

WORLD METEOROLOGICAL ORGANIZATION

COMMISSION FOR INSTRUMENTS AND METHODS OF OBSERVATION

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

First Session

Geneva, Switzerland

14-17 March 2005

FINAL REPORT



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EXECUTIVE SUMMARY

This report provides a summary of the first session of the CIMO Expert Team on Remote Sensing Upper-Air Technology and Techniques, ET- RSUT&T. The ET, in response to the need for greater collaboration, both from within and outside of the WMO, requested participation by stakeholders in instruments and techniques. Participation included representatives from the Hydro-meteorological Equipment Industry (HMEI) Association.

The ET was tasked by CIMO to review the ground-based remote sensing technologies and techniques used in upper-air monitoring, their accuracies and potential for future integration. Details contained in the document present information on member approaches used to calibrate and validate instrument performance. In addition, information relating to various approaches to the integration of complementary instruments is provided by the various meteorological services participating in the ET meeting.

GENERAL SUMMARY

1. ORGANIZATION OF THE SESSION

1.1 Opening of the session

1.1 The first session of the Expert Team on Remote Sensing Upper-Air Technology and Techniques (ET-RSUT&T) was held in Geneva, Switzerland, 14-17 March 2005. Dr Alexei Ivanov, the Chairperson of the ET- RSUT&T, opened the session. The list of participants is given in [Annex I](#).

2.1 Following the opening of the session, Mr S. Chacowry, Director of Cabinet of External Relations, welcomed the participants to Geneva. In his opening statement, he pointed out some of the most important issues relevant to the agenda of the meeting and wished participating experts a productive meeting and an enjoyable stay in Geneva.

3.1 Dr John Nash, vice-president of CIMO and Mr Rainer Dombrowsky, the co-chairman of OPAG Upper-Air also welcomed participants and wished everyone a fruitful and productive meeting.

1.2 Adoption of the agenda

1.2.1 The ET adopted the [Agenda](#) for the meeting, which is reproduced at the beginning of this report.

1.3 Working arrangements for the session

1.3.1 It was agreed that Dr Ivanov would be assisted by Mr Dombrowsky in chairing the meeting. They will alter in the chairmanship on a daily basis.

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

2. REPORT OF THE CHAIRMAN

2.1 Dr Ivanov presented his report on the activities of the Expert Team (ET) on Remote Sensing Upper-Air Technology and Techniques (RSUAT&T) since its establishment. He referred to the decisions of CIMO-XIII, which served as the basis for defining the ET's Terms of Reference (TOR). Dr. Ivanov followed with a brief description of the draft work plan as presented in the Annex of general summary of the plan for the working session of the ET. He further clarified the main tasks of the CIMO OPAG Upper-Air and pointed out other potential tasks that may be relevant to the ET. These included requests of other technical commissions, such as the calibration of satellite remote sensing instruments and radiofrequency issues related to the ground based atmospheric monitoring systems.

3 GPS WATER VAPOR MEASUREMENTS

3.1 Presentations by the various members in attendance validated the fact that they had several systems or had established a full network to assess the operational potential of these systems for both Numerical Weather Prediction and Climate application. Each reporting member briefly discussed their experiences in developing their network, techniques used in validating the performance of their systems and how they were applying these measurements to various aspects of their operations. All members provided favorable responses when asked how they were using the high temporal frequency signals from GPS to assess various aspects of the atmosphere. Members of the ET who are also associated with COST716 provided information on an upcoming investigation of GPS and its uses. Several members reported that GPS derived Integrated Water Vapor (GPS-IWV) in near-real time and applications vary from being used to compliment their operational radiosonde network to using the measurements as a proxy for moisture soundings in Numerical Weather Prediction. These measurements have found application in operational

weather forecasting, climate monitoring, atmospheric research, as well as satellite calibration and validation. The members were in agreement that these measurements could be made with high reliability under all weather conditions. Retrieval accuracies have been shown to be comparable to radiosonde measurements, and GPS-IWV appears to provide a cost-effective approach to measuring atmospheric water vapor.

3.2 The members were in general agreement that the quality of IWV derived from GPS MET is thought to be compatible to that obtained from radiosonde observations. GPS MET data have proven to provide high temporal resolution when compared with conventional measurements. However, IWV from GPS MET only provides an integrated value of the profile. The vertical information of water vapor can be retrieved from GPS-derived slant water vapor (SWV) and tomography techniques. Work plan element 1a calls for the review of national and regional GPS procedures with the goal of developing international operational procedures for GPS water vapor networks.

3.3 Work plan element 1a and c calls for the review of national and regional GPS procedures with the goal of developing international operational procedures for GPS water vapor networks.

3.4 Individual member reports are contained in the [Annex IV](#) to this report.

4 COMPLEMENTARY USE OF MODERN DOPPLER RADARS AND PROFILERS IN THE UPPER-AIR NETWORK

4.1 Wind Profilers (WPR)

4.1.1 Active ground-based remote sensing systems such as profilers are used by Member countries to provide wind speed and direction, profiles of vertical motions, position of the melting layer and other related information. These systems are operated to monitor atmospheric conditions. Member reports proved the quality of data being collected by these systems and their value to the meteorological community. Some national meteorological and hydrological agencies assimilate these data into the NWP model, use these data in weather now-casting, or used in an integrated fashion to complement their radiosonde network providing improvements to atmospheric profiling, and used in support of airport safety.

4.1.2 Regional experiments and thorough investigations have been conducted with various tropospheric WPRs to determine their operational suitability. These experiments have shown that WPR direction and speed detected by these systems compare favorably with radiosonde profiles. Many of these experiments have led to or will lead to future WPR deployments and network expansions. These results have led to high space- and time-resolution wind measurements suitable for weather warnings, watches, and numerical forecasts. These data have produced improvements in forecast and warning accuracy as well as statistical improvements in model output.

4.1.3 Special emphasis is still being placed on improving the standard signal processing for WPRs, which will improve the system performance characteristics such as data accuracy and availability under all kind of meteorological conditions. At present many of these networks show a technical reliability of about 98% or more and provide data up to 12 km in height (dependent on frequency) with the data availability greater than 70 percent. Depending on the type of profiler (frequency used, pulse length, vertical resolution, etc.), the maximum measuring height may be as high as 16 km, however, with the data availability progressively reduced.

4.1.4 Due to external problems strict quality control measures must be applied to maintain high quality data. Presenters expressed concern over the need for better algorithms and techniques to remove unrealistic data due to migrating birds, aircrafts, wind turbines, electromagnetic field, ground-clutters and other contaminations. A multi peak processing algorithms may improve data availability by 10 to 20 % in some systems as it eliminates and replaces suspicious and unrealistic wind data due to all kind of contamination. Neural networks may be another technique to improve

data quality, however, it needs site-specific “training” before applied. There is a strong need for an operational performance control, such as the one applied by MeteoSwiss.

4.1.5 Another concern expressed by some team members was the concern over discrete characteristics of WPR data. The representative from the Japan Meteorological Agency (JMA) described the variation in height coverage due to seasonal variation. In the summer the JMA network provides height coverage between 6 and 7 km and during the winter season only between 3 and 4 km. This seasonal variation of the height coverage results from the seasonal difference in water vapor in the lower troposphere.

4.1.6 During the last decade WPR systems have proven both, their potential for improving numerical weather forecasts, as an additional tool for short-term forecasting and now-casting purposes. These systems have proven their technical and operational suitability and usefulness for deployment in national and regional networks. The usefulness of WPRs for NMHS has been well illustrated through the operational experience of profilers in Europe, the United States and Japan, the EUMETNET-WINPROF experiment and its focus on assimilation of WPR data into NWP models, and finally COST720 with its focus on integration of systems with the goal of improving temperature and humidity profiling. WPRs and other ground-based remote sensing systems such as microwave radiometers and LIDARs were identified as being current or future elements of any integrated upper-air network.

4.1.7 Individual member reports are contained in the [Annex IV](#) to this report

4.2 Modern Doppler Radars

4.2.1 All members reported that they have either completed the upgrading of their radar network or will be upgrading their radar network with Doppler radar systems. Some representatives reported that their networks were operating S-band, C-band or X-band radars and some networks were operating a mix of systems depending on function and cost. Several representatives with established networks reported ongoing efforts to upgrade systems to dual polarization. Software requirements for Doppler radar and other ground-based systems require constant review and must evolve to meet the ever-increasing user requirements. Many of the presenters made reference to the extensive use of the Doppler radars for nowcasting and the use of Velocity Azimuth Display (VAD) wind profiles as one element in identifying severe weather environments. Operational procedures have been developed by Doppler radar operators in such a way that the operational forecaster is able to maintain situational awareness while having the ability to investigate in greater detail individual thunderstorms in an efficient way and timely fashion.

4.2.2 The advances in Doppler radar technology and algorithms have proven the value of the system not only in localized severe weather situations, but on a larger scale when investigating synoptic systems such as tropical cyclones and their application to the investigation of the lower atmosphere for lower and middle level wind shear. For this reason alone some national agencies have positioned Doppler radars at or near airports. Independent investigations have documented the accuracy of wind speed measurements to be accurate within about 1m/s, and wind direction to an accuracy of about 10 degrees. Doppler radars are used not only for wind calibrations but for calibration of rainfall mapping as well as a complementing technology to surface rain gauge networks and satellite rainfall estimates. . Considerable processing is required to produce rainfall mapping and this is still evolving. These techniques allow the forecaster to provide accurate precipitation now-casts up to 1 hour and short-term precipitation forecasts up to 6 hours by combining with NWP.

4.2.3 Assimilation experiments of Doppler velocity data to the next generation non-hydrostatic model have proceeded. One such experiment has shown that use of data of 3D Doppler velocity as well as GPS integrated vertical water vapor data provide quality information and perform well in forecasting the development of severe thunderstorms associated with low-level convergence of moist air preceding the development.

4.2.4 Real-time operational use of Doppler radars requires a strict data quality control regiment to maintain the system's high performance scan strategy. The quality and accuracy of Doppler radar data is very important to post-processing and data analysis to the climate and hydrologic sectors.

4.2.5 The various presentations highlighted that data quality is higher today, thanks to improvements in digital technology and that polarization has become more affordable. During the last decade Doppler radar systems have proven both, their potential for improving numerical weather forecasts in general and as an additional tool for short-term forecasting and nowcasting purposes. The technical advances and operational advances make this system suitable for deployment in national or regional networks. NWP data assimilation systems emphasize the need for estimates of uncertainty of the radar data that are consistent within and across national boundaries. This requires the development of the science and algorithms for the estimation of these measurements and their uncertainties. These measurements included reflectivity, precipitation rate, radial wind and VAD wind. Science, algorithm and Intercomparison workshops should be developed.

4.2.6 Individual member reports are contained in the [Annex IV](#) to this report.

5 OPERATIONAL USE OF LIGHTNING DETECTION METHODS

5.1 The various aspects of Lightning Detection Systems (LDS) of UKMO, Brazil, Vaisala, TOA Inc., Canada, Korea and Japan were presented, such as system networks, the various techniques being used, network sensor types and quality of network measurements. The Vaisala representative reported on the technology verification methods providing many examples of quality assessment both direct and indirect methods currently being used to verify system and network performance. He also introduced some on going research activities regarding applications and illustrating LDS usefulness in long range lightning detection, which can perhaps being incorporated to NMHS operational tools and integrated to other remote sensing or NWP operations. The representative of UKMO presented an overview of their Arrival Time Difference (ATD) LDS, which was designed to locate flashes on the entire globe at long-range detection.

5.2 The Brazilian Lightning Network, as several others, is a consortium of government agencies, universities and electrical companies. Their network of 50 sensors reported detection results varying from 70 to 90 percent at an accuracy of around 2 km. The Brazil report as a number of other reports indicated that future projects would include the expansion of networks, the development of user-end applications, inter-system comparisons and data assimilation into NWP.

5.3 The JMA has implemented the SAFIR total lightning system. This differs from most other networks that report only cloud to ground lightning. Total lightning is significant from an understanding perspective but also as a hazard to aviation.

5.4 Lightning detection networks were becoming more affordable and would be easily extended to other national or regional areas. Performance of LDS may vary from 70 to 90 percent depending on range, location, season (Japan reported worse performance during the winter, 30 to 60 percent, than summer, 80 to 90 percent) and the sensor frequency being used (LF systems used for long-range applications do not provide accurate results at longer distances).

5.5 The meeting concluded the following:

- LDS have well defined applications and should play a larger role in operations.
- Despite the number of regional networks much of Asia, Africa, India and South America are still poorly covered. The UK representative indicated that that addition of a few additional sensors in the southern hemisphere would extend their coverage towards African and India.
- Today's technologies are capable of very accurate measurements of time and location, but more can be done.

- Total lightning has value for some applications but is currently available only from VHF systems.
- Coverage is possible with VLF in data sparse areas, but will likely require linkage through satellite applications.
- Verification of lightning detection systems should be done by network owners at a level commensurate with other meteorological observation instruments.
- Most of the existing networks are heterogeneous (either LF or VLF, or both). Few manufacturers have combined LF/VHF networks to detect both cloud-to-cloud and cloud-to-ground lightning within one network.
- Technical difficulties diminished, but the effects of propagation and topography still remain.
- The technology to identify both cloud-to-cloud and cloud-to-ground lightning currently exists, but the majority of systems measure cloud-to-ground lightning only. This will likely remain the situation until the need for Intra-cloud data increases.
- Reporting of flashes or individual strokes remains an issue and will be addressed by the various needs of the different user groups.
- LDS network performance needs to be verified this includes detection efficiency, peak current estimates and location accuracy. Methods including independent measurements should be applied as much as possible as well as conducting inter-system comparisons should also be encouraged at both national and regional levels.

5.6 The meeting was presented with a description of a number of commonly used methods to evaluate LDS performance. It was noted by that any of the following methods independently or in combination could be used to verify performance. The different methods include instrumented towers, rocket triggered lightning, video camera studies and network inter-comparisons. Each method has its strengths and weaknesses and papers on each of these methods are available from a number of sources such as the American Meteorological Society.

5.7 Work plan elements 4a-c call for the review of national and regional LDS procedures with the goal of developing international operational procedures for LDS. Details of these actions are contained in the Work Plan.

5.8 Individual member reports are contained in the [Annex IV](#) to this report.

5 INTEGRATED PROFILING SYSTEMS AND OTHER UPPER-AIR MEASUREMENT TECHNIQUES

6.0.1 To achieve the goal of an integrated observing “system of systems”, agencies must identify and integrate multi-purpose observing systems and networks within their enterprise architectures to meet cross-functional observational requirements in a cost-effective manner. This effort will require agencies to exploit their information technologies and communications infrastructure, their platforms and research-to-operational capabilities, and education and training capabilities. Several presentations were made reflecting these concepts.

6.0.2 The integration of profiling systems can be accomplished on either of two levels; the first approach is the combination of systems to improve one single meteorological parameter such as wind, temperature, humidity or cloud parameter. This is achieved through improved vertical resolution, vertical coverage and/or data quality. An example for this type of integration objective would be the combining of WPR and microwave radiometer and achieving enhanced vertical resolution of WPR measurements or the combination of Sodar and WPR of different systems to achieve enhancements in vertical data coverage compared to the using a single system. The second approach to integration is through the identification of new parameters using the synergy derived between two or more systems. This is achieved through simultaneous evaluation of

multiple remotes-sensing techniques. An Example of this form of integration is the combination of WPR with acoustic sources (RASS) to derive temperature profiles as well as wind profiles. A second example of this form of integration is the simultaneous use and evaluation of cloud radar, microwave radiometer and lidar (ceilometer) in order to receive microphysical cloud property profiles, which cannot be derived reasonably using one single profiling system.

6.1 Projects for integration of different ground-based observing techniques

6.1.1 Experiments such as Operational Wind Profiler Programme (WINPROF) and the Coordinated Wind Profiler Network in Europe (CWINDE) have proven the value of integrating complimentary data from different systems that can provide a positive impact to the quality of forecast products. During the period between 2002 and 2004 the first phase of the EUMETNET WINPROF was successfully implemented. The outcome resulted in the operational assimilation of CWINDE network data by several NHMSs into their NWP models. The comparison between NWP analysis data (model background) and WPR measurements from the 482 MHz system at Lindenberg Observatory, Germany showed that the WPR data, which are available every 30min, provide equal or higher quality data than the radiosonde wind measurements.

6.1.2 With the improvements in data quality and availability of WPR networks, the continuation of the EUMETNET activity, WINPROF-II, is under way. The goal of this effort is to integrate European WPR network into the EUCOS (European Composite Observing System) Programme.

6.1.3 Following the WPR-related experiments under COST-74 and COST-76 a new European research activity has been defined. This activity known as COST-720 will focus on the development of "*integrated ground-based remote-sensing stations for atmospheric profiling*". This five-year activity began in 2001 and is organized on two levels. The first addressing basic operational techniques and algorithms and the second addressing the feasibility of integrating of different ground based remote sensing upper-air platforms. This effort is addressing the development of complex algorithms taking into account measurements of more than one basic technology, (WPR, cloud radar, microwave profiler, ceilometers or others) in order to derive standard parameters of higher quality and vertical resolution with the goal of deriving new parameters through the combination of several different remote-sensing instruments.

6.1.4 Within COST-720 an experiment, TUC-2003, was conducted in the aerological station Payerne, Switzerland. The objective of this experiment was to use several technologies in combination to detect the upper boundary of fog and its change with time.

6.1.5 A second and final major campaign of COST-720 is being organized to assess the effectiveness of new techniques derived for the use in the integration of different water-vapor lidar systems, FTIR spectrometer, Doppler wind lidar, and Ka-band cloud radars. First results of this campaign are envisaged to be available with the end of COST-720 in 2006. One of the special issues to be investigated will be the question of whether ground-based microwave or water-vapor lidar systems will have any impact on NWP model forecasts.

6.1.6 In Canada, the development of an integrated approach to measurements is being led by collaboration between McGill University and the Meteorological Service of Canada as well as various efforts within the Cloud Physics and Severe Weather Research Division of the MSC. Each system is focused on a particular meteorological problem. McGill/MSR has developed the Canadian Mesoscale Observational Testbed (CMOST) for mesoscale applications including hydrological studies. The Alliance Icing Research Study, AIRS-II, project has an extensive set of cloud radars, profilers, surface observations, etc that is focused on the study and forecast of icing conditions and precipitation type. A special workstation (AVISA) is developed to integrate the various data sets. Integrated observation systems will focus on precipitation, particularly snowfall. Canada is working towards a prototype disdrometer network for the calibration of weather radar, high-resolution estimation of precipitation type and measurement. Validation of the Cloudsat will involve integrated measurements to both validate the precipitation retrievals but also their physical foundation.

6.1.7 The Russian effort in system integration is in its early stages. The Russian remote sensing community will prepare a draft review for operation aspects of different ground-based remote sensing observing techniques for vertical profiling of temperature, wind, humidity and cloud structure using various systems. The Russian presenters were of the opinion that it would be useful to combine microwave tropospheric profilers data with doppler radar data for acquiring water vapor profiles and liquid water profiles in clouds. For determining narrow elevated temperature inversions it will be useful to integrate microwave temperature profiler data with SODAR and weather radar data.

6.1.8 The future “system of systems” is NOAA’s Integrated Observing system (IOS) consisting of three elements; the Integrated Upper-Air Observing System (IOUS) – a network with a Climate, Aviation, and NWP focus; the Integrated Surface Observing System (ISOS) – a network with a Climate, Public, and Surface Transportation focus; and the Integrated Ocean Observation System (IOOS) – a network with a Climate and Marine Transportation focus.

6.1.9 The mission of the IUOS will be to support NOAA’s ocean and surface integrated observing systems. A successful integration will improve time and space resolution as well as accuracy. The vision for IUOS is to develop a system capable of improving short term warnings and forecasts by observing precursor conditions related to high-impact weather events, detect changes in regional and hemispheric conditions impacting transportation, and provide climate quality information for monitoring climate change.

6.1.10 Work plan elements 5a calls for the review of national and regional integration procedures with the goal of developing international operational procedures for such system integration approaches. Details of these actions are contained in the Work Plan.

6.2 Operational Aspects of different ground-based remote sensing techniques for vertical profiling

6.2.2 Mr Engelbart (Germany) presented results of the IOM Report No.79 on the Operational Aspects of WPRs. Further details could be found on CIMO/IMOP website: <http://www.wmo.int/web/www/IMOP/publications-IOM-series.html>.

6.2.3 Mr Kadygrov (Russian Federation) presented first draft IOM Report on Operational Aspects of Different Ground-Based Remote Sensing Observing Techniques for Vertical Profiling of Temperature, Humidity, Wind and Clouds. ET members, and interested experts, are invited to provide further comments and addition to this draft report, which could be downloaded from: <http://www.wmo.int/web/www/IMOP/meetings/Upper-Air/RemoteSensing/DocPlan.html>.

7 WORK PLAN

7.1.1 The outcome of the discussion on the above agenda items were recast into a detailed Work Plan that specifies actions and deliverables for all tasks that were put forward to the team by CIMO-XIII and CIMO-MG. The Work Plan is in [ANNEX II](#).

8 ANY OTHER BUSINNES

8.1 Radiofrequency issues

8.1.1 Due to the increasing demand for radiofrequency spectrum, there is more or less constant pressure on the frequency bands presently assigned for meteorological purposes. They are particularly attractive for other users such as satellite operators because they are almost always allocated on a worldwide basis and not regional.

8.1.2 The threat to meteorological Frequency bands comes from passive sensing devices. At present the most prominent threat is from problems related to ultra wide band (UWB) systems that plan to operate near 24 GHz, this frequency is used to observe the emissions from water molecules. This data serves to calibrate many different space-based systems yielding, among other parameters, temperature and humidity. See [Annex III](#) for further details.

8.1.3 C-Band frequencies, where many worldwide radar networks operate, were specifically mentioned as being under threat.

8.1.4 The meeting noted that the emissions from future GALILEO GPS satellites might cause problems with the Vaisala RS 80 GPS wind finding system. The meeting, however, agreed that this is not an issue as the RS80 radiosondes will be replaced by the RS 92 GPS well before the launch of GALILEO. The Vaisala RS 92 GPS wind finding system decodes GPS signals and should not have problems with GALILEO system.

8.1.5 Work plan elements 6a calls for a study related to frequency existing and future frequency allocation problems. Details of these actions are contained in the Work Plan found in the Annex to this report.

8.2 Global criteria for tracing the improvements of radiosondes over the last two decades

8.2.1 At the last CIMO expert team meeting on upper-air systems intercomparisons (ET on UASI-1, Geneva, 17-20.03.2004), the following task was defined: *Develop performance measures to demonstrate the continuous improvement in the quality of upper-air observations*. The required action is to “elaborate global criteria for tracing the improvements, based on previous intercomparisons and recent radiosonde development, and including remote sensing”. The deliverable will be an “IOM report on global criteria for tracing the improvements of radiosondes”. In the first draft of our paper we propose to focus on the definition of appropriate criteria which should later be used by the CIMO, the National Meteorological and Hydrological Services (NMHS), and the manufacturers in order to trace the improvements in the quality of upper-air observations. Ideally such criteria should be based on data already available in the previous IOM reports, and should also be defined as guidance to be included in any further CIMO UASI field campaigns and national or international inter comparisons to ensure the required continuous tracing. Finally any manufacturers or National Meteorological and Hydrological Services could use these criteria to trace the quality improvements of their radiosondes and sounding stations.

9 DRAFT REPORT OF THE SESSION

9.1 The members of expert team prepared their inputs for the final report, a draft of which was subsequently prepared by the Secretariat. Final report will be posted on the CIMO/IMOP website: <http://www.wmo.int/web/www/reports.html>.

10. CLOSURE OF THE SESSION

10.1 The session was closed on 17 March 2005 at 17h15.

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WORK PLAN
Expert team on Remote Sensing Upper-Air Technology and Techniques
(2003-2006)

No.	Task description	Person responsible	Action	Deadline	Deliverables	Deadline
1	Investigate error characteristics of water vapor measurements and explore compatibility between the different types of measurement:					
1 a)	Develop operational procedures of GPS water vapor networks	Siebrén de Haan & Masahito Ishihara & Rainer Dombrowsky	<ol style="list-style-type: none"> 1. Extend the review of the current status of GPS MET within each of the WMO Regions. In addition request information on sensor accuracy and the collection of data in real-time. 2. Review national/ regional operational procedures of GPS MET networks 3. Develop and agree on an international operational procedure for GPS MET networks 	Sep.05 Dec.05	<ul style="list-style-type: none"> • IOM Report on the national/regional operational procedures of GPS water vapor networks and agreed international procedures 	Mar.06
2	Complementary use of modern Doppler radars and profilers in the U/A network:					
2 a)	Improve quality and availability of remotely sensed upper wind measurements	Paul Joe & Sin-Ho Kim	<ol style="list-style-type: none"> 1. Review the status of the quality and availability of remotely sensed upper wind measurements 2. Make suggestions to improve quality and availability of remotely sensed upper wind measurements 3. In cooperation with the HMEI develop links between manufacturers and regional projects aimed at system 	Sep.05 Dec.05 Jan.06	<ul style="list-style-type: none"> • IOM Report on the Status of QM and availability of remotely sensed upper wind measurements in regional projects and on their improvements • Developed links between manufacturers and regional projects aimed at system integration 	Mar.06 Apr.06

No.	Task description	Person responsible	Action	Deadline	Deliverables	Deadline
			integration			
2 b)	Report on the suitability of modern radars and wind profilers for deployment in NMHS	Paul Joe (radars) & Sin-Ho Kim (radars) & Reinaldo Silveira (radars) & Dirk Engelbart (profilers) Rainer Dombrowsky (profilers) & Masahito Ishihara (profilers)	1. Review the suitability of modern radars for deployment in NMHS and on Weather Radars used by Members 2. Review the Weather Radars used by Members 3. Review the suitability of wind profilers for deployment in NMHS	Sep.05 Sep.05 Dec.05	<ul style="list-style-type: none"> IOM Report on the suitability of modern radars for deployment in NMHS Updated IOM Report No. 69 "Weather Radars used by members" IOM Report on the suitability of wind profilers for deployment in NMHS 	Jan.06 Jan.06 Mar.06
2 c)	Prepare and publish a guidance material on operational aspects of wind profiler radars in Europe, United States and Japan	Same as 2 b)	1. Review operational aspects of wind profiler radars in Europe, United States and Japan	Sep.05	<ul style="list-style-type: none"> IOM Report on the operational aspects of wind profiler radars 	Jan.06
3	Monitor and report on calibration of satellite remote sensing instrumentation	Alexei Ivanov & Rainer Dombrowsky	1. Request to CBS to report on calibration of satellite remote sensing instrumentation	Jun.05	<ul style="list-style-type: none"> Report provided to CIMO MG 	Apr.06
4	In consultation with HMEI, determine the operational use of lightning detection methods					
4 a)	Review the progress in the compatibility of lightning detection remote-sensing and conventional in-situ observations	Reinaldo Silveira & Siebren de Haan	1. Review the status in the compatibility of lightning detection remote-sensing and conventional in-situ observation	Sep.05	<ul style="list-style-type: none"> IOM Report on the system characteristics including current accuracy standards and QA being used 	Jan.06

No.	Task description	Person responsible	Action	Deadline	Deliverables	Deadline
4 b)	Propose evaluation methods for operational lightning detection systems	& Masahito Ishihara & Martti Husu	1. Review existing evaluation methods for operational lightning detection systems and propose the standard evaluation method	Sep.05	• IOM Report on Evaluation methods for operational lightning detection systems	Jan.06
4 c)	Monitor and report on national and regional lightning detection projects and networks	& Bruce Summer	1. Review national and regional lightning detection projects and networks	Sep.05	• IOM Report on the progress in the compatibility of lightning detection remote-sensing and conventional in-situ observations	Jan.06
5	Promote, facilitate and assist with developments in integrated profiling systems and report on other upper-air measurement techniques					
5 a)	Monitor the progress of projects set up to integrate different ground-based observing techniques together to provide improved sensing of vertical profiles of temperature, humidity and cloud structure, and precipitation detection	Dirk Engelbart & Eugeny Kadygrov & Rainer Dombrowsky & Guan Hong & Paul Joe	1. Review the operational aspects of different ground-based observing techniques, such as lidar, microwave radiometer, sodar, RASS, that can provide remote sensing of vertical profiles of temperature, humidity and cloud structure 2. Review the projects set up to integrate different ground-based observing techniques together to provide improved sensing of vertical profiles of temperature, humidity and cloud structure	Dec.05 Dec.05	• IOM Report on the operational aspects of different ground-based remote sensing observing techniques • IOM Report on integrated profiling technologies and techniques	Jan.06 Feb.06
6	Development of technical information for support of radio frequency sharing policy for WRC					
6 a)	Frequency allocation for weather and profiler radars	Alexei Ivanov & Bhukan Lal & Paul Joe & HMEI	1. Study the problems related to Frequency allocation for weather and profiler radars and coordinate it with ET B.1	Sep.05	• Recommendations to ITU and Members	Jan.06

No.	Task description	Person responsible	Action	Deadline	Deliverables	Deadline
7	Improve the global radiosonde network					
7 a)	Promote WMO intercomparison of remote and in situ U/A sounding systems	Alexei Ivanov	1. Based on the evaluation of current situation in Member countries, make proposals, in coordination with ET B.2, for future intercomparison of remote and in situ U/A sounding systems	Feb.06	<ul style="list-style-type: none"> • Report to CIMO-XIV 	Jun.06

Radiofrequency issues

The meteorological community utilizes frequency spectrum mainly for three purposes:

(i) For telecommunication. This includes the collection and dissemination of processed and raw data, e.g., from radiosondes, satellites, remote data collection platforms (buoys, remotely piloted vehicles, etc.), and for the control and housekeeping of satellites.

(ii) For active remote sensing. This category encompasses mainly meteorological radars and wind profiling radars. The meteorological radars track clouds and estimate precipitation, Doppler radars measure also winds from the displacement of scattering particles (mainly precipitation or cloud droplets). Wind profilers are sophisticated Doppler radars measuring vertical wind profiles even under clear air conditions and - if properly equipped with an acoustic source - also temperature profiles.

(iii) For passive remote sensing. Either space-based (satellite) or surfaced-based radiometers observe the natural electromagnetic emissions of particular molecules. From these, physical parameters such as temperature and humidity can be deduced, or concentrations of atmospheric constituents can be derived. Depending on the method employed, surface values, integral values, or vertical profiles may be obtained.

Due to the increasing demand for radiofrequency spectrum, there is more or less constant pressure on the frequency bands presently assigned for meteorological purposes. They are particularly attractive for other users (e.g. satellite operators) because they are mostly allocated on a worldwide (and not regional) basis. It is difficult to estimate the actual value of these bands because the loss of the data and the subsequent deterioration of the forecast with all the detrimental effects on agriculture, tourism, traffic, damage by severe weather, etc. cannot readily be assessed.

Probably the most threatening development is the fact that active transmitters endanger those radiofrequency bands which are used for passive sensing. It must be recognized that these frequency bands represent a natural resource which is gradually being depleted. Most of the frequencies used in passive sensing are in the upper GHz-range which was not extensively used for communication purposes until recently. However, as new technologies are developed, also these frequencies are more and more used for communication purposes, putting the passive sensing at risk. The presently very prominent problem relates to ultra wide band (UWB) systems that are planned to work near 24 GHz, a frequency range that is used to observe the emission from water molecules. This data serves for the calibration of many different space-based systems yielding, among other parameters, temperature and humidity. According to Radio Regulations, any transmission in this band is prohibited, nevertheless, it must be feared that there will be man-made emissions in this band in the very near future.

In order to solve the problems, the meteorological community should find means to demonstrate what value the different frequency bands have for their activities. It has been shown, that the loss of satellite-based radiometer data due to interference from active systems would result in a significant reduction of the forecasting capability: The ability to forecast the height of the 500 hPa level with a given skill factor would, e.g., be reduced by about 10 hours on the northern, and by about 48 hours on the southern hemisphere. The loss of satellite data has more detrimental effects than the loss of either all the surface data or all upper-air data on the forecasting quality!

Further, in many countries the communication between meteorologists and communication people should be improved. For a telecom person it is not necessarily obvious that even a slight increase in the noise level - e.g. caused by an UWB system - will make passive sensing impossible. On the other hand, the different bands used for passive sensing must be prioritized. It is highly unlikely that all bands that are presently used for measuring physical parameters and atmospheric

constituents will continue to be available in the future. The efforts for keeping certain bands free for passive sensing must be concentrated on the really important ones.

Active radiofrequency systems must be licensed and they are registered. Since a number of years, WMO keeps also a database covering satellite-based passive systems, i.e., radiometers. However, at present there is no inventory of surface-based radiometers, making it difficult to argue for protecting certain bands for passive observations. The WMO Steering Group for Radiofrequency Coordination will deal with this issue at its next meeting.

The awareness of the national meteorological services in relation to radiofrequency allocations must be increased. Decisions at the different International Telecommunication Union (ITU) levels are ultimately made by the members of ITU, and these members are the national telecom authorities. Consequently, national meteorological services should seek the dialogue with their national telecom administration and make them aware of the value of radiofrequency spectrum for their operations. This should not be restricted to the frequencies actually used in a certain country (e.g. for radiosondes or wind profilers), but should also cover satellite-based systems operated by international (e.g. ESA) or other national (e.g. NOAA) organizations from which all WMO members profit.

COUNTRY REPORTS (Not edited)

Brazil

The Brazilian Lightning Network is compounded from a consortium among government, universities and electrical companies, with about 50 sensors from distinct manufactures and specifications. Results have shown that detection accuracy varies from 70 % to 90 % at 2 km. Future projects include enlargement of network, development of user-end applications, inter-system comparisons as well as integration with NWP models.

Canada

The data assimilation group of the Meteorological Service of Canada in collaboration with the Natural Resources Canada conducts research in the use of GPS for meteorology. Studies were conducted where GPS sensors were co-located with radiosondes in order to compare precipitable water estimates. The International GPS System was also in the comparison. Results indicated a dry bias in the radiosonde data. 1D VAR experiments were conducted and indicate that considerable error reduction is possible in moist environments and not much in dry environments. Precipitable water comparisons indicate that the radiosonde may have a dry bias.

Canada has a modest Wind Profiler network: four 915 MHz systems and two 49 MHz systems. Two of the 915 MHz wind profilers are used for cloud physics research studies of precipitation, boundary layer processes and bird migration. Another focus of the research was the quality control of the wind retrievals. Other wind profiler applications include using the echo power to determine the height of the boundary layer and using the doppler spectrum to retrieve the drop size distribution. Wayne Hocking of the University of Western Ontario has been funded to develop a 49MHz network of profilers. A unique aspect is the ability to provide high-resolution data in the troposphere. The profiler winds from the U.S. demonstration network have been assimilated into the operational forecast model for over a year. In spite of a degraded subset of the data being used, slight improvements are being achieved.

Canada has just finished a major upgrade of the radar network, increasing the number of radars from 20 to 31. All the radars are Doppler C-Band radars except for McGill, which is a S-radar. The King City Radar has been upgraded to dual polarization. The project was done in-house. Software requirements indicate that the software must continue to evolve as the requirements for a multitude of users become established and refined. The severe weather package uses algorithms to identify thunderstorm features and this information is presented in such a way that the forecaster is able to maintain situational awareness while having the ability to "drill down" to greater detail on individual thunderstorms in an efficient way.

The MSC has implemented a lightning network using the technology from Global Atmospheric Incorporated (now Vaisala). Being part of the North American Lightning Detection Network, results in greater efficiency and more accurate locations. Climatological studies have changed the perception of the location patterns of severe weather. Also, it has revealed a maximum of lightning activity near the Gulf Stream, which was not known before. Using this comprehensive data, a lightning forecast model has been developed. The system is monitored via a novel web application where the user can quickly interrogate the status of any station, get a network performance image or dynamically generated efficiency or location maps.

The development of an integrated approach to measurements is led by McGill University and the Cloud Physics and Severe Weather Research Division. Each system is focused on a particular meteorological problem. McGill/MSR has developed the Canadian Mesoscale Observational Testbed (CMOST) for mesoscale applications including hydrological studies. The AIRS-II project has an extensive set of cloud radars, profilers, surface observations, etc that is focused on icing conditions. A special workstation is developed to integrate the various data sets. Cloudsat and

GPM calibration/validation will develop integrated observation systems focused on precipitation, particularly snowfall. Canada is working towards a prototype disdrometer network for the calibration of weather radar, high-resolution estimation of precipitation type and measurements of snowfall.

China

CMA launched the bidding process firstly for a 12-16 km and a 6-8 km troposphere wind profiler radars in 2002. There was an inter-comparison experiment made between 6-8 km troposphere wind profiler and L-Band upper-air sounding radar and GPS upper-air sounding system in July to November 2004. The inter-comparison experiment shows that the wind direction and speed detected by this troposphere wind profiler reflects the wind field information of the atmosphere well, which coincides with the wind found by L-Band radar and GPS Sounding system. CMA plans to deploy an experimental network of 30 wind profiler radars soon.

China Meteorological Administration plans to construct 158 radar sites. It's about 74 sets of Doppler radars have been installed and put into operation until end of 2004, and about 41 sets of Doppler radars are installing now. The radar system can supply over 70 meteorologically significant products. They obtained a lot of significant useful data on the various weather systems, e.g. Typhoon, cold front, convergence line, meso cyclone, hail cloud and tornado etc. The accuracy of wind speed measurement is about 1m/s, and wind direction is about 10 degree. Radar equipment causes small errors in speed measurement while algorithm and object (of wide speed spectrum) cause big errors, the latter being the principal factor affecting the accuracy.

Germany

After several years of thorough investigations using a 1290 MHz and a 482 MHz WPR system at Lindenberg Observatory the German Meteorological Service has started to set up a small network of 482 MHz WPR systems including RASS additions, whose fourth and last system will be set up near Bayreuth, in summer 2005.

The German network is already part of the Coordinated Wind Profiler Network in Europe (CWINDE) network and is used nationally to complement the existing upper-air radiosonde network. Hence, its main purpose is connected to the supply of assimilation data for NWP as well as for providing an additional tool for nowcasting of severe weather and strong wind shear in Germany. The WPR network is furthermore linked with a comprehensive system of automatic and manual quality control of all measured data as well as with several procedures for hardware control and regular maintenance. Comprehensive research has been done and is continued to be done in order to control all potential sources of errors, which especially prerequisite a thorough understanding of all these errors. Therefore a special emphasis is still being laid on an improvement of the standard signal processing for WPR systems, which shall help to improve the system performance, i.e. data accuracy and availability under all kind of meteorological conditions. Currently the network systems show a technical reliability of about 98% or more and provide data up to about 12 km in height with an availability of 70% or more.

According to the experience from the German and CWINDE network, special emphasis must be laid on a very careful choice of system parameters, where these parameters have to take into account technical limitations of the WPR technique. One of the major reasons for blacklisting of WPR systems at NWP data assimilation centers can frequently be attributed to an incorrect choice of system parameters, which should therefore be considered for new systems only from well-experienced users.

India

India has been using GPS technology for seismological and other purposes. It has plans to install GPS for water vapor measurement for use in NWP models for forecasting. There is a plan to install six GPS systems in next two years.

One wind profiler (RASS) has been successfully working for the last two years at Pune. In future there is a plan to replace Pilot Balloon Observations (PBO) by WPR/RASS. There are 62 PBO at present spread over the country. There is a plan to replace 48 PBO by WPR/RASS in phased manner in the near future and remaining to replace by state of the art radiosonde stations.

IMD has convention as well as modern DWR. Cyclone detection S-Band Radar. IMD has a network of 11 S-Band cyclone detection radars covering Indian East and West Coast line. East West – KOLATA, PARADIP, VISHAKHAPATMAR MACHLIPATNAM, CHENNAI, KARAKAL. West Coast – COCHIN, GOA, MUMBAI, BHUJ.

Three DWR have already been installed at KOLKATA, CHENNAI and MACHILIPATNAM on the East Coast and fourth one is likely to be installed by mid 2005. (These radars have replaced the old conventional radars). An indigenous DWR is already installed and operational on Srihasikota near East Coast of India. Thus, out of 11 S-Band radars, 5 are DWR.

Future Plan:

Replacement of remaining S-Band conventional radars by DWR

To fill-up the gap between the existing cyclone detection radars, there is a plan to install 7 more DWR along the East and West Coast of India

DWR installed – are being used in the aviation weather services in order to detect the low-level wind shears. IMD has examined effectiveness of DWR for monitoring severe weather like Norwesters and found it as a powerful tool for Nowcasting. Storm Detection X-Band radars. IMD has 26 X-Band storm detection radars, which are being replaced by the state of the art radars.

India has a plan to establish a network LDS in a phased manner for use in weather forecasting.

Japan

GPS meteorology in Japan has been developed along with GEONET (GPS Earth Observation NETWORK) of the Geographical Survey Institute, Japan. Integrated water vapor IWV (or Precipitable water vapor PWV) from GPS meteorology is ready to use in the operational numerical weather prediction (NWP). Vertical profiling of temperature and water vapor using satellite-borne occultation technique is being examined. Vertical profiling of water vapor using down-looking technique is on the way of research. Derivation of 3D water vapor fields with tomography technique is also on the way of research.

Accuracy of GPS IWV. Comparison between GPS IWV and Radiosonde-derived IWV during June 1999 to May 2000. GPS IWV is estimated with non-real time data processing using accurate information on orbits of GPS satellites. High correlation between them was obtained on the average.

Impact of GPS Meteorology to NWP. Several experiments of data assimilation of GPS IWV to NWP showed improvement for severe rainfall events. A statistical score for precipitation, however, indicated that the impact of GPS IWV was almost neutral. One of the reasons might be that the GPS receiver sites were sparsely distributed compared to the rainfall systems. Another reason was lack of vertical profile of water vapor. After the observation system experiments made with the mesoscale model (MSM) using GPS IWV over land and TMI (TRMM Microwave Imager) IWV over ocean, it was found that the complementary use of GPS IWV and TMI IWV can improve accuracy of NWP. Impact of GPS-derived water vapor and radial wind from Doppler radars on NWP was also examined. In case of a severe thunderstorm, simultaneously assimilating of GPS IWV, GPS-derived slant water vapor (SWV) and radial winds from Doppler radars well reproduced the rainfall area, because low-level convergence of wind with water vapor was accurately predicted using the data.

GPS tomography technique was studied using 75 GPS receivers in the area of 20 km square around Tsukuba. 3D distribution of water vapor in a severe thunderstorm was derived. Vertical profiling of water vapor and temperature using space-borne occultation technique is being

examined in order to use in the global numerical model in accordance with launching of new satellites. It is expected that accuracy of forecasts in data-sparse regions will be improved.

To further use of GPS meteorology in JMA, there is a need to obtain GPS signal from GPS stations in real-time, to obtain accurate information on orbits of the GPS satellites, to obtain vertical profile of water vapor particularly at the lower troposphere for NWP of severe rainfall events, and to obtain distribution water vapor over ocean.

Thirty-one L-band (1.3GHz) wind profilers are in operation in Japan (25 profilers from April 2001 and six profilers from March to June 2003). The wind profilers are located throughout Japan, giving the high priority on observations in the middle and western Japan where severe heavy rainstorms frequently occur. Systematic availability has been more than 98%. JMA is studying the retrieval of humidity data from WPR signal.

Strict quality controls are adopted at the stages of the signal processing and data processing in order to maintain the data being high quality : migrating-bird removal, ground-clutter rejection, the homogeneity check of winds, quadratic surface check of winds and so on. 10-minute average data of wind are created in BUFR and are put onto GTS every hour for global exchange from April 2002.

Characteristics of the wind profiler data. The height coverage of the JMA profiler network is 6 to 7 km in summer season and 3 to 4 km in winter season. This seasonal variation of the height coverage results from the difference of water vapor in the lower troposphere. It was found from comparison with winds from the NWP model that the accuracy in wind measurement is comparable to that in radiosonde observations.

Impact to NWP. The threat score for severe rainfalls in case of not using wind profiler data in the mesoscale model was 0.02, and the score was improved to 0.05 by using wind profiler data. Several impact experiments on NWP using the mesoscale model concerning heavy rainfall events illustrated that the forecasts of locations of the rainstorms were well improved by using the wind profiler data.

Migration-birds contamination. For L-band wind profilers, migrating birds are one of the most serious contamination sources. In the most serious period of the contamination in Japan, 12% of the total amount of the wind profiler data was contaminated by migrating birds. Nearly half of bird-contaminated data are retrieved by QC removing spectra subset from migrating-birds.

JMA are operating three types of weather radar : conventional weather radar network(20 sites), Doppler radars for Airports (8 sites) and conventional weather Surveillance Radar for airport (1 site).The conventional radar network provides national-wide radar-echo composite maps every 10 minutes, composite maps calibrated with the raingauge network AMeDAS every 30 minutes, precipitation nowcast up to 1 hour, and very short-term precipitation forecast together with the mesoscale NWP model up to 6 hours. Doppler radars installed at 8 airports are monitoring low-level wind shear around the airports.

Twenty conventional weather radars will be replaced to Doppler radars. First Doppler radar will be installed in Tokyo in April 2006. The main purpose of the project is to provide 3D Doppler radar data as well 3D radar-echo mapping into NWP models by using 4D variational data assimilation technique in order to improve accuracy of forecast for severe weather events.

The assimilation experiments of Doppler velocity data to the next generation non-hydrostatic model have been preceded. One of the experiments showed that use of data of 3D Doppler velocity as well as GPS integrated vertical water vapor data well forecasted development of a severe thunderstorm because low-level convergence of moist air preceding the development was retrieved.

JMA has operated a lightning detection system since 2000 mainly for the purpose of aviation weather services. The system consists of 29 detection stations located at the airports and a Control Center at the Tokyo International Airport. Each detection station has five VHF interference

antennas for intra-cloud discharges, a LF antenna for cloud-ground strikes, a GPS receiver and a signal processor. Signals from lightning detected the stations are sent to the Control Center in real-time, and are processed at the Control center. Results from the lightning detection system are provided to users in form of domestic maps and national-wide maps.

Performance of lightning detection. Cloud-ground strokes are detected up to 400 km from the coast of Japan. Detection of Intra-cloud discharges is limited to 200 km from the coast. Comparison of lightning detections was made between the lightning detection system and conventional in-situ lightning observations within circles of 20 km around each weather station. The efficiency during whole year in 2002 is 72%, the efficiency in summer season was 80 to 90%, and the efficiency in winter season was 30 to 60%. Detection error occasionally occurred due to interference with other radio stations or noise sources, and data quality control has been made mainly by using comparison with radar echoes.

Korea

The Korea Meteorological Administration (KMA) has started to set up the Korea Wind Profiler Network (KWPN) of 1290 MHz Wind Profiler System in 2003. Now KMA has operated four wind profiler systems. KWPN will consist of 10 wind profiler systems. Therefore KMA plans to set up six wind profiler systems dependent on financial budget until 2010.

KMA has a Doppler Radar Network consisting of 4 S-band Doppler Systems and 5 C-band Doppler Systems. KMA plans to replace 3 systems of 5 C-band Doppler Radar Systems with S-band system in the near future. To track Typhoon effectively, KMA is constructing another S-band Doppler Radar System in Jeju Island. Finally, KMA will set up a new Doppler Radar System consisting of 8 S-band systems and 2 C-band systems in 2008.

KMA had operated the Lightning Detection System (LDS) of the Magnetic Direction Finding (MDF) method since 1987. In 2001, KMA replaced the old LDS system with the Total Lightning Detection System (TLDS) using the technology from Global Atmospheric Incorporated (currently Vaisala). TLDS consists of 7 LF IMPACT-ES sensors and 17 Lightning Detection and Ranging - LDAR II sensors. A LF IMPACT sensor is mainly to detect cloud to ground discharge and a VHF LDAR II sensor is only to detect intra-cloud discharge. TLDS can detect cloud to ground flash up to 400 km from the coast of the Korean Peninsula and intra-cloud discharge to the southern part of the Peninsula.

The Netherlands

The use of GPS observation at KNMI is currently in a transition from research to operation. International research is embedded in the European TOUGH (Targeting Operational Usage of GPS Humidity) project, while preparation of operational GPS processing for meteorological purposes, to be conducted within a nationally funded project, is incorporated in the EUMETNET program EGAVP.

KNMI there is currently concentrating on Integrated Water Vapor measurements for nowcasting purposes, Slant Water Vapor measurements from GPS to recover three dimensional water vapor fields, Investigation of the quality of slant delay measurements for use in NWP within the European Project TOUGH, Investigation of high temporal frequency signals from GPS to assess the atmospheric stability. An implementation of operational activities will start in June 2005. The Dutch GPS network will most likely be enlarged from 6 to 29 stations.

There is an operational lightning detection network of 7 sensors (Vaisala).

Russian Federation

Currently there are different modern remote sensing ground based instruments developed and manufacturing in Russian Federation (microwave temperature profilers for atmospheric boundary layer, microwave radiometers for measurements of total water content, for measurement of liquid water path in clouds and average temperature of liquid water in clouds, lidars for temperature and

wind profiling, lidars for aerosol measurements, SODARs). There are also a new network of 8 temperature profilers (Moscow, Dolgoprudny, Zvenigorod, N.Novgorod, Ufa, Orenburg, Krasnojarsk, Tomsk).for urban meteorology, for investigation of urban heat island and for improving of local weather forecast, air-pollution forecasting and forecasting of dangerous meteorological conditions. But real work with integration of remote sensing data and instrumentation is in a very beginning in Russia now.

For ET meeting from Russian remote sensing community was prepared Draft of review for operation aspects of different ground-based remote sensing observing techniques for vertical profiling of temperature, wind , humidity and cloud structure.

As about integration of different system for receiving of a new parameters: our opinion that it will be useful to combine microwave tropospheric profilers data with Doppler radar data for getting water vapor profiles and liquid water profiles in clouds.

For determination of narrow elevated temperature inversions it will be useful to integrate microwave temperature profiler data with SODAR data and weather radar data.

Switzerland

Integrated water content obtained from the Swisstopo AGNES GPS antenna network is also used in MeteoSwiss. These data are currently used for a sensitivity analysis on the improvement in aLMo Swiss weather forecast model. These data will also serve for inter comparison with other collocated system in Payerne, in particular the radiosonde measurements, as well as a water vapor Raman lidar instrument currently under development in collaboration between MeteoSwiss and the Swiss federal institute of technology in Lausanne (EPFL).

In Switzerland two low-tropospheric wind profilers are currently operated. One is in operational use in Payerne, and the second profiler is a mobile and research instrument currently in operation at Zurich airport. The main activities related to Wind Profilers in Switzerland are the following:

- Participation to EUMETNET-WINPROF and direct contribution to the CWIND network – data transferred via GTS, and assimilation of WP data into the NWP models (ECMWF, LM)
- Participation to the COST 720 action, with focus on integration of systems for improving temperature, humidity, and cloud profiling at low altitude range.
- Improvement in the wind profiler data processing in collaboration with IACETHZ
- Direct contribution to the radio frequency protection agency in Switzerland
- Use of wind profiler data to improve weather forecast (within the COST 723 action)
- Development of specific quality control tools for continuous / on line / real time control of wind profiler data.
- excellent system availability
- possible poor operation caused by (a)location characterized by a high level of electromagnetic noise (airport) or complex topography; (b)hardware aging (relays, ..); (c) software limitations (single peak, ..)
- possible contamination caused by (a) bird migration, (b) heavy convective precipitation, (c) air planes (on airports)

The usefulness of wind profilers for NMHS was illustrated with these examples:

- European level: (a) EUMETNET-WINPROF with a focus on assimilation of wind profiler data into NWP models (>60% of the systems); (b) COST720 with a focus on integration on systems to improve mainly temperature and humidity profiling; an example was shown using wind profiler SNR used to improve the humidity profiling capabilities of a microwave radiometer.
- Presentation of the project CN-MET dealing with the survey of atmospheric conditions in case of a nuclear accident (Centrales Nucléaires et METéorologie): the setting up of a new regional network integrating in situ measurements, ground-based remote sensing profiling systems (wind profilers and microwave radiometers) associated to a high resolution NWP model making very short forecasts with a high assimilation rate constitute the frame of this project.

Wind profilers and other ground-based remote sensing systems (microwave radiometers, lidars,...) are part of the current and future MeteoSwiss plans.

At MeteoSwiss, three meteorological Doppler radars are currently in operation, located respectively in the southern part of Switzerland (Monte Lema), Western part (La Dôle), and Northeastern part (Albis) of Switzerland. They provide essential information for our weather forecasters, in particular for warning and now casting issues. Among others, products such as 2D maps of precipitable water or alarms for extreme events are produced operationally. Post-processing and data analysis on important information such as accumulation maps of heavy rains' events complement the hydrological products. Research and development on the weather radar's data analysis has been performed in part within the frame of the EUMETNET-OPERA program. In a recent contract signed with Météo France, both NMHSs are currently developing a new radar site on the Jura mountain (Franche Comté - Montancy) under the umbrella of the EU INTERREG programme. This fourth meteorological radar will help enhancing the quality of our products for hydrology application in the western part of Switzerland, improve our knowledge and expertise in double polarization radar, and confirm our close cooperation with Météo France. It will also be a first step towards the renewal of the Swiss radar network, a task that will be addressed in the next years.

The next generation of lightning detection network has been recently decided based on the system provided by Meteorage France.

USA

The U.S. presentation described the current state of the national GPS demonstration network, a network of over 200 platforms. The demonstration network is currently being used to evaluate the accuracy of radiosonde moisture observations. This is being done through data denial experiments by the use and non-use of GPS data and their impact on weather forecasts. GPS data remains complimentary to radiosonde data, but have been successfully used as proxy for moisture soundings in numerical weather prediction models.

Since 1994 evaluations of GPS utility have been conducted in the areas of operational weather forecasting, climate monitoring, atmospheric research, and satellite calibration and data validation. These evaluations have raised confidence in the use of GPS, complimentary to the operational radiosonde network. Conclusions which led to this confidence level, GPS has high reliability under all weather conditions, retrieval accuracies have been comparable or better than integrated radiosonde measurements without known problems at high humidity or low temperature, and finally GPS-IPW is a cost-effective system and there appear to be no technical impediments to its future operational implementation.

An overview of techniques using dual-frequency GPS ground receivers. The presentation described how NOAA's Forecast Systems Laboratory, through successful collaboration, developed a National GPS Meteorological Demonstration Network. The network currently has over 200 sites and others are projected to join the demonstration network over the next several years. The ultimate goal of this demonstration network is to implement the network into NOAA's meteorological operation no later than the end of the decade.

The ground-based GPS network has shown its value in measuring total column PWV under all weather conditions with less than five percent. The system can provide 30-minute average PWV measurements with an average latency of 18-minutes. These higher resolution measurements and the increased number of data points have made a significant impact on the forecast accuracy of models such as NOAA's Rapid Update Cycle model. The presentation did provide a brief discussion of the technique used in data analysis, discussed data accuracy, and examples of subjective forecasting techniques.

The National Oceanic and Atmospheric Administration (NOAA) Forecast System Laboratory (FSL) has operated a network of 404-Mhz tropospheric wind profilers since 1992. Most of these profilers operate in the central United States. The importance of data from the wind profiler network for

forecasting has been documented through data denial experiments with the Rapid Update Cycle (RUC) model.

These results are available through on-line supplements associated with the recent American Meteorological Society Bulletin article, December 2004, Benjamin, Schwartz, Szoke, and Koch, NOAA/FSL, Boulder, Colorado. The results of these experiments have shown the high quality of the data both from spatial and temporal enhancements. The contribution from profiler data reduced the error in short-range wind forecasts. Forecast errors for height, relative humidity, and temperature were also reduced by 5 to 15 percent when averaged over vertical levels. The contribution from profiler data improved the short-range (3-hour) forecast accuracy between 12 and 28 percent at all mandatory levels from 850-150 hPa during these experiments.

Tropospheric wind profilers have been in operation since 1988 and evaluated for suitability since 1994. Through high space- and time-resolution National Profiler Network (NPN) wind measurements have shown improvement in weather warnings and watches, and numerical forecasts issued by NOAA weather forecast offices having access to elements of the NPN. Statistical improvements in probability of prediction, false alarm ratio, and warning lead-time have been realized for severe weather events such as tornadoes and flash floods. Lead-time improvements were also noted in winter storm, fire weather, and turbulence warning events. Statistical improvements were also realized in watch and outlook accuracy and NWP improvements from 0- to 12-hour forecasts. These results provide the evidence needed for future operational implementation.

To achieve the goal of an integrated observing "system of systems", NOAA must identify and integrate multi-purpose observing systems and networks within extensible enterprise architectures to meet cross-functional observational requirements in a cost-effective manner. This effort will require NOAA to exploit its information technologies and communications backbone, its platforms and research-to-operational capabilities, and education and training capabilities. The future "system of systems" (IOS) will be comprised of three elements; the Integrated Upper-Air Observing System (IOUS) – a network with a Climate, Aviation, and NWP focus, the Integrated Surface Observing System (ISOS) – a network with a Climate, Public, and Surface Transportation focus, and the Integrated Ocean Observation System (IOOS) – a network with a Climate and Marine Transportation focus.

The mission of the IUOS will be to support NOAA's ocean and surface integrated observing systems. A successful integration will improve time and space resolution as well as accuracy. The vision for IUOS is to develop a system capable of improving short term warnings and forecasts by observing precursor conditions related to high-impact weather events, detect changes in regional and hemispheric conditions impacting transportation, and provide climate quality information for monitoring climate change.