Report of Mission to Beijing, China, 30 Oct to 7 Nov 2017
Liisa Jalkanen

I was invited by WMO as an expert in urban issues to attend the following meetings and undertake visits, held at the China Meteorological Administration (CMA), in Beijing, China:

A. Joint Meeting of the Commission for Basic Systems (CBS) Open Programme Area Group (OPAG) on Public Weather Services (PWS) Expert Team on Services and Products Improvement and Innovation (ET/SPII) and the PWS Expert Team on Impact of Multi-Hazard Prediction and Communication (ET/IMPACT), 30 Oct to 2 Nov 2017
B. Meeting of the CBS/OPAG-PWS Implementation/Coordination Team on PWS (CBS/OPAG-PWS ICT/PWS)
C. Visit to the Beijing Meteorological Observatory and Institute of Urban Meteorology, 6 Nov 2017
D. Visit to the Public Meteorological Service Centre, 7 Nov 2017.

All presentations made at the above events are available from me.

Part 1. Meetings

This report focuses on matters relevant to urban aspects, the Secretariat is preparing an actual report of the meetings.

A. Joint meeting of ET SPII and IMPACT

I had been invited to attend the meeting in order to brief the ET-SPII and ET-IMPACT on urban issues related to WMO activities and plans, as a basis for the expert teams' consideration of the inclusion of urban matters in their work.

During the opening and introductory presentations and remarks by Prof Meiyan Jiao (CMA), Gerald Fleming (ICT/PWS Chair), Eli Jacks (ET/IMPACT Chair), Will Lang (ET/SPII Chair) and Miriam Andrioli (C/SDD), following points were made, amongst others:

- The meeting will feed into the preparation for the CBS session to be held in the spring 2018, where Service Delivery Strategy (SDS) is to be promoted
- The CBS session will feed into the May 2018 Executive Council (EC) and further to the WMO Congress (Cg) in 2019, where the plans for the next 4 year period will be approved; thus it is necessary to think here 5-6 y ahead in time
- Need to consider how GMAS is to be taken into account in PWS
- The importance of Impact Based Forecasting (IBF) (most of the persons present are working on this), how to implement IBF globally and especially in developing countries
- The importance of the WMO Report No 1150 "WMO Guidelines on Multi-hazard Impact-based Forecast and Warning Services", and the fact that it is being used, came up over and over again during the meeting: the thinking has changed from "what the weather will be" to "what the weather will do" (i.e., its impact). In this context vulnerability and exposure are key concepts, on which the overall risk to a hazard is based. It was noted that the evaluation/verification/validation of IBF is difficult.
- A forecast should trigger action that will give (a) benefit(s)
- The forecaster needs to have much wider knowledge and understanding for IBF than for traditional weather forecasts
- The techniques of IBF need still development

- There is the need to collect impact based data, which is new type of data for the WMO community; exposure etc. data difficult to get for various reasons
- One of WMO challenges is the seamless concept between weather and climate scales; how is this service to be delivered?
- Considering urbanization, we will need to work with new partners, which may not be straightforward
- It was noted that IBF could possibly be enhanced /brought forward through regional workshops, such as was taking place the week of 6 Nov in Republic of Korea.

After introductory talks, the members of both expert teams gave presentations on their and their services' activities, during the first two days. Included was also my presentation on urban issues related to the WMO activities and plans, the summary is provided in *Annex 1*.

The presentations given by the ET/IMPACT and ET/SPII members are summarized in the meeting report that is in preparation by the Secretariat. In *Annex 2* I have compiled the points from each presentation that relate to, or could be applied to, urban issues. Annex 2 can serve as a basis for developing a list of best urban practices and case studies. Regarding the countries in Annex 2, especially Australia, Canada, China (including Hong Kong), France, Japan, New Zealand and USA would be useful to be approached for further details on urban activities. Argentina could provide more information on the concept of the Meteorology and Society department. UK should also be approached. In addition to the information provided in the Annex, it is to be noted that Volcanic Ash Advisory Centres (VAACs), located in New Zealand and Argentina, amongst others, are also useful for informing urban areas of the onset of volcanic ash plumes, which can cause disruption including to air traffic, with most airports located in, or in the close surroundings of, cities. As discussed at the meetings, it would be best to make a survey of all WMO Members regarding their urban services.

Common Interface for Service Delivery by video with Jeremy Tandy; discussion.
For this Common Interface, it needs to be considered how urban services would be included. At the end of the meeting, CMA gave a presentation on the CISD. Gerald Fleming noted that for the meeting participants, the task is not to think of technical aspects but to think of the users.

Weather Ready Nations (WRNs) by video
The presentation included a list of steps on how to set up the project, list of challenges; collaboration between NMHS and DRR managers. There was discussion on the role of RAs and requirements. This setting up the project - information could be helpful in piloting urban services.

President of CBS
Michel Jean, President of CBS, addressed the meeting by video on 2 Nov. He discussed the Common Interface for Service Delivery (CISD) and urban services, amongst other issues. He noted that moving to higher resolution and longer time frames in weather prediction is a real possibility to do services for cities. In this area, ocean and marine hazards need to be included. Urban areas are very concentrated areas and often located in vulnerable areas. He noted that GURME pilot projects are being built up in Santiago and Mexico City within GURME. Novelty approaches can be very useful, such as in Montreal using rain water sewage systems as a reservoir, which allows for managing the water flow of the city. With air quality, private base is coming to the picture.

The participants were divided into two groups to work on “Summary of best practices for impact based service delivery (IB SD), associated gaps and recommended ways forward”. This included five areas from the Report 1150:
Area 1. Partnerships
Area 2: Impact-Based Information and Service Development
Area 3: Functional Requirements for Impact Based Forecasting
Area 4: Impact-Based Training and Capacity Development
Area 5: Impact-Based Service Validation.
Provision of Urban Services was added as Area 6.

The results were discussed in plenary. Eli Jacks compiled a cleaned-up version that was presented and discussed at the ICT.

Practically all of the items under Areas 1-5 apply to urban issues. The final list presented at ICT, with some slight modifications and removal of two action items that had to do with naming storms and collaboration with WRNs, is in *Annex 3*. This will be very relevant for planning the PWS service delivery focused on urban areas.

B. Meeting of the ICT/PWS

Tang Xu gave an introductory presentation *How we could further implementation of WMO Strategy for Service Delivery*. The main points relevant to urban services were:

- The elements of the Operating Plan for 2020-2023 includes “ Urban services and science: air quality, disasters, climate change adaptation” with the number of countries with functional urban services as the measure
- The performance indicators for Strategic Objective “1.4 Enhance information and services to support decision-makers” are:
  - Number of NMHSs with documented inputs to (a) National Adaptation Plans and (b) Nationally Determined Contributions
  - Number of Members with (a) urban specific severe weather (b) urban flooding and (c) air quality services
  - WMO services help UN organizations in weather and climate preparedness
- WMO information for reuse (value added products) within the UN system
- Actionable and fit-for-purpose flagship work, such as Urban and environmental operation and services in PWS.

Gerald Fleming informed the meeting of the relevant decisions and timelines regarding WMO constituent bodies and the delivery of PWS draft decisions and text. This included reference to EC-69 decisions regarding urban items. Gerald Fleming reminded the meeting that we need to remember to ask: Who is this for?

Eli Jacks and Will Lang presented the results from the joint meeting of ET/SPII and ET/IMPACT, held 30 Oct to 2 Nov, with comments from Jennifer Milton.

Ivan Cacic gave a presentation on GMAS, with a lot of discussion. This system will be relevant also for urban areas. He noted “It is very important to see what is not visible to others.” He also noted that the development of GMAS is not a block process but we need to continue with what can be done and leave aside what cannot be.

Alexander Gusev presented the RosHydromet system MeteoAlert, which is in its beginning stages and will be applied in Eastern Europe and Central Asia.

The meeting discussed urban matters as per relevance to PWS Programme and for SDS.

According to Decision 41 (EC-69):

- EC decided to expedite the work on a **Guide** for Urban Integrated Hydrometeorological/Climate/Environment Services, using the expertise of the WMO GAW Urban Research Meteorology and Environment (GURME) that would steer the transition from research to operations, to be approved by Cg-18;
- EC requested that **CBS** with CAS, in consultation with other Technical Commissions, develop **guidelines** *based on Members' best practices for an integrated operational platform, to support urban service delivery needs*.

Miriam Andrioli explained to the meeting the differences between the above two: the *Guide* is already being developed by a Task Team with external experts, with Veronique Bouchet representing WDS, with the main contributions from the Research Department and planned deadline for delivery of final draft by end of April 2018. The *Guidelines* is a PWS task and a stand-alone document, the preparation of which has not started yet. The meeting noted that developing the Guidelines is a considerable task, discussed the scope of the document, how to go about this task, the timeline for it and noted that resources are required. Jennifer Milton informed the others that Canada has an urban strategy which is partly implemented and multidepartmental in scope. This could serve as one of the best practices. It was noted that the urban applications are a special case of what the PWS Programme and the two ETs are already doing. It was also noted that the urban *environment*, in a wide meaning of the word, is the first priority. This will be a cross-cutting element in WMO with PWS lead. Collaboration and partnerships with other organizations and universities are important.

There was discussion on how to include urban questions in the upcoming CBS TECO spring of 2018 and on establishing a Task Team (TT) for developing the Guidelines document requested by EC-69. It was noted that having good co-chairs in the TT is one of the key elements. The group was requested to think of appropriate experts for the TT. The decisions and actions on these questions are available in the meeting report under preparation by the Secretariat.

There was discussion on CISD, private sector involvement, artificial intelligence, Big Data, application of technologies to PWS delivery, the General Service Delivery Guide, implementation plan for IBF, Competency Framework, and socio-economic benefits. Regarding special themes such as health and road transportation, it was noted that these are relevant for the urban area.

Part 2. Canadian perspective for urban best practice

In addition to the information provided in Annex 2 in the presentation by Jennifer Milton, Meteorological Service of Canada (MSC), I had discussions with her about the provision of urban services in Canada. She provided me with the presentation "Enhancing Public Weather Services - With a Focus on Cities" and the publication "Meteorological Services to Support Urban Resilience and Climate Change Adaptation", by Prediction Services Directorate, MSC, June 2016. The latter is a draft and not for redistribution, and thus is not considered here.

An urban strategy is needed as globally 50 % of humans, specifically 80 % of Canadians, live in urban areas, and due to the increasing end-user demands (municipalities, public health agencies, emergencies, transport, water management).

Developing forecasting tools in urban environment are needed for:

1) Improving meteorological forecasts (including hydrology)
2) Public health and comfort (e.g., heat, air quality)
3) Public safety and disaster risk reduction (e.g., High Impact Weather, pollutant transport and dispersion)
4) Urban planning strategies
5) Support to transport industry including aviation services.

Regarding the state of science and services of urban predictions, the perspective for MSC, linked with MSC's Service Strategy, is to address:

- priorities of urban centres with respect to vulnerabilities (high risks zones and/or populations) to hazards to reduce impacts
- information needs required to support decision-making by all levels of government and in particular municipal authorities
- infrastructure and demographic considerations

and to :

- assist innovation of MSC's urban stakeholders by facilitating access and use of existing data and products
- develop a meteorological vigilance approach at the urban scale
- work through strategic partnerships and alliances to foster resilience/climate change adaptation at the urban scale.

MSC's approach on sustaining the evolution of Public Weather Prediction and enhancing services, with the focus on cities:

- Approach to modelling towards "seamless forecasting" and covering the entire spectrum from minutes to seasons
- Increasingly integrated systems (coupled atmosphere-ocean-ice modelling) for weather and climate studies, to improve long-term forecasts and to present a more comprehensive status of the state of the environment
- Improvements in data processing, increases in data assimilation and model resolutions to better represent urban environments (for example, High Impact Weather management, climate change resilience, urban planning).

The Service Strategy Framework recommends engaging users and stakeholders in order to:

- better understand their decision-making processes and needs
- jointly develop products and services that users will find useful and usable
- disseminate products effectively
- guide stakeholders and users in the interpretation and use of the MSC's products and services
- identify nascent technologies and networks that offer opportunities for enhanced or innovative products.

Urban strategy considerations:

- What is MSC's role and what should be its service offerings taking into consideration the needs and priorities of cities?
- How does the urban context influence other MSC service offerings? What are the gaps?
- What are tools and resources required?
- What are the cost/benefits implications and how are we going to evaluate the performance outcomes?

In Canada, as elsewhere, a big sporting event has enhanced Public Weather Services, namely through the 2015 Pan Am Games innovations. Environment and Climate Change

Canada (ECCC) has designed a high-resolution state-of-the-art automated atmospheric monitoring network to provide data informing forecast and numerical weather prediction systems, which produced Games-specific alerts (Advisories, Watches and Warnings), and forecasts at a fine temporal and spatial resolution. This provided the following benefits/opportunities:

- Automated sensor comparison analysis
- High resolution modeling
- Enhancing dissemination services
- Testing next generation alerting
- Strengthening partnership NoNetwork, Health index
- Legacy data for urban modelling development.

Air Quality Modelling is provided, amongst others, in support of new regulation:

- Over 85,000 homes on the Island of Montreal have wood stoves or fireplaces, a significant source for bad air quality during the winter time.
- MSC has conducted *What if Air Quality scenarios* to guide the city of Montreal in developing a new regulation over wood heating.
- The City of Montreal has adopted a by-law that will take effect on 1 October 2018, prohibiting the use on its territory of wood-fired devices that have not been certified by a recognized organization (< 2.5 grams/hour of fine particle)

Rain related examples:
City of Montreal uses ECCC radar data (evaluation of precipitation rate) with their rain gauges (real time validation) in an urban hydro meteorological model to produce high resolution heavy rain predictions to manage and reduce heavy rain sewage overflows events. ECCC provided data and expertise to support the winning team of 2016 Aqua Hacking Challenge in developing a forecasting application: artificial intelligence model able to predict water quality from precipitation, river flow and city data on spills, to replace current 30 h water quality analysis delay.

Part 3. Visits to CMA

The summary of my visits to CMA, as mentioned in C and D on page 1, is in *Annex 4*. This may provide information on best urban service delivery practices and case studies for use in developing urban and environmental operation and services in PWS.

Annex 1

Summary of presentation made by Liisa Jalkanen at the Joint Meeting of CBS/OPAG ET/SPII and ET/IMPACT.

The world population reached 7 billion mark in 2011 and it is expected to rise to 9 billion by 2050. Currently over half of the population is living in urban areas, by 2050 this is expected to grow to 66% of the total population. Considering the cities with 1 million inhabitants or more, between half and two thirds of these are located in areas that face high risk of exposure to at least one natural disaster. As we have seen around the globe, hazards experienced in areas with a large population can have wide and disastrous consequences. Thus the UN and specifically WMO are addressing the needs of the urban population as an urgency, with the WMO Strategic Plan 2016-2019 recognizing urbanization as one of the key external factors influencing WMO priorities. Within the UN, the New Urban Agenda was adopted at the United Nations Conference on Housing and Sustainable Urban Development (Habitat III) in Quito, Ecuador, in October 2016, it was endorsed by the United Nations General Assembly in December 2016. Urban issues have been included in the Sustainable Development Goals, SDGs, where goal no 11 is specifically targeted at sustainable cities and communities.

The WMO Congress at its 17th Session addressed urban issues in a holistic manner including all WMO technical Programmes and passed Resolution 68 (Cg-17) (2015): Establishing a WMO Cross-Cutting Urban Focus. Cg-17 considered the vital role of NMHSs in the provision of effective PWS in support of the delivery of user-targeted meteorological and hydrological services in urban areas. Furthermore, Cg-17 agreed that service delivery for urban settings should be given focused consideration and stressed the importance of the provision of impact-based forecasts and warning services in urban areas. Cg-17 agreed that WMO and its Members can make a tangible positive impact on the urban environment by providing forecasts and integrated services that are tailored and targeted to the wide-ranging needs of urban authorities and population. EC sessions 68 and 69 provided further guidance on the development of service delivery strategy to address urban needs, with Decision 41, EC-69 (2017) on "Guidelines for the Development of Integrated Operational Platform to Meet Urban Service Delivery Needs".

It is estimated that 6.5 million people die annually due to air pollution; this issue has become an urgent public health crises. At WMO, the GAW Urban Research Meteorology and Environment Project (GURME) addresses this problem by aiming at enhancing the capabilities of NMHSs in providing urban-environmental forecasting and air quality services. Several GURME pilot projects have been undertaken to build air quality forecasting capabilities in for instance India, starting in New Delhi and expanding to other cities, and in Beijing and Shanghai in China. These projects have had the end-user in mind by providing different types of products and advisories through TV/radio, internet, sms and email alerts, and digital displays.

For a project on providing operational urban services, the following are especially required: Involvement of the users, stakeholders and authorities from the beginning; political willingness for the urban project; good collaboration; good plan for execution, including capacity development; and appropriate management for the project. The many challenges include: Connecting the different disciplines/experts and studies towards provision of the product/service; to connect the relevant authorities; to build a system that will continue after the pilot phase. Some of the needed actions are: Map and investigate good experiences; build upon existing lessons learned; develop guidelines (for cities) for better use and integration of services for different sectors, remembering

that specific services are often required as part of the whole; apply the WMO Strategy for Service Delivery in urban areas.

Local, national, regional and international collaboration is critical for success and the products need to be usable, useful and used.

Annex 2.

The presentations given by the ET/IMPACT and ET/SPII members are summarized in the meeting report that is in preparation by the Secretariat. In this Annex are compilations of the elements from each presentation that relate to, or could be applied to, urban issues. Annex 2 can serve as a basis for developing a list of best urban practices and case studies.

ET/IMPACT members

Roger Deslandes, BOM, Australia* gave two presentations during the meeting *"Challenges of providing 'early warning' for weather disasters"

- "It should be understood that forecasts possess no intrinsic value. They acquire value through their ability to influence decisions made by users of the forecast" (Weather and Forecasting, 8, 286 Alan H Murphy (1931-1997))
- Key challenges:
  Impact-based decision support
  - Relationships: Governments expect an integrated, seamless (agency) response that deliver benefits and outcomes to our communities
  - Agencies need to realize benefits of government investments in services: The BoM's new supercomputer – Australis; it is used to routinely run, e.g., City/State Weather Prediction (4 km), Global and Coastal Ocean Prediction (11 km, 4 km), POAMA Climate Outlooks (multi-week, multi-month) and many other environmental models. Coming next to Australis: City/State Weather Prediction (1.5 km), Storm Surge Prediction Modelling, amongst others.
  - Big Data – intelligent alerting to navigate through
  - Fire weather/heat waves

  Unleashing our value:
  - Embedding forecasters with our partners– understanding decisions; being the valued advisor & providing expert interpretation
- Partnerships discussed in connection with community impacts.

"Placing Hazard Impact and Risk Assessment at the core of our Operations"
All of this presentation is relevant also in the urban areas

- National Hazard Impact and Risk Assessment: in general; before, during and after.
- Tools were presented for 1) community impact 2) operational impact 3) hazard risk. Regarding community impact, vulnerabilities to a hazard were discussed at length, also exposure and impact modifiers were discussed.
- Contingency and resource planning
- Post event review management.

Chris Noble, New Zealand, presentation on activities of Meteorological Service of New Zealand Ltd. (MetService) including Impact-based Severe Weather Warnings Research project by Social Scientist Dr. Sally Potter
Service delivery is provided through: Websites (incl. mobile friendly) – public and commercial; Social media now a key channel (dedicated role, 7 days); Mobile apps – free for Urban/Rural, Mountain/Ski, Marine; Public email subscription for Outlook/Watch/Warning; Client delivery via: email / sms / fax(!) / ftp; Branded videos (via in-house TV studio, broadcast meteorologist).

They provide special forecasts, such as BBQ Index and washing day forecast, and non-routine social media forecasts from the media shift meteorologist. There are products tailored to client's needs, such as road marking forecast. Regarding warnings, there is a wide range of messages used to describe broad- and local-scale severe weather. It was noted that the experience of using of CAP can be useful for WMO for providing examples.

Warnings are given in three stages: Outlook – Watch – Warning, which then call for actions: Plan – Be Ready – Act. There was discussion throughout the meeting on these terms, they vary, other services may use Advisory as first stage, for example JMA uses the terms advisory, warning, emergency warning. The distinction is not very clear especially between Watch and Warning. Watch can be taken for, and used by media as, a Warning. Confusion can arise also from use of technical language.

The study by Dr Sally Potter on weather warning definitions (six types) and their perception and actions by the public was presented. The examples were for a city. Further research is needed as even though impact based warnings were more effective at altering perceptions, they were not much more effective in prompting a response.

Regarding challenges and gaps: Inter-agency approach needed (Timeliness, Who owns the message? Is everyone ready/willing to collaborate?); Exposure and scale (Should rural area be warned same as urban? How to manage variable thresholds?); Lack of a national weather impact database; Increasing demand for on-site consultant/embedded meteorologist.

Lee Lap Shun, HK Observatory, Impact-based Forecast and Warning - Hong Kong Experience

The different weather warnings given by Hong Kong (HK) Observatory were presented. The landslip, storm surge, and fire danger warnings and weather impact on road and air traffic were discussed specifically. The following gaps were mentioned: Understanding of relationship between weather and all kinds of impact (e.g., blockage of drainage, vehicles on highway/bridge, flooding at underground facilities, fallen trees, etc.); Collaboration with stakeholders (government departments, NGOs and other organizations); Acquisition of data and availability of tools (e.g. a Common Operational Picture for all essential organizations).

Prem Goolaup, Mauritius Meteorological Services, Status of Impact-Based Forecast and Warning Services in Mauritius: Success and challenges

The service provides Provision of Service for the following weather hazards: Tropical Cyclone, Heavy Rainfall (Torrential Rain), Flood and Flash Flood, Storm surge and High Waves, Landslide (and rock fall), Tsunami (low probability), Drought (water stress). As per current practice, the National Disaster Risk Reduction and Management Centre (NDRRMC) gathers site specific information from first responders who are posted over the whole island and would then issue a bulletin on radio and TV with necessary advices and precautions. Examples on heavy/torrential rainfall was discussed at length, including vulnerability and exposure.

Carolina Cerrudo, National Meteorological Service of Argentina (SMN), Impact based forecasting in Argentina: in the beginning of the process

Some of the products include: Issue forecasts and advisories for: Aeronautic, Public, Marine, Energy, Media; Forecasts for specific end-users from different sectors: Energy, Media, Tourism, Public events (shows, sports); Weather alerts; Storm warnings; Outlooks of high impact weather events for the following two weeks. Regarding working with the community, Alert.ar is a project based on improving the warning lead time,

providing quality information of remote sensing and numerical forecasts convective scales. Since 2016 NMS has created the Meteorology and Society Department, with the objective of working on vulnerability, impact and risk communication. This includes anthropology, sociology, geography specialists; Social and interdisciplinary construction; Workshops with users about products and communication. “Alertamos” app: It’s the first official app from Argentina that allows any citizen to report Surface Weather Phenomena.

The following gaps and challenges were presented: Difficulty in the obtaining of the information of risk and impact due to the organization by municipality of the civil defenses, the organization at the national level makes recommendations, but does not decide how to work in the DC; Lack of national impact data base; Lack of human resources, big challenge: only 36 forecasters and 15 assistants for 2.780.000 km2 (Surface of continental Argentina), need to find a smart way to employ the human resources and fulfill with the requirements (Meteofactory will be a good help); Training on the impact data integration in the forecast – How; Regionalization of impact data. Different kinds of impact in different regiones – How; How to work with variable thresholds; Improve coordination with other organizations; Arrival of the forecasts and warnings everywhere, communication protocols.

Jennifer Milton, Meteorological Service of Canada (MSC), Building a Weather Resilient Canada – highlights, challenges and considerations towards impact-based services in MSC

The Challenge is: “Warning systems need many components to be effective: Dissemination is one, warning content is another. Having the most powerful dissemination tool (or hazard based warnings) does not imply the warning system will convey the most understandable, complete and useful information needed to support users in their decision making process. Better risk communication to support the warning system’s credibility and its capacity to trigger a reaction among its audience.” (MSC vigilance project charter).

Further challenges are:

Ensure timely delivery of consistent (seamless) weather (and environmental)-related warnings and information in both official languages; Enable the production of these through the use of efficient, interoperable and adaptable tools/applications; Make optimal use of research-based developments, innovations and NWP; Establish and/or promote and sustain collaboration to ensure information is relevant to pre, during and post-event decision making by key stakeholders (incl. general population); Adapt service to changing requirements.

Weather and environmental programmes, partnering with health authorities: Air quality forecasts, smog alerts and to inform regulatory regime (model scenarios); Air Quality Health Index (AQHI) with Health Canada and provinces; Heat alert programs in collaboration; Warning products may be issued by 3rd party; NWP developments of which Wild Fire Smoke Prediction System ‘Fireworks’. Integrates current knowledge of the health impacts associated with air pollution; strong partnership: development, implementation and communications (Health agencies- provinces, municipalities, NGOs and EC).

Lessons learned and considerations: Partnerships and Preparedness are key.

(1) Partnerships: Multi-level (Federal, provincial, municipalities), provincial responsibilities, jurisdictions, mandates; universities (DRR, perception of risks); internal/external

(2) Preparedness

- Proactive engagement and collaboration with stakeholders

- Understanding needs & vulnerabilities (and their evolution)
- Integrated response plan established: clarify mandate, define roles and plan of action
- Contingency planning for sustainable and resilient systems and services
- Situational awareness – ongoing assessment and communication of risks
- Emergencies are an opportunity to test new products, services, contingencies, and assess surge capacity

(3) Tools & information

- Inter-operability
- Built on NWP development
- Experimental (high resolution) products supporting impact-based services
- Delivery means: for stakeholders. Include alternates
- IT support for development and implementation

(4) Prediction & Services

- Need for consistency in approach for implementation and messaging
- Role of national operations
- Considerations with respect to cumulative and compounding effects
- Pilots of impact-based approaches
- Observation networks

(5) People

- Changing role of operational meteorologists
- Cross training and embedded staff in 3rd party organizations support success of intervention
- Capacity development and training essential:
  - Create an impact-based culture within MSC – social background and education, culture, language, prior experience
  - Holistic understanding of impacts of weather, hydrology, climate interactions
  - Based on PWS competency framework and MSC-based
  - Stakeholder outreach and training, partnerships, communication.

MSC's approach on sustaining the evolution of Public Weather Prediction and enhancing services:

- Approach to modeling towards "seamless forecasting" and covering the entire spectrum from minutes to seasons
- Increasingly integrated systems (coupled atmosphere-ocean-ice modelling) for weather and climate studies, to improve long-term forecasts and to present a more comprehensive status of the state of the environment
- Improvements in data processing, increases in data assimilation and model resolutions to better represent urban environments (for example, High Impact Weather management, climate change resilience, urban planning)
- Focus on High Impact Weather decision-making support for the general public and public authorities - risk assessment and communication (embedded experts, early warning), emphasis in ensemble forecasting approaches (probabilistic forecasts, threshold probabilities, prediction uncertainties)
- Expand model applications in environmental prediction (for example water, ice, waves, air quality…) that rely directly on the outputs of the "core" Numerical Weather Prediction systems to support other federal agencies' mission (for example Public Security, Agriculture, Health, Natural Resources)
- Identify gaps and learning opportunities to develop competencies in personnel
- Open data ("powered by ECCC") to allow a tier added value offer.

In summary:

- Changes to MSC warning programmes to address multi-scale multi-hazard approaches further supporting our authoritative alerting mandate;
- Pilots for impact-based approaches assess Disaster Management Agencies requirements for weather, climate and water information, forecasts and warnings and will guide further development;
- Successful implementation through (1) collaboration and partnerships (2) development of competencies of staff (3) work flow and tools (4) support for program and work duties.

Cyrille Honoré, MeteoFrance, Impact based forecasting and Decision Support services

Impacts are a pillar of the Vigilance warning system.
Firstly we will need to provide information on what the weather will do in an understandable way. Then the people should ask: What do I need to do? This deserves an objective guidance and/or directives, from an authoritative voice, with institutional framework and clear mandates.
The overall annual assessment involves stakeholders and deals with: forecasts; impacts reported from Civil Security, Ministries, medias, etc.; anticipated preventive actions.
Examples for agriculture, ground transport, health, and forest fires were presented.
Only some feedback has been received from mayors, this could be improved.
Lessons learned:

- An impact based service is sustainable
- Main difficulties lie in :
  - Vulnerability assessment
  - Damage and loss recording /monitoring
  - Impact model design
- Solutions to search from :
  - Partnerships, including PPPs
  - Digital collaboration and tools
  - Training and communication.

Wang Qiang, Shanghai Meteorological Service, CMA, Exploration of Impact-based forecast and warning services in Shanghai

This presentation dealt completely with urban issues, specifically in the megacity of Shanghai.
One strives for a safe city. Critical (weather-sensitive) locations such as downtown, airports, harbors, etc., are highly sensitive to climate and weather events.
The frequent disasters occurring in Shanghai include typhoon, rainstorm, lightning, and gale.
Magnification Effect: Even slight weather events can trigger significant loss of life and property due to high population density and critical economic activities. Largest number of deaths occur from thunderstorms, due to high population density and the magnification effect.
Domino Effect: Natural hazards can lead to accidents, life and economic losses. Secondary and tertiary effects of weather induced disasters can have severe short and LONG TERM consequences.

Transition from basic forecasts to impacts-based forecasts through establishment of hazard weather event impact assessment model based on coordination between SMS and different sectors. Transition from warnings based on fixed meteorological thresholds to the endurance capacity of users to disasters through establishment of users' risk matrix.

The impact-based forecast and warning service takes both the users' capacities and the decision-making processes into account, making itself a brand new interactive style of forecast service.
The Integrated Operational Platform of SMS consists of data support, forecast area, service area, risk analysis area and emergency warning center.

Development in respect of impact-based forecasts and risk-informed warnings focus on urban flooding, aviation, marine navigation, health and transportation based on high resolution numerical weather forecasting products. Regarding health IBF and warning service,

- Develop approaches of health impact-based forecast and benefit evaluation of the forecast service;
- Develop health impact-based forecast and warning service on several target diseases with professional guidance;
- Establish standard procedure of multilateral coordination and response on warning;
- Improve service delivery capacity through adaptation of new media;
- Provide service to vulnerable group and key sectors sensitive to extreme weather and air pollution.

Through cooperation with operation and management centre of Shanghai Metro Company, the rail traffic impact forecast and early-warning operations will be applied, taking wind, visibility, high temperature, strong convective weather into consideration, and the rail transit platform is established which is affected by multi-meteorological elements and real-time monitoring of high-impact weather and warnings has been realized.

Regarding marine IBF and warnings, these are based on two ensemble forecasts (En-Warms and EC), to develop impact-based forecast products. Coordinated with Donghai Navigation Safety Administration (DNSA), to disseminate impact-based forecast to ships with AIS system. This is important due to the large number of losses at sea.

Urban flooding IBF and warning service:

- To develop key techniques for urban flooding simulation, urban flooding impact assessment, urban flooding impact forecast and risk warning.
- To develop professional and comprehensive urban flooding impact forecast and risk warning products.
- To build a response and interaction system, to improve multi-channel dissemination system and to provide service to communities.

This consists of data sharing mechanism (long-term sharing and regularly updating): partnership building with Civil Administration, Construction and Traffic Committee, Plan Bureau, Land Administrative Bureau, Education Board and so on. The Shanghai Urban flooding assessment Model (SUM) can simulate rainfall runoff process within city and further calculate surface water depth and distribution based on DEM and etc. The urban flooding issue was discussed with detail, consisting of, for instance, warning products and the dissemination system.

In summary:

1. Compared with the traditional weather forecast, the impact-based forecast and risk-based warning is more practical as they meet the needs of users, while they also require close cooperation with users. Probabilistic impact-based forecast and determinate impact-based forecast are important depending on users’ demands.

2. The weather may not be changed after forecast is made. But *impact* of weather may be changed. Impact-based forecast is linked with the emergency action to reduce impact of weather. So validation of impact-based forecast, feedback from users and impact monitoring are important.
3. Local government care about both disastrous (high) and minor (low) impacts of weather for the urban safety. New technologies should be developed to build impact model. Big data technology is a good way to do this. Mobile apps very important for local authorities.
4. Implementation of Impact-based forecast and warning services, integration with current SOPs should be considered. The best way is to develop the new generation of SOPs after some pilot projects applied.

Junya Fukuda, Japan Meteorological Agency (JMA), JMA's Impact/Risk-Based Early Warning System: Perspective and Lessons Learned

The three vital components of JMA's Early Warning System are: weather observations; forecasts/warnings; co-operation with DRR stakeholders. The three components are inter-related and all need to be updated and enhanced. The cooperation, communication and partnership with DRR stakeholders, e.g., local governments, are the key component to establish and operate effective EWS which is used for appropriate emergency response. It is necessary to build and maintain relationships with local governments.

The warning zone is divided into municipalities which are responsible for issuing evacuation information. Regarding criteria for warnings/advisories, JMA utilizes parameters having a correlation with the hazard potential and determine criteria for each municipality through coordination with the local government:

- Formulate common understanding regarding disasters targeted for warning/advisory with local government
- Collect disaster statistics from local government
- Draft criteria by using disaster statistics and authorize them with local government.

Lessons learned

- In order for our warning services to lead to more appropriate emergency response, such as
    - Prompt judgments of issuing evacuation orders by Mayors
    - Proactive evacuation of residents
- Information and Services Development
    - Convey proactively the risk of hazardous phenomena that have much social impact, even if the probability is not high
    - Develop information formats that help users understand risks of hazardous phenomena and their urgency
- Partnership Development
    - Promote the efforts to help DRR stakeholders and residents interpret and utilize JMA's warning information

Approach

- Information and Services Development
    - Provide Probability of Warnings
    - Provide Time series of Expected Warnings / Real-time Disaster Risk Map
- Partnership Development
    - Construct strong connection with DRR stakeholders in normal situation
    - Dispatch experts for DRR to DRR stakeholders.

Propability of warnings

- In order to convey proactively the risk of hazardous phenomena that have much social impact, even if the probability is not high,

- Show the probability of warning-level phenomena with two categories of high and middle, specifying phenomena and time frame in alert.

Time series of expected warnings

- In order to develop information formats that help users understand risks of hazardous phenomena and their urgency
- Provides time series of expected warnings in a table format with color corresponding to risk to enable users to understand risk and urgency more visually and easily than previous text format.

Partnership development
Co-operation with local governments
Normal situation

- Consensus on warning criteria
- Dispatch of experts for local DRR to local government
- Advice on revision of Local Disaster Management Plan and "Decision and Dissemination Manual for Evacuation Advisories and Orders"
- Instruction and training about how to use information
- Collaborative emergency drilling and DRR awareness activities
- Development and maintenance of information dissemination system

Disaster situation

- Forecaster briefing
- Hotline consultation
- Involvement in local government's disaster management headquarters

After disaster

- Provision of tailored meteorological information for supporting disaster relief activities
- Review the emergency response with local governments to improve the response further.

Construction of face-to-face relationship:
"Top level sales" during normal situations, that is, for instance meetings with mayors, regular visits, communication on SNS, dissemination awareness, training. These relationships will then be used when there is a hazard risk.
Advice during disaster situation: Weather commentary from Director-General of Meteorological Office, sharing the risk of approaching disaster, issuing instructions for prompt evacuation orders by Mayors and rapid evacuation of residents.

ET/SPII members

Armstrong Chen Hong Kong Observatory, Progress Update on the World Weather Information Service (WWIS)

The WWIS was established by CBS-XII (2000) as a Pilot Project under PWS Programme. Hong Kong Observatory (HKO) develops, operates and maintain the website on behalf of WMO. The purpose is to: provide a centralized source of official weather information; encourage the media and the public to make good use of official weather information; enhance the visibility of NMHSs, especially those in developing countries. In 2005 this became an operational part of PWS. MyWorldWeather apps have been launched in 2011 and 2013. This is a WIS DCPC since 2014.

Current status:

- Weather info for 2123 cities
- 135 members provide forecasts for 1997 cities
- 169 members provide climatological Info for 1961 cities

- 11 language versions: English, Arabic, Chinese, Portuguese, Spanish, French, German, Italian, Russian, Polish, Korean.
- WMO members: 191 (185+6) vs 135 members sending forecast
- Around 51% of participants provide forecast less than 5 day lead time
- Around 43% of city forecasts less than 5 day lead time
- On average, around 59% of the participating members provided forecast to the WWIS on relatively routine basis (counted as having forecasts available on WWIS in more than 25 days in a month)
- Reminders were sent to the focal point of countries from time to time but less than 20% responded.

Forecasts are provided to WWIS through GTS, FTP, Direct feed from NMHS website, Email, and Webform submission. The provision of automatic vs manual is 0.43 vs 0.57. Members who sent forecast manually were two times more likely to have operational issues than those who sent forecast through automatic means.

The gap:

- No forecasts for some big cities, e.g., Cario, Manila, Casablanca, Mexico City, Dhaka, Ho Chi Minh City, etc.
- Forecast range too short for some cities (5-day)
- Availability Issue.
-

A slide on GMAS was also provided.

There was discussion here and at several other times during the meeting on the getting weather forecasts from the internet: Google (without implications of their quality) comes up easily vs weather information from NMHSs. It was noted that people these days need to get their information in less than 2 s, otherwise they search elsewhere. Also, there should be global coverage for the forecasts on an internet portal, if not, this will also undermine the use of the data.

Yoshiro Tanaka, Japan Meteorological Agency (JMA), Rebooting Weather-for-Business Activities in Japan - for Advanced Use of Weather Data in Business –
As most businesses are located in urban areas, the concept and discussion presented in this talk are also applicable in urban areas.
Current status: Dynamic increase of productivity using weather data is expected in broad-ranging industries considering IoT and AI technology development. But … advanced utilization of weather data is not achieved in many cases. Weather data is “dark data” with much potential. It will become more valuable when combined with other data, and/or used with leading-edge technology.

Weather-for-Biz Consortium (WXBC):

- To jointly promote business that truly utilizes weather data, a Consortium, WXBC, comprising of private enterprises, including private weather services, as well as academia and government bodies was established in March 2017.
- Its Mission: Creation of advanced business models and utilization of new weather data using IoT&AI as well as continuous improvement of weather data and necessary capacity development.

Rebooting WX for Biz Activities by joint efforts of industry, academia and government.
It was noted that private sector would bring good and interesting added value, where most of this value would be outside of the NMHSs.

John Koch, NOAA/NWS, USA, Challenges and Opportunities in PWS Delivery

John Koch has had a lot of experience in dealing with weather information in cities, such as New York. He stresses that the message needs to be short and simple.

New media/Social media:

Challenges: How do we keep up? What is real? Speed of evolution

Opportunities: Access to more data, expansive reach

Technology advancements

Challenges: How do we keep up? Agency culture change. Budget. Buraucracy

Opportunities: Forecaster efficiency. Situational awareness

Public-Private-Partnership:

Challenges: Blurred lines, Skill sets, Resources, Other agendas

Opportunities: Active role in protection of life and property, Build relationships, Extend reach.

It was noted that for IBF and for the new/social media, forecasters need to change into opposite personality types than what they are now. This came up several times during the meeting.

According to John Koch's experience there is difficulty in marketing probabilistic forecasts to users, they prefer deterministic (yes/no) information, especially DRM managers.

During discussion it was mentioned that the real level of accuracy is not the perceived accuracy, better looking information was seen as more accurate.

Armstrong Chen, Hong Kong Observatory, Challenges and Opportunities in Public Weather Service Delivery presented by emerging science and technology

This presentation was about *An Experience Sharing on the Joint venture on big data pilot project to Study the Impact of Heavy Rain on Traffic Speed*, a collaboration between Hong Kong observatory, Transport department and Office of government chief information officer, with the purpose to forecast traffic speed at individual road segments in the next 30 min to one hour.

Location-based Nowcasting Service

- Available on mobile app
- rainfall nowcast for the next 2 hours at your location
    - data from SWIRLS QPF
- personalized automatic alerting service based on user location and expected rainfall

Generally speaking, more than 90% of all 610 road segments covered in this study had a traffic speed prediction accuracy larger than 80% in 2016.

Crowdsourcing very important, using MyObservatory.

Possible way forward:

- To employ crowd-sourcing technology to derive a real-time traffic map
- To collect other impact data such as flooding, traffic incidents, etc.
- To further develop the ANN model to extend the coverage of the road network in the territory

Challenges and opportunities:

- Need state of the art weather forecast system, but not enough
- Need crowd-sourcing technology to complete the "puzzle" to complement traditional observations
- Need big data platform and know-how
- Need know-how in artificial neural network (ANN)/AI
- Serve users in transport sector and the public by providing impact-based rain forecast/warning services

Siobhan Ryan, Met Éireann, Ireland

Impact Based Decision Making – current gaps…

There is an increasing need for information on what impact the weather will have in addition to information on what the weather will be.
The meeting discussed the naming of storms and specifically if mid-latitude, long duration storms (high impact events) should be included within PWS guidance; naming storms can improve communication and awareness about them.

The current paradigm in Met Éireann is to issue forecasts of what the weather will be for a given time and location. Warnings are issued based on meteorological thresholds. In an impact based decision making paradigm, it is envisaged that there will be

- Information on possible impacts included in all forecasts, warnings and communications
- Probabilities and uncertainties included in forecasts and warnings
- A structured and ongoing partnership between Met Éireann and Stakeholders
- A suitable operational protocol for dealing with severe weather events
- Systematic verification forecasts and warnings.
- Prompt analysis, reporting and debriefing post event

Five strategies to address the above are:

- Develop partnerships with stakeholders

  'Successful Impact based forecasting requires collaboration with others who have the additional necessary expertise, resources and knowledge to deliver impact services that NMHSs cannot do on their own.'
- Put in place technical infrastructure and forecaster tools
- Optimize organizational and operational structures
- Implement training, outreach and education
- Engage in meteorological and climatological research.

The example of road surface forecasting was presented.

Ana Portillo, State Meteorological Agency of Spain (AEMET) Emerging technologies – challenges and opportunities

This talk consisted of big data, GIS format, mobile apps and general comments.
AEMET open data policy: freely available, contributes to crowdsourcing, citizen science.
Meteorological tool for road transport discussed. They follow INSPIRE EU directive that provides data specifications for a wide variety of data, it is a good opportunity to share environmental data in an interoperable format.
"Customer journey" is a good way to work on service delivery.
Prediction is given for the next 7 days for over 8000 municipalities of Spain.
Private sector is the most important driver in new technologies.

Annex 3

IMPACT BASED SERVICE DELIVERY,
SUMMARY OF
BEST PRACTICES, ASSOCIATED GAPS, AND RECOMMENDED WAYS FORWARD

Area 1: Partnerships

Best Practices:

- **Conduct annual and "as required" assessments between NMHS and DMAs, and other relevant authorities, to improve services and clarify needs.**
  - Should include factors such as warning timeliness, whether proper action was taken, whether life and property was protected to the extent possible. Were warnings relevant?
  - What benefits were observed as a result of the warnings? (possible link to impact based metrics)
  - Are the thresholds appropriate – was there over-warning?
  - Pre-season assessments should also be held to ensure roles, responsibilities, SOPs are clear
  - Utilize QMS that provide metrics that can be tracked over time.
  - Partners agree on clear requirements for data formats to facilitate collaboration and NHMS support.
  - Good working NMHS – media relationships are established.

- **Co-locating NMHS advisers with disaster management partners.**
  - Consider permanent co-location with disaster management partners as resources allow. Could also be seasonal as-needed.
  - Assure proper IT configuration at the partner's site; otherwise consider distance coordination from home office.
  - Ensure understanding of user requirements at a very targeted level to include data formats and specific procedures to ensure proper interpretation of NMHS information.
  - Conduct periodic drills/exercise to ensure proficiency (link to training).

- **Setting Memoranda of Agreement with DMAs and other municipal entities.**
  - Standard practice to explore wide variety of available partnerships.
  - Ability to cascade agreements to the operational level to ensure staff on bother sides can develop common operational practices, relationship building, and development of mutual trust

Gaps:

- Some NMHS still not have clear authority as the "single authoritative source" from a legal perspective, and also with respect to partners. Can the NMHS "single authoritative source" be delegated? How can we inspire private sector partners to "buy in" to a strategy?
- Inaccessibility to some partner impact data. In some cases, NMHS must purchase it.
- Inconsistency in data formats between partner data and NHMS needs (for example, for running models). Also a lack of data transfer automation. (See 6th bullet under Best Practices)
- Need to maintain a catalogue of available, competent staff resources to serve partners
- Partner impact data are not also in machine readable format.
- NMHS may not be able or entitled to conduct "end to end" services (example: road weather) because of public/private constraints.

- Need to ensure records of events and performance, including informal commentary/feedback in addition to numerical data (such as benefits to partners and pro-active actions taken), are retained via QMS.

Ways Forward:

- Individual NMHS should strengthen partner relationships to stress to partners how provision of impact based data may support service provision of these data to partners and the public. Raise need to higher levels as possible. Establish joint efforts to develop thresholds and SOP at working level. In some cases, data can be provided by private sector.
- Encourage use of WMO SDS (and competency frameworks) to define baseline for PWS performance.

- **Proposed recommendation to EC from CBS Management Group:** WMO PRs should address the single authoritative voice issue as a high priority and provide generalized guidance with regard to standard public/private duties. PRs should also encourage an update of the WMO Register of Alerting Authorities.
- **Proposed action for ET SPII:** To support provision of IBF for partners, develop a template that would encourage requirement definition of data formats across the spectrum of need. Also collect examples of customer supply agreements for NMHS reference.
- **Proposed action for ET IMPACT:** Assemble examples of interactions between NMHS and partners, especially during big events, as a reference source of PWS website, such as CMA annual meeting with partners, NZ annual survey with regional authorities, and HKO interactions not only with DMA but with all other gov't depts.
- **Proposed recommendation to EC from CBS Management Group:** Stress importance of enhanced QMS database in view of movement to IBF.
- **Proposed Secretariat Action:** Ensure WMO RA workshops have one day set aside for IBF best practice discussions. Use regional training centres to support this action and integrate outcomes of these discussions into list of IBF best practices.
- **Proposed Secretariat Action:** Establish a one-stop shop for cross-cutting WMO documentation related to socio-economic benefits SEBs, partnerships (DRR, WWRP, WB, HiWeather, etc.) and solicit NMHS to send examples to populate this link.
- **Proposed ET SPII action**: Gather and publish examples of people working in embedded advisor roles. Stress best practices and pitfalls. Also create a draft template for team review and create the first "day in the life" style one-pager.

Area 2: Impact-Based Information and Service Development

Best Practices:

- Linking directly to partners and users to set impact-based criteria and build impact based models to support provision of critical decisions.
- Provision of spatially and temporally-specific information in easy understood formats (e.g., color coded maps and time series display)
- Integration of social science into impact-based system design.
- Availability of hotline consultation during severe events.
- Provision of support to partners and users during recovery efforts.
- Collection of ongoing feedback from those we serve to support creation and updating of IB metrics
- Availability of a data sharing mechanism with partners (example, situational awareness platform)
- Provision of action-based mitigation information with impact based forecasts, as enabled by policies of individual NMHS.

- Collaboration with local governments to institutionalize impact-based service protocols into regulations, and into planning and execution processes (could influence release of needed impact information from partners).
- Use of CAP in the production and dissemination of hazard alerts.
- Ability and commitment to sustain disaster management partner collaboration at all phases of events.
- Maintenance of situational awareness regarding changing exposure due to large public gatherings.
- Assurance of cross-border collaboration to harmonize impact information.

Gaps:
- Need to learn "what works" and "what does not work" in implementing IBF systems.
- With an overall strategy to "do no harm" to existing, individual NMHS alerting systems, need to raise for resolution:
  - Lack in consistency with respect to language and color coding within NMHS and *among* NMHS. (Part of this need is to enable foreigners to immediately understand system.)
  - Are some colors (e.g., yellow) dismissed?
  - Message language and number of "products"
  - Optimal use of symbols, including emoji's
  - Optimal ways to effectively express uncertainty.
- NMHS' need to address accessibility issues in the delivery of consistent impact information (e.g., multiple languages, including sign language, visually impaired).
- Forecasters need tools to integrate external data sources in addition to traditional meteorological data in the provision of IBF, and assure data quality.
- Increased need for smart-tools for forecasters (e.g., dashboards, Big Data platforms) to process, interpret and display IBF information to support decision making
- In trying to meet partner needs, we may not have the resources to respond to all requests.
- Need to adapt to being able to collect and process large volumes of impact information.
- Need to address harmonizing warning communication in countries where non-NMHS entities issue warnings.
- Need to discuss harmonization issues relating to the naming of storms for various hazards.
- Difficulty in accounting for changes in vulnerability on expected impacts (e.g., land development).
- Ability to fund needed social science is very limited.

Recommended Ways Forward:
- NMHS should update vulnerability maps periodically to adjust to changing demographics/land use.
- NMHS should redouble commitment to work more closely with local governments to assess needs and ensure impact based forecasting protocols are up to date.
- Strongly recommend that NMHS prioritize social science as an important component of IBF

- **For ICT discussion:** How do we set a course to best integrate external data sources and assure their quality, and to deal with increased needs relating to the integration of new forecaster smart tools, dashboard, etc.?
- **Proposed Secretariat Action:** Collect and organize best practices from WMO RAs, SWFDP and all other ongoing operational initiatives (e.g., WRNs initiative) so that PWS may integrate into this document.
- **Proposed PWS resolution:** PWS will provide personnel resources to collaborate with CISD and GMAS on issues relating to harmonizing color, expressing uncertainty, use of symbols and other hazard communication issues. Consideration will be given to ISO 22324 pertaining to hazards as part of this activity.

- **Proposed Secretariat action:** Collaborate with SPII to reference any relevant ISO standards. Note WCAG example. Explore way forward for harmonizing languages and accessibility role.

Area 3: Functional Requirements for Impact Based Forecasting

Best Practices:

- Creation of digitized threshold information.
- Use of social media to deliver forecasts and warning information.
- Efforts to support World Weather Information Service (WWIS).
- Initiation of a GMAS effort to harmonize warnings across NHMS
- CMA: 'Everyone, everywhere should have at least one way to access and understand the warnings'
- Provision of a reliable and robust impact & warning database to ensure warnings are disseminated in a complete and timely manner (overcome latency issues).

Gaps:

- Systems need to have dynamic and flexible vulnerability thresholds - and regular review to update them - able to use relevant (e.g., local) expertise to advise on thresholds.
- Need dynamic impact databases.
- Need to collect knowledge of antecedent conditions, meteorological and otherwise
- Need to understand the difference between changing exposure and changing vulnerability in the generation of IBFs.
- Need to understand scales required for IBF.
- Need interdisciplinary research into weather sensitivity analysis- establish mechanisms for how weather affects other factors, e.g., typhoon pros and cons for wind turbines.
- Need to optimize impact-based information production via inter-operational tools and applications.
- Need to create a global, seamless, comprehensive web-based information service including over the ocean to support private industry at required response rates. Issues: lack of capacity across NMHS
- Need to optimize graphical displays and dissemination capabilities to support IBF.
- Need to set standard for achieving vulnerability analyses.
- Need to improve model granularity to better account for local impacts to support impact modelling, and downscaling techniques relevant to IBF.
- Need high-resolution data assimilation systems and access to higher resolution and diverse observations
- Need to determine how to best utilize and store crowdsourcing data – extend survey.
- Need forecasts for some big cities to support WWIS. Also need to extend forecast ranges for others.
- Need to determine how to manage and prioritize the volume of data down to the cell phone level.

Recommended Ways Forward:

- Create data analytics approaches, and systems to organize the data for decision makers, including other non-meteorological data
- Develop requirements for training that would better enable forecasters and decision makers to understand the spectrum of available information and smart tools.
- Develop semi-automated systems to gather, organize, sift and present data to aid decision making - especially at smaller/urban scales.
- Engage geospatial data specialists to ensure non-meteorological (e.g., impact) data can be presented and compared – interoperability of information systems.
- Develop a seamless approach (spatial scales) – consistency from larger to local scales

- Members to develop range of approaches for communication of IBFs relevant to range of users (different channels, media)

- **Proposed ET SPII action:** Publish examples and advice on creating digital strategies (data, geospatial data, social media) and capabilities for PWS, both for external and internal use as a new PWS Digital Roadmap. Involve the IT community and other stakeholders in this activity.

Area 4: Impact-Based Training and Capacity Development

Best Practices:

- Provide clearly defined competencies, updated for latest IBF requirements, and for a variety of delivery roles within the IBF spectrum (media, emergency managers, forecasters)
- Provision of training that focused on blended learning, repetition and building experience, focused on needs of individuals, shadowing ('double banking',) and sharing of 'war stories'.
- Simulation training to enable forecasters to encounter real-life scenarios in a "safe" mode.
- Some users (partners, civil aviation, local government, and media) occasionally participate in briefings to learn about the process.
- Focus on storytelling to effectively convey forecast uncertainty and impact. Including provision of best practice examples.
- Execution of cross-training between NMHS and disaster management partners to increase awareness of roles, responsibilities and needs (e.g., when is service and advice needed the most and in what form)
- Provision of forecaster training on local effects, use of real time situational awareness maps, and other nowcasting tools to enable forecasters to understand and communicate specific vulnerability and exposure factors in their area of responsibility, including for non-meteorological events.
- Ongoing competency assessment to account for staff turnover and refresher needs.
- Provision of targeted training and certification for specific competency areas.

Gaps:

- Need to train on how to better effectively communicate risk, uncertainty, and "story-telling".
- There is a gap between university curricula and the real-life needs of the new forecaster role.
- Need to train on impact-based data integration.
- Need to better articulate the changing role of the forecaster, both internally and externally.
- There are human resource limitations in some NMHS that limit time for training, and resource limitations that hinder the development and deployment of needed training.
- Need culture change training to stress new roles are now more important than old ones.
- Also need an outreach campaign to familiarize the public with the NMHS move towards IBF.
- Need to more fully engage with ETR group and Global Campus.
- Need to assemble all available training internationally, organized by category, in a one-stop shop.
- Need to increase scope of simulation training.
- Need to provide training on IBF methods for disaster managers to build trust and understand common language.

- Need science-based forecaster training on latest impact models to equip them to interpret them wisely.
- Need provision of targeted training and certification for specific competency areas

Recommended Ways Forward:
- Based on WMO competency guidelines, NMHS to expand available training to include targeted areas (fire, hazardous materials, etc.) as identified by partners
  - Note: Circulate COMET modules, curricula as reference
  - NWS is developing "boot camps" to forecasters on IDSS roles and needed competencies.
- Each NMHS consult commercial and non-commercial partners for any required training to serve them, and then decide upon certification protocols (either self or via established requirements)

- **Proposed ET IMPACT action:** Gather and share best practice training examples from ET members. Use RA II/IIIs workshops for knowledge sharing, to provide local examples and pitfalls.
- **For ICT discussion:** How can WMO influence university curricula and help identify knowledge, skills and abilities required for the new paradigm?
- **For ICT discussion:** Review and update Competencies to ensure focus on IBF KSAs (e.g., risk assessment, establishing partnerships, and change management).
- **Proposed Secretariat action:** Work with WMO education and training program and WMO Regional Training Centers act to assemble existing training information into a one-stop shop.
- **Proposed Secretariat action:** Consult WMO Panel of Experts in Education & Training and WMO training centers to provide training recommendations for disaster management training, expression of uncertainty, storytelling, and interpretation of impact based forecast models.

Area 5: Impact-Based Service Validation

Best Practices:
- Enable NMHS to provide their governments with impact-based metrics demonstration the benefits of their services.
- Develop and utilize impact tables and databases
- Develop key Performance Indicators for IBF
- All IBF metrics are agreed upon with users .
- Use historical insurance data, and data from other sectors
- Regularly consult with users to ask if the NMHS services provided are useful, including whether messages were received, understood and acted upon (e.g., information should be "**useful", "usable", and "used".**

Gaps:
- How to measure benefits of warnings, when risks are mitigated by warnings? Need to focus on measuring our ability to forecast/warn for the impacts.
- We tend not to capture impacts outside forecast events, which can introduce bias in metrics.
- Need to understanding of user needs for different lead times.
- Need to understand the economic costs of warnings (especially urban).
- Need to have impact data in real time.
- Need to upgrade loss recording and monitoring capabilities.
- Need to develop non-threshold methodologies to assess forecast benefits.

Recommended Ways Forward:

- Recommend NMHS take advantage of opportunities to engage economists and social scientists to assist with development of impact-based metrics and how to communicate IBFs to users.
- Recommend NMHS conduct subjective, post-event assessments involving users (e.g., routine survey).
- Recommend NMHS develop methodology for capturing impacts (e.g., from other authorities, crowdsourcing, spotter networks, archiving and categorizing (e.g., automated impact recognition from photos/webcams).

- **For ICT discussion**: How can we access needed social science expertise to support IBF?
- **Proposed PWSD action with Secretariat**: Collect and publish examples of post-event assessments and methodologies for collecting impacts.
- **Proposed action for ET SPII:** Link through HiWeather/WWRP Verification Group/WMO Forum to share knowledge on verification and report back to OPAG (through Chief WWRP).
- **Proposed action for ET IMPACT and SPII:** Collect examples highlighting infusing social science into new product development and assessment.
- **Proposed Secretariat Action**: Collect names of experts on social sciences and economists that could support NMHS with selected needs.

<u>Area 6: Provision of Urban Services</u>

Best Practices:

- Collaborative plan for engaging with a wide range of other agencies.
- Involvement of marine and aviation users and authorities.
- Involvement of water management, air quality health/medical, transportation, food, utilities (e.g., Shanghai example – temperatures critical for electricity for air conditioning).
- Targeted information from sensitive groups and to support urban conservation.
- High density observations to facilitate IB modelling and services.
- Idea of 'smart city' involves public/private approach.
- Megacities often have own weather networks (e.g., X-band but need to share staff, collaborate.

Gaps:

- Traditional threshold-based systems break down – magnification/domino effects mean have to use IBF.
- How to ensure visitors are equally warned, protected.
- Collect information on those NMHS that are already providing useful urban-specific services.
- Case studies of effective urban-specific services.
- Collect impacts related to big cities being near the coast (flooding) and having major airports (ash).
- Define options for best serving data.
- Recognition of the variation in types of urban environments wrt IBF.

Recommended Ways Forward:

- Provide sample scenarios that could lead to development of case studies that highlight the distinct needs within the urban environment.
- Data collection.
- Encourage engagement with construction, city planners, etc.
- Tailor IBFs to achieve best results (e.g., different evacuation/stay home strategies).

Annex 4. Visits to the Beijing Meteorological Service and PMSC

On Monday 6 November 2017 I visited the Beijing Meteorological Service (BMS) at the Beijing Meteorological Observatory location and the Institute of Urban Meteorology (IUM), CMA. I was accompanied by Mr Xu Wanzhi from the Department of International Cooperation, CMA.

Beijing Meteorological Service

At the Beijing Meteorological Service I met with Ms Ji Chongping, Director, Beijing Municipal Weather Forecast Center, Ms He Na, Mr Li Xun, Ms Fang Xiaoyi and Mr Du Wupeng. Several presentations were given, I do not have any of these files.

Ji Chongping gave an overview of the Beijing Municipal Weather Forecast Center (BMWFC). Regarding human resources, the total staff number is 47, of which 72 % are female and 79 % have an MSc or PhD.
The Center is one of eight Regional weather forecast centers of CMA and needs to coordinate with four Provincial weather forecast centers in North China, in areas like severe weather forecast consultation, key technical research and training activities.
BMWFC is working in following areas:

- Severe weather monitoring and warning and 0-10 day weather forecast
- Weather service for decision making (city safety, public life, big social events, etc.)
- Weather forecast mechanism analysis and scientific research

The major meteorological hazards that affect Beijing are: heavy rainfall, thunderstorms, hail, strong wind, heat wave, cold wave, fog, and haze.

The numerical models in use have been developed by the Institute of Urban Meteorology (IUM).

The meteorological disaster warnings have different criteria in the different provinces and are based on evaluation of climate data and cooperation with national or local disaster prevention and mitigation management, who can define or adjust the warning criteria. The four warning levels (with colors blue, yellow, orange and red) are the same for whole China.

Regarding customers and services, weather services are provided for:

- City safety: collaboration with over 20 authorities in support of safe operation of the city
- Public life: provide weather forecast and warning information through different media, first to issue life weather index in China, such as UV Index, Cold index (human cold, not temperature), Morning exercise Index, Picnic Index, Car washing Index, in total over 20 Indices exist, different index in different areas as per need and demand.
- Big social events: more than 30 important/big events are held per year.

He Na demonstrated how the very useful Forecasting Platform works. The Very short-range Interactive Prediction System (VIPS) is used to give:

- Integrated observation, analysis, prediction, and warning
- Real-time warning, information sharing, regional real-time cooperation
- Combined subjective and objective predictions.

It includes an Intelligent Grid Analysis and Prediction System (iGrAPS) and RMAPS model is used. On the screen one has “monitoring circle”, “watching circle” and “warning circle”. Through a graphical system (circling with screen pen what is included), the number of

municipalities involved is determined. If it is one or two, one connects directly with them, if it is three or more or in the center of Beijing, one will connect with the Beijing Government. There are 14 areas in Beijing.
After circling with the screen pen an area, one goes automatically to the template page to formulate the warning. Regarding flooding, forecasting is especially important for the mountainous area and from June to September. There are five categories of flood warnings.

Li Xun briefed on the weather service for City Safety. These are provided for the public and as special services, for instance for transportation and energy sector (electricity consumption).

Regarding transportation, Beijing does not have traffic jams but traffic collapses. Even light rain may cause problems. The light rail transport is sensitive to the wind speed and icing. They are using an impact based traffic flow forecast. Data mining is used to analyze past and other data in order to get a general and particular picture. Due to the Survey for Behavior of Driver, it is possible to imitate behavior according to different types of weather.

Beijing has been divided into 6000 smaller areas, also underground, for the Waterlog Risk forecast. Risk is classified as per car, bus etc.

In the energy sector for heat supply there is a need to balance energy savings, between emissions and “cozy life”. It is to be noted that water pipelines are very long (possibility for energy losses). Regarding power supply, 25 % is provided from Beijing, the rest from outside. An impact based product is delivered, especially for wire icing and line galloping. They also issue electric load forecasts and warnings (as required) for devices that are running.

In 2017 there was convergence of all media/interaction for one authoritative voice “Smart Weather”. Smartphone forecasts are based on Grid Forecast. For example, subway stations forecast is given to the subway manager, e.g., during thunderstorms people stay inside the subway station, which can cause dangerous situations as the station will become very crowded in a short time. Another example is the “Red leaves map” showing the locations for enjoying the autumn leaves and their color.

Du Wupeng introduced the Urban Climate Service for Beijing. They provide forecast and assessment services around key social activities and safe operations applications. For example for construction, urban planning and agricultural purposes, the latter for nearby rural areas. Seventy cities have done this urban planning. Through the cyclical rolling model “business – science- … business” good service benefits have been obtained. The target is “The City that Can Breathe”. In this context ventilation corridors are very important (weather service can model the ventilation for different plans to inform city planning). Climate forecasts are also provided, for big events. They have over 10 y of collaboration with city planners. There are three steps:

- All knowledge of climate for, e.g., avoiding heat island, polluting factory
- Suggest ideas for the city planning
- Several plans, office will evaluate all plans to find the best one.

Institute of Urban Meteorology

At the Institute of Urban Meteorology (IUM) I met with Mr Shiguang Miao, Director, Ms Min Chen, Ms Xiaodong He, Mr Jiannong Quan, and Ms Zhou Chunhong (CAMS), Hailin

Gui (National Meteorological Center) and Jianming Xu (Director, Shanghai Center for Environmental Meteorology). Five presentations were given, I have all these files.

Shiguang Miao gave an overview of the Institute of Urban Meteorology (IUM). Beijing Meteorological Service (BMS) is 1 of 31 provincial met. Bureaus in China, led both by the CMA and Beijing Municipality, with the former as the core leadership. IUM is a sub unit of BMS, while also directly under CMA. The Mission of IUM is to understand the urbanization effects on weather and climate and to support forecasting and service of urban meteorology. IUM consists of five branches and an Administrative Office:

- Urban Meteorological Observation and Analysis
- Urban Boundary-Layer Modelling
- Numerical (Chemical) Weather Prediction
- Nowcasting
- Developmental Testbed Center.

The work consists of research to development to applications. IUM is also known as the National Center for International Collaboration on Urban Meteorology.

IUM is concerned with urban research, forecast and service. The research is to reveal the facts and mechanisms about interactions between urban and high-impact weather such as precipitation and fog/haze; the forecast will meet various service demands from nowcasting to short-term prediction in megacities and the service consists of a dedicated urban service for urban flooding, urban planning, energy, etc. IUM is undertaking with international collaboration a Study of Urban-impacts on Rainfall and Fog/Haze (SURF), details of this were presented. The objectives are to

- Observe and study
  - Urban turbulence
  - PBL structures in urban and rural areas
  - Urban impacts on precipitation
  - Urban impacts on fog/haze
- Develop fine scale urban forecast models
- Train younger scientists via international cooperation and research.

SURF includes also deployment of new instruments.

The Rapid-refresh Multi-scale Analysis and Prediction System (RMAPS) is focusing on nowcasting-to-short-term in urban area and provides the core operational nowcasting, very-short-range to short-term (0-12h) prediction capabilities and systems in metropolitan areas. The focus on 0-12hr forecasts with high-resolution (1km), high-frequency (10-minute) update cycling, with emphasis on assimilation and blending of local data, and integration of various techniques and products. They try to change nowcasting techniques from extrapolation-based to model-based and involve urban, land-surface and aerosol effect in physics package.

The integrated urban service consists of:

1. Decision support meteorological service
2. Public meteorological service
3. Traffic meteorological service
4. Energy meteorological service
5. Urban flooding warning service
6. Tour meteorological service
7. Urban agriculture meteorological service
8. Risk assessment in meteorological service
9. Climate adaptation urban planning service
10. Impact assessment of climate change

Min Chen briefed about RMAPS (mainly) and SURF technical details and applications, with examples. Greatly improved forecasts of precipitation and temperature mainly benefit from improved RMAPS core prediction capabilities and systems more in-depth understanding on mechanisms and evolutions of local severe convective weather systems. RMAPS model system has widely supported the national and regional forecast service. Products of RMAPS-ST/NOW/IN support:

- Severe Storm Nowcasting and Warning
  - National Meteorological Center
  - Regional/Provincial Weather Service Center
- Renewable Energy Resource:
  - National Meteorological Public Service Center
  - Private Sectors
- Public Service:
  - Decision-making
  - Transportation
  - Flash-flooding warning
  - Aviation
  - Prevention and reduction of natural disasters
  - Smart-phone Applications.

Shiguang Miao gave an introduction to the Beijing Study of Urban-impacts on Rainfall and Fog/haze (SURF) project, a collaboration with international scientists, started in 2014 and ending in 2018. He noted that scientists are needed urgently as the public and government need us to improve forecasts to suggest measures to reduce future losses. The goal of SURF is to study two high-impact environmental problems in the Beijing and surrounding areas: heavy rainfall and fog/haze. The science objectives are:

- Promote cooperative international research to improve understanding of urban weather-systems via workshops and field studies
- Evaluate and improve high-resolution (~1 km grids) numerical urban-weather forecast-models
- Enhance urban Wx forecast-utility for social, economic, and environmental applications, e.g., health, energy, climate change, air quality, urban planning, and emergency-response management
- Specific objectives of Summer TS rainfall & Winter-aerosol field studies: better understand Beijing urban, terrain, convection & aerosol interactions.

Several workshops have been organized, Sue Grimmond and Walt Dabbert have participated in these. Also mini-classes have been organized and field experiments.

The future of SURF:

1. SURF data: QC/QA and sharing
2. New equipment and new data
   - The new network of ceilometers
   - Soil moisture network
   - Urban and weather satellite remote sensing
   - In-situ thermal remote sensing
3. New sciences
   - Interaction between urban and heat/cold wave
   - Interaction between fog/haze and weather
   - Interaction between urban and terrain (Phase II)
4. R2O: Research to Operation
5. Outreach, Education, and Dissemination
6. Phase II: MOUNTAOM

MOUNTAOM (Mountain Terrain) is being established in order to answer the following questions:

- How can we combine radar, lidar, wind profilers, and other sensors to fill the gap between the city and the mountains?
- How does precipitation evolve once it is initiated in elevated terrains and moves to the city?
- What is the interaction between urban and terrain?

Science Objectives

- Promote cooperative international research to improve understanding of 4-D boundary-layer structure in mountain terrain via workshops and field studies
- Evaluate and improve high-resolution (~10-100 m grids) numerical models (LES, IBM, or mass consistent model)
- Enhance forecast-utility for urban and mountain terrain, and for Winter Olympics applications.

Xiadong He presented the Sustainable and Resilient City - Urban Climate Map system of Beijing (BJ-UCMap). More than 20 countries have developed their own UCMap system at various scales by applying mitigation measures and climatic guidelines to urban planning practices. Note that current research and applications are limited to low-density cities in developed countries. They use Beijing as a case study to develop an urban climate map (UCMap) system for *high-density* cities in China and to propose a series of climatic spatial planning guidelines for improving the urban climatic conditions.

The BJ-UCMap system consists of five parts:

1. Basic research
   - Assess the impact of the natural environment and typical urban morphology elements on the thermal load and ventilation potentials (through observation and numerical simulations in microscale)
   - Develop a set of basic input layers
2. GIS-based assessment on current urban climatic conditions
   - Integrate the combined influence of urban thermal load and urban ventilation potentials
   - Develop an urban climatic analysis map (UC-AnMap)
3. Numerical-simulation-based method for detecting fresh-air ventilation paths
   - Explore quantitative fresh-air ventilation paths based on RMAPS-Urban modeling system of IUM
   - Define the principles of potential fresh-air ventilation paths
4. Observation-based analyses of mountain-valley breezes
5. Establish a comprehensive BJ-UCMap system
   - Develop an urban climatic recommendation map (UC-ReMap)
   - A series of available mitigation measures and climatic spatial planning guidelines are proposed for science-based planning practices.

Basic layers, including topographic height, sky view factor, green space, building height, and building coverage, etc., are designated and placed into a geographic information system (GIS) for hierarchical calculation to evaluate the thermal load and urban ventilation potentials. The urban climatic analysis map provides a platform for climatic information and evaluation. It clearly indicates that the hierarchical urban climatic classifications are consistent with the nearly closed "Single Center + Rings" urban layout of Beijing, which leads to a strong thermal load and poor ventilation in most urban areas within the Fourth Ring Road.

Principles of potential fresh-air ventilation paths
(the first three were summarized by Barlag and Kuttler, 1991)

(i) nearly straight free paths must be kept to the center of the city
(ii) surface roughness along these free paths must be kept low
(iii) surfaces in these areas should have a cooling effect on the air moving slowly toward the center
(iv) there should always be a clean/fresh air source from which air moves to the central city and along the paths
(v) the main orientation of ventilation paths should be approximately aligned with the prevailing wind direction.

Observation-based analyses of mountain-valley breezes and urban heat island circulation

- The distribution of mountain-valley breezes for various seasons are studied using hourly automatic weather station observations during 2008-2012
- The mountain breezes (from the hills toward the city center) in summer and winter are natural urban climatic resources that can used in urban planning
- The synergy between urban-induced heat island circulation and reasonable green wedge planning could deliver cool/fresh air from the suburbs to city center.

The resultant UC-ReMap would identify the areas which are more in need of attention and improvements from the urban climatic perspective. Accordingly, urban climate-valuable areas, urban climate-sensitive areas, and the final fresh-air ventilation paths of Beijing are spatially identified. A series of key planning recommendations primarily focused on reducing the thermal load and improving urban ventilation are proposed with reference to the Beijing city master plan (2004-2030). The UC-ReMap of Beijing is planning-oriented to provide a holistic platform of climatic information for planning, decision-making, and taking action.

Case studies have been made in Stuttgart and Kassel in Germany, Lisbon, Portugal, Tokyo, Japan, and in Hong Kong and Beijing.

Regarding future efforts: making cities more climate-resilient

1. Adapt to climate change
   - Study the spatial and temporal distribution of climate change in the past century for Beijing and the beijing-tianjin-hebei urban group
   - Simulate the climate change trends in the future 30-50 years
   - Consider the climate change trends in urban planning and urban group planning
2. Adapt to meteorological disaster
   - Carry out risk assessment and zoning study of major meteorological disasters
   - Put forward planning strategies to deal with extreme weather events from the perspective of planning early warning
3. Adapt to urban climate
   - Study the partitioned rainstorm formulas and district wind roses to perfect the BJ-UCMap system
   - Simulate the impact assessment of urban ventilation paths and vertical greening (roof greening and wall greening).

Shiguang Miao gave a presentation for Haibo Hu, as he was unable to attend, on Risk assessment in meteorological service. He discussed risk assessment of meteorological disaster, risk warning in meteorological service, risk analysis and uncertainty reduction in meteorological service under extreme weather conditions and lightning risk assessment.

Risk assessment of meteorological disasters (urban flash flood, hail, fog, etc.) are made for large scale events, e.g., Beijing Olympic Games, celebration on National day. They have simulated and analyzed the decision-making procedures of the meteorological service concerning an extreme thunderstorm event using a Bayesian decision-support model. The flooding and debris flow risks on that day were assessed, and also the historical flooding records were consulted. Lightning risk assessments have also been made.

Their study suggests the following approaches be used to improve the meteorological service, which is critical for risk reduction and mitigation when responding to severe weather.

1) A decision-support model should be introduced in the meteorological service to facilitate an optimal decision-making process
2) The emergency response department should promote emergency response levels corresponding to the severe weather warning levels sent by meteorological centers
3) It is advisable to provide users with the uncertainty information for severe weather forecasts and warnings. Such a practice allows the end users to make their own decisions based on their own businesses requirements.

The presentations were followed by discussion, mainly on the best practices, gaps and ways forward. Jianming Xu from Shanghai Meteorological Service (SMS), CMA, noted that urban service is a very wide field. He is mainly dealing with air quality forecasting (AQF). Regarding benefits he had two points:

1) It is very important to establish close connection with the Environment Bureau (EB) for AQF. SMS has done this in 2013 by paper by Shanghai government clarifying their responsibilities. They have a Platform and discuss daily based on the Platform, jointly issue the forecast. With the data assimilation system, EB contributes by, e.g., updating emission data. Trust is very important. The most important is that the government asked for them to do this together.
2) The support from the Shanghai GURME project was very important, it helped increase science to operations AQF.

In Beijing, this type of close collaboration does not exist, CMA looks at haze and fog conditions and discusses with EPA. The forecasters may also go to discuss the haze and fog face to face with national environmental monitoring station staff, in the near future will set up facilities for video discussion. If EB issues bad air quality warning early enough, government will take action to reduce pollution, such as by restricting the use of cars.

In Shanghai, considering emission reduction strategies, pollution can be divided into two kinds:

1) Transported: no suggestions are made
2) Stable weather: suggest to conduct emission strategy by EB

During rainy months SMS sends staff to flood departments, used to issue only forecast on city level, from 2017 as per the small districts.

Xu Wanzhi noted that partnerships are very important, for instance with the railway agencies, working together through projects and programmes, for which there is no requirement to apply for approval by the government, which makes working together more easy to be accomplished.

The staff jointly annually apply for projects from municipality or science foundation authorities, report progress to government and the agencies, then transfer research to

operational mode, between CMA and others. The importance of regular international collaboration and joint meetings was stressed, for instance twice a year for a project. The Urban Planning Office also funds research projects.

It is a challenge to answer to the needs of urban planning and other authorities, who request urgent action to very quickly improve modelling and forecasting. Another challenge is making clear current climatic condition for planning partners. Land use data is needed from another agency, this is needed for good planning.

Concerning the way forward:

- Improve numerical model system to have seamless from micro scale to meso and climate scale
- Need more communication between agencies, if want to be operational, from beginning of research phase.

Chunhong mentioned that CMA Unified Forecasting CUCA is nation and urban wide, and will be developed for street scale and upscaled to global level (GRAPES). As broad issues are included and lots of agencies involved, it may bring difficulties. She is now in the WMO GAW Scientific Advisory Group on Modelling Applications (SAG-APPs) and thinks that the group could look at these issues. To sum up: different strategies are required for different stages of the work.

Visit to the Public Meteorological Service Centre

I visited the Public Meteorological Service Centre (PMSC), CMA, on 7 November 2017. Present at PMSC were: Mr Pan Jinjun, Ms Zhao Fan, Mr Yang Zhenbin, Ms Han Xiao, Ms Wang Yan, Ms Ke Xiao and Mr Xu Wanzhi.

Zhao Fun made a presentation on "*The Strategy of Mete-media in the Era of Media Convergence and The Partnership with Other Media"* and Yang Zhenbin gave a "*Brief Introduction for Centre of Wind and Solar Energy Resources, CWERA*"; I have both presentations.

China Weather TV was launched in May, 2006, sponsored by the CMA, it has 114 employees and national coverage. In all the cable channels in China, the coverage of China Weather TV ranked first, covering more than 120 million families, about 440 million people. They provide weather forecasts and early warning, weather news and documentaries. In the smartphone era, what is happening to television in China? In recent years there has been significant declines in traditional television viewing and a rapid rise in online video viewing. China Weather TV's Omni-media Strategy: Television is still an important medium and will remain so for years to come, but it will not be the dominant force. As weather video provider, we react to the decline in traditional television viewing and the rise of online viewing. They have one media director and one chief scientist who look at which news can be used, which news to give up, the media director also sees to the language of the message "translation" so that it is understood. They are developing an Omni-Media Sharing System to exchange videos. They have a new team called "Innovator" that is building the digital audience. Partnerships are important, for past 20 years have collaborated with PHOENIX TV, in 2016-2017 have made many new attempts, and expanded the cooperation with many media, especially new media platforms.

China Weather TV would be very interested to collaborate with WMO, for example by preparing documentaries or sending a reporter to cover a conference.

CWERA was established in 2005, it works in the field of wind and solar energy. Regarding wind, wind energy resource is monitored by using historical data from the last 30 y and by current data; wind resources are assessed by the system WERAS/CWERA across China, including on-shore and off-shore wind, multi GW wind bases and provincial wind farm planning projects. For solar resource monitoring and assessment, monitoring stations are planned to be enhanced. The CWRA/CMA system forecasts power generation for wind farms and PV stations. Grid meteorological services are also provided, as are hydropower and high-speed railway meteorological services. Ice covering of cables is a hazard as if there is also wind, the cable may be “dancing” which may cause collapse of the powerline if high amplitude.

There are more than 1000 wind farms and solar parks, high variability in output as wind varies greatly and fast. It is expected that by 2050 most of the energy will be solar. China plans to develop “distributed solar plants”.

PWS is developing weather services to specific users, the partners can see the product through an interface, website, special app and by mobile internet.

The persons working on the Weather TV have a media background, they are graduates from the Communication University. Naturally they will need to get to know meteorology, as they work in CMA: they usually study by themselves, have training 1 time / 2 weeks, with expert who gives a lecture to improve the use of information, staff is also sent to CMA training centres (for varying length of time, a week, 3 months, 6 months), courses can be also, e.g., 4 h/week x 3 months. Training is being given in the new media.

On the hotline consultation and severe weather programme, special experts interpret phenomena and forecast to the public and may compare with old, famous events such as a certain typhoon. Beijing transport radio is very useful for informing persons in cars, taxis etc.

Feedback is provided by annual user census by questionnaire, routine meetings with partners (e.g., from energy sector), media hits. PMSC is co-operating with two companies that provide information on number of viewers, their age and what they liked. PMSC also invites audiences to see a programme and then do a survey to see what they like.

For the specialized meteorological service, users are involved from the very beginning, otherwise they will not pay for the service; there is discussion which leads to improvements. During special events or periods, such as the spring festival, transportation and the movement of people is massive and very important requiring special services to the public, local governments, and transport sector.

Ms Fao and her group are very interested to collaborate with WMO. They have from 2002 onwards a lot of video materials on DRR which they could provide for WMO. They could also make videos for WMO. It would be very interesting for Ms Fan to join a conference and find out what other countries are doing in media. We should inform her of possibilities and invite her to participate. This should be on a planning and director level event, not one for presenters. Perhaps as the visibility of NMHSs is becoming more and more important for several reasons, it would be an idea to organize a media communications meeting. Ms Fan Zhao gave me the DVD on Climate Change: China’s Actions that has been prepared for this year’s COP, such a DVD is prepared each year, since 2007, on China’s actions on combating climate change.