of opinion that may appear.

Laser ceilometers

4.1.14 The former chair of the CIMO ET-RSUATT, Mr Dirk Engelbart, lead the development of ISO standard on LIDARs. The team that produced this document encompasses experts from NMHSs as well as from the industry. It should be noted that the development of this standard was a task of the ET-RSUATT workplan (see Annex IV) and that large contributions of the work were provided by CIMO experts. This document is presently under voting in the committee stage of the ISO standard development process.

4.1.15 The Joint Meeting reviewed the document and recognized that it was an excellent and thorough document though some small adjustments were still needed. It represents a clear output of CIMO ET-RSUATT providing clear guidelines to Members. This standard is very demanding for the manufacturers that would want to develop LIDARs according to the standard, but is not so demanding for the users of the systems.

4.1.16 The participants in the Joint Meeting were requested to provide any request for modifications of the draft standard to Mr Calpini by 15 December 2009 at the latest and that he would transmit a comprehensive review of the document directly to the authors according to their request.

4.1.17 In 2008, WMO signed working arrangements with ISO that allow the development of common ISO/WMO standards. At the time when this work was initiated, WMO did not have such working relationship with ISO, which explains why this document was officially developed under an ISO committee with large contributions from WMO experts. The Joint Meeting was of the opinion, that the contribution of the former chairman and of the WMO experts needed to be recognized and recommended that this document be further finalized as a common ISO/WMO standard. The Joint Meeting requested the WMO Secretariat to approach ISO and follow-up on this proposal.

Micro-wave radiometry

4.1.18 Mr Koldaev presented the current status of and perspective for microwave remote-sensing that can be summarized as follows:

Current status of microwave remote sensing

- ***Space born instruments:*** There are a few satellites with the ability of multi spectral microwave remote sensing. These satellites provide regular as well as R&D data for common use. Among the parameters delivered by recent space born systems are: temperature profile of atmosphere, water vapour path, liquid water path, rain precipitation estimate, wind over the sea surface, and sea ice indication.
- ***Ground based instruments:*** There are just three companies world wide (from Germany, Russia and USA), providing serial production of ground based microwave radiometers. Some instruments are corresponding to the needs of unmanned automatic operations and are consequently used on the serial base. Others are used mostly for supporting data quality control at GPS sites. Microwave temperature profilers are operationally used in Russia Hydro Meteorological Service for the local NWP of pollutions accumulation and for supporting boundary layer radiosonde soundings (at about 20 sites). They are used world wide mostly by local Environment Protection Agencies (about 20 sites). Most microwave radiometers are used in R&D purposes.
- ***Aircraft born instruments:*** There are a few research aircrafts (NOAA, NASA, MSC, Roshydromet) equipped with microwave radiometers that are used for R&D purposes only.

Perspectives for microwave remote sensing

- ***Space born instruments:*** All items proposed in the Vision 2025 of the GOS are supported. In addition to that, it is proposed to pay special attention to combining of the space platforms carrying active precipitation radars with microwave radiometers for measurement of super cooled water into the precipitable clouds. It could be very useful to utilize the International Space Station as a platform for microwave remote sensing of clouds and precipitation in the tropical regions because of its orbit parameters and ability to provide service for the instruments in case of unexpected situations.

- ***Ground based instruments:*** the Implementation Plan for the GOS needs to be corrected in item G22 with the aim of definite explanation of the utilization of different remote sensing instruments. As referring to ground based microwave remote sensing, the most pragmatic utilization of it is in combining of radiosonde sounding with microwave measurement of temperature profile, humidity profile, Liquid Water Path, and Water Vapour Path. (Combining with radar wind profiling will be of great appreciation also). To utilise microwave radiometers for routine measurements at radiosonde sites, it is necessary to provide such an instruments with all weather unmanned operation with fully automated self calibration procedure and on-line data transmission to the centres collecting aerological data.
- ***Aircraft born instruments:*** It is proposed to start development of module type microwave systems, with unmanned full automatic operation abilities. After testing of this system on R&D stage, it can be recommended to start negotiations with ICAO about installation of such equipment on board of aircraft executing regular flights.

4.1.19 Though some meteorological services are in the process of setting up MWR networks, the Joint Meeting noted that microwave radiometers are not readily used in an operational mode. Only the measurement of temperature with microwave radiometers can be considered as operational at present. The Joint Meeting recommended that CIMO develop guidance material on the operational use of passive micro-wave profiling.

GNSS Water Vapor

4.1.20 The Joint Meeting was presented with a draft document describing the theory of estimating integrated (total atmospheric column) water vapour from Global Navigation Satellite System signal delays and retrieving geophysical parameters such as integrated (total atmospheric column) precipitable water vapour from them. The document provides suggestions for data exchange protocols for the ground-based GNSS observations themselves, and quantities estimated or derived from them, such as tropospheric signal delay and integrated (total atmospheric column) water vapour. Finally, it provides guidelines for the operational use of these data and products in numerical weather prediction and nowcasting derived from the experience of the E_GVAP programme within EUMETNET.

4.1.21 The author of the working document 4.1(6) presented to the meeting stresses that the guidelines presented in this document reflect the current understanding of the processes and/or protocols used to make GNSS water vapour measurements, and should be reviewed and revised as our understandings of these factors improve.

4.1.22 The Joint Meeting recognized that this document was an excellent draft that should be further developed. To that effect, the participants in the Joint Meeting were requested to provide detailed proposals for change and improvement of the document to Mr Gutman by 15 December 2009, which he would transmit to the author of the document for his further work.

4.1.23 The Joint Meeting supported the proposal that raw and processed GNSS data should ideally be exchanged. However, there are proprietary issues with GNSS raw data as these systems are generally not owned by NMHSs. An overview of the current contractual situation would be necessary. In many cases the geodetic community is owner of the data and there exist contracts with the Met Services on the use of the data. An overview of the different arrangements would be helpful to recommend steps for an unrestricted data exchange.

4.2 **Asses the status/plans of implementation for other surface based remote sensing systems by WMO Members in relation to meeting user requirements for all application areas and provide updates to the WMO CEOS of observations systems capabilities database as necessary**

4.2.1 No report provided.

5. REVIEW THE IMPLEMENTATION PLAN FOR THE EVOLUTION OF THE GOS

5.1 Implementation Plan for the Evolution of the Global Observing System (EGOS-IP)

5.1.1 This Vision of the Global Observing System (GOS) in 2025 provides high-level goals to guide the evolution of the Global Observing System in the coming decades. The future GOS will build upon existing sub-systems, both surface- and space-based, and capitalize on existing, new and emerging observing technologies not presently incorporated or fully exploited. Incremental additions to the GOS will be reflected in better data, products and services from the National Meteorological and Hydrological Services (NMHSs); this will be particularly true for developing countries and LDCs.

5.1.2 The general trend and issues for the GOS include the response to user needs and requirements. The GOS will become part of the WMO Integrated Global Observing System (WIGOS), which will integrate current GOS functionalities, which are intended primarily to support operational weather forecasting, with those of other applications: climate monitoring, oceanography, atmospheric composition, hydrology, and weather and climate research.

5.1.3 The remote-sensing observing systems components of the GOS include:

- **Weather radar** systems will provide enhanced precipitation products but with increased data coverage. They will increasingly provide information on other atmospheric variables. There will be much improved data consistency and new radar technology. Collaborative multi-national networks will deliver composite products;
- **Coastal HF Radars** will provide for ocean currents and wave data;
- **Profilers** will be developed and used by more applications. A wider variety of technologies will be used, including lidars, radars and microwave radiometers. These observing systems will be developed into coherent networks and integrated with other surface networks;
- **Global Navigation Satellite System** (e.g., GPS, GLONASS and GALILEO) receiver networks, for observing total column water vapour, will be made operational and extended;
- **Lightning detection systems**

5.1.4 The Joint Meeting was informed that the current EGOS-IP is drawing to close and that the next iteration of the EGOS-IP will be extended from 2015 to 2025. The Joint Meeting was also informed that it was expected that this new version will developed over the next two to three years. The Joint Meeting was also requested to review the current version of the EGOS-IP in relation to the surface based remote sensing component of the GOS. All comments and recommendations made by the Joint Meeting on the IP will be made available to the next meeting of the ET-EGOS for their consideration. (For the latest version of the EGOS-IP see http://www.wmo.int/pages/prog/www/OSY/WorkingStructure/index.html).

5.1.5 The Joint Meeting made the following comments to the current version of the EGOS-IP:

- GOS/GN7: Recommendation/Action:

New processing techniques are emerging to process radar data to produce accurate precipitation estimates from ground based weather radar. Inter-comparison of these techniques is required to quantify the errors, to document the algorithms and assumptions and to identify their applicability and benefit on a global basis for the benefit of WMO member. The action is to conduct a series of workshops to inter-compare and document the techniques for the benefit of WMO members.

- GOS/GN7: Recommendation/Action:

In order to use precipitation estimates from radars (or satellite) or radar networks, the quality of the data is required for radar data merging purposes, use in hydrological and data assimilation applications. A task force is needed to conceptualize the overall vision and propose pragmatic approaches for implementation since this is urgently needed.

- GOS/G5: Recommendation/Action:

Stratospheric observations - Stratospheric measurements are especially important for the climate change community and must include measurements of meteorological as well as trace gases parameters. Requirements for a stratospheric, global observing system should be refined. Document the respective needs for radiosondes, radiances, wind data, humidity data, trace gases noting the availability and required density of existing data sources, including GPS sounders, MODIS winds and other satellite data.

- Considerations for evolution of the GOS in developing countries:

Under Paragraph 4.6: Some members have resources to support the rehabilitation and sustainability of some stations in critical locations. However there is little understanding of the priorities and it is recommended that RAs are asked to provide a prioritized list of stations to be rehabilitated. Once this priority list exists action can be taken to improve the GOS but without the list little progress to improve the network may be possible.

5.2 UK’s Response to the Implementation Plan for the Evolution of the GOS

5.2.1 The current Implementation Plan for the Evolution of the GOS (EGOS-IP) consists of a number of action areas. The ET-EGOS routinely requests the status of activities in Members to address the EGOS-IP. In addition to responding to each action point within the EGOS-IP, the UK Met Office also uses the reply as an opportunity to request clarification on some EGOS-IP action areas or to offer advice or proposals for support in the implementation of some actions. Whilst the UK Met Office’s response to the requests for updates is collated into the summary report presented to the ET-EGOS it is also felt the response could be used as a mechanism to open up informal dialogue between members on some of the issues raised in the EGOS-IP. Many of the mechanisms available to members to discuss issues are very formal but the responses to the EGOS-IP could be circulated more widely to encourage debate to discussion between members outside the RAs and Technical Commission’s structures.

5.2.2 The Joint Meeting noted that there is requirement to examine good examples of where composite networks have been developed. The Joint Meeting discussed how NMHSs could respond to changing user requirements when designing meteorological observing networks. The Joint Meeting noted that there are several NMHSs that have used the current version of EGOS-IP to assist with defending their funding streams that support observing networks that not only meets needs of users as specified in the EGOS-IP but also their international responsibilities.

6. DEVELOP GUIDANCE AND METHODOLOGY FOR SURFACED BASED REMOTE SENSOR MONITORING

Brazil

6.1 The Brazilian National Institute of Meteorology (INMET) is the official responsible for surface weather forecasting in Brazil and the Permanent Representative of Brazil with WMO. INMET has been operating two surface based observation network:

- Surface weather station;
- Upper-air weather station.

6.2 Since 2000, the INMET has started a programme of replacement of surface weather stations, from more conventional to automated surface weather stations. Actually, the INMET has about 300 conventional weather station and around 450 automatic weather station (November 2009). For the upper-air observations, the Brazil has approximately 40 stations. The upper-air network is operated by: INMET, Brazilian Air Force and Brazilian Navy.

6.3 The weather radar network in Brazil is not integrated yet because there are many different institutions operating different radar bands with different equipment designs. Currently, Brazil has: 22 weather radar in operation; 2 under installation; 4 in planning stages; 15 under discussion.

6.4 Brazil has an Integrated National Network of Lightning Detection (Rindat), but only a portion of Brazil (Central Southern region) has sensors to lightning detection. This data is available in: http://www.rindat.com.br/.

6.5 Brazil at present does not have an operational network of wind profilers nor LIDARs. Instruments of this type have been used in specific field experiments for research purposes (e.g. LBA Experiment in Amazonia).

China

6.6 Recently 146 weather radars (S band and C band Doppler radars) have been built and used in operational severe weather watching and nowcasting. Additional 58 weather radars are being developed in China. C band and X band mobile polarization radars are used in field experiment and weather modification. The cloud radar and phase array radar are also developed in China.

6.7 The fuzzy logical based algorithm is used to detect the anomalous propagation ground clutter and radio interference. The regional 3-D mosaic of reflectivity was developed and used in operation. The wind retrieval with single Doppler radar (3DVAR) and dual Doppler radar were tested with weather case and linked to mosaic system to provided wind file to forecaster. Radar Operational Software Extension (ROSE) and Severe Weather Warning and Analysis system (SWAN) will be used in operational watching and warning severe weather.

6.8 The Joint Meeting was informed that currently the China Meteorological Administration (CMA) does not intend to migrate their X-Band radars into an operational mode. The Joint Meeting was also informed that within China there are currently a number of additional radars other than those operated by CMA, approximately 50, covering major airports within China. The Joint Meeting also noted that there is a requirement for this group to examine the use and implementation of Cloud Radars as part its work plan.

Japan

6.9 The overview of the observation systems in the Japan Meteorological Agency (JMA), are as follows:

- Weather radar observation
- Wind profiler observation
- Lightning detection
- Lidar observation
- GPS observation

6.10 Observations are carried out with surface based remote sensors. Two observations: radar observation and GPS precipitable water monitoring, were presented during the Joint Meeting.

6.11 There are two radar observation networks: general weather radar network and Doppler radar for airport weather (DRAW). The general weather radar network consists of 20 radars: 12 Doppler radar and 8 conventional radars. The DRAW consists of 9 Doppler radars. The JMA operates 29 radars in total. The characteristics of general weather radar: frequency, wavelength, peak power, pulse width, antenna diameter, beam width, observation range, observation interval, distance resolution, were shown.

6.12 Radar data from 20 radar sites are sent to the center system at the JMA headquarters and to backup system at Osaka district meteorological observatory. In the center system, remote control of 20 radars and data processing are performed. Three dimensional radar observations are carried out to get data with horizontal resolution of 1km x 1km, vertical resolution of 1km, and time resolution of 10 minutes and 5 minutes for 2-km level intensity. From the radar data, composite radar echo intensity and radar echo indexes are produced for monitoring heavy rainfall. And also mesocyclone detection carried out with Doppler radar for tornado watch. The Joint Meeting was informed of the positive impact of Doppler velocity on numerical weather prediction.

6.13 The purposes of DRAW are as follows:

- Monitoring the precipitation and air currents in areas surrounding airports and flight routes;

- Automatic detection of precipitation distribution and low level wind shears from the obtained data; and

- Providing the results to the airport weather service and air traffic control. From the functional requirements, radar specification are determined as follows: azimuth resolution of 0.64˚ (Antenna Diameter 7.1m), range resolution of 150m, elevation angles from 0.7deg to 45.9 deg, and observation range of 120km. Two observation modes: aerial mode (normal condition) and airport mode (adverse weather condition) were explained. And also wind accuracy and performance for shear line and microburst detection were shown.

6.14 GPS precipitable water monitoring are carried out with the GEONET (GPS Earth Observation NETwork) operated by the Geophysical Survey Institute. Data flow and accuracy of GPS PW data were presented, and the positive impact on numerical prediction and monitoring with GPS PW data for heavy rain case were demonstrated.

6.15 The Joint Meeting noted that JMA currently has plans in place to develop an integrated observation monitoring system and is planning on designing an improvement to the QC of radar and profiler data and other observation systems. The Joint Meeting was also informed that within Japan there are other radar systems in operation, including 26 radars in the Ministry of Land, Infrastructure, Transport and Tourism and several from the Power Generation Industry; currently JMA does not have access to the data from the Power Generation Industry radars.

Switzerland

6.16 An operational upper-air network designed to take into account both the geographical scale and complex topography of Switzerland was recently made operational in close connection with a high resolution NWP model. This project was dealing with the meteorological surveillance of the Swiss nuclear power plants. The three sites are equipped with a wind profiler and a microwave radiometer to get profiles of wind, temperature and water vapor. These profiles are used for assimilation (wind) and for model verification and comparison (temperature and water vapor). Various QC/QA steps are automatically performed and independent statistics allow a quasi real-time check of the performances and quality of the network.

6.17 The Joint Meeting was informed that most of the profilers operate mainly in the northern hemisphere, with Japan, USA and Europe with the majority of stations. The Joint Meeting noted that within Switzerland there were problems with monitoring the performance of the profilers against NWP as it was demonstrated that some profiler and radiosonde data exhibited significant biases compared to NWP.

6.18 The Joint Meeting agreed that the question of vertical resolution requirements need to be address. The Joint Meeting noted that there has been significant discussion within the European Windprof Project regarding the type of vertical resolution mode to send to users one mode. This Windprof project is currently sending two modes of vertical resolution to users which will likely be combined to a single mode for to all users. This single mode will be at a higher resolution in low levels and more course resolution at the higher levels.

6.19 The Joint Meeting was also informed that currently within Switzerland the maximum heights achieved for wind profilers was around 8km with an average around 4-5 km in more than 50% cases and minimum heights approximately 100m. It was noted that for certain application areas, such as aeronautical meteorology this would not be suitable as the temporal resolution would not be sufficient to derive appropriate wind shear information.

6.20 The Joint Meeting agreed that integrated water vapour measurements from radiometers are comparable to that of GPS water vapour measurement. The Joint Meeting also discussed the requirements for the calibration of radiometers, typically microwave-interferometers and radiometers are generally calibrated a few times a year and at the end of campaigns. The Joint Meeting noted that there is a requirement to develop common methodology for the calibration of radiometers against other observation systems.

Turkey

6.21 The Turkish State Meteorological Service (TSMS), as the authorized governmental establishment for all meteorological related works in Turkey since 1937, has been operating three surface-based observation networks to be able to perform its tasks for providing the meteorological services and products required by the domestic and international users. These are surface observation network of almost 600 Automated Weather Observing Systems, weather radar network of 4 C-Band Doppler Radars and upper-air observation network of 8 GPS based radiosonde stations. The networks have been designed to be centrally monitored, operated and maintained remotely from the centre by means of several communication options such as satellite, radio-link, terrestrial lines, ADSL and GPRS. TSMS has been executing the projects for expanding the existing networks by adding new systems and improving the capabilities for observing and forecasting the weather. Furthermore, TSMS is open for the regional and international cooperation with WMO members.

6.22 The Joint Meeting was briefed on the efficiencies achieved to the Turkish observing systems when the Turkish State Meteorological Service moved to a more centrally managed maintenance centre. It was also noted that as a consequence of the more centralized systems in place the Turkish State Meteorological Service will be operating over 200 unmanned stations in Turkey by the end of 2011.

United Kingdom

6.23 In addition to the conventional surface based remote sensing observing networks monitoring practices described by other Members of both expert teams, the UK presentation focused on the engagement of staff in the monitoring practices for SBRSO Networks. Firstly the clear identification of a Network Manager for each type of SBRSO Network was felt to be important as this person would act as the focal point for the day to day management of the system and delivery of data users in the application areas. In addition this person would drive continuous improvement of the system through the identification of system weaknesses and recommendations for system improvements. Whilst not responsible for the technical developments themselves these network managers have a direct interest in ensuring the developments are introduced into operations as this will improve the quality, or reliability, of the operational systems.

6.24 In addition the importance of receiving feedback on the performance of the operational observing systems was highlighted. Forecasters are routinely using the outputs from SBRSO Networks and are in a strong position to determine if the outputs from the SBRS systems are working correctly. However it is important to provide feedback to forecasters on their feedback to ensure a positive dialogue is maintained with an important user community. The use of operational SBRSO systems in research experiments is also important as this may expose deep lying and sometimes complex issues with operational systems. Therefore engagement with the research community is always welcomed.

6.25 The Joint Meeting was informed that the use of microwave radiometers in the UK Met Office is currently used in a purely R&D mode and at present there are no plans in place to migrate this system to operational.

USA

6.26 The WSR-88D network consists of 159 S-band Doppler radars which are monitored by the local weather forecast office and also by the Radar Operations Center (ROC) in Norman, Oklahoma. The ROC monitors the status of the field radars at least once per hour to ensure the radar is operating and transmitting data. The ROC also monitors the radar products to check for data quality issues. The ROC provides radar maintenance and troubleshooting assistance to the field sites via a Hotline facility which is operated 24 hours per day.

6.27 The data from the field radars is transmitted to Advanced Weather Integrated Processing Systems (AWIPS) at the local forecast offices, and is then transmitted over NOAANet for further distribution and archiving at the National Climatic Data Center (NCDC) in Asheville, North Carolina. Data from the 45 FAA C-band Terminal Doppler Weather Radars (TDWR) is also ingested by AWIPS processors and archived at NCDC. In addition to monitoring the operational status of the WSR-88D and TDWR radars, the ROC monitors the status of the communications networks which carry the data to operational users and distribution centers.

6.28 The network of approximately 950 automated surface observing systems (ASOS) is monitored by the local forecast offices and by the ASOS Operations and Monitoring Center (AOMC) in Silver Spring, Maryland. The AOMC performs automated processing of all ASOS observations and hourly reports, which are transmitted over FAA and NWS data networks. The AOMC inspects the hourly reports for special symbols generated by the ASOS stations which indicate that maintenance is required, checks for missing measurements, and monitors the values reported by the various sensors for reasonableness.

6.29 The current network of 35 wind profiler radars is monitored by the Profiler Control Center (PCC) in Boulder, Colorado. Data is transmitted over leased lines and the Geostationary Orbiting Earth Satellite (GOES) communications system. Profilers send data to the PCC at six minute intervals where it is checked for data quality and forwarded for distribution and archiving. The PCC monitors the network for system failures, and coordinates remedial maintenance with NWS technicians. NWS plans to upgrade the profiler network. The hardware and signal processors will be modernized, and the data will be distributed over NOAANet to end users and NCDC. After modernization the profilers will be monitored and maintained by the local weather forecast offices, and will also be monitored and supported by the ROC.

6.30 The Joint Meeting noted that the quality of the radar dome is an important aspect to the ongoing radar operations and quality of radar products. It was also noted that as part of a maintenance schedule there are number of factors that require constant attention including the impacts of ultraviolet radiation and the degradation of the hydrophobic coatings used on the radar dome.

7. WORK PLAN

7.1 The Joint Meeting discussed the current revisions of the work plan for both the Expert Teams. The Joint Meeting agreed that the actions linked to tasks within the work plans should be less general and cover more specific objectives and outcomes. The Joint Meeting agreed on the work plans as provided in Annex IV.

7.2 The Joint Meeting recognized that the CBS ET-SBRSO is a newly formed team. In the past, there was no CBS team addressing specifically surface-based remote-sensing systems. On the other hand the CIMO team had been established earlier and was covering some work items that would actually now fall under the mandate of the CBS team. The Joint Meeting agreed that in the future the work items that relate to network issue would be covered by CBS ET-SBRSO, while those that cover instrument capabilities and characteristics would be covered by the CIMO ET-RSUATT. However, the Joint Meeting agreed that it had been very beneficial to have a Joint Meeting of the two teams and recommended that in the future both team should again meet in Joint Meetings, as far as possible. Also, experts nominated in one of the team could contribute to the work items of the other team to make best use of each others capabilities.

8. OTHER BUSINESS

Radiosonde intercomparison in China

8.1 The Joint Meeting was informed about the plan of CIMO to carry out a high-quality radiosonde intercomparison in Yangjiang, China in July 2010. A Meeting of the Expert Team on Upper-Air Systems Intercomparisons (ET-UASI) and International Organizing Committee on Upper-Air Systems Intercomparisons was held in Yangjiang, Guangdong Province from August 30 to September 5, 2009. It decided that the 8th intercomparison of high quality radiosonde systems would be held in Yangjiang, China, from July 12 to 31, 2010.

8.2 For sake of validating and checking up each other, it is planned to deploy different observing systems during next year's intercomparison, by use of many different equipments and instruments, such as: cloud radar, Lidars, boundary layer wind profiler, etc.. Following the requirement of ET-UASI, China Meteorological Administration conducted research on the remote-sensing equipments that China can offer to participate in the 8th International Upper-air Sounding Equipments Comparison. CMA is planning to provide six parts of observation equipments and they are as follow:

- Part I: Cloud-detection Radar
- Part II: Ceilometers
- Part III: Lidars
- Part IV: Doppler Weather Radar
- Part V: Mobile Boundary Layer Wind Profiler Radar
- Part VI: All-sky imager

8.3 By observing simultaneously with the six different equipments, it is hoped to obtain a variety of the property parameters, such as: cloud base height, multiple stratus structures, wind direction and speed (wind shear), vertical integrate liquid (VIL) in rain and water vapour phase etc.

8.4 It was recalled that the expert that had been nominated to manage the remote sensing instruments during the Radiosonde Comparison, Mr Dirk Engelbart had resigned. Therefore, the project team that met in September 2009 to plan the intercomparison requested the joint CBS-CIMO meeting to develop a small task team to take on this responsibility and to work with the experts from China. The Joint Meeting was also requested to see whether they could identify suitable systems which could be available and shipped to China for the test.

8.5 Mr LI Bai requested the members of the Joint Meeting to provide guidance on the observation (scan) models that should preferably be used with the different equipments.

8.6 Participants in the Joint Meeting that will send representatives to the intercomparison campaign recognized that, in spite of their interest for the measurement set that could be obtained from a variety of remote-sensing systems, providing support to and/or supplying additional remote-sensing instruments was beyond their capabilities.

8.7 The Joint Meeting agreed on the following recommendations regarding the use of remote-sensing instruments in the radiosonde intercomparison campaign:

- to provide vertical scanning of the cloud radar is key to understand the performance of the radiosondes
- the use of a GPS antenna would be mandatory

- the project team should aim at scheduling flights at the time of overpasses of CLOUDSAT/CALYPSO (A-train)
- the use of a Chinese research aircraft with capability to measure temperature, pressure, humidity and drop size imaging capabilities should be considered
- to use of MWR for integral water vapour and integral liquid could be appropriate as liquid water cannot be seen by the radars that were presented
- the work needed to evaluate the remote-sensing data should not be underestimated
- ground-based remote sensing systems should be set up mainly to help radiosonde systems.

8.8 The Joint Meeting asked the HMEI representative and other NMHSs to consider bringing remote-sensing instruments to the campaign and Mr Koldaev to investigate whether the Russian Federation would be interested in participating in the campaign with a MWR. It was noted that any decision to that effect would need to be taken in a near future to ensure the completion of import formalities in due time and to deploy and test the systems sufficiently in advance of the intercomparison start.

8.9 The Joint Meeting considered the possibility to set-up a task team to manage the remote sensing instruments during the Radiosonde Comparison. The Joint Meeting regretted that it was not able to set-up a support task team for the intercomparison and recommended that the remote sensing instruments be used mainly to help in the analysis of the radiosonde systems rather than to assess the remote-sensing instruments.

8.10 The Joint Meeting recommended that CMA takes the responsibility for the management of the remote-sensing instruments provided by CMA and develop a database with their measurements that could be used for the analysis of the intercomparison and shared with people interested in analyzing this dataset together with the radiosonde measurements. The Joint Meeting welcomed the proposal of Mr LI Bai to be in charge of this.

9. CLOSURE OF THE MEETING

9.1 The session was closed on 27 November 2009 at 15h00.

ANNEX I

List of participants

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ANNEX II

WMO Guidance Statement on Weather Radar/Wind Turbine Siting

The WMO expresses concern over increasing deployment of wind turbine farms and stresses the need for adequate consultation, protection and mitigation efforts. The WMO addresses its concern to policy makers, to national radio administration agencies, to national hydrological and meteorological societies, to wind turbine farm developers, to commercial vendors of wind turbine equipment and to the meteorological community.

Protection of weather radar data is critical to the continued function and improvement of weather sensing, monitoring, forecasting, and warning, and is therefore in the best interests of public safety and security. Weather prediction models and localized operational forecasts increasingly depend on national networks of ground-based Doppler weather radars and wind profilers for severe weather warnings such as tornadoes, flash flooding, land-falling hurricanes, precipitation (rain, snow, hail) forecasts, aircraft icing and air traffic/weather avoidance. Worldwide, Doppler radar and wind profile networks are now contending with increasing pressures by wind farms.

Wind farms have already had an impact on operational weather radar networks, creating confounding ground echoes that create a significant loss of data or create false precipitation for hydrological applications. The rotating blades can create confound velocities which could potentially be mistaken to be severe weather such as a tornado. While, weather radars have been moved by the wind farm developers; generally, the meteorological community has no jurisdiction on the location of the wind farms and relies on cooperative “good neighbour” polices for mitigation.

Development of new radar and wind profiler networks and wind farms will require strategic planning for mitigation by the meteorological and wind farm communities. The WMO and the meteorological community rely on and support mandated international and national radio agencies and will pro-actively encourage and support these agencies' efforts to promote and to protect the meteorological use of unobstructed space. The WMO encourages national radio agencies to develop acceptable obstruction criteria and to provide tools to help the wind farm developer on site selection.

The range between wind turbines and the weather radar can be used to generally describe the impact on radar quality and also used to provide a mitigation strategy for co-operative siting of weather radars and wind turbines. Below are the general guidelines for typical radars, flat terrain situations and may require modifications for specific situations and for particular radars. Higher powered radars such as S Band (10 cm wavelength) radars with less attenuation may necessite increasing the range limits in the table.

Range	Potential Impact	Guideline
0-5 km	The wind turbine may completely or partially block the radar and can result in significant loss of data that can not be recovered.	Definite Impact Zone: Wind turbines should not be installed in this zone.
5-20 km	Multiple reflection and multi-path scattering can create false echoes and multiple elevations . Doppler velocity measurements may be compromised by rotating blades.	Moderate Impact Zone: Terrain effects will be a factor. Analysis and consultation is recommended. Re-orientation or re-siting of individual turbines may reduce or mitigate the impact.
20-45 km	Generally visible on the lowest elevation scan; ground-like echoes	Low Impact Zone: Notification is recommended.

	will be observed in reflectivity; Doppler velocities may be compromised by rotating blades.	
>45km	Generally not observed in the data but can be visible due to propagation conditions	Intermittent Impact Zone Notification is recommended.

The WMO encourages funding and implementation of studies to develop technologies to mitigate the impact. Weather radar signal processing techniques or use of other materials to construct wind turbines may be able to mitigate clutter at long ranges. Further, the WMO recommends the results of these studies be made available to commercial weather radar and wind turbine manufacturers.

It is in all nations' best interests to protect unobstructed space for weather radars and wind profilers that are essential and critical to the accurate forecasting of adverse weather. Local, national and technological solutions are sought. The WMO will support and provide guidance material and tools to protect unobstructed space for weather radars and wind profilers.

ANNEX III

DRAFT

WMO Guidance Statement on

Weather Radar/Radio-Frequency Shared Spectrum Use

(Adapted from AMS statement)

The WMO expresses concern over increasing pressure on weather radar-related radio frequency bands and stresses the need for adequate protection and mitigation efforts against the loss and shared use of this spectrum. The WMO addresses its concern to policy makers, to national radio-frequency administration agencies, to national hydrological and meteorological societies, to commercial vendors of telecommunication equipment and to the meteorological community.

Protection of traditional weather radar-related radio frequencies is critical to the continued function and improvement of weather sensing, monitoring, forecasting, and warning, and is therefore in the best interests of public safety and security. The meteorological community increasingly relies on remote-sensing technologies for both routine and experimental observations of weather and climate. These activities require global access to radio frequency spectrum by not only by radars but also wind profilers, microwave radiometers, and telemetry systems, as well as satellite-based passive and active sensors. The progress in weather warning services and other meteorological predictions made in recent years is largely attributable to these technologies.

Weather prediction models and localized operational forecasts increasingly depend on national networks of ground-based Doppler radars for severe weather warnings such as tornadoes, flash flooding, land-falling hurricanes, precipitation (rain, snow, hail) forecasts, aircraft icing and air traffic/weather avoidance. Worldwide, Doppler radar networks are now contending with increasing pressures on shared spectrum usage with unlicensed broadband wireless applications. As already experienced in Europe, the impacts of radio-frequency interference by wireless communications can render weather radars blind in particular directions or even over large portions of their coverage. The situation is exacerbated by the ubiquitous and unlicensed nature of these wireless applications that could lead to a total loss of the related spectrum for weather radars.

Development of new radar technologies, including adaptive scanning strategies, shorter pulses, polarization, pulse compression, frequency and phase agility is on-going. Current and planned satellite radar systems measure clouds and precipitation important for weather forecasting and global climate change research and assessment. Varieties of other space-based and ground-based radio technologies are currently in experimental use and may require future radio spectrum allocations.

New communications applications make the radio frequency spectrum an extremely valuable commodity, and so the frequency bands used for operational meteorology and research are in increasing jeopardy. The WMO and the meteorological community rely on and support mandated international and national radio-frequency agencies and co-operation with the telecommunication authorities and industries to continue to protect or to appropriately share these radio frequencies. The WMO will pro-actively encourage and support these agencies' efforts to protect meteorological uses of the radio frequency spectrum. The WMO encourages national radio-frequency agencies to develop a clear definition of interference, permissible or otherwise, and a remedial process or solution if shared use becomes a problem. The WMO encourages funding and implementation of studies to determine the impact of the total or partial loss of one or more frequency bands used by current operational observing systems and by planned systems. Further, the WMO recommends the results of these studies be made available to national radio-frequency agencies and the telecommunications industry to encourage dialogue between active and passive users of the spectrum. Vigilance is necessary, as degradations of meteorological data due to intrusions or shared usages will evolve over time. Cooperation with national radio-frequency agencies, the telecommunications industry, and with other spectrum users is encouraged both to advocate support for critically important meteorological use of radio spectrum and to mitigate potential problems.

It is in all nations' best interests to protect radio frequencies essential for meteorological activities that are critical to the accurate forecasting of adverse weather. Global solutions are sought and should be advocated. The WMO will participate in international frequency management activities, to encourage their involvement and development.

ANNEX IV

ET-SBRSO WORK PLAN

No.	Task	Deliverable/Activity	Due	Responsible	Status	Comment
1	To contribute to the development and implementation of concept of WIGOS and provide relevant advice and support to the chairperson of ICT-IOS.	Address relevant items of WIGOS Implementation Activities. Agreed by EC-WG/WIGOS-WIS-2. *Proposed activity:* *1 – Review WIGOS IP to extract ET SBRSO actions.* *2 – Establish WIGOS Implementation Task that facilitate improved exchange of data and products not directly owned by NMHSs (where restricted license agreements exist)* *Deliverable: Proposal to WIGOS IP*	2nd Quarter 2010	Stewart Goldstraw (Seth Gutman)		
2	Assess the new potential capabilities of SBRS observing systems, in terms of their operational implementation.	Review available studies and document provide CIMO with a view of advising Members of their operational implementation. *Proposed activity: Work closely with CIMO ET-RSUATT to ensure current developments in SBRSO systems is up to date and limitations of SBRSO systems in terms of measurement integration period and extent of observation are fully understood.* *Deliverables:* *Recommendations provided to CBS on operational implementation.*	2nd Quarter 2010	Russell Cook (Ercan Büyükbas)		
3	Assess the status of implementation of and plans for SBRS observing systems by WMO Members.	Review and document the status and plans of WMO Members. *Proposed activity: Request from members the*	2nd Quarter 2010	Amaury Caruzzo (Ercan		

No.	Task	Deliverable/Activity	Due	Responsible	Status	Comment
		status of implementation of operational Wind Profiler, GNSS IWV and Microwave Radiometer Networks. SBRSO Questionnaire to be created sent to Members and returns analyzed. Plus encourage late Weather Radar Questionnaire responses. *Deliverables:* *1. Report on the results of the questionnaire to be published as a CBS Technical Report* *2. Data available for upload into a Surface Based Remote Sensing Networks Database.*		Büyükbas & Stuart Goldstraw)		
4	Document the above capabilities and implementation status/plans, through updates to the WMO/ CEOS database of observing system capabilities.	Represent the information documented above in terms of appropriate updates and additional entries within the WMO/ CEOS database of observing system capabilities. *Proposed activity: Analyze results of Weather Radar -/ Lightning and SBRSO questionnaires relating to system accuracy, review conclusions of analysis by CIMO/CBS ET members and then upload results to WMO-CEOS Database for Observing System Capability.* *Develop procedures for the routine collection of information regarding the status of SBRSO systems.* *Deliverables:* *1. Updated WMO-CEOS Database for Observing System Capabilities.* *2. Procedures in place to collect annual status of operational SBRSO Systems.*	4th Quarter 2010	Hirofumi Mizushima		
5	In collaboration with ET-EGOS, assess the contribution of SBRS observing systems to meeting	Review the Statements of Guidance for accuracy and completeness in relation to SBRS observing systems, referring to user requirements as	3rd Quarter 2010	Dominique Ruffieux		

No.	Task	Deliverable/Activity	Due	Responsible	Status	Comment
	the user requirements for observations for all application areas represented by WMO and WMO-sponsored programmes.	captured by the WMO/ CEOS database as necessary. *Proposed activity: Review the 10 SoGs with respect to the '5' operational SBRSO Systems and report on the suitability of each of the SBRSO Systems for each Application Area.* *Deliverables: 10 Reports on the suitability of the 5 operational SBRSO System Technologies. To be updated within 5 months of the SoGs being updated*				
6	Make recommendations on how the integration of such observing systems within the GOS might be taken forward.	Review the Implementation Plan for the Evolution of the GOS and propose changes and additions for SBRS observing systems. *Proposed activity: Contribute to the development of the new EGOS-IP, providing feedback on the development of the draft.* *Deliverable: Feedback to ET-EGOS on the new version of the EGOS IP in time for IOS-ICT in June 2010.*	2nd Quarter 2010	Liu Liping		
7	Assess the systems for collection and distribution of data from SBRS observing systems, and make appropriate recommendations.	Review systems for collection and global distribution of SBRS observational data and make recommendations for their improvement in response to stated user requirements. *Proposed activity: Develop a proposal for the development of regional data centres for the collation, processing and exchange of Weather Radar Data (strongly aligned with WIS evolution)*	4th Quarter 2010	Volker Lehmann		

No.	Task	Deliverable/Activity	Due	Responsible	Status	Comment
		Deliverable: Proposal to be developed and endorsed by RAs in 2011/12 and recommendations for methods to enable Global Data Exchange for Weather Radar Networks to be presented to CBS in 2013				
8	Monitor the status of operational networks of SBRS observing systems and provide technical advice on such systems, including both operational and R&D systems, to WMO Members and RAs.	Report on the operational networks and on key developments in SBRS observing systems to ICT-IOS, drawing attention to actions required by CBS to promote the development of such systems within the WIGOS. Respond to requests for advice on SBRS observing systems from other CBS entities, as necessary *Proposed activity: As above.* *Deliverable: Chairman's report to annual ICT-IOS meeting*	1st Quarter 2010	Stuart Goldstraw		

ANNEX IV

WORK PLAN
Expert team B.3 "Remote Sensing Upper-Air Technology and Techniques (ET-RSUATT)" (2007-2010)

No.	Task description	Persons responsible	Action	Deadline for action	Deliverables	Deadline for deliverables
1	Review latest developments in the field of remote sensing technology and report to Members;	**S. Gutman** **(with contrib. from all experts)**	Preparation of a Report summarizing the current status and latest developments	Mar 2008	Report to ET session	Nov. 2009
2	Review current Wind Profiler Net-work operational activities, identifying strengths, weaknesses and operational costs. Identify best practices including siting and calibration and quality control, noting the need for close collaboration with users, such as the data assimilation community. Provide improved guidance material for the members;	**K. Akaeda / S. de Haan** **(supp. by O. Sireci)**	Preparation of guidance material with particular reference to the Final Report of the EUMETNET programme WINPROF-II (T. Oakley – ET UASI), Japan and USA	Nov 2008	Updated technical note (Report)	March 2010
3	Work with ET-UASI to design and conduct an intercomparison to evaluate Profiler wind quality;	**V. Lehman (D. Engelbart, T. Oakley)**	LUAMI-2008 campaign at Lindenberg Observatory for development / testing of profiler quality and QC procedures plus Raman lidar experience	Sep 2009	IOM-Report on the capabilities of Raman lidar and its suitability for operational application	Mid 2010
4	Monitor implementation of Micro-wave Radiometers as operational systems and report on progress, specifically quality of temperature measurements in the planetary boundary layer;	**A. Koldaev / K. Akaeda**	Workshop on microwave profiling in COST-ES0702 (EG-CLIMET)	May 2009	Report on suitability and operational aspects for MW radiometry Draft guidance material on use of MWR (emphasis on PBL performance)	Nov. 2009 March 2010

5	Monitor implementation of GPS Water Vapour Networks as operational systems and report on progress. Evaluate quality of data in suitable intercomparison including radiosonde and microwave radiometer. Develop operational guidelines and recommend suitable operational data exchange protocols;	**S. de Haan** **(K. Akaeda / Bai Li)**	Evaluation of GPS WV network performance	May 2009	Report	Mar. 2010
6	Evaluate and report on the potential of the Raman water vapour lidar as an operational upper-air observing system for the troposphere;	**D. Engelbart**	Preparation and realization of the LUAMI-2008 campaign	Sep 2009		
7	Facilitate activities associated with improving the quality of weather radar operations, including signal and data processing, by initiating a series of intercomparison workshops exercising radar algorithms on common data sets;	**P. Joe** **M. Kitchen** **K. Akaeda**	Preparation and realization of workshops on the use of weather radar and related signal-processing algorithms	Dec 2007	Summary and syllable of the workshops Plan for first workshop	Nov. 2009 Mid 2010
8	Establish comprehensive database of the global use of weather radar; (To be followed up by CBS-ET)	**O. Sireci /** **P. Joe**	Preparation of the web-based data base	May 2009	Results of Q for DB Data base on the global use of weather radar	Nov. 2009 Mid 2010
9	Provide guidance on weather radar siting and operation with respect to wind turbines and sources of radiofrequency interference;	**P. Joe /** **M. Kitchen /** **O. Sireci**	Evaluation of special investigations and experiences with respect to radiofrequency interference / Preparation of guidance material	May 2009	Report on recommendations for weather radar siting and operation	Nov. 2009
10	Review current weather radar network data exchange methods and make recommendations on the preferred method to be adopted by WMO for international exchange, noting OPERA's BUFR implementation and its limitations;	**M. Kitchen /** **S. Gutman /** **Paul Joe /** **K. Akaeda /** **Bai Li /** **Seung-Sook Shin**	Review of experience from regional weather radar networks with respect to data exchange	Sep 2008	Draft proposal Summary of recommendations	Nov. 2009 Mar. 2010

12	Review current operational lightning detection networks, and report on strengths and weak-nesses, including coverage, accuracy, reliability and cost effectiveness. Undertake Moroccan intercomparison of existing systems and make recommendations for enlargement of the networks to poorly covered areas, such as Africa;	**M. Dahoui** **(Successor of M. Dahoui)**	Preparation and realization of intercomparisons of existing lightning detection networks	Sep 2008	Report on a review of current operational networks	Nov. 2009 To be considered in the next period
13	Working with ET-UASI to initiate a series of pilot projects and testbed studies to establish the principles for the optimal mix of sensing systems to improve both temporal and spatial capabilities for future operational upper air networks, noting the need for close collaboration with users, specifically the data assimilation and NWP communities;	**S. Gutman /** **Bai Li / Seung-Sook Shin** **A. Koldaev**	Realization of pilot projects and testbed studies (e.g. LUAMI-2008) in collaboration with ET-UASI (T. Oakley) Realization of pilot projects in polar regions (A. Koldaev)	Aug 2009 June 2009	Summary of results from the projects and testbed studies Description of the implemented system and summary of results	To be considered in the next period May 2010
14	Review and update existing training material and support OPAG-CB in the production of suitable training workshops, reference material and guidelines for all operational aspects of remote-sensing systems.	**O. Sireci**	Workshops and training courses in collaboration with OPAG-CB	Dec 2007	Syllabus and updated training material	Dec. 2008
15	ISO – Preparation Ceilometer	**D. Engelbart**	Preparation of an ISO guideline on Laser ceilometers	Apr 2009	Guideline for using ceilometers (visibility lidar)	Dec. 2009