



**REPORT OF THE THREE SPECIAL PANELS ON
Creating a “Global weather and climate ready society”**

FUTURE WEATHER ENTERPRISE

ORGANIZED AT:

WORLD WEATHER OPEN SCIENCE CONFERENCE

(WWOSC-2014)

HELD IN MONTREAL - AUGUST 16-21, 2014

AT PALAIS DES CONGRÈS

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Table of Contents

1	Introduction.....	3
2	Organizing Team.....	3
3	Structure of this Document.....	4
 PART I: Executive Summary		6
 PART II: Summary Report of the three Panels on the Future Weather Enterprise		12
1	Introduction.....	13
2	Description of the Panels.....	13
3	Outcomes	17
3.1	General.....	17
3.2	Data	18
3.3	Weather Services	20
3.4	Human Resources.....	22
3.5	Moving forward	22
3.6	Summary and Next Steps	25
 ANNEXES		
ANNEX A: PANEL 1 TRANSCRIPTS.....		3
ANNEX B: PANEL 2 TRANSCRIPTS.....		33
ANNEX C: PANEL 3 TRANSCRIPTS.....		61

1 Introduction

The World Meteorological Organization (**WMO**) conducted the first World Weather Open Science Conference (**WWOSC**) in Montreal, Canada, August 16-21, 2014. The Conference brought together the weather science and user communities (over 1000 attendees) for the first time to review the state-of-the-art technologies and map out the scientific frontiers for the next decade and more. A two-day special session, co-sponsored by the American Meteorological Society (**AMS**) and the Canadian Meteorological and Oceanographic Society (**CMOS**) focused on enhancing collaboration across the weather enterprise (public, private and research sectors) to benefit societies worldwide.

At a time when the impacts of weather and climate are growing dramatically, the interaction among these three enterprise sectors is increasingly important. The session was designed to enhance the dialogue and collaboration across the global weather community and to identify areas where greater collaboration among the enterprise's three sectors could significantly benefit people worldwide. This White Paper provides a summary of the panel discussions and recommends the next steps.

2 Organizing Team

The idea of organizing the Panels on the “Future of Weather Enterprise” originated from Mr. Jerry Lengoasa, Deputy Secretary General of WMO and Dr. Michel Béland, the Co-Chair of the WWOSC-2014 Conference.

The Canadian Meteorological and Oceanographic Society and the American Meteorological Society were asked to organize the Panel Sessions. A committee shown below was formed and it decided the definition of the Panels as well as invited Moderators and Panelists which are shown in Part 2 of this Report.

Organizing Committee of the Panels on Future Weather Enterprise



Dr. Jack Hayes - Chair
VP – Harris Corporation, USA



Dr. Harinder Ahluwalia
President CMOS
Canada



Dr. William Gail
President – AMS
USA



Mr. Jim Abraham
Retd. DG - Monitoring
Environment Canada



Dr. Brian Mills
Applied Climatologist
Environment Canada



3 Structure of this Document

This document is structured in three parts:

- 1) The first part is the Executive Summary which is a descriptive summary of the entire proceedings of the three Panels – speeches as well as the Q&A session.
- 2) The second part, which explains the overall purpose of each of the three Special Panels, the identification of the moderators and the panelists. It also provides notable quotes from various speeches of the three Panels and the recommendation of the future work required to carry on this mission which we believe is very important for the future of the Weather Enterprise as well as for creating a “Weather Ready Globe”.
- 3) The third part consists of three Annexes providing the transcripts of all speeches as well as the Q&A session of each of the three Panels.



PART I:

**EXECUTIVE SUMMARY OF THE THREE SPECIAL
PANELS ON
FUTURE OF THE WEATHER ENTERPRISE
(WWOSC-2014)**



EXECUTIVE SUMMARY

An Open Science Conference was organized by WMO in Montreal in August 2014 in which three special Panels sponsored by the Canadian Meteorological and Oceanographic Society and the American Meteorological Society were organized to discuss the “Future of the Weather Enterprise” for the Public Good. The global framework of climate services identified four priority areas: Health, water, food security and disaster risk reduction.

Recognized leaders in the international Weather Enterprise from all sectors participated in these panels and presented their views. The presentations were followed by a Q&A session after each of the three panels.

The panelists raised a number of common messages that reinforce the importance of collaboration within the Weather Enterprise:

- The Weather Enterprise has been traditionally defined as consisting of the Public, the Private and the Academic sectors. During the Panel discussions, two additional entities were recommended: Non-Governmental Organizations (NGO’s), such as the University Corporation for Atmospheric Research (UCAR) and National Meteorological Societies, such as American Meteorological Society, Canadian Meteorological and Oceanographic Society, etc. The National Societies can act as a “glue” between the other sectors because of their neutrality. AMS plays a very important role among the three sectors in the US and mediates disputed areas. Other National Meteorological Societies can learn from their experience.
- Partnership is not only important between the five sectors but also with the end users – the customer. It was also stated that it is important to open ourselves up to be user driven and needs driven, not so much by the capability that we have as a science but rather in addressing what society needs and what the end user needs.
- Sound international cooperation continues to strengthen across the Weather Enterprise - a success story for which the World Meteorological Organization (WMO) has been playing a very critical role in developing the building blocks of the global weather enterprise – be it the Global Observing System, the Global Telecommunication System, Regional Forecasting Centres, World Meteorological Centres, the World Weather Research Program, and, recently the Global Framework for Climate Services and several others.
- The improvements and the progress that have occurred over the past few decades have made a tremendous contribution to society and the preservation of life on our planet. People who did not know that a flood could wipe out their village in the next two hours now - given the growth of science in weather services - have the potential to know two days in advance to take precautions, greatly reducing loss of life, preventing property damage and avoiding unnecessary government and private expenses.
- The focus of the future evolution of the Weather Enterprise must not be the constraints of the past and present but possibilities of the future. Partnering among the sectors of the

Weather Enterprise should be looked upon in itself as a public good. The world is looking at this community to continue progress over the coming years and decades; especially in the face of what is a changing environment; the need for much more collaboration among the different sectors and countries was echoed by many panelists and attendees.

- The importance of open source for software was stressed. Most of the progress happening today in Silicon Valley is because of the use of open source software; it is shared and people build on each other's work. This type of strategy fosters science and computing science and can greatly benefit the Weather Enterprise.

The important role of data as a foundation for all weather services was a key outcome of the discussion. Addressing the challenges of Least Developed Countries – was identified as a priority:

- The contribution of the members of the Hydro-Meteorological **Equipment** Industry (HMEI) was recognized as a very important component of the Weather Enterprise.
- Since data constitutes the backbone of all services, it needs to be as freely available as possible. After a period of disagreement between the Public and Private Sectors, the U.S, Canada and Norway have realized the importance and benefit of availability of freely available data collected by their National Meteorological Services. The consensus was that this example should be followed by other countries too because free availability of weather data has been proven to be a critical component of the success of the Weather Enterprise.
- Another issue which was highlighted was that we are getting only a small subset of the data actually available today. Efforts need to be made to share data more broadly and to use as much of the available data as possible to get the maximum benefit from the information contained therein.
- Network of Networks is the concept under which a great amount of optimization in cost and efficiency can be achieved. Each country should exploit that idea to achieve maximum coverage and efficiency. This also raises a need for standards, standardized and open access to observations and government services.
- In the Least Developed Countries (LDCs), of course, there is hardly any Private Sector and even the Government Sector is not very experienced; a great deal of capacity building and assistance is needed through various organizations such as the WMO itself and International Aid Programs from World Bank, US Aid, CIDA, European Agencies, etc. Building infrastructure in these countries is very important because we see that nearly 2/3rd of the world does not have the infrastructure required to produce good forecasts. Although a lot of data can be obtained from satellites, ground-based observations are a very important part of input to NWP models.
- The WMO Resolution 40 which was passed in 1995 was cited as an impediment to development of the future weather enterprise and it was agreed that it needs to be

reviewed. Panelists recommended that these discussions be started as soon as possible. However, any revisions to WMO Resolution 40 must be cognizant of the fact that the weather enterprise consists of countries which are at different states of economic, social, political and scientific level, i.e. this enterprise is not homogeneous and hence there cannot be any “one size fits all” solution.

- With the exception of some gaps especially in the boundary layer, the Developed Countries and some Developing Countries largely have good observational capability. There is a huge swath of the planet that has little or no observation capabilities to be able to produce high quality forecasts and warnings. WMO and some Private Sector companies – Earth Networks cited its Local Data Network in Guinea as an example – are trying to fill that gap but it is a daunting task, because once the implementation agency has completed its portion of a project (especially in the case of Public sector implementation), the infrastructure often is not maintained and becomes non-functioning. In the case of private sector companies, the uncertainties related to the safety of their investment and the return on it hamper sustainability. The optimum solution can come through Public and Private (International/National) collaboration. It was suggested that some kind of fund needs to be created to ensure that firstly assistance is provided to LDCs for creating infrastructure and secondly, some type of Insurance is provided to the private sector foreign investors to safeguard their investment.
- In addition, local capacity building in these countries must be taken up with a much higher priority – and with a greater sense of urgency. Training is critical but an expensive undertaking especially follow-on training that is needed after the initial training. Computer-Based Training (CBT) is a possible option to keep costs affordable and should be given a high priority.
- It was stated that the Private Sector is ready to take a risk by investing in technology, observations, products and services in advance that the public sector partners should take advantage of. The data from existing private infrastructure should be leveraged before the Public Sector invests in new data. In order to make such a proposition viable, some thinking is required to ensure that National Meteorological Services are not left with critical data gaps if the private sector company or companies providing such services decide to withdraw them, e.g. for insufficient return. In addition, how this fits into the paradigm of data being freely available needs to be considered.
- It was pointed out that our science and our ability to observe the earth has run ahead of super computing power that we have available to make that science and observations worthy to scientists and hence to the society at large. Hence, there is an acute need for more super computing power if we truly wish to realize the enormous potential of collected data.
- A lot can be done about in-situ observations from surface-based observation systems, however, one of the great challenges is how we observe the oceans. It was suggested that the investment in space-based infrastructure and ground-based infrastructure needs to be optimized – e.g., more observations are required to cover the ocean.



- Remote sensing is key to weather forecasting. Three key points related to remote sensing were highlighted:
 - 1) Weather satellites continue to be critical to weather forecasting; next generation of capability is coming on-line and has much promise and improvements.
 - 2) Concerns about potential gaps and significant reduction in overall coverage, cost, and schedule overruns issues are on the forefront.
 - 3) Maybe there is an opportunity for new business models, new ways of thinking and providing data and information but who pays for data that is freely exchanged will continue to be a challenge. This needs to be kept in mind in discussing any such solution.
- Private companies feel that there is a lot of investment available from the private sector to fill the gap. Therefore, a cooperative effort between the Public and Private Sectors to develop infrastructure might be the solution. However, there is a reluctance from some in the Public Sector to involve the Private Sector in the provision of infrastructure. But the stories of the same kind of reluctance were narrated by Panelists in the case of communications satellites and mapping satellites; both of which now enjoy a strong private sector involvement.

Ultimately, decision-making for protection of life and property depends on an effective service delivery model that builds on the complementary strengths of all of the components of the Weather Enterprise:

- There are National Meteorological Services in some Developed Countries which have their own affiliated Private Sector businesses that exploit the forecast and prediction that the NMHS produces. Since the Weather Enterprise of the future will be borderless, this factor could have a negative impact on the Private Sector in those countries because of an unlevelled field; hence these countries should keep this aspect in mind.
- Whereas forecasting and warning of severe weather conditions must stay the responsibility of National Weather Services, the customized weather products which are business, time and location specific for various business sectors should be handled by Private Sector companies where feasible. All countries should be encouraged to support their private sector, therein lies the future of the Weather Enterprise.
- Regarding distribution of weather information, it was stated that Internet, mobile phones, and tablets have become major means of accessing weather data and companies like AccuWeather, The Weather Companies (TWC), etc. are reaching billions of people through this media. It was stated that whereas at one time 94% of users got their weather information from National Weather Services, today because of these new mobile technologies and the Private Sector's capability to produce quality forecasts, the trend is reversed – 94% of the weather information is accessed through Private Sector companies which have worldwide reach.



- Today people expect weather information to be real time, hyper local with social connections because mobile devices provide 2-way connectivity. The Private Sector is quite suited to fulfill that requirement in collaboration with the Public Sector.
- The progress since the 1970s has been truly remarkable and the scale of enterprise needed to provide the level of forecast skill and reach the public, businesses and government is extremely challenging. The amount of observations collected around the world is ever increasing. Therefore, the challenge of actually taking observations and using them in forecasting cannot be under-estimated. If the Weather Enterprise truly wishes science to do what is expected from it in the coming years, it must work in partnership because the scale of the enterprise as well as the sophistication and complexity of the technologies required are no longer something that a single organization or even a single country can sustain.
- A few years ago, conversations between National Met Services and the super-computing community resulted in enhanced computing capability services that they have offered to Centres like the ECMWF and others running weather models. This simple business model change was from buying hardware to buying a service. The question then is, is that possible for data? Can data be provided as a service instead of buying systems from vendors? NMHSs could buy data from systems installed by the private sector. As already stated, the trend has already been started by some companies, at least in the US.
- Other continents can also learn from the experience of Europe (where EUMETSAT and ECMWF have led the collaboration concept) and North America where data and infrastructure are being opened up. In addition, it was asked whether, in today's connected world, large infrastructure including super-computing to run weather models is needed in every country. Can fewer but higher quality models achieve better results irrespective of where they originated from? Weather sees no boundaries, hence are there enterprise collaboration strategies and options that can reduce costs and improve service to society?
- One of the most successful collaborations between the public and the private sector was created when ICAO and WMO collaborated in creating the World Area Forecast Service (WAFS). Under this collaboration, the UK Met Office and NWS USA produce and broadcast quality aviation weather forecasts and Private Sector companies provide the reception and processing equipment. This has greatly benefitted the entire world community.
- UCAR is a great example of collaboration between Academic Sector, Public Sector and Private Sector and has been able to enhance the R&D through NCAR and training through the COMET Program. UCAR also acts as an incubator for many new companies. On the other side, NOAA states that its policy is to unite inventors and US companies in mutually productive business relationships to maximize the benefits of public money to the society. These are examples of R&D collaboration between three operational sectors and are worth looking into by other countries.



A sustainable Weather Enterprise will depend on an effective workforce:

- Changing work environment and roles raise an issue about training of undergraduates. Should WMO facilitate a review, perhaps in partnership with international meteorological societies of the meteorologist course requirements? What is a core requirement to be a meteorologist? That is an issue Universities are facing right now and it needs to be resolved.
- There is a need to attract additional talent by more strongly involving the younger generation – including many with skills in information technologies. The collaborative model of Silicon Valley and usage of the talent of some of its stalwarts can help the Weather Enterprise resolve many issues it might not be able to resolve by itself.
- For commercialization of R&D to get the maximum value, the private sector is most suitable and this idea should be followed by all countries.
- It was also stressed that procurement by various government organizations needs to be based on validated requirements and proper clear specifications to avoid purchasing the wrong equipment which has been a problem in many procurements. In other cases, the purchasing issues and vested interests hamper the progress of infrastructure and vast amounts of authorized money is allowed to lapse because of these issues. In addition, in many cases the maintenance and life cycle management issues can also adversely impact the infrastructure.
- Getting access and sharing the values that the whole community brings to the table will provide a synergistic benefit which will make the Weather Enterprise stronger, better and more relevant to everyone we serve.

The common theme of the Panels was Public Good.



PART II:

SUMMARY REPORT OF THE THREE SPECIAL

JOINT PANELS ON

FUTURE OF THE WEATHER ENTERPRISE

(WWOSC-2014)



1 Introduction

This Part of the Report provides a summary of the panel discussions and recommendations for the next steps. It first describes the mandate of each of the three panels and identifies the moderators and panelists.

2 Description of the Panels

The special joint session on the “Future of the Weather Enterprise Infrastructure” was a series of three complementary panel sessions designed to advance dialogue on the collaboration of private, public and academic elements of the weather enterprise. The first two explored important issues and problems related to infrastructure and services while the final panel, Enhancing Weather Community Collaboration, was oriented towards finding solutions.

The term, “**Weather Enterprise**” is intended to comprise all of the components that enable a benefit to society at large. Generally, three main sectors are considered to make up the Weather Enterprise: the Public sector (government), the Private sector (also referred to as the weather industry), and the Academic (or research) sector. However, in planning for the panel discussions, the organizing committee recognized that non-profit organizations (such as the University Corporation for Atmospheric Research (UCAR) in the USA) and professional societies (such as the Canadian Meteorological and Oceanographic Society and the American Meteorological Society) are also important components of the Weather Enterprise. In addition, the users – the clients we are supposed to serve – is also a part of this enterprise.

In assembling the panels, the organizing committee attempted to ensure both sector and geographic diversity; approximately 40 recognized leaders in the international Weather Enterprise were canvassed for availability and willingness to participate. Eighteen accepted invitations and represented the Enterprise on the panels.

Panel 1: Weather Services Infrastructure: Sustaining What we Have and Building for Tomorrow

For this panel, infrastructure was defined as anything necessary to design, develop and deliver products and services. It includes weather and climate observations, models and numerical weather prediction, and the applications required for specific customer decision-making needs. It also includes the underlying information technologies (data processing, visualization, communications) as well as the education, training, and management of people - weather service providers, R&D scientists, and, especially, clients and users.

Panelists were asked to consider the gaps and weaknesses in present infrastructure that limit achieving the full potential of weather services, and what infrastructure improvements are needed to increase the value of weather services to society.

PANEL 1: Weather Services Infrastructure



David Parsons - Moderator
Director
University of Oklahoma School of Meteorology



Krystin Lyng
Legal Counsel -
Norwegian Met Service



Bob Marshall
CEO – Earth Networks USA



Anne Miglarese
President,
Planet IQ, USA



Julia Slingo
Chief Scientist
UK Met Office



Ajit Tyagi
Retd. DGM IMD, India
VP IMS



Eric Webster
VP and Director Env. Services ITT
Exelis Geospatial Systems USA

Panel 2: Weather Services – Present Status, Trends, and Innovations

For this panel, Weather Services were defined as the research and development, production, delivery, and evaluation of weather, water and climate information and knowledge to support customer decision-making. Customers were broadly defined to include agencies, organizations and enterprises from government, non-government, public sector, private industry, and academia. The discussion was intended to focus on today's weather services: the strengths, the weaknesses, and the gaps. Panelists were asked where weather services are meeting the customer need, where they are not, and where is the greatest need for improvement. Discussions also focused on how collaboration could accelerate exploitation of improved service capabilities by developing and least developed countries worldwide.

PANEL 2: Weather Services



Jim Abraham - Moderator
Retd. Director General of Monitoring
Environment Canada



Mike Eilts
CEO –Weather Decision
Tech. USA



David Grimes
President – WMO
ADM – EC-MSC



David Kenny
CEO – The Weather
Channel, USA



Hans Joachim Koppert
Head Business
Deutscher Wetter Dienst
Germany



Barry Myers
CEO – Accuweather
USA



Roland Stull
Univ. of British Columbia,
Canada

Panel 3: Enhancing Weather Community Collaboration to Meet Shared Goals for the Weather Enterprise

The final joint panel, *Enhancing Weather Community Collaboration*, was intended to advance dialogue on the collaboration of private, public and academic elements of the weather enterprise. The panel discussion was intended to consider ideas where better collaboration is needed to improve infrastructure and services. Panelists were asked what areas offer the most collaboration potential for producing measurable service improvement, and what factors prevent or inhibit collaboration. Furthermore, panelists were asked to suggest the next steps that would start the weather community down this path.

PANEL 3 Enhancing Weather Community Collaboration



Jack Hayes - Moderator
VP – Harris Corporation, USA



Harinder Ahluwalia
President CMOS (Canada)



Tom Bogdan
President – UCAR USA



Brian Day
President HMEI
Canada



Bill Gail
President – AMS



Jerry Lengoasa
WMO –
Deputy Secretary General



Louis Uccellini
Director NWS, USA

3 Outcomes

In this section, key observations and solutions are identified – most reflecting a consensus of panelist statements and ensuing discussion. Outcomes are grouped into six sections: General – statements which apply across the board; Data; Weather Services; Human Resources; Moving Forward; and Next Steps.

3.1 General

- 1) Weather patterns in a naturally variable and changing climate will put new pressures on society. There is a sense of urgency for the required services from the future weather enterprise to ensure safety of life and livelihoods by building on today's successes.
- 2) The weather enterprise of the future will require Earth Systems thinkers and actors. Training and academic program need to change to handle this new 'seamless observations' and 'seamless prediction' to 'seamless services'. Early career scientists need encouragement and incentives to think and act in a multi-disciplinary fashion.
- 3) The Weather Enterprise is not a uniform homogenous global entity. Wide disparity exists between developed and Least Developed Countries (LDCs) with respect to the capacity/infrastructure of National Meteorological and Hydrological Services, quality of academic institutions and presence of a private sector. The roles of different components of the Weather Enterprise will, therefore, vary from country to country.
- 4) Traditionally, the Weather Enterprise has been considered as being composed of the Public, Private and Academic (or Research) Sectors. There are three other entities which are important contributors to this enterprise:
- 5) A fourth sector needs to be added: In addition to government, industry, Academia, not-for-profit foundations are currently also playing a very large part. These four groups need to work as a team.
 - a) Scientific and professional societies can act as an intermediary between the sectors, smoothing and enhancing the interactions to the benefit of the enterprise. In the US, the American Meteorological Society (AMS) played a central role in developing today's close sector collaboration. The enterprises of different nations and regions vary in their needs, but societies play an important role in enterprise evolution.
 - b) User sectors, for example, agriculture, water, health, energy, disaster management and others, should also be considered part of the Weather Enterprise. They provide keen insights on gaps in products and services that impact decision-making.
- 6) International cooperation has been the hallmark of the world meteorological community. It is based on the realization that weather and climate do not follow political boundaries. The WMO has played a key role in building international cooperation in the fields of global observations (World Weather Watch), communication (Global Telecommunications System, WMO Information System, etc.), data processing and

forecasting (World Meteorological Centers, Global Data Processing Centers, Regional Specialized Meteorological Centers, etc.), services through Regional Climate Services and the Global Framework for Climate Services, promoting research (WWCP, WWRP) and conducting field programs (GARP, THORPEX etc.). The Weather Enterprise should build on governing principles of WMO.

- 7) The Private Sector has emerged as an important part of the Weather Enterprise. It has been swift in adopting new technologies, establishing specialized networks and providing value added services. Its expertise, experience and innovation should be harnessed to strengthen the Weather Enterprise. Observational Networks established by the private sector need to be integrated with national networks. A public – private partnership in the provision of specialized services, such as high power computing, data management, communication facilities and maintenance of observing systems should be encouraged. Since the presence of the private sector and its expertise is not uniform across countries, a calibrated, cautious approach is required in promoting the private sector in LDCs.
- 8) Academic and research institutions have contributed immensely to human resource development, better understanding of the science of meteorology and developing new technologies. Public and Private sectors should work towards strengthening academic and research institutions and promoting robust research. Academic institutions in developed countries should develop partnerships with academic institutions in developing and least developed countries to improve the quality of meteorological education and training in these countries.

3.2 Data

- 1) Sustenance of a high quality global observational network (surface, upper air, ocean, satellite) is an absolute necessity for the success of the Weather Enterprise. National governments are primarily responsible in operating and sustaining basic observational networks in their countries. However, there are many countries where the state of the observational network is far from satisfactory. The Weather Enterprise in partnership with WMO should work towards supporting these countries in establishing and sustaining a basic meteorological observational network. For this, efforts may be made by the Weather Enterprise to raise funds from donor/lending organizations (e.g., Climate Change Green Fund, World Bank and other regional development agencies).
- 2) High-quality weather, hydrological and climate information is the foundation for the weather and climate enterprise. Looking to the future, all need to support the two main goals established by WMO's Commission of Instruments and Methods of Observations:
 - a) Promote high-quality information
 - b) Develop worldwide compatibility to ensure worldwide comparability
 - (i) Use the WMO Commission for Instrumentation and Measurement Operations (CIMO) Guide to generate Specifications and Standards



- (ii) Carry out routine maintenance and life-cycle management – including worldwide training on measurement systems
 - (iii) Ensure sustainable funding to maintain worldwide programs
- 3) It is important that all data be made available to all sectors – ideally, free of charge. This is the case in some advanced countries (with limited exception of some data) but not in developing and least developed nations. Since meteorological data is a very important resource both for researchers as well as service providers, its open availability in all countries is essential for the advancement of the Weather Enterprise.
- 4) Due to the limited availability of funds, even advanced countries have limitations to enhance their infrastructure. Here again the private sector could install networks, provided that the National Weather Service guarantees the purchase of data. This relieves the NWSs from implementing and maintaining complex systems, the costs are reduced (because data can be sold to other large users) and it is generally easier for departments to get O&M money as compared to capital money.
- 5) International cooperation in augmenting and sustaining the oceanic observing system needs to be promoted by the Weather Enterprise.
- 6) Weather satellites form a key component of the global observing system. Their sustenance should be a top priority of the Weather Enterprise. Some countries are facing budget challenges in sustaining their weather satellite programs. The Weather Enterprise needs to provide a unified voice supporting continued governmental funding for satellite programs in these countries. The Weather Enterprise should also support WMO's Satellite program and other international satellite partnership programs fostering global partnerships. Participation of the private sector in this initiative is important.
- 7) Weather satellites continue to be critical to weather forecasting; the next generation of capability is coming on-line and has much promise and improvements. Concerns about potential gaps and significant reduction in overall coverage, cost and schedule issues are on forefront within the US and other countries. There may be opportunities for new business models, new ways of thinking and providing data and information but it may conflict with the desire by Met agencies for free and open access information.
- 8) Quality data drives effective decision-making. Most of the panelists and participants supported an Open Data policy, certainly by governments whose taxpayer funded programs are intended to benefit society. As well, data collected by the private sector and by academia must be shared in a strategic way such that societal benefit, especially public safety and security, is not compromised. For example, funding agencies, supported by government funding, should have an open-data sharing policy, and researchers should be recognized for the data that they collect and share. In the case of the private sector, where data may be considered proprietary, strategies and policies need to be developed and encouraged to maximize the benefit of the data, by ensuring it is available for research and other non-profit use. Governments have a role in enabling this outcome.



- 9) Data policies have helped the global community exchange critical information for development of the enterprise. It is time to review some of them or create new enabling policies for further improvement and advancement in the weather enterprise (including open-source policies).
- 10) Many changes have occurred since WMO Resolution 40 was passed in the 1990s. Science and technology have provided new capabilities (sensors, models, etc.) and exploitation is slow due to a variety of factors – not the least of which are government policies and budgets. A forward-looking re-examination of this resolution and its related Resolution 25 related to hydrology is needed.
- 11) Data is a key requirement for the weather enterprise to succeed. Data acquisition (from space-based and surface-based in situ or remote) technologies has been a constant challenge for the enterprise for a long time. The trade in observation systems technologies has seen the gap between developed and developing countries continue to grow and has also seen various initiatives being developed to address the challenge from organizations of Ministers (African Ministerial Conference on Meteorology – AMCOMET) to new programs, e.g. GEOSS. It is time to revisit the current data acquisition model and develop a 'data-as-a service' business model. Would this provide relief for governments to focus on service development and improvement?

3.3 Weather Services

- 1) The National Meteorological Services are expected to provide weather forecasts and warnings. Venue-specific and business-specific Forecasts and Nowcasts can be best handled by Private Weather Service companies.
- 2) The map of the world with a 24 hour capture of the location of electronic requests to one private sector Weather Company shows that we have a global weather community today. And all of this information is being made available to the world's citizens for free. It shows that over 1.5 billion people have access to private sector weather information and they are not paying for it. This is a clear example of how private sector contributions can benefit society and motivates public-private sector collaboration.
- 3) Public access to weather on mobile devices is the global norm. And the people who are getting this information are also not paying for it. Nor are they paying for patent license fees for the use of location-based technology and other weather reporting technology. It was mentioned that the major weather companies may have reached one billion USD in annual revenue from the performance of these services. But there are billions more being generated by companies building mobile devices that bring these wonderful weather services to the world and by electronic transmission service providers also generating revenue and taxes throughout the world by delivering these weather services.
- 4) The weather enterprise is alive and well and serving the global population needs in ways never envisioned 20 years ago. Information wants to be free and technology is letting it loose on the world. And, billions more of the world's people will have access to vital, lifesaving weather information in the coming few years. People who did not know if a flood would wipe out their village two hours from now, will know two days in advance to



evacuate. Lives will be saved, property will be salvaged, and government expenditures will be conserved. Partnering between government and the weather industry is a good public service.

- 5) Academia's traditional place in the Weather Enterprise is: Educate future employees of the Enterprise; and, Research the atmosphere and find new ways of **making, tailoring & delivering** weather & climate forecasts. However, there are trends by some Universities to: **Make** daily operational ensemble NWP forecasts; **tailor** NWP output to client needs; **deliver** products via the Internet; and, spin-off private companies. Such trends are enabled by: Community NWP & Climate **models**; Initial Conditions & Boundary Conditions (timely & free): GFS, NAM, GEM, NAEFS, other; inexpensive **cluster computers**. **Limited focus**: domains, products.
- 6) Academia makes operational forecasts to: Develop (and sell) innovative forecast products/services; generate revenue; purchase resources (computers, salaries); enhance research capability; and devise new forecast capabilities.
- 7) One panelist presented his comparison of merits of Enterprise Sectors (rank ordered "best" to "worst": P= Private Sector; A=Academia; G=Government):
 - Responsiveness: P – A – G
 - Creation of new foundational capabilities: G – A – P
 - Tailoring of display/product: P – A – G
 - Longevity: G – A – P
 - Innovation: A/G – P
- 8) General trends observed in the weather enterprise:
 - Humans evolving from forecasters to interpreters – should WMO and professional societies change the meteorology course requirements?
 - Data: In the cloud
 - Crowd sourcing: Widening variety of data input (cell phones, lightning sensors, smart electric meters); Distributed computational processing
 - Pseudo monopolies: Global private sector; national (government weather services)
 - Backlash against monopolies and data restrictions
 - Less than optimal improvement progress due to data restrictions
- 9) Road blocks inhibiting collaboration and ultimate slowing improved products and services to society:
 - Parochialism – weather maps stop at borders
 - Nationalism – preference for nationally produced forecasts over better international forecasts
 - Tariffs – extra fees across borders
 - Mindset of national forecast centers on who "could/should" do operational forecasting



- Underbidding by national forecast centers
- Inability of public to differentiate between good forecasts and pretty forecasts
- The “cloud” vs privacy
- Lethargy to innovation

3.4 Human Resources

- 1) A number of panelists discussed the importance of considering the people dimension of the Weather Enterprise. Certainly, advancement and sustainability will require a strategy to ensure sufficient high quality personnel are available and retained in the enterprise.
- 2) It is recognized that the skill-set requirements are changing substantially, with multi- and interdisciplinary talent being required that covers the broad aspects of the physical, chemical, biological and social sciences. Employers and agencies that establish professional standards and policies, including the WMO, need to consider the evolving change in competencies required for the diverse roles within the weather enterprise.
- 3) Components of the weather enterprise should promote the growth and development of their personnel by encouraging mobility and developing exchange within components of the enterprise.

3.5 Moving Forward

- 1) Creating a '**global weather and climate ready society**' is a pressing challenge of our time. All sectors (academic, private and government) have a role to play and the WMO is well placed to play a global coordinating role in making the endeavor a success.
- 2) The public sector has strengths in terms of stability and wide reach; the private sector has strengths in terms of efficiency, swiftness and niche specialization. Both working in a collaborative mode can contribute to the improvement of weather and climate services. The Weather Enterprise should create a mechanism for consultation at the national level between public and private sectors to identify areas of synergetic collaboration.
- 3) Building collaboration in the US:
 - a) The US National Academy of Sciences report, “Fair Weather”, played a seminal role in making changes in the positive collaboration among the three sectors happen. It recognized that some level of tension is inevitable but an acceptable price to pay for the excellent array of weather products and services in the US. It made a number of important observations relevant to enterprise development anywhere in the world and could provide useful insights for building collaboration elsewhere.
 - b) Experience building a more collaborative environment: Drawing distinct boundaries between what the sectors should and should not do in providing products and services did not work in the US. Rather, progress occurred when it was recognized that there are grey areas requiring discussion and negotiation –



and mutual appreciation and respect for the roles of each sector that benefit the entire enterprise.

- 4) Building collaboration internationally will require executive-level involvement, patience and persistence. Expectations need to be kept in check. Small steps forward in which intersections of interest are explored that benefit society and the enterprise as a whole will result in progress.
- 5) The Weather Enterprise should consider an enterprise vision statement and guiding principles. Public good in terms of safety and well-being of citizens, sustainable economic development, and promoting advancement of research should form a basis of the vision statement.
- 6) The Enterprise vision should build off a unique aspect of what we do: “Predict” as the weather and climate enterprise expands into the water domain. These expanded capabilities could also be applied to food security (agriculture), infrastructure (especially along coasts), energy security and health – areas that are likely to dominate the landscape and successful collaboration among all sectors will be necessary to realize the full potential of the enterprise.
- 7) The combination of a sluggish economy with declines in government spending have had dramatically adverse impacts on the weather enterprise. At the same time, decaying and neglected infrastructure and tendency to cut costs and build everything right to the margins increases society’s vulnerability to losses from extreme weather events. It is imperative that public, commercial, academic and foundation/NGO sectors work together to seek a common ground, as well as develop an understanding and commitment to distinct individual roles and responsibilities.
- 8) Sectors should contribute what they are best at. And, the survival of the weather enterprise should be a higher priority than the success of any single entity or individual. We owe this collectively to the next generation.
- 9) Together, the sectors must determine what is freely available, what is subsidized, what is an entitlement and what is simply just nice to have. This must be done with the understanding that if we do not prioritize and reallocate resources within our enterprise ourselves, others will take those resources and send them elsewhere. If not now, when? If not us, who?
- 10) Today's undergrads, grad students, postdocs and early career professionals deserve the same opportunities that we were afforded by our predecessors. It is up to us to honor that commitment.
- 11) Since many advanced countries run global models, the lack of quality data from LDCs and many developing countries affects the accuracy of Global Models. There are two ways for providing infrastructure for the LDCs. One way is to provide the required funds through the World Bank and various aid programs implemented by advanced countries (e.g. USAID by the US Government, CIDA by the Canadian Government, etc.) and through WMO. Another way is to let Private Sector companies from developed countries install the infrastructure in LDCs but some reliable entity such as WMO, WB, etc. provides

- a guarantee of the investment and return. An example of such a project is the Earth Networks Early Warning System implemented in Guinea.
- 12) In many cases the problem in improving infrastructure in developing countries is due to contracting procedures which are very cumbersome and delay projects by multiple years, hence depriving them the opportunity to enhance their infrastructure. These countries need to greatly improve their contracting procedures.
 - 13) Capacity building through investment in infrastructure and training in LDCs is crucial for “The Future of the Weather Enterprise”.
 - 14) One of the best examples of collaboration between the Public Sector and Private Sector is the World Area Forecast Service (**WAFS**) system of ICAO, developed and operated in collaboration with WMO. Under this project, the two World Area Forecast Centers (**WAFCs**), one in Exeter, UK and the other in Silver Spring, Maryland, USA, run Global Models and also produce weather charts for usage by aviation. They also receive significant weather charts from various countries, as well as produce their own. They distribute all these aviation products through two systems, SADIS (Satellite Distribution of Aviation Weather) and ISCS (International Satellite Communication System) implemented by the UK Met Office and NWS, USA, respectively. Over the last couple of years, the weather products have been increasingly distributed by them through the Internet. All countries have access to this data through these networks and the Processing System available from private vendors.
 - 15) Engagement of the end-user in the development of the services, to make them relevant, applicable and have utility is needed to ensure the future weather enterprise remains relevant for decision-making. Given the diversity of end-users and their needs, this active engagement will open up new ways of thinking, new models, new volumes of data, applications, etc. The enterprise should be ready for this growth.

Fundamentally, the Special Panel emphasized the importance of collaboration and partnership within the enterprise, as well as outside with key stakeholders. The rapid growth and costs of technology and the associated enormous amounts of data being generated, makes it difficult, if not impossible, for agencies to fund the infrastructure required to meet societal needs.

The continued rapid increase in the frequency and costs associated with weather-related disasters requires a thorough understanding of the changes in risk and vulnerability, as well as the environmental change. It is imperative that there is a close partnership with weather-sensitive sectors, such as emergency management, health, energy, agriculture and transportation.

Given the unique challenges in developing and least-developed countries, a priority should be given to strategies to enable the people of these areas to benefit from the evolution of the global weather enterprise.

Effective communication is fundamental to achieving societal benefits. Partnerships with the media, providers and developers of mobile and other communications technology will enhance the likelihood of timely information and applications being effectively used.



We should look at existing collaboration models that work (e.g. UCAR, ICAO-WMO Collaboration for WAFS), and modify others to make them even better (e.g. HMEI).

3.6 Summary and Next Steps

The three Panel discussions involving experts from the five sectors of the Weather Enterprise (Public, Private, Academic, NGO and Meteorological Societies) resulted in collecting a wealth of ideas from different perspectives of panelists. Collective wisdom contained in this report provides a potential “way ahead” for the Weather Enterprise.

Given the scope of the challenges and opportunities within the weather enterprise, the WMO is encouraged to engage an advisory group to assist in the analysis of the suggestions contained herein and come up with a prioritized list of recommendations and time frames required to move forward effectively. We believe that we owe it to the society at large and to all those who are making great contributions for a Weather Ready World.